Regulating Two-Sided Markets: An Empirical Investigation

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Abstract

We use confidential bank-level data to study the impact of interchange fee regulation on payment card services when merchant acceptance is not complete. We find that consumer and merchant welfare improved when interchange fees, transfers among banks, were reduced. Furthermore, bank revenues increased because the increase in the number of transactions offset the decrease in the per-transaction revenue. In particular, our results suggest that interchange fee regulations had increased the quarterly growth rate of debit card transaction volumes by 2 percent to 25 percent whereas credit card interchange fee regulation increased the quarterly growth by 6 percent to 30 percent depending on the specific regulatory intervention. Furthermore, quarterly growth of issuer revenue increased by 1 percent to 26 percent depending on the specific regulatory intervention.

Key words: consumer choice, merchant adoption, payment cards

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1. Introduction

The recent financial crisis has increased the calls for regulation of financial services. A small, but controversial section of the Dodd-Frank Wall Street Reform and Consumer Protection Act gives the Federal Reserve the authority to regulate U.S. debit card interchange fees to promote greater efficiency of retail payment systems. The regulation of interchange fees by public authorities occurred in several other countries during the past decade. Using a unique Spanish proprietary bank-level dataset, we are able to study the impact of different interventions by the public authorities during 1997 to 2007 on merchant acceptance, consumer adoption, transaction volumes, and issuer and acquirer revenues.

Payment networks are the backbone of any well-functioning financial market. Specifically, retail payment networks allow buyers of products and services to transfer monetary value to sellers. Increasingly, these monetary transfers are initiated with payment cards. Given the limited number of networks and the collective setting of network fees by competitors, antitrust authorities and regulators have scrutinized these fees and other business practices. Over the last decade, economists have questioned whether government intervention can improve social welfare. In addition, some policymakers have encouraged the migration from paper-based instruments such as cash and checks to electronic alternatives such as payment cards.

In this article, we study different episodes of government encouraged reduction in interchange fees for debit and credit cards. Our main results are as follows. First, we find strong evidence suggesting that merchant acceptance has increased because of a reduction in interchange fees. Second, consumer adoption of debit cards did not significantly decrease over the period because of lower interchange fee. Given the multi-functionality of debit cards, i.e. ATM access and POS payment, many consumers were carrying cards prior to using them for

POS purchases. Credit card adoption increased dramatically during the period of interchange fee reductions despite increases in annual fees. Third, bank payment revenues from debit and credit card services are positively related to increased transactions resulting from lower interchange fees. Our results for bank revenues suggest that the increase in the number of transactions appears to offset the decrease in the per-transaction revenue. We estimate that the additional quarterly growth in debit card issuer revenue from each regulatory intervention increased from 2 percent to 16 percent on average and credit card issuer revenue increased from 3 percent to 26 percent on average. The impact of lower interchange fees on the quarterly growth of acquirer revenue was also positive but significantly lower in magnitude.

Payment cards are generally characterized as a two-sided market. Rochet and Tirole (2003) define a two-sided market when the price structure, or the share that each type of agent pays the platform, affects the total volume of transactions.[1] The key aspect of these markets is the presence of indirect network externalities and how fee structures are able to internalize these externalities. Often platforms will subsidize the participation of one set of agents by extracting surplus from the other set of agents to internalize this externality. For example, online news providers may not charge eyeballs that view their sites but earn all of their revenue from advertisers.

Payment card networks are comprised of consumers, their financial institutions (known as issuers), merchants, their financial institutions (known as acquirers) and a network operator or platform. A consumer makes a purchase from a merchant. Generally, the merchant charges the same price regardless of the type of payment instrument used to make the purchase. Consumers often pay annual membership fees to their financial institutions for credit cards and may pay

[1] For a broader description of this market, see Armstrong (2006), Rochet and Tirole (2006), Rysman (2009), and Weyl (2010).

service charges for a bundle of services associated with transactions accounts. Merchants pay fees known as merchant discounts. Acquirers pay interchange fees to issuers.

Empirical research on the impact of changes in interchange fees on usage is almost non-existent. Hayes (2007) uses structural break analysis to study the impact of interchange fee regulation in Australia. He uses aggregate level monthly data on the changes in share of credit card purchases. Given the maturity of the Australian market, he finds no evidence of structural breaks resulting from an almost 50 percent mandated decrease in interchange fees. While the change in interchange fees may not have affected long run trend of credit card usage, the sharing of economic surplus among agents may have shifted.

There are some empirical investigations of other two-sided markets (Argentesi and Filistucchi, 2007; Dubois, Hernandez-Perez, and Ivaldi, 2007; Kaiser and Wright, 2006; and Rysman, 2004). Our approach is similar to Rysman (2004) who uses a simultaneous equation estimation technique study the tradeoffs between consumers and advertisers in the market for yellow pages. He estimates the consumer demand for yellow page usage as a function of advertising and the inverse demand for advertising as a function of consumer usage. He is able to identify a positive network effect.

Our article is organized in the following way. In the next section, the market for payment services in Spain along with the regulatory actions taken by the public authorities. We describe our dataset in section 3. We discuss our empirical strategy in section 4. In section 5, we present our results. We discuss robustness tests in section 6. Finally, we offer some concluding remarks in section 7.

2. Spanish Regulatory Developments

Spain represents a unique laboratory to study the effects of encouraged or mandated interchange fee ceilings on consumer and merchant payment card adoption and usage. Very few countries have had repeated interventions to reduce interchange fees over a significant time period and have had significant changes in acceptance, adoption and usage. In 2000, Spanish residents relied more on cash to make purchases than their neighboring countries. Carbó Valverde *et al.* (2003) report that Spain had a currency to GDP ratio of 8.9 percent compared to 6.2 percent for Germany, 4.7 percent for Portugal, and 3.2 percent for France. Similarly, Spain had far fewer non-cash transactions per capita per year at 56 than Germany (177), Portugal (94), and France (196) in 2000.

As noted above, many central banks and regulatory bodies have encouraged the migration to electronic payment instruments to increase the efficiency of payment systems by reducing their costs. For example, the European Central Bank (ECB) stated that "increasing non-cash payments is a way of improving retail payment revenues and cutting back operational costs" (ECB, 2010). In Spain, the Secretary of State for Commerce and Tourism created a Special Commission to study the usage of payment instruments in Spain and the transition from cash to card payments (Bank of Spain, 2007). Comparatively, Spain's acceptance of debit cards by merchants was relatively low compared to other advanced economies.

One strategy to increase usage of payment cards is to reduce merchant acceptance cost. A key determinant of merchant fees is the interchange fee. As in other countries, Spain also experienced antitrust scrutiny on interchange fees. The collective setting of interchange fees by the three networks in Spain was a major cause of antitrust concern. There have been four important events that significantly affected the setting of interchange fees in the Spanish

payment card industry since the late 1990s. All government-initiated events are summarized in Table 1. These agreements were sponsored by the Spanish Ministry of the Economy or the Ministry of Industry, Tourism and Trade. The first regulatory decision on interchange fees took place in May 1999. The Spanish government promoted an agreement between the three payment networks and the main merchant associations to reduce maximum multilateral interchange fees to 2.75 percent in July 2002. [2] Maximum interchange fees varied significantly across merchant categories. For example, in 2002, the average interchange fee was 2.79 percent in casinos and 0.63 percent in gas stations.

To a large extent the evolution of Spain's interchange fee antitrust scrutiny and regulation were affected by a European Commission (EC) decision regarding European Union (EU)-wide cross-border interchange fees in 2002.[3] In 2002, the main government intervention was triggered by the European Commission (EC) Decision 2002/914/EC of 24 July, regarding Case No. COMP/29.373 – Visa International – Multilateral Interchange Fee.[4] Following these investigations of the EC, the TDC followed suit and requested the Spanish payment card networks to provide information on Visa's methodology for determining interchange fee for Visa. From July 2002 to January 2003, the maximum interchange fee was reduced from 2.75 percent to 1.85 percent.

[2] In motivating this decision, the Ministry of Economy received a report from the Spanish Antitrust Authority (TDC) stating, *inter alia*, that "interchange fees will be reduced permitting an adequate adoption by merchants and, ultimately, by cardholders" (TDC, No. A 264/99, 26 April 2000).

[3] In July 2002, the EC cleared Visa's European cross-border interchange fees and offered some insights on the position of EU competition authorities with regard to the setting of interchange fees. The EC found that there were upward pressures on the level of interchange fees. More recently, MasterCard and the European Commission have agreed on a substantially lower multilateral interchange fees for cross-border European transactions. In April 2010, Visa Europe and the European Commission reached an agreement on multilateral interchange fees for intra-regional immediate debit transactions in the European Union. Under the agreement, Visa Europe will cap these fees at 20basis points (0.2 percent) for four years. There is still discussion between Visa Europe and the EC with regard to credit card fees.

