Recent innovations in inter-bank electronic payment system in Mexico: the role of regulation

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1. Introduction

One of Banco de Mexico's (BM) main responsibilities is the proper functioning of the payment systems, in particular those considered to have systemic importance. Therefore, Mexico's Central Bank has directly been involved in the promotion and deployment of efficient payment systems. The prime example of this responsibility is the set up of the Interbank Electronic Payment System (SPEI)[4] which is owned and operated by BM. SPEI is a hybrid system that combines the advantages of a real time and a multilateral settlement system. It has a low operational cost for banks and it does not impose a transaction amount limit, blurring thus the separating line between a large and a small value payment system.

SPEI is aimed at sending electronic transfers between financial institutions and their clients. It started to work in August 2004 and replaced another large value payment system, named SPEUA,[5] which was also run by BM. Soon after SPEI was implemented, it took over all the transactions that were previously carried through SPEUA.

In the nearly four years SPEI has been in place, the number of transactions it carries has multiplied by a factor of eight. During this period, BM has promoted a number of institutional changes, regulatory measures and agreements with banks in order to foster SPEI usage. This process has extended SPEI's character from a large value payment system used mainly for financial market transactions among banking institutions and large treasuries, to a rather widespread mechanism to send electronic transfers between private persons.

The main goal of this paper is to test the impact that institutional adjustments and BM regulatory measures have had over SPEI's adoption process. We model such adoption process by means of an S-shaped learning curve (logistic curve). This type of model has frequently been used to represent the adoption process of innovations in several markets, including payments (Snellman and Vesala, 1999).

In this model three parameters are estimated: the saturation point or maximum fraction of payments that will be carried by SPEI in the long run, the point at which the rate of adoption is the highest (inflexion) and the adoption rate (slope of the curve). We define the variable of

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[4] In Spanish, Sistema de Pagos Electrónicos Interbancarios.

[5] In Spanish, Sistema de Pagos Electrónicos de Uso Ampliado.

interest as the fraction of payments made with SPEI over the total number of transactions made with its substitutes, which includes direct debits, checks, a t+1 electronic transfer system (EFT), and SPEI. We then obtain the impact that institutional changes have had over the parameters described above. Additionally, we measure the impact that macroeconomic (demand) variables may have had over SPEI's adoption process.

We find that some of the measures adopted had a significant impact on the adoption process. In particular, the minimum amount for a SPEI transaction was removed and an important reduction in the price of transfers under 100 thousand pesos was agreed; the latter was achieved through the setting of a price cap on those transactions. Such a price cap was set up by the largest banks. The joint action of these measures has had a positive impact on the maximum fraction of total payments that is carried out with SPEI.

A secondary goal of this paper is to test differences in adoption levels of the clients of different banks. We find that indeed, the adoption process is not homogeneous across banks. Moreover, the impact of institutional changes varies across banks. Given that SPEI's originating orders are usually provided through the internet, those banks that have developed an efficient internet access, register distinctly higher adoption rates.

All banks participate in SPEI. Therefore, there is not an adoption issue at the bank level. The adoption decision is really in the hands of account holders that choose the means to make their payments; however, banks' decisions have an impact on consumer payment choices in several ways. In the first place, banks affect consumers' choices through the prices they charge for the services. In the case of SPEI, they also have an impact through the infrastructure of internet transactions they provide to their clients, since that is the most common channel to send SPEI payments.

There have been a number of institutional changes, regulatory decisions and industry agreements that have allowed SPEI to be rapidly adopted in recent years. After it was introduced, SPEI inherited the transactions that were carried out through SPEUA and, temporarily, even some of its practices. Due to technical constraints SPEUA had a minimum transaction amount which banks also imposed on their same day payment services; banks adopted a similar practice when SPEI was first introduced, although it was not caused by a technical constraint. Moreover, there were no standards for customers to readily identify the originator in third party transactions because SPEUA's mainly carried payments between banks. Also, it was until 2005 when banks started introducing systems to allow their clients to make SPEI payments through the internet. Additionally, banks priced low value electronic transfers out by setting high charges to them, in relation to checks. When these constraints were removed, either by regulatory changes or agreements between banks, the adoption of SPEI moved at fast rates, and the average value of transactions decreased across time. Furthermore, in order to improve competition, BM has recently allowed non-banks to participate directly in SPEI.