[4] For a summary of these decisions, see Arruñada (2005).

In May 2003, the Spanish Congress requested the TDC to investigate the setting of interchange fees and to follow the basic principles that the European Commission adopted for EU-wide cross-border interchange fees. The TDC refused several proposals of the networks on their setting of interchange fees. In December 2003, the TDC announced that the 'special authorization' for the setting of interchange fees of the three payment card networks was going to be revoked although this decision was not formally undertaken until 2005. Several attempts from the industry to maintain their 'special authorization' for the setting of interchange fees were refused during these two years and the networks were requested to set levels of interchange fees that only reflect operating and fraud costs. The maximum interchange fee was progressively reduced from 1.85 percent in January 2003 to 1.75 percent in December 2005.

The most important regulatory action for the Spanish payment card industry took place in December 2005. Some TDC resolutions required the card networks to only include two costs when setting domestic multilateral interchange fees (MIFs): a fixed cost for processing each transaction and a variable ad valorem cost for the risk of fraud (TDC Decisions of 11 April 2005, No. A 314/02, No. A 318/2002and No. A 287/00). As a consequence of this resolution, the Spanish government promoted an agreement between payment networks and merchant associations to establish a timetable to progressively reduce interchange fees from 2005 to 2009, with different schedules for debit and credit cards. Debit card fees were set as a fixed transaction fee regardless of the purchase amount. The maximum debit card interchange fees were set to .53 euros/transaction for 2006, .47 euros/transaction for 2007, .40 euros transaction for 2008 and .35 euros/transaction for 2009. As for maximum credit card interchange fees, they were set to 1.40, 1.30, 1.10 and .79 percent for 2006, 2007, 2008 and 2009, respectively. The average interchange fees for all cards were effectively reduced from 1 percent in December 2005 to .70 percent in

December 2009. Average debit card interchange fees declined from 0.39 to 0.31 euros/transaction from 2005 to 2009 while credit card interchange fees fell from 1.23 to 0.67 percent.

Adoption and usage: main figures

During 1997-2007, debit card transactions increased from 156 million to 863 million and credit card transactions increased from 138 million to 1.037 billion. The reduction in interchange fees increased the acceptance and usage of payment cards. As shown in Table 2, from 1997 to 2007, the number of debit cards has increased by 40.9 percent while the number of credit cards has increased by 207.1 percent. During the same period, the number of transactions increased substantially with debit card transactions being five times larger in 2007 than in 1997 while credit card transactions increased by seven times. Furthermore, the average number of POS transactions per card per year has increased from 7.1 to 27.8 during the same period.

Consumer preferences for debit and credit cards differ. Adoption for debit cards by consumers may have reached a saturation point earlier than credit cards because they were adopted for their ATM functionality more than a decade before. In particular, the number of debit cards reached its peak in 2003 (33.1 million) and decreased to 31.5 million in 2007. However, the number of credit cards increased monotonically during the period, reaching 43 million in 2007. Spanish consumers increased their holdings of credit cards even though credit card annual fees increased. According to our sample data, average credit card annual fees increased from 18.53 euros in December 1997 to 28.16 euros in December 2007.

Table 2 also shows that the average value of debit card transactions have increased significantly from 38.5 to 46 euros/transaction (in real terms) between 1997 and 2007. The increase in average real debit card per transaction value can be explained by the greater usage of

these cards for payments of larger-value purchases at the POS. On the other hand, the average credit card transaction value decreased from 58.5 to 54.3 euros (in real terms). The lower average real credit card per transaction value may result from the greater usage of these cards among consumers for lower-value purchases. As for interchange fees, although the Bank of Spain only offers data from 2002 onwards, combining this information with our sample data for 1997, we observe that interchange fees decreased on average from 3.42 percent in 1997 to 0.90 percent.

3. Our Dataset

The data

We use proprietary quarterly payment card data from 45 Spanish banks from 1997:1 to 2007:4. Administrative data is less likely to be associated with measurement error than consumer and merchant survey data. These data are adjusted to reflect mergers during our sample period to create a balanced panel by backward aggregating all premerger data on merging banks prior to their merger. In total, there are 1,980 panel observations.[5] The database contains quarterly bank-level (acquirer and issuer) information on payment cards, ATMs and POS terminals as well as prices for debit (interchange and merchant fees) and credit card transactions (interchange fees, merchant fees and annual credit card fees). Our data also includes merchant acceptance and transaction volume by acquirer and number of cardholders and transaction volume by issuer. Our data allow us to test, for the first time, some of the fundamental predictions of the two-sided market theoretical payment card models.

[5] Our sample banks represented 56.7 percent of total card payment transactions in 1997 and 64.8 percent in 2007 when compared to the aggregate data provided by the Bank of Spain.

Definition of the variables

Table 3 provides the main definitions of the posited explanatory variables and their scope (bank-level, network-level and dummy variables). Our banks in the sample belong to two of the three Spanish networks, Euro6000 and Servired (the other network is called 4B). Although our data is primarily bank-level, we also have aggregate information available for each one of the three networks.[6] The distinction between bank-level and market-level variables is important for our empirical purposes. For example, a consumer's decision to adopt an issuer's payment card is dependent on the total number of merchants that accept the card in all the three networks. Similarly, a merchant's acceptance of debit cards is dependent on the number of cardholders that have debit cards. From the data we observe that most of the issuers and acquirers operate in different regions. Therefore, merchant acceptance by acquirer has been computed as an (branch weighted) average of merchant acceptance in the different regions where the (acquirer) bank operates. Similarly, the variable for merchant acceptance at the market level has been computed as a branch-weighted average of the percentage of merchants accepting cards for purchase transactions in the regions where the bank or any other banks belonging to the same network operate over the total number of merchants in those regions.

Additionally, although the maximum and minimum thresholds of interchange fees for different merchant activities is set at the network level, the average acquirer-level merchant fee varies depending on the actual fee charged and the proportion of the bank's POS debit and credit transactions by merchant sector. Therefore, the merchant discount fee charged by an acquirer is computed as a transaction weighted-average of merchant discount fees charged by the bank in the different merchant sectors using the acquirer's POS machines.

[6] A consumer's payment card belongs to only one payment network. However, there are some merchants that belong to more than one of these three networks although these merchants are early adopters of payment cards. Smaller merchants generally belong to one network.

Importantly, our data also permits us to consider some non-monetary costs that may affect decisions regarding adoption and usage by consumers and merchants. In particular, there are non-monetary costs that affect the adoption of a card such as the 'shoe leather' costs involved in the distance to reach a cardholder's bank branches to withdraw cash. If the density of branches of a consumer's bank is high, the willingness of a consumer to adopt a debit card would be low because their cash acquisition cost would be low.

When a consumer chooses to use a payment card, the density of ATMs from other issuers affects her decision to use a debit card. To capture the opportunity cost of using a debit card, we compute a rival ATM density variable as a proxy of the relative costs of withdrawing cash at rivals' ATMs.

We also consider other variables such as region-specific control variables that may influence card transactions. For example, our crime data is region specific and measures robberies and assaults per 1,000 residents in a given region. If the acquirer or issuer operates in more than one region, we use a weighted average by the number of bank branches in the region.

We also include four regulatory dummies to measure the impact of the different interchange fee regulations and or agreements between the Spanish government and market participants on merchant acceptance and consumer adoption. These regulatory dummies represent the year when the regulatory intervention was introduced (or the implementation of agreements between market participants) and takes the value 1 from that quarter onwards and zero otherwise. These dummies allow us to study the impact of regulation on acceptance, adoption, and usage. Furthermore, we would expect each market intervention to have a different impact. In section 7, we explore other empirical ways of capturing the effects of these regulations for robustness purposes.

Summary statistics and trends of our data

The summary statistics for the variables that we use for our empirical model are shown in Table 4. Figure 1 depicts the evolution of some of these variables.. The trends shown match up closely with the descriptive data from the Bank of Spain shown in Table 1 for the whole industry. As shown in Figure 1, interchange and merchant fees are highly correlated (simple correlation is .94). Besides, the evolution of these fees seems to be asymmetrically related to the evolution of annual fees. Interestingly, despite increases in annual fees over time, merchant acceptance –percentage of merchants accepting cards- grows over the whole period and, in particular, after the regulatory interventions. While the average quarterly increase in merchant acceptance is .26 percentage points, the changes were particularly significant in the quarter right after the 1999 regulation (.35), the 2003 regulation (0.48) and the 2005 regulation (0.36). These percentage changes were of similar magnitudes in the quarters following the first one after the regulation. Similarly, the number of POS and cards and related transaction volumes also increase significantly, in particular following the 2003 and 2005 regulations. The number of POS in the quarter following the 2003 and 2005 regulations increased by 2.5 and 4.1 percent, respectively; the number of cards increased by 2.1 and 1.9 percent, respectively, and POS transactions increased by 3.9 and 3.6 percent, respectively. In the rest of the paper, we empirically estimate the impact of regulatory events.

4. Empirical Strategy

The theoretical payment card literature predicts that the interchange fee is socially optimal if increasing or decreasing the fee results in a lower aggregate surplus for consumers,

merchants, and banks. Our empirical analysis will focus on how decreasing interchange fees affected merchant and consumer adoption of payment cards as well as issuer and acquirer transaction volume and revenue. We will compare the impact of lowering interchange fees on two types of payment cards—debit and credit. In our empirical analysis, an issuer or an acquirer is our unit of study. In other words, we will study the impact of lowering interchange fees on an acquirer's changes in merchant acceptance in the region that it operates in and its transaction volume and an issuer's changes in its number of cardholders and its transaction volume.

Merchant acceptance and consumer adoption

Lowering interchange fees is likely to increase merchant acceptance of payment cards because some non-payment card accepting merchants would choose to accept payment cards at a lower fee. However, if a sufficient number of cardholders give up their cards, merchant benefits from card acceptance may decrease. In other words, in addition to the level of fees, merchants also consider consumer adoption in their acceptance decisions.

On the other hand, lowering interchange fees is likely to increase cardholder fees. The level of increase in consumer debit card fees is difficult to measure because of the bundle of services offered with a transaction account or a line of credit. On the other hand, credit cards have explicit annual fees. Facing higher fees, some cardholders may abandon their payment cards. But, if the increase in fees is associated with greater merchant acceptance, cardholders may value their cards more and continue to hold them. Alternatively, if the demand for payment cards is sufficiently inelastic, consumers may continue to hold their payment cards.

We estimate equations (1) and (2) that identify merchant acceptance and consumer adoption decisions:

$$Merchant\ acceptance = f(X_{ma}, C, R) \qquad (1)$$

$$Consumer\ adoption = f(X_{ca}, C, R) \qquad (2)$$

where X_{ma} and X_{ca} are the exclusion restrictions that identify the merchant acceptance and consumer adoption decisions, respectively, and C and R are vectors of control variables and regulatory dummies that are common to both equations, respectively. All variables (except for the regulatory dummies) are expressed as the difference between the logarithms of current quarter and the quarter before. These differences can be interpreted as quarterly growth rates. We study the impact of interchange fees separately for debit and credit cards. For merchants, they face an explicit per-transaction fee to process either a debit or credit card transaction. Merchant debit and credit card acceptance exclusion restrictions include the merchant discount fee and the number of cards in the network by type of payment card. Consumer debit card exclusion restrictions are own branch density and lagged merchant acceptance. For credit cards, the consumer exclusion restrictions are credit card annual fees and one-period lagged merchant acceptance.

There are some key differences in how issuers charge their customers for debit and credit cards. Cardholders do not generally pay a fixed or per-transaction fee for their debit cards. The pricing for debit card services is often bundled with other banking services such as access to ATMs. Thus, to isolate a fee for debit card services separately is not possible. Instead, we use an instrument to proxy for debit card benefits. The instrument that we use is the issuer's own branch network. When own branch density is high, consumers are less likely to have a debit card because the shoe-leather cost of visiting a bank teller to acquire cash is relatively low. Higher density of branches would most likely negatively affect the adoption of ATM and debit cards. A limitation with this instrument is that we are unable to separate ATM card and debit card

adoption because they reside on the same plastic card. However, having such a card is a necessary step to make debit card payments.

In addition, there is the indirect network effect—as merchant acceptance increases, the value of having a debit card increases. If the direct cost of holding a debit card is close to zero, we would expect an increase in debit card issuance as the proportion of merchants that accept debit cards increases. Eventually, debit cards may reach a saturation point i.e. when most residents have their ATM/Debit cards. Merchant acceptance enters the cardholder adoption decision as a lagged explanatory factor. The logic behind this specification is that merchant acceptance and fees may be contemporaneously related while transactions, issuance and usage may be determined by observed previous acceptance.

Unlike debit cards, credit cards are stand alone products that usually have explicit fees. Reductions in credit card interchange fee revenue should result in higher annual fees for cardholders to offset lost issuer interchange revenue. We have provided evidence earlier that credit card annual fees have indeed increased in Spain during our sample period.

Our control variables for all regressions are acquirer and issuer size, the crime rate, and a time trend. Given that payment processing is a scale business, we take bank size (in terms of the number of debit/credit card transactions as a total of network transactions to control for any increase in bank size during the sample period. We use crime statistics to capture the effect of crime on the decisions of merchants and consumers to accept payment cards.[7] We would expect that as crime increases the adoption of payment cards to increase because payment cards are more secure than cash in the event they are stolen or lost. In order to control the (mainly upward)

[7] Some theoretical money models suggest that crime may be a reason to move away from cash (He, Huang, and Wright, 2005).

trend in the data for merchant acceptance, number of cards and number of transactions, we use a linear time trend.[8]

Although equations (1) and (2) contain potentially different sets of exogenous explanatory variables, the error terms of consumer adoption and merchant acceptance are assumed to be correlated across the equations. This correlation implies that even if a separate equation-by-equation estimation would be consistent, it will not be as efficient a simultaneous equation method.

Since our model specification allows acceptance and adoption variables to interact with variables related to number of transactions this may create non-linear cross-equation restrictions on the specified parameters. In order to deal with these restrictions, the simultaneous equations are estimated using a General Method of Moments (GMM) routine with acquirer and issuer specific fixed effects. The GMM estimation relies on a set of orthogonality conditions which are the products of equations and instruments. Initial conditions for estimation are obtained using three-stage least squares (3SLS), which is a restricted version of the simultaneous equation GMM model. Unlike the standard 3SLS, the GMM estimator allows for heteroskedasticity in addition to cross-equation correlation where some variables (as merchant acceptance in our case) may appear both as exogenous and (lagged) endogenous variables in the different equations (Hansen, 1982; Wooldrige, 2002).

Acquirer and issuer transaction volume

Unfortunately, our data does not allow us to study transaction per card or per merchant. Instead, we have transaction volume data by acquirer and issuer. However, changes in acquirer and issuer transaction volume are ideal instruments for the impact of changes in payment card usage resulting from changes in the interchange fee. Our dependent variables for usage are

[8] We also have tried other trend variables such as price level, GDP, and quadratic trend specifications.

average quarterly transactions per POS terminal by acquirers and average quarterly transactions by card by issuers separated into debit and credit card transactions.

Unlike adoption and acceptance decisions, we estimate acquirer and issuer transaction volumes separately. Given that our unit of study is acquirers and issuers, estimating the volumes separately is appropriate for transaction volumes. Our regressions for debit and credit card issuer and transaction volumes are:

$$\textit{Acquirer transaction volume} = f(X_{atv}, C, R) \qquad (3)$$

$$\textit{Issuer transaction volume} = f(X_{itv}, C, R) \qquad (4)$$

where X_{atv} and X_{itv} are the exclusion restrictions that identify the acquirer transaction volume and the issuer transaction volume equations, respectively, and vectors C and R are the same as in equations (1) and (2).

For acquirer transaction volume, we use an acquirer's quarterly transactions per POS terminal as our dependent variable. The exclusion restriction that identifies the acquirer transaction volume is an interaction term of its merchant acceptance and the total number of debit or credit cards in that network. The probability of a transaction on an acquirer's terminal increases when the number of merchants served by the acquirer increases or the number of total debit or credit cards increases.

Next, we analyze what factors affect issuer transaction volume. The dependent variable is the number of transactions per issuer per card. The key explanatory variable is an interaction term of the merchant acceptance in the network and the number of cards issued by the bank. We include the same control, except for the own ATM density for debit cards, and regulatory dummies as in the other regressions.

To capture usage costs, we use the density of rival ATMs in the transaction volume equation as a proxy for the benefit of using debit cards. Given that ATM owners impose surcharges for cards issued by competitor banks, as the likelihood of using one of these ATMs increases, the benefit to having a debit card increases. We do not consider rival ATM density for credit card transaction volume.

Identifying issuer and acquirer revenues

Unfortunately, we are unable to measure acquirer and issuer profits directly, but we are able to study the impact of changes in interchange fees on bank revenue. As we have discussed in the data section, average total issuer and acquirer revenues have increased during our sample period despite reductions in interchange fees. The loss in per-transaction revenue may be made up by a greater number of transactions. If costs remain constant or grow slower than revenues, acquirer or issuer profit may increase with increasing revenue. Given large economies of scale and scope, one might expect that costs would not grow as fast as revenues. In fact, marginal cost may even be decreasing if issuers and acquirers are not facing capacity constraints.