The rest of the paper is organized in the following way. The second section contains a technical description of SPEI. The third section describes SPEI evolution and its importance among the non-POS non-cash total payments. The fourth section includes a description of the institutional changes and regulatory measures undertaken by BM to promote the use of SPEI. The fifth section describes the methodology and data. The sixth section presents estimation results and the last section briefly concludes.

2. SPEI's features

SPEI is a large-value fund, near real time payments system to make transfers between participant institutions among themselves and on behalf of their customers. It began operating on August 13, 2004. Bank's costumers use SPEI for their time critical or important payments since the system's rules force Banks to send and credit SPEI transfers within

minutes, besides each payment order contains information allowing identification of the issuer accountholder and the beneficiary and that information is included in the beneficiary's account statement at no cost.[6] Consequently, SPEI has become the central system for the settlement of large value payments and urgent client-to-client payments in Mexico.

2.1 Technical characteristics

SPEI effectively combines the characteristics of a real time gross settlement system with the liquidity savings of a multilateral netting system. This is achieved by running very frequent settlement cycles, during which a heuristic algorithm chooses a subset of payments pending of settlement that can be netted, on a multilateral basis, and settled with the participants' balances. In the BIS classification SPEI is a hybrid system.[7]

Within the system, participants may assign high priority to particular payments and reserve part of their account balance to settle only these payments. As payment orders enter the system, they are kept in a pending-payments queue. SPEI runs a process frequently – on the order of seconds – to decide which payments can be settled with the participant balances held at the moment. If a payment cannot be settled due to a sender's lack of liquidity, the payment is held in the queue until the next cycle takes place.

Participant banks must send customers payment orders to recipient banks within 10 minutes after an order is accepted. Recipient banks must credit payments to their customers within 10 minutes after a payment is received. In case the beneficiary account cannot be credited, the receiving institution has 20 minutes to return the funds to the issuing institution.

Pending payments are canceled at the end of the day. Afterwards, the SPEI account balances are transferred to the corresponding accounts in the system that manages the bank's Current Accounts in BM (SIAC).[8]

Safety in the SPEI system is based on digitally signed messages. Participants must use authorized digital certificates and passwords obtained in accordance with the rules of the Public Key Infrastructure[9] developed by BM. Communications in SPEI use an open protocol (ie system communication rules are public). The protocol allows participants to develop automatic processes (Straight Through Processing), in order to provide improved services to their customers.

In SPEI neither participants nor the BM, grant any credit lines. No overdraft is allowed in the system and the participants have to manage the liquidity in their account. SPEI is connected to SIAC and the Mexican Security Settlement System, so that participants can efficiently transfer funds across them.

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6 See, Banco de México, Circular 1/2006.

7 Committee on Payment and Settlement Systems – Bank of International Settlements, "New developments in large-value payment systems", CPSS Publications, No. 67, May 2005

8 SIAC is the system that administers the current accounts that all banks and some financial institutions have in the Central Bank. This system is also used by BM to provide liquidity to participants. SPEI (and other payment systems) has its end-of-the-day settlement in SIAC.

9 In Mexico, Infraestructura Extendida de Seguridad.

2.2 The process of a payment

The process of a typical SPEI transaction is as follows:

1. The issuer accountholder instructs, usually via the internet, his bank to make a transfer through SPEI.
2. Provided the costumer's account has enough funds to perform the transaction and all security checkpoints have been cleared, the issuer institution sends to BM a digitally signed instruction to transfer the money. As mentioned before, the issuer accountholder is allowed to include information to specify the purpose of the payment and to identify the sender.
3. BM verifies the syntax and digital signature of the transfer. If everything is correct, an acknowledgement is sent to the issuer and the transfer is queued to be processed in the following settlement cycle.
4. If the issuer institution has enough liquidity, the transfer is settled in the following settlement cycle and both issuing and receiving institution are notified.
5. After the receiving institution gets the notification, it credits the amount of the transfer in the beneficiary's account, using the information included by the issuer accountholder.

BM charges the originating institution a per transaction fee.[10] The issuing institution charges the issuer accountholder a fee, usually fixed, per transaction, while the receiving institution does not charge a fee to the receiving accountholder. It is worth mentioning that SPEI does not allow receiving banks to charge an interbank fee in order to finish the transaction up.

3. Evolution of SPEI

As SPEI started to work in August 2004, it substituted SPEUA, another electronic transfers system. SPEUA was introduced in 1995 and was used to perform large value transactions mainly between financial institutions. After SPEUA started to work, it showed very high rates of growth until 1997 and from that point on, the number of transactions grew slowly (see Figures 1a and 1b).[11]

The behavior of SPEI differs from the adoption process experienced by SPEUA. Since its introduction, SPEI has been adopted at high rates, achieving during the last year an average annual accumulated rate of growth of 50%. Thus SPEI did not only take over the transactions previously carried out with SPEUA but it increased dramatically the processing of low value operations.

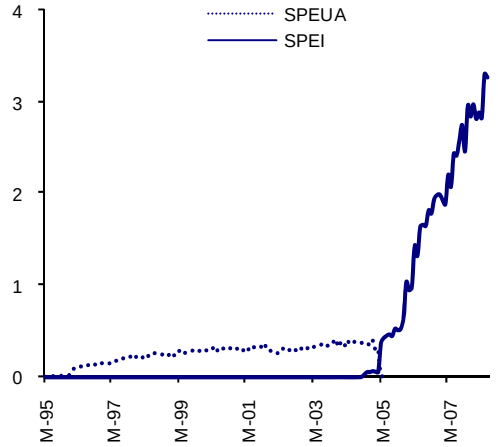
[10] Until December 2007 it also charged a fixed annual fee; this has been eliminated.

[11] We assume that high value transactions, which were rapidly adopted, are originated by financial institutions while low value operations are transfers sent between individuals.

Figure 1

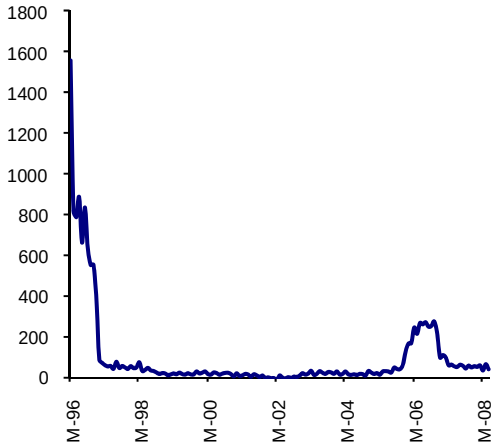
a) SPEUA and SPEI transactions

Million transactions



b) SPEI transactions

Annual Growth Rate (%)



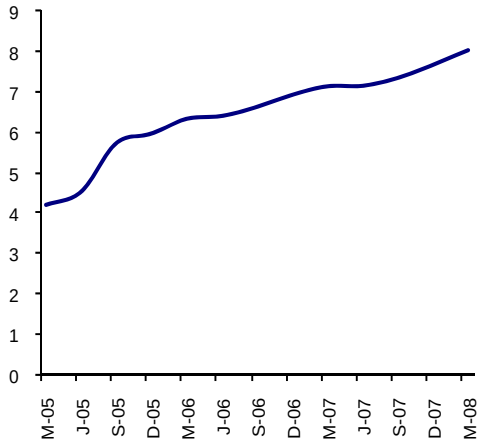
Source: Banco de Mexico.

The rapid adoption of SPEI and the increasing number of low value transactions are expressions of the growing penetration of electronic payments in Mexico. This is related to the rising access of accountholders to perform transactions over the internet who have the ability to carry out SPEI transactions directly (see Figures 2a and 2b). In the last case, there seems to be a network externality effect over the total number of SPEI transactions since a new accountholder can send and receive transfers to and from all the other previously existent account holders.