As before, we separate banks into issuers and acquirers for debit and credit cards. Our dependent variables are issuer and acquirer payment card revenue by type of card. For issuers, this would be the product of the average interchange fees and the number of transactions and total annual fees collected (only for credit cards). For debit cards, we only use interchange fee revenue. For acquirers, this would be the difference between the merchant discount charged and the interchange fee paid multiplied by the number of transactions. Similar to our transaction volume regressions, our explanatory variable for acquirers is one-quarter lag of the interaction of merchant acceptance of a specific acquirer and the total number of cards in the network. Our exclusion restriction for issuers is the number of cards issued by each issuer the quarter before

times the proportion of merchants accepting in the whole network. Our exclusion restriction for acquirers is the proportion of merchant acceptance of debit and credit cards, respectively, times the number of debit and credit cards, respectively, in the network. We also include our vector of control and regulatory variables.

5. Main Results

In tables 5-9, we report our regression results. Generally, we find that consumers and merchants benefit from reductions in interchange fees during our sample period because an increase in merchant card acceptance results in greater adoption and usage of payment cards. Furthermore, we find that issuer and acquirer revenues increased because lower interchange fees resulted in more transactions. The revenue from increased transactions offsets the decrease in per-transaction revenue for issuers during our sample period. For acquirers, the percentage difference between the merchant discount and the interchange fee remained steady for a significant part of our sample.

Debit and Credit Card Adoption

Table 5 shows the results corresponding to consumers and merchant adoption of debit cards. We find that a 10 percent reduction in the rate of decline per quarter in the average merchant discount fee by an acquirer resulted in a .48 percent rate of increase in merchant acceptance per quarter.

Neither bank size nor crime is statistically significant. The signs of all the regulatory dummies except for 1999 suggest that lower interchange fees strongly impacted the rate of merchant acceptance. However, the impact of each intervention was different suggesting that not

all interventions were equal in convincing merchants to adopt debit cards. For example, the estimated coefficient of the regulatory dummy for 2002 suggests that after that regulation, debit card merchant adoption increased by an additional 1.2 percent quarterly, even after controlling for influence of the rest of the explanatory variables. By the same token, the quarterly increase in merchant acceptance related to the 2003 and 2005 regulations are an additional 1.6 percent and 1.3 percent, respectively. Note that in 2005, there was a change in the way debit card interchange fee was imposed from a transaction percentage to a fixed per-transaction fee.

While we are unable to isolate a price effect for consumer adoption debit card services, we find strong evidence to support our hypothesis that consumers value greater merchant acceptance and react to increases in the price of the main alternative payment instrument—cash. Specifically, a 10 percent increase in the rate of merchant adoption per quarter resulted in a 4.6 percent increase in the quarterly adoption rate of debit cards by consumers. As issuer's branch density increases, consumer adoption of debit cards decreases. Specifically, a 10 percent increase in the quarterly growth rate of issuer's branch density resulted in a .05 percent decrease in the quarterly growth rate of debit card adoption.

As mentioned before, the underlying dynamics of credit card adoption is significantly different from debit card adoption. Reductions in credit card merchant discount fees increased merchant acceptance of credit cards (see table 6). Specifically, a 10 percent increase in the rate of decline of the average merchant discount of an acquirer increased the growth rate of merchant acceptance of credit cards by 1.6 percent. As for the number of credit cards in the network, a 10 percent quarterly growth rate in this variable resulted in a 1.63 percent quarterly growth in the acceptance of credit cards by merchants. Note that only the last two regulatory dummies are significant—with coefficients .11 and .20—suggesting that the initial regulatory interventions

were not as effective in increasing merchant acceptance as the last two. In particular, credit card merchant acceptance increased by 1.1 percent quarterly after the 2003 regulation and 2 percent quarterly after the 2005 regulation.

As our priors suggested, the number of cards issued is positively impacted by the number of merchants that accept credit cards (table 7, column 3). Specifically, a 10 percent increase in the quarterly growth rate in merchant acceptance increases the quarterly growth of credit card issuance by 3.0 percent. A key result is that growth in the number of cards issued is not affected by the annual fee suggesting that the interchange fee was not previously socially optimal. We are unable to disentangle two potential reasons for this insignificance. First, consumers may be fairly inelastic to increases to credit card annual fees. Second, they are willing to pay higher fees if more merchants accept credit cards. Regardless of why consumers do not respond to prices, there may be benefits to increasing merchants that accept credit cards by imposing higher costs on consumers. These benefits stem from the network externality of merchant acceptance.

The impact of lower interchange fees on merchant acceptance is positive for both debit and credit cards. Merchants increase acceptance when their fees fall. The impact of lower interchange fees on debit card adoption is less clear for two reasons. First, debit card also serve as ATM cards and isolating their debit functionality is difficult. Second, debit card services are bundled with other transaction services. On the other hand, credit card annual fees increased because of lower interchange fees but consumer adoption increased.

Debit and Credit Card Transaction Volumes

Now, we turn to payment card transaction volume. First, let's consider the impact of interchange fee regulation on merchant debit card transactional volume from looking at acquirer transactional volume per POS terminal as the dependent variable (table 7, column 2). The

interaction of merchant acceptance at an acquirer and the total number of cards—showing network effects—is significant and positive suggesting that the rate of growth of debit card transactions has increased because there are more merchants and consumers on board. Specifically, a 10 percent quarterly growth rate in this interaction resulted in a debit card transaction quarterly growth rate of .27 percent. Additionally, a 10 percent increase in the quarterly growth rate of rival ATM density—which proxies for the cost of cash withdrawal—resulted in a .22 percent increase in the quarterly growth rate of debit card transactions at POS terminals.

All the regulatory dummies are positive and significant suggesting that regulatory intervention increased the quarterly usage at merchant locations. The increase in the quarterly rate of transaction growth is highest for the period after 2005 suggesting that the later regulatory interventions had more impact on transactional volume at acquirers. The coefficient of the dummy for the 2005 regulation is .24 suggesting that, other things equal, the effect of this regulation in the quarterly rate of increase in debit card transaction volume at POS was 2.7 times higher than the effect of the 2003 regulation (.09), 1.8 times higher than the regulation of 2002 (.14), and 12.5 times higher than the regulation of 1999 (.02).

The increase in issuer transactions proxies for the increase in consumer usage, albeit imperfectly. The key explanatory variable is the interaction of merchant acceptance and cards issued by the issuer. The interaction term is significant and positive suggesting that an increase in consumer and merchant adoption growth rates increases the rate of growth for consumer transactions (table 7, column 3). Specifically, a 10 percent increase in the quarterly rate of growth of the interaction of network merchant acceptance and debit cards issued by an issuer resulted in a .47 percent quarterly growth rate in an issuer's debit card transactions per card.

Furthermore, a 10 percent increase in the quarterly growth of rival ATM density resulted in a .63 percent increase in the quarterly growth rate of issuer debit card transactions per card. In other words, an increase in cash acquisition costs strongly encourages usage of debit cards.

All the regulatory dummies are positive and significant suggesting that decreases in debit card interchange fees increased debit card transactions for issuers. As before, the later regulatory actions impact issuer transaction volume growth more. Specifically, the increase in issuer transactional quarterly growth rate after 1999 intervention is .06 whereas the increase in the quarterly growth rate for the 2005 dummy is .22.

We report credit card acquirer and issuer transaction volume regressions in table 8. A 10 percent increase in the quarterly growth of the interaction term of acceptance by merchants using the same acquirer and total credit cards in the network results in a 2.09 percent increase in the growth of acquirer transactions at the point of sale (table 9, column2). Interestingly, the crime rate is also positive and statistically significant. One cautious interpretation would be that credit cards unlike debit cards are used for large purchases and merchants are more willing to accept them because carrying large amounts of cash is undesirable in high crime areas. The regulatory dummies when significant have positive signs, with a particularly high economic impact of the dummies for the regulation of 2003 (.16) and 2005 (.30).

We report the issuer transaction volume in table 8, column 3. We find that a 10 percent increase in the quarterly growth rate of the interaction term of merchant acceptance in the network and credit cards issued by an issuer results in a 1.63 percent increase in issuer transaction volume. The coefficient on the crime rate is also significant and positive suggesting that higher crime rates induce shift from cash to credit cards, which are generally used for higher-value purchases. Importantly, all the regulatory dummies are significant and positive and

the impact of the 2003 and 2005 dummies on the increase in quarterly growth rate of credit card transaction volume are particularly high (.11 and .29, respectively).

Reductions in interchange fees have increased usage of both debit and credit cards. Furthermore, different interventions lead to different impact on usage. These effects also differ between debit and credit cards.