Figure 2

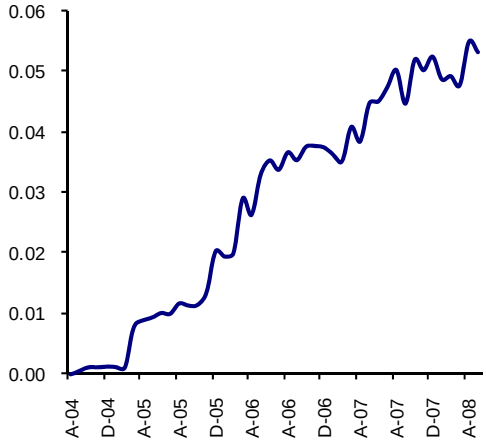
a) Accountholders that perform electronic transfers over the internet

Million accountholders



b) SPEI monthly transactions per account

Transactions



Source: Banco de Mexico.

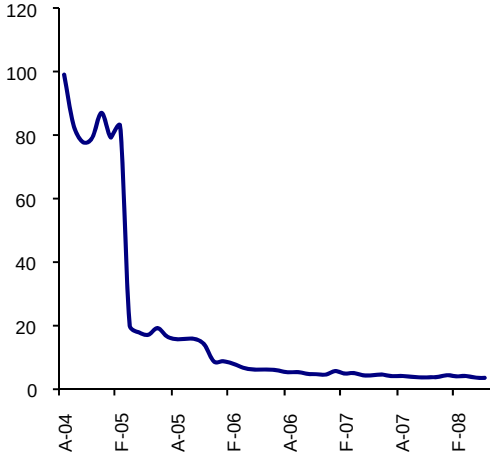
Given that low value transactions are taking off, the average transaction value of SPEI has dramatically decreased. The mean value depicted in Figure 3a is still high since some very large value transactions are sent through SPEI. However, transactions over 1 million pesos only represent 10% of total number of processed operations.

The rate of adoption is heterogeneous across transaction value brackets; while low and medium value transfers are showing the highest growth rates, large value transactions are growing at stable rates. That is, the adoption process of high value transactions in SPEI occurred almost instantaneously; however, low value transactions are still being adopted at high rates (see Figure 3b). This can be attributed to the fact that high value transactions are mainly carried out between institutions while personal transactions tend to be low value.

Figure 3

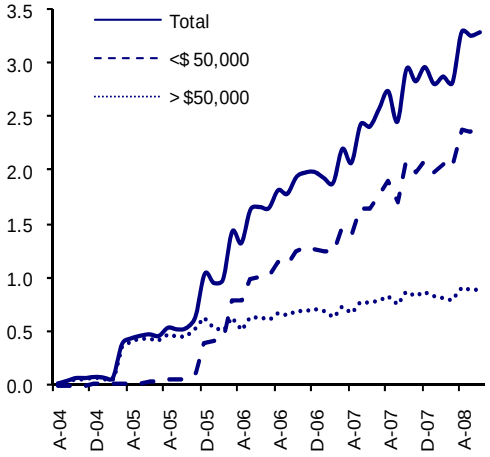
a) SPEI average transaction

Million Pesos



b) SPEI transactions by value brackets

Million transactions



Source: Banco de Mexico.

3.1 The relevance of electronic payments in Mexico

Not all payment mechanisms are close substitutes. For instance, in Mexico bank cards cannot be considered good substitutes of checks because the latter are generally not accepted at points of sale. Therefore, in order to study SPEI's adoption, we restrict our scope to those payment mechanisms that could be its closest substitutes; that is, direct debits[12] and deferred electronic transfers (EFT)[13] among the electronic payments and checks among the paper based payments.

[12] Direct debit is a transaction instructed in advance by the accountholder that authorizes his bank to transfer a fixed amount of money to a predefined account (beneficiary's account) at the request of the beneficiary's bank. In Mexico, direct debits, checks and EFT are registered and compensated by a privately run Automatic Clearing House (Cecoban S.A. de C.V.), but the settlement takes place in a system run by BM, SIAC, one day after they are sent, on the basis of the information sent by Cecoban.

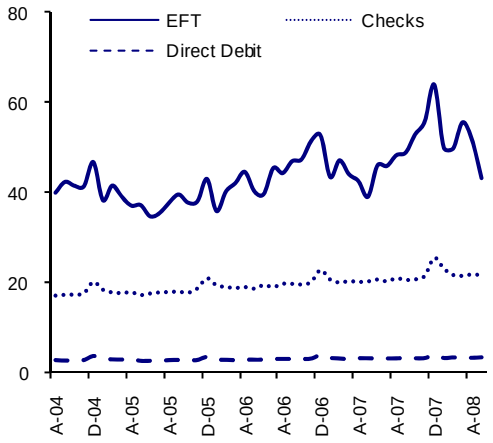
[13] EFT is a system of deferred transfers of funds between clients of different banks which is particularly useful for payroll distribution. In this case, the account of the client that sends the payment is immediately affected, although the money is not credited in the account of the transfer recipient until next day.

Electronic payments have been on an expansion path in the current decade; simultaneously, transactions performed with checks have remained stagnant. Despite the noticeably higher growth rate of electronic payments, checks are still the single most used mechanism.

Figure 4

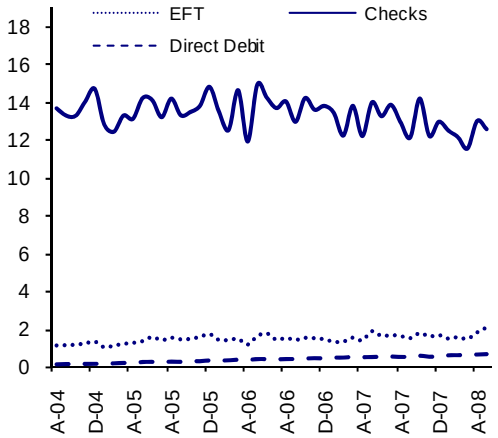
a) EFT, checks and direct debit transaction

Million transactions



b) EFT, checks and direct debit average value

Thousand Pesos



Source: Banco de Mexico.

If the transactions made with SPEI, EFT, direct debit and checks were expressed as percentage of total operations performed with these mechanisms, SPEI would register the most dynamic behavior, accounting for 13.9% of the total at the end of 2007 after representing only 2.9% in 2005. Furthermore SPEI seems to be substituting the usage of checks whose participation has fallen equivalently (see table 1) while the percentage of payments performed with EFT remains quite stable. The latter may be related to the fact that some banks still tend to promote the use of EFT over SPEI for certain transactions, in order to keep the float for a day.

Table 1

Percentage of payments

Year	SPEI	EFT	Direct Debit	Checks	Total
2005	2.9	8.8	1.6	86.6	100.0
2006	9.3	8.5	2.4	79.7	100.0
2007	13.9	8.9	3.1	74.1	100.0

Source: Banco de Mexico.

It is relevant to contrast the importance of SPEI in Mexico with similar systems in other countries. Comparing first with other Latin-American countries of similar development, the penetration of SPEI measured by the value of transactions as a proportion of GDP is similar to that of large value payments in Chile and higher to equivalent systems in Brazil and Argentina. Nonetheless, compared to large value payments in developed countries, SPEI's penetration remains rather low.

Table 2

Large value payments

Value of transactions as a percentage of GDP (in %)					
Country	**2002**	**2003**	**2004**	**2005**	**2006**
Belgium					
ELLIPS	4,983.60	4,935.10	5,065.80	5,718.60	6,136.50
France					
TBF	5,891.90	6,040.00	6,530.10	7,096.60	7,542.80
Germany					
RTGSplus	5,822.40	5,940.60	5,714.80	6,170.30	6,492.80
Italy					
BI-REL	1,941.70	1,854.20	2,019.00	2,310.60	2,559.50
Japan					
BOJ-NET	3,672.40	3,828.40	4,098.60	4,314.10	4,985.00
FXYCS	1,246.90	982.9	863.4	801.9	868.8
Netherlands					
TOP	5,363.70	5,509.90	6,042.90	6,031.00	5,989.40
Singapore					
MEPS	6,335.50	6,125.80	5,458.80	6,478.40	6,627.60
Sweden					
E-RIX	60.6	75.4	68.1	76.3	63.9
Switzerland					
SIC	10,305.00	10,204.20	9,289.10	8,854.60	9,221.60
United Kingdom					
CHAPS Euro	2,403.60	2,689.50	2,704.70	2,985.00	3,240.80
CHAPS Sterling	4,537.90	4,560.00	4,373.20	4,210.10	4,478.60
United States					
Fedwire	3,875.60	4,081.30	4,098.50	4,170.40	4,340.00
European Union					
TARGET	5,467.00	5,681.20	5,788.00	6,155.70	6,418.90
Mexico					
SPEI	-	-	-	1,251.88	1,425.27
Argentina					
MEP	172.66	205.22	237.43	261.49	275.65
Brazil					
SITRAF	n.a.	52.43	104.14	127.07	121.23
Chile					
LBTR	n.a.	n.a.	1,267.12	2,100.17	986.67