Bank revenues

In table 9, we report our results for bank revenues. In the second and third columns, we report debit card acquiring revenue and debit card issuing revenue regression results, respectively. In the fourth and fifth columns, we report credit card acquiring and credit card issuing revenue regression results, respectively. In both sets of regressions, the increase in the quarterly growth of number of transactions is positively correlated with the quarterly growth of bank revenues suggesting that while per-transaction revenue may have decreased, overall revenues increased because the revenue from increased transactions volume offset the decrease in per-transaction revenue for the time period of our sample. This evidence also seems to be supported by descriptive data, as shown in Figure 2, where transaction volume—and, in particular, for issuers and after 2003 and 2005 regulations—increased in parallel to revenues.

However, the impact of the regulatory interventions are more significant on the issuing side than the acquiring side as also evidenced by the magnitudes of the coefficients and the goodness of fit. This result is consistent with the fact that the acquiring side of the business may be more competitive and any reductions in interchange fees would result in an equal magnitude decrease in the merchant discount. We reported earlier that the correlation between the movements in merchant discounts and the interchange fees are close to one. On the issuing side, the quarterly rate of decrease in interchange fees is positively and significantly related to the

quarterly rate of bank revenues suggesting that competition may have been too intense on the issuing side resulting in "too high" merchant discount and interchange fees. In turn, fewer card transactions took place at this socially inferior interchange fee.

6. Robustness tests

In this section, we conduct several robustness tests to consider alternate explanations for increased adoption and usage of payment cards.

Other Simultaneous Equation Specifications

We have tried other specifications for the simultaneous equations estimations. In particular, we estimated the system using two-stage-least squares, three-stage least squares and seemingly-unrelated regressions. Although the results were overall qualitatively similar, the goodness of fit of these estimations was far poorer than our GMM estimations.

In the GMM baseline results, autocorrelation tests are included to examine the possibility that lagged values of the dependent variables might affect, at least partially, the current values of these variables. In this case, a "dynamic" specification with lagged dependent variables as regressors could address these feedback effects. However, the values of these tests in all our regressions suggest that the null hypothesis of no serial correlation cannot be rejected and, therefore, do not warrant using dynamic specification. In any event, regressions using dynamic panel techniques were also undertaken and the coefficients of the lagged dependent variables were not found to be significant in any of the equations.

Variations in regulatory dummy specification

As for our stepwise dummies showing the effects of changes in interchange fee regulation, various alternatives were considered. The dummies were introduced one by one in

the equations and the results were very similar to those obtained when they are included altogether.

Additionally, to identify the regulatory changes, a potential disadvantage of the dummies is that they are a stepwise and discontinuous approximation of the regulatory effect across time. Linear splines give a more precise approximation of the effect of interchange fee regulations as a set of continuous linear functions. Therefore, as a robustness check, we reran our regressions with splines instead of dummies (not shown for simplicity). We approximate the splines as the difference in the number of quarters between four subintervals (the regulatory events). The end points of the linearly approximated subintervals are known as "knots" and the specification of the spline is $f(x) = \alpha_i[(x_{i+1} - x)/(x_{i+1} - x_i)] + \alpha_{i+1}[(x - x_i)/(x_{i+1} - x_i)]$ when $x \in (x_i, x_{i+1})$ and 0 otherwise, where x is the quarter considered, and x_i are the "knots." The use of splines did not change our results with all the coefficients for the regulatory events maintaining their signs and no statistically significant differences with the estimated values of the coefficients from the dummies in our baseline results.

Estimations for different sub-periods and related regulatory effects

A simpler (although less informative) approach to likely changes in merchants' and consumers' adoption and usage of debit and credit cards is to estimate our main equations for four different time periods (1997-1998, 1999-2001, 2002-2004 and 2005-2007). The effects of changes in debit merchant discount fees on merchant adoption and of merchant acceptance in the network on the number of debit cards are from 1 to 3 times higher in the 1999-2001 and 2005-2007 periods than in the other two periods.[9] These differences are statistically significant according to Wald tests of differences in the estimated coefficients and suggest that the dynamics

[9] The results are not shown for simplicity but they are available upon request to the authors.

of prices and adoption and usage particularly increased in the periods where interchange fees were reduced to a larger extent due to government interventions. In the case of credit cards, related differences in the magnitude of the coefficients for the abovementioned sub-periods are a bit lower (from 1 to 1.5 times higher) although also statistically significant according to Wald tests (not shown for simplicity).

Alternative control variables

The results also seemed robust to alternative specifications of the control variables and, in particular, the time trend. A potential weakness of the proposed specification is that the trend is not appropriately capturing over time changes that may overlap with the identified impact of regulatory dummies. In particular, factors such as non linear trends, business cycle influences or technological changes may affect our results. In order to control for these potential influences we have also tried other types of variables to pick them up such as a quadratic time trend, GDP growth and Internet penetration. It may also be the case that the dynamics of adoption and usage may be different in territories with different levels due to idiosyncratic features such as differences in the presence of tourists that may make adoption and usage potentially heterogeneous across regions, thereby affecting to a larger extent those banks, merchants and consumers in more touristic regions. We have considered these influences by estimating our main equations for two sub-samples separating regions over the median value of tourism revenues over GDP and below that median value. The results for all these alternative specifications (not shown for simplicity) suggest that none of these alternative specifications significantly change our baseline results and conclusions since our main variables exhibit the same signs and similar coefficient magnitudes.

7. Conclusion

The structure of fees in two-sided markets has been addressed in the theoretical literature but there has been little empirical analysis regarding the impact of changes to fee structures. Theory predicts that platforms in two-sided markets may subsidize the participation of one set of agents by extracting surplus from another set of agents to internalize indirect network externalities. We find evidence that reducing interchange fees have a positive effect on consumer and merchant adoption and usage when merchant adoption is far from complete.

While we are unable to study the impact of interchange fee regulation on bank profits, we find that bank revenues increased because the increase in the number of transactions appears to offset the decrease in the per-transaction revenue. However, there is most likely a critical interchange fee below which revenues no longer increase. Unfortunately, given our data limitations, we are unable to quantify the critical interchange fee.

Interestingly, other market-based solutions may result in maximizing social welfare such as price discrimination based on the benefits received by each merchant and each consumer. For example, in other countries such as the United States, interchange fees for new entrants such as grocery stores in the 1990s were reduced significantly by payment card networks to encourage merchant acceptance of payment cards without government encouragement. Such market-based strategies also internalize the merchant adoption externality. Thus, our results should not be viewed as a blanket endorsement for government-encouraged interchange fee reductions.

Once merchant and consumer adoption is complete, interchange fee regulation may only result in redistribution of surplus among participants, most notably between banks and merchants. In other words, interchange fee regulation would not necessarily improve social

welfare. In this case, we are agnostic about the distribution of surplus among payment card market participants.

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Table 1: Regulatory Actions Affecting the Setting of Interchange Fees

Year	Regulatory action	Regulatory body	Main implications for interchange fees
1999	REDUCTION OF INTERCHANGE FEES	THE SPANISH MINISTRY OF THE ECONOMY	Maximum interchange fees were gradually reduced from around 3.5 percent in 1999 to 2.75 percent in July 2002.
2002	INVESTIGATION ON THE SETTING OF INTERCHANGE FEES (MORAL SUASION)	SPAIN'S ANTITRUST AUTHORITY	Maximum interchange fees were reduced from 2.75 percent in July 2002 to 1.85 percent in January 2003.
2003	PROPOSALS FROM THE NETWORKS ON THE SETTING OF INTERCHANGE FEES ARE REFUSED (MORAL SUASION)	SPAIN'S ANTITRUST AUTHORITY	Maximum interchange fees were reduced from 1,85 in 2003 to 1.75 in 2005
2005	A REDUCTION OF INTERCHANGE FEES AND A FINAL DATE FOR THE ADOPTION OF A COST-BASED MODEL	THE SPANISH MINISTRY OF INDUSTRY, TOURISM AND TRADE	From January 2006 until December 2008, the maximum level for an interchange fee would be progressively reduced. The fees decreased from 1.75 percent in 2005 to 0.88 percent in 2009.

Source: Summary of regulatory developments mainly based on the following resolutions: Spanish Antitrust Authority (Tribunal de Defensa de la Competencia, TDC) resolution on the reduction of interchange fees (24 September 1999), Resolution of the European Commission (DG Competition COMP/29373) on the setting of cross-border interchange fees by Visa International (July 24, 2002), TDC inquiries on the setting of interchange fees by the card networks SISTEMA 4B (inquiry A 314/2002) and SERVIRED (inquiry 318/2002). TDC resolution denying the special authorizations on the setting of interchange fees to all Spanish card networks and requiring them to reduce these fees and to adopt a cost-based model (April 11, 2005).