Sources: BIS. Statistics on payment and settlement systems in selected countries. Committee on Payment and Settlement Systems of the Group of Ten Countries, Banco de México, INEGI, Brazil Central Bank, Argentina Central Bank, Chile Central Bank.

4. The regulation and measures adopted by BM to promote SPEI

The legal framework that justifies BM activism in SPEI's promotion comes from three laws: BM Law, the Payment Systems Law (PS Law) and the Law of Transparency and Financial Services Restructuring (LTOSF). The mandate of this set of laws is such that BM has a responsibility not just with the deployment of payment systems, but with the design of an efficient payments industry.

BM Law provides it with the authority to regulate the payments industry and to promote the usage of the most efficient payment means. This law states as one of BM's main purposes "…promoting the sound development of the financial system and fostering the proper functioning of payment systems" (Art. 2). Additionally, in December 2002, the PS Law was

promulgated, giving BM powers to oversee and supervise the administrators of the systemically important payment systems, in order to assure their proper functioning (Art. 19).

The LTOSF is mainly directed towards the protection of consumers of financial services. This law states that BM is "entitled to regulate commissions … charged by financial entities in order to promote the proper functioning of the payment systems" (Art. 4).[14] From BM's perspective, SPEI is the most secure and efficient payment mechanism; since it does not have a minimum payment limitation, it can be used to perform almost any transaction; that is, the difference between large and retail payments is blurred in this system. BM has adopted regulatory measures and promoted agreements between agents to foster SPEI, in order to achieve a more efficient payment industry; to that effect, it has used or threatened to use, the regulatory powers provided by the law (Negrin, 2005).

Within the above legal context, the intervention of BM has addressed several issues that may have affected SPEI's adoption. BM set standards in order to facilitate banking interconnection; it has tried to make SPEI more attractive for banks and consumers through cost and price reductions, and it has attempted to level the playing field between participants by granting direct access to SPEI to non-banks. It is worth mentioning that these efforts are inscribed in the reform process that BM launched in 2004 in order to encourage the use of the most efficient payment systems and to foster banking competition (Negrin, 2005, Ortiz, 2005). In the following paragraphs we review different measures adopted by BM that may have affected SPEI's adoption. We then identify those measures whose impact will be analyzed in the econometric model.

One of the main problems that the development of electronic payments has faced in Mexico is bank's reluctance to adopt intercommunication standards. Even though SPEI's formats always included information so that the receiver of the transfer could easily identify the sender, banks were not sending or processing that information. This was also due to the fact that in some other services receiving banks used to charge the receiver for identifying the sender. This situation hindered the adoption of SPEI since the lack of identification standards caused many transactions to be rejected. Therefore in July 2005, BM issued a regulation that forced banks to identify the sender of the transaction and to provide that information to the recipient, free of charge, over the internet and in written statements. It is relevant to mention that in SPEUA banks were neither forced to get identification information from the sender nor to provide it to the receiver.