Table 2: Recent Trends in Card Payments in Spain (1997-2007)

All the monetary magnitudes are expressed in real terms

	1997	**2007**
Total Number of Debit Cards (millions)	22	31
Total Number of Credit Cards (millions)	14	43
Total Number of Debit Card Transactions (millions)	156	863
Total Number of Credit Card Transactions (millions)	138	1037
Average number of POS transactions (per card and year)	7.1	27.8
Average number of ATM withdrawals (per card and year)	23.9	32.6
Average Value of Debt Card Transaction (€)	38.5	46.0
Average Value of Credit Card Transaction (€)	58.5	54.3
Average POS density (POS/km^2)	1.28	2.89
Average ATM density (ATMs/km^2)	0.07	0.12
Average Interchange Fee $^{(*)}$ (percent)	3.42$^{(a)}$	0.90
Average Debit Card Interchange Fee$^{(**)}$ (€/transaction)	3.61$^{(a)}$	0.40
Average Credit Card Interchange Fee$^{(**)}$ (percent)	3.19$^{(a)}$	0.93

(a) As the earliest public data available for the average interchange fees for the entire Spanish market is 2002, we compute the 1997 values from our sample data.
(*) Average percentage value of total debit and credit, on-us and intersystem interchange fees.
(**) As a consequence of the intervention of the Spanish Ministry of Industry, Tourism and Trade in 2005, a distinction is made between the applicable debit card interchange fees and credit card interchange fees, with debit card transactions becoming a fixed amount per transaction and credit card transactions continuing to be a percentage amount per transaction.

Source: Bank of Spain and authors' own calculations

Table 3: Variable Definitions

VARIABLE	DEFINITION	SCOPE
***MACCD*$_{it}$** : Debit card merchant acceptance by acquirer	Computed as (branch-weighted) average of the percentage of merchants accepting debit cards for purchase transactions in the regions where the bank operates over the total number of merchants in those regions.	Bank-level
***MACCC*$_{it}$** : Credit card merchant acceptance by acquirer	Computed as (branch-weighted) average of the percentage of merchants accepting credit cards for purchase transactions in the regions where the bank operates over the total number of merchants in those regions.	Bank-level
***MACCDN*$_t$** : Debit card merchant acceptance in the network	The percentage of merchants accepting debit cards where the network operates.	Network-level
***MACCCN*$_t$:** Credit card merchant acceptance in the network	The percentage of merchants accepting credit cards where the network operates.	Network-level
***MFEED*$_{it}$:** Merchant debit card discount fee	Average (transaction-weighted) debit card merchant discount fee charged by the bank computed as the (transaction-weighted) average discount fee charged to the merchants accepting the bank POS device.	Bank-level
***MFEEC*$_{it}$**: Merchant credit card discount fee	Average (transaction-weighted) credit card merchant discount fee charged by the bank computed as the (transaction-weighted) average discount fee charged to the merchants accepting the bank POS device.	Bank-level
***DCARDS*$_{it}$**: Number of debit cards by issuer	Total number of debit cards issued by a bank.	Bank-level
***CCARDS*$_{it}$:** Number of credit cards by issuer	Total number of credit cards issued by a bank.	Bank-level
***DCARDSN*$_t$**: Number of debit cards in the network	Total number of debit cards issued by the network.	Network-level
***CCARDSN*$_t$** : Number of credit cards in the network	Total number of credit cards issued by the network.	Network level
***DEBPOSTR*$_{it}$**: Debit card transactions at the POS	Debit card transactions per POS terminal by an acquirer.	Bank-level
***CREDPOSTR*$_{it}$**: Credit card transactions at the POS	Credit card transactions per POS terminal by an acquirer.	Bank-level
***DEBISS*$_{it}$** : Debit card transactions (issuer perspective)	Debit card transactions per card by issuer.	Bank-level
***CREDISS*$_{it}$** : Credit card transactions (issuer perspective)	Credit card transactions (month-end/no interest) per card by issuer.	Bank-level
***BRDS*$_{it}$** : Branch density	Number of an issuer'branches per km^2 in the regions where the bank operates.	Bank level
***RATMD*$_{it}$** : Rival ATM density	Number of an issuer's rival bank ATMs per km^2 in the regions where the bank operates.	Bank-level
***AFEECRED*$_{it}$** : Annual credit card fee	Average (asset-weighted) annual credit card fee changed by the bank.	Bank-level
***BSIZE*$_{it}$:** Bank size (in the card network)	Number of bank card transactions over the total number of card transactions in the network in which the bank operates.	Network-level
***CRIME*$_{it}$**: Crime rate	The (asset-weighted) ratio of robbery & assaults per 1000 inhabitants in the regions where the acquirer or issuer operates.	Bank-level
BANKDACR*$_{it}$: Bank (debit card) acquiring revenues*	Acquirer income from debit card merchant discount fees	Bank-level
BANKDISR*$_{it}$: Bank (debit card) issuing revenues*	Issuer income from debit card interchange fees	Bank-level
BANKCACR*$_{it}$: Bank (credit card) acquiring revenues*	Acquirer income from credit card merchant discount fees	Bank-level
***BANKCISR*$_{it}$** *: Bank (credit card) issuing revenues*	Issuer income from credit card interchange fees and credit card annual fees	Bank-level
REG99: Regulation dummy 1999	This variable takes the value 1 during the time that the level of interchange fees were reduced by regulation from 1999 to 2002 and zero otherwise.	Time dummy
REG02: Regulation dummy 2002	This variable takes the value 1 from 2002 to 2003 and zero otherwise and controls for changes related to the moral suasion pressures following the investigation by the Spanish antitrust authority on the collective setting of interchange fees.	Time dummy
REG03: Regulation dummy 2003	This variable takes the value 1 from 2003 to 2005 and zero otherwise and controls for the increasing pressures and moral suasion on the setting or interchange and the refusal of the proposals for special authorization of collective determination of these fees by the card networks.	Time dummy
REG05: Regulation dummy 2005	This variable takes the value 1 from 2005 onwards and zero otherwise and controls for changes related to a regulatory initiative on the reduction of interchange fees and the requirement of adoption of a cost-based model for interchange fee setting.	Time dummy
SOURCES: All variables related to card payments have been provided by a payment network of 45 Spanish banks. The crime rate variables have been obtained from the Spain's Statistical Office (INE). EXPLANATORY NOTES: - All monetary magnitudes are expressed in real terms. - All variables (except for regulatory dummies) are in logarithms		

Table 4: Summary Statistics

	Mean	Std. dev.	Min	Max
Debit card merchant acceptance by acquirer in regions where it has branches ($MACCD_{it}$) (percent)	55.36	2.16	51.15	59.36
Credit card merchant acceptance by acquirer in regions where it has branches ($MACCC_{it}$) (percent)	57.23	1.97	52.12	61.06
Debit card merchant acceptance in the network ($MACCDN_t$) (percent)	58.02	2.02	53.60	61.94
Credit card merchant acceptance in the network ($MACCCN_t$) (percent)	59.37	1.92	53.51	62.49
Merchant debit card discount fee by acquirer ($MFEED_{it}$) (percent)	1.36	1.18	0.36	3.18
Merchant credit card discount fee by acquirer ($MFEEC_{it}$) (percent)	2.03	1.93	1.06	3.56
Number of debit cards by issuer ($DCARDS_{it}$) (millions)	0.48	0.72	0.02	4.2
Number of credit cards by issuer ($CCARDS_{it}$) (millions)	0.55	0.94	0.01	4.9
Number of debit cards in the network ($DCARDSN_t$) (millions)	16	5.8	12	21
Number of credit cards in the network ($CCARDSN_t$) (millions)	20	6.3	10	32
Debit card transactions at the POS by acquirer ($DEBPOSTR_{it}$) (millions)	11.14	34.18	0.11	88.1
Credit card transactions at the POS by acquirer ($CREDPOSTR_{it}$) (millions)	12.28	56.26	0.09	94.7
Debit card transactions by issuer ($DEBISS_{it}$) (percent)	1.21	4.16	0.04	10.27
Credit card transactions by issuer ($CREDISS_{it}$) (percent)	1.60	5.21	0.02	12.56
Branch density by issuer ($BRDS_{it}$) (Branches/km^2)	1.1	0.6	0.4	1.9
Rival ATM density by issuer ($RATMD_{it}$) (ATMs/km^2)	0.9	0.4	0.3	1.5
Annual credit card fee by issuer ($AFEECRED_{it}$) (euros)	15	10	3	35
Bank size (in the card network) ($BSIZE_{it}$) (percent)	1.16	4.02	0.01	11.28
Crime rate ($CRIME_{it}$)	0.37	0.21	0.10	0.68
Bank (debit card) acquiring revenues *(BANKDACR)* (€ millions)	4.31	2.19	0.08	45.23
Bank (debit card) issuing revenues *(BANKDISR)* (€ millions)	25.43	13.84	0.32	114.15
Bank (credit card) acquiring revenues *(BANKCACR)* (€ millions)	6.17	3.12	0.11	54.89
Bank (credit card) issuing revenues *(BANKCISR)* (€ millions)	28.06	14.16	0.23	131.12