SPEUA imposed a minimum transaction amount for transfers that went through it.[15] On technical grounds SPEI did not require such a limit; however, banks needed time to set up their infrastructure in order to carry the larger volume of transfers expected by allowing transactions of lower amount. Therefore, they did not permit their customers to send payments lower than 50,000 pesos, disallowing low-value transactions to be sent through SPEI.[16] Once BM considered that the adjustment period had passed, it agreed with banks to remove such constraint in SPEI transfers.[17] Despite this, BM detected that some banks kept on setting minimum transfer restrictions and issued regulation that, forced banks to eliminate such limits by February 2007. Again, this regulation has been fundamental in SPEI's

[14] In Mexico there is a Commission for the Protection of Financial Services' Consumers (Condusef). However, this commission has no regulatory powers. Its main function is to protect consumers from banks' abusive practices, by providing them with information, free legal advice and by mediating with the banks (Condusef Law Art. 5).

[15] Such limit was declining over SPEUA's life time. In the end the minimum transfer was set at 50,000 pesos.

[16] These transfers were processed by EFT and settled one day after they were sent.

[17] Banks started to allow transactions below 50,000 pesos at different times. However, from December 2006 on, it´s clear that all banks had adopted this agreement.

adoption process because it has greatly widened the transactions that may be carried out through the system.[18]

Another relevant barrier to SPEI's adoption has been the way banks price these transactions. Not only were SPEI prices for final customers unrelated to the cost of the transaction for the issuing bank, but they were much more expensive than substitute payment mechanisms like EFT and checks. In 2005, sending a SPEI transfer was almost 10 times more expensive than issuing a check and twice as expensive as sending an EFT (Castellanos et al, 2008). Moreover, banks usually offer a number of free of charge transactions with checks. It has been found that this kind of price distortion acts as an obstacle for checks replacement in other countries (Humphrey, et al, 2000).

BM and the largest banks in the system agreed that it was necessary to correct this distortion, considering that SPEI transfers are much more efficient than alternative payment mechanisms. Therefore, in March 2006 the largest banks decided to set a cap of 11 pesos on the price of SPEI transfers whose value was under 100,000 pesos, provided the transfer was instructed via Internet. It is important to point out that this does not represent a price agreement because each bank sets its own price under the constraint that it could not be higher than the 11 pesos ceiling; this can be confirmed in table 3. The rest of the banks followed through in this agreement by May of 2007.

There are several other measures that were not expected to have a large impact on adoption, but that were necessary in order to increase efficiency and to enhance competition in financial markets in general; they are described below.

In order to promote SPEI's usage among banks, BM has reduced the fees it charges to them. In the first place, the per transaction fee charged to the sender was reduced from 1 to 0.5 pesos in April 2006. Moreover, in February 2008 the system started receiving payment instructions during the night charging for them 0.1 pesos per transaction. Secondly, the annual fixed fee charged to participating institutions was eliminated in January 2008. As a consequence, it was expected that the reduction in costs would make SPEI more attractive for banks. Notice that these measures will only have an impact on SPEI's adoption by customers to the extent that they are passed on to final prices.

In terms of participation, when SPEI was conceived, only banks were allowed to be a part of it. Therefore, non-bank financial institutions could only participate in the system through a bank. This put financial institutions other than banks at a competitive disadvantage since charges for their transactions were set by their banks. In order to remove this competitive barrier, BM issued a regulation in May 2006 to allow the direct participation in SPEI of non-bank institutions such as stock brokers, insurance companies, exchange dealers, investment societies, pension funds administrators (Afores) and other non-bank financial institutions (Sofoles y Sofomes). As of June 2008, 29 non-bank institutions participated in SPEI. The regulation states that non-banks are subject to almost the same rules as banks in their participation in SPEI; nonetheless they are free to decide whether or not to participate in the system. It is important to indicate that this measure is not expected to have a large impact on adoption since most non banks were already sending their transactions by SPEI and its main impact is expected to be on competition. In fact, non-bank institutions originate less than 3% of the total number of transactions.

[18] Additionally, a bilateral agreement that was used to send transfers between the two largest banks was eliminated since it infringed the LTOSF.