Table 5: Consumers and Merchants Adoption (debit cards)
Simultaneous Equation estimation (GMM with fixed effects)
(Clustered standard errors by bank in parentheses)

	Merchant adoption (debit cards)	***Consumer adoption (debit cards)***
	Merchant acceptance by acquirer($MACCD_{it}$)	*Number of debit cards by issuer ($DCARDS_{it}$)*
Constant	0.26E-11 (0.001)	0.21E-12 (0.001)
Merchant acceptance in the network ($MACCDN_{t-1}$)	-	0.4630** (0.054)
Merchant debit card discount fee ($MFEED_{it}$)	-0.0481** (0.015)	-
Number of debit cards in the network ($DCARDSN_t$)	0.0017** (0.013)	-
Branch density ($BRDS_{it}$)	-	-0.0054** (0.043)
Bank size (in the card network) ($BSIZE_{it}$)	0.0108 (0.018)	0.0443** (0.018)
Crime rate ($CRIME_{it}$)	-0.0293 (0.184)	-0.0123 (0.852)
Linear time trend	0.0205** (0.024)	0.1951** (0.078)
Regulation dummy 1999 (REG99)	-0.0254* (0.025)	0.0926** (0.061)
Regulation dummy 2002 (REG02)	0.0119** (0.014)	-0.1425* (0.086)
Regulation dummy 2003 (REG03)	0.0163** (0.006)	-0.1007 (0.053)
Regulation dummy 2005 (REG05)	0.0129** (0.013)	-0.1852** (0.095)
Adjusted R^2	0.84	0.71
Number of observations	1935	1935
Sargan test of overidentifying restrictions (p-value in parentheses)	70.61 (0.006)	
AR(1) (p-value in parentheses)	-0.1018 (0.897)	
AR(2) (p-value in parentheses)	−1.240 (0.310)	

** Statistically significant at 5 percent level*
*** Statistically significant at 1 percent level*

Table 6: Consumers and Merchants Adoption (credit cards)
Simultaneous Equation Estimation (GMM with fixed effects)
(Clustered standard errors by bank in parentheses)

	Merchant extensive margin (credit cards)	*Consumer extensive margin (credit cards)*
	Merchant acceptance by acquirer ($MACCC_{it}$)	*Number of credit cards by issuer ($CCARDS_{it}$)*
Constant	-0.30E-06 (0.001)	0.53E-06 (0.001)
Merchant acceptance in the network ($MACCCN_{t-1}$)	-	0.2985** (0.084)
Merchant credit card discount fee ($MFEEC_{it}$)	-0.1585** (0.073)	-
Number of credit cards in the network ($CCARDSN_t$)	0.1630** (0.078)	-
Annual credit card fee ($AFEECRED_{it}$)	-	0.6023 (0.430)
Bank size (in the card network) ($BSIZE_{it}$)	0.0045* (0.004)	-0.0013 (0.012)
Crime rate ($CRIME_{it}$)	0.0696* (0.082)	0.0651** (0.079)
Linear time trend	0.1694** (0.001)	0.1388** (0.042)
Regulation dummy 1999 (REG99)	-0.0950 (0.073)	0.0372** (0.016)
Regulation dummy 2002 (REG02)	0.0633 (0.084)	-0.0231 (0.032)
Regulation dummy 2003 (REG03)	0.1124** (0.096)	0.2651** (0.077)
Regulation dummy 2005 (REG05)	0.2023** (0.072)	0.2955** (0.098)
Adjusted R^2	0.87	0.93
Number of observations	1935	1935
Sargan test of overidentifying restrictions (p-value in parentheses)	152.28 (0.001)	
AR(1) (p-value in parentheses)	-1.198 (0.231)	
AR(2) (p-value in parentheses)	−1.677 (0.094)	

** Statistically significant at 5 percent level*
*** Statistically significant at 1 percent level*

Table 7: Debit Card Transaction Volume for Consumers and Merchants. Each equation estimated by 3SLS with fixed effects
(Clustered standard errors by bank in parentheses)

	Acquirer transaction volume (debit cards)	***Issuer transaction volume (debit cards)***
	Debit card transactions per POS terminal ($DEBPOSTR_{it}$)	*Debit card transactions per card (issuer perspective) ($DEBISS_{it}$)*
Constant	0.04E-13 (0.001)	-0.04E-10 (0.001)
Merchant acceptance by acquirer ($MACCD_{it-1}$)X Number of debit cards in the network ($DCARDSN_t$)	0.0271** (0.015)	-
Merchant acceptance in the network ($MACCDN_{t-1}$)X Number of debit cards by issuer ($DCARDS_{it}$)	-	0.0467** (0.013)
Rival ATM density ($RATMD_{it}$)	0.0217* (0,018)	0.0628* (0.029)
Bank size (in the card network) ($BSIZE_{it}$)	0.0429* (0.029)	0.0120 (0.018)
Crime rate ($CRIME_{it}$)	0.1488 (0.156)	0.1157 (0.961)
Linear time trend	0.1866** (0.017)	0.1158** (0.037)
Regulation dummy 1999 (REG99)	0.0201* (0.023)	0.0963** (0.025)
Regulation dummy 2002 (REG02)	0.1402** (0.018)	0.0669* (0.024)
Regulation dummy 2003 (REG03)	0.0925* (0.026)	0.1108* (0.071)
Regulation dummy 2005 (REG05)	0.2451** (0.015)	0.2201** (0.084)
Adjusted R^2	0.90	0.76
Number of observations	1935	1935
Sargan test of overidentifying restrictions (p-value in parentheses)	144.07 (0.001)	155.26 (0.001)
AR(1) (p-value in parentheses)	−1.620 (0.137)	−1.484 (0.121)
AR(2) (p-value in parentheses)	−1.402 (0.168)	−1.339 (0.162)
** Statistically significant at 5 percent level* *** Statistically significant at 1 percent level*		

Table 8: Credit Card Transaction Volume for Consumers and Merchants
Each equation estimated by 3SLS with fixed effects
(Clustered standard errors by bank in parentheses)

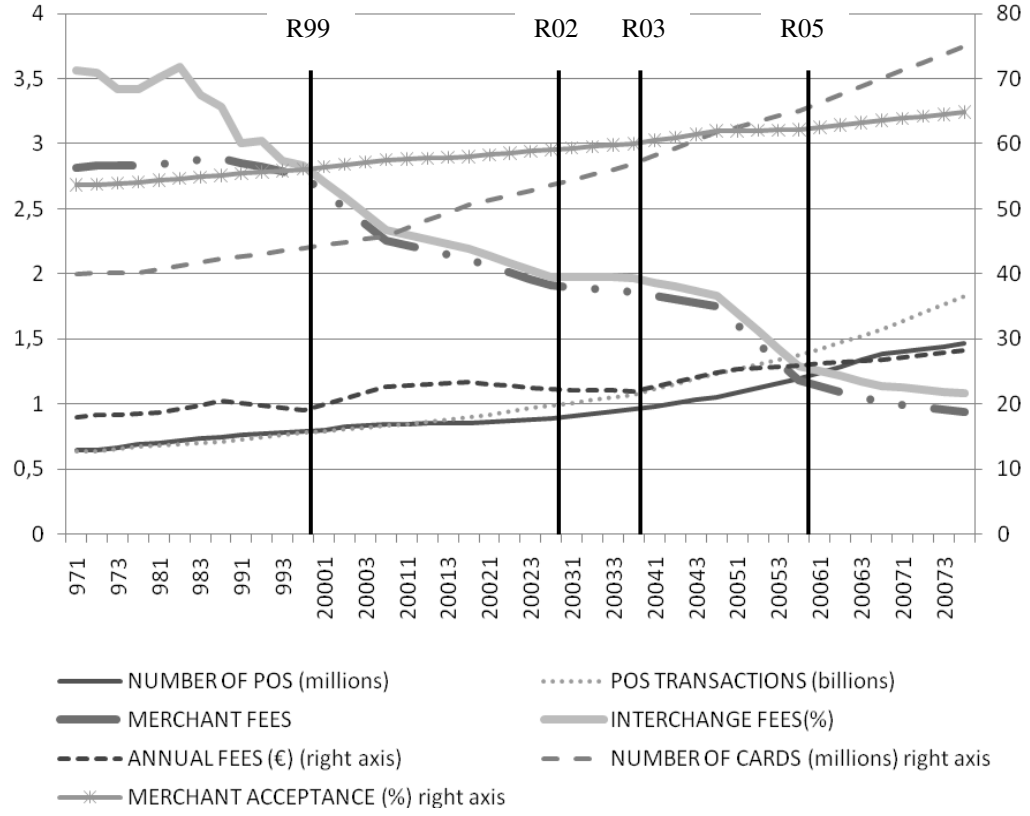
	Merchant intensive margin (credit cards)	*Consumer intensive margin (credit cards)*
	Credit card transactions per POS terminal ($CREDPOSTR_{it}$)	*Credit card transactions per card (issuer perspective) ($CREDISS_{it}$)*
Constant	0.11E-07 (0.001)	-0.10E-06 (0.001)
Merchant acceptance by acquirer($MACCC_{it-1}$)X Number of credit cards in the network ($CCARDSTN_t$)	0.2088** (0.094)	-
Merchant acceptance in the network ($MACCCN_{t-1}$)X Number of credit cards by issuer ($CCARDS_{it}$)	-	0.1631** (0.083)
Bank size (in the card network) ($BSIZE_{it}$)	-0.1652 (0.345)	0.0152** (0.040)
Crime rate ($CRIME_{it}$)	0.0963* (0.068)	0.0568* (0.027)
Linear time trend	0.2452** (0.013)	0.1996** (0.084)
Regulation dummy 1999 (REG99)	0.0657 (0.080)	0.0760* (0.034)
Regulation dummy 2002 (REG02)	0.2414** (0.073)	0.2168** (0.080)
Regulation dummy 2003 (REG03)	0.1652* (0.090)	0.1173* (0.071)
Regulation dummy 2005 (REG05)	0.3005** (0.074)	0.2952** (0.090)
Adjusted R^2	0.71	0.91
Number of observations	1935	1935
Sargan test of overidentifying restrictions (p-value in parentheses)	66.34 (0.02)	101.03 (0.01)
AR(1) (p-value in parentheses)	–0.6453 (0.421)	–0.8964 (0.324)
AR(2) (p-value in parentheses)	–1.176 (0.192)	–0.904 (0.123)
** Statistically significant at 5 percent level* *** Statistically significant at 1 percent level*		

Table 9: Impact on Bank Issuing and Acquiring Revenues
Each equation estimated by 3SLS with fixed effects
(Clustered standard errors by bank in parentheses)

	Bank (debit card) acquiring revenues (BANKDACR)	*Bank (debit card) issuing revenues (BANKDISR)*	*Bank (credit card) acquiring revenues (BANKCACR)*	*Bank (credit card) issuing revenues (BANKCISR)*
Constant	0.10E-07* (0.001)	0.09E-10* (0.001)	0.06E-08* (0.001)	0.09E-09 (0.001)
Merchant acceptance by acquirer ($MACCD_{it-1}$) X Number of debit cards in the network ($DCARDSN_t$)	0.0393* (0.017)	-	-	-
Number of debit cards by issuer ($DCARDS_{it}$) X Merchant acceptance in the network ($MACCDN_{t-1}$)	-	0.1503** (0.012)	-	-
Merchant acceptance by acquirer ($MACCC_{it-1}$) X Number of credit cards in the network ($CCARDSN_t$)	-	-	0.0714** (0.009)	-
Number of credit cards by issuer ($CCARDS_{it}$) X Merchant acceptance in the network ($MACCDN_{t-1}$)	-	-	-	0.1685** (0.012)
Rival ATM density ($RATMD_{it}$)	0.0018 (0.007)	0.0069 (0.040)	-	-
Bank size (in the card network) ($BSIZE_{it}$)	0.0694** (0.051)	0.1305** (0.081)	0.1805** (0.021)	0.0761** (0.013)
Crime rate ($CRIME_{it}$)	0.0383 (0.079)	0.0206 (0.084)	0.0326 (0.046)	0.0300 (0.028)
Liner time trend	0.6499** (0.107)	0.6631** (0.113)	0.5612** (0.013)	0.8104** (0.093)
Regulation dummy 1999 (REG99)	0.0115 (0.077)	0.0209 (0.093)	0.01218 (0.037)	0.0314 (0.071)
Regulation dummy 2002 (REG02)	0.0191 (0.029)	0.0894** (0.013)	0.0324 (0.020)	0.0625** (0.010)
Regulation dummy 2003 (REG03)	0.04537* (0.023)	0.1432** (0.024)	0.0983* (0.018)	0.1841** (0.013)
Regulation dummy 2005 (REG05)	0.019 (0.024)	0.1673** (0.031)	0.1025 (0.016)	0.2633** (0.011)
Adjusted R^2	0.53	0.88	0.58	0.87
Number of observations	1935	1935	1935	1935
Sargan test of overidentifying restrictions (p-value in parentheses)	225.06 (0.001)	216.10 (0.001)	161.16 (0.001)	193.04 (0.001)
AR(1) (p-value in parentheses)	–0.6952 (0.521)	–0.8102 (0.396)	–08197 (0.348)	–0.7255 (0.441)
AR(2) (p-value in parentheses)	–0.7840 (0.523)	–0.7524 (0.445)	–0.8310 (0.389)	–0.8619 (0.395)

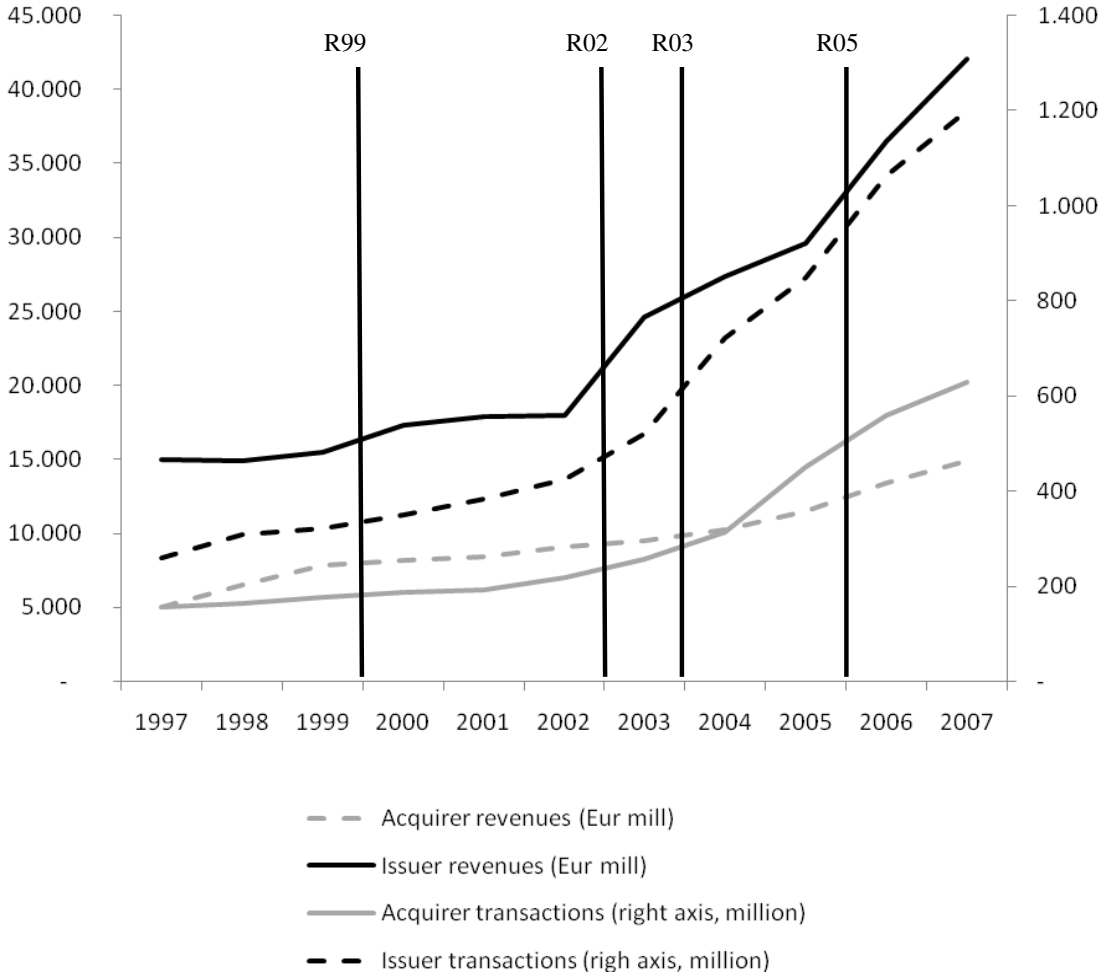
** Statistically significant at 5 percent level*
*** Statistically significant at 1 percent level*

Figure 1: Adoption, transaction volumes, fees and regulatory events



Note: Rxx: regulatory event and year (xx).

Figure 2: Acquirer and issuer revenues and transactions (1997-2007)



Note: Rxx: regulatory event and year (xx).