Table 3

SPEI's fees

Bank	Personal Accounts		Firms' Accounts	
	Less than 100,000 pesos	Greater than 100,000 pesos	Less than 100,000 pesos	Greater than 100,000 pesos
ABN AMRO	*	*	10	10
Afirme	11	50	11	50
Azteca	11	11	24	24
Bajío	11	60	11	60
Banamex 1/	10	10	10	10
Banjercito	7	30	7	30
Bank of America	*	*	from 2.50 to 11	from 12 to 85
Banorte	5.5	5.5	5.5	75
Banregio	0	0	3	75
Bansi	0	0	0	0
BBVA Bancomer	7	80	8	80
Inbursa 2/	0/10	0/10	10	10
IXE	10	50	10	50
Mifel	11	70	11	70
Monex	5	5	5	5
Santander	5	5	5	50
Scotiabank	10	50	10	50
Tokyo	15	15	15	15

Bank	Personal and Firms' Accounts			
	Less than 50,000 pesos	From 50,000 to 100,000 pesos	From 100,000 to 1 million pesos	Greater than 1 million pesos
Bx+	0/25	0/75	0/75	0/75
HSBC	5.5	11	35	40

Figures at October 2007 in Mexican pesos.

Source: Information provided by the institutions.

* The bank does not offer the service.

1/ The fee charged on personal accounts is a monthly payment that allows to perform an unlimited number of transfers while the fee charged on firm accounts is per transaction.

2/ The personal account "Inbursa CT" does not charge a fee on SPEI. The rest of the accounts offered by the bank charge a fee of $10 per transaction.

Finally, BM started to offer a free of charge service in its web page ("MI SPEI") that allows SPEI's users to track the status of their transfers. There are two tracking numbers that can be used in MISPEI: a number provided by the accountholder at the time of issuing the transaction or a number provided by the issuer institution once it accepts the instruction. As a result users know immediately the time when the transaction enters the system, when it is sent to the recipient's bank and whether the transaction could be completed. Table 4 presents a summary of the measures adopted and described throughout this section and its starting date.

Table 4

Start date of measures adopted

Measures Adopted	Start date
SPEI enters	August 04
SPEUA shuts down	March 05
Generalized provision of SPEI through Internet	July 05
Sender identification standard set	
Price cap agreeement	March 06
Fee´s reduction to 0.5 pesos	April 06
Non-banks entry to SPEI	May 06
Introduction of MISPEI	Sep 07
Remotion of fixed fee	January 08

Source: Banco de Mexico.

5. Methodology and data

In order to describe the adoption of SPEI and to measure the impact of the regulations that BM has taken, we use a logistic model which depicts the adoption process as a symmetric S-shaped curve. This type of model has been frequently used to describe the adoption process of innovations. In this model, adoption rates are low in the immediate period after the innovation is introduced, followed by a period of rapid growth and, finally, there is a phase of stable adoption rates until the innovation reaches its saturation point.

Geroski (2000) asserts that the S-shape of the adoption process can be explained by the epidemic and the probit models. In the first of them adoption is an increasing function of the information available about the technology, which in turn, will be a positive function of the number of adopters. This implies that early adopters provide non-adopters with information about the new technology and its benefits. As adoption increases, the number of non-adopters decreases and as a result the growth rate of adoption declines and approaches the maximum number or proportion of potential adopters. This model also assumes that early adopters need very little information to start adopting the innovation.

The Probit model assumes that different firms or individuals decide to adopt at different times. Thus, in order for a person to adopt a new technology, she must satisfy a minimum value of some variable (for instance, income) and assumes that such characteristic is distributed among the population as a normal random variable. As the minimum value required decreases (for example because it is cheaper to adopt the innovation), a greater proportion of the population decides to adopt; however the bell shaped distribution implies that the growth rate will tend to increase approaching the maximum and will decrease from that point on. Thus, adoption is characterized by an S-shaped curve.

In terms of the payments, a logistic approach was followed by Snellman and Vesala (1999) to forecast the “electronification” of payments in Finland. They applied the S-shaped learning curves to several transaction types and found that the S curves fit the data well and, among other things, that cash displacement in Finland was getting close to its saturation point. However, Jyrkönen (2004) found that when the time series analyzed is extended for the case of Finland, no S shape is visible; she then proposes dynamic regression models to forecast the electronification process.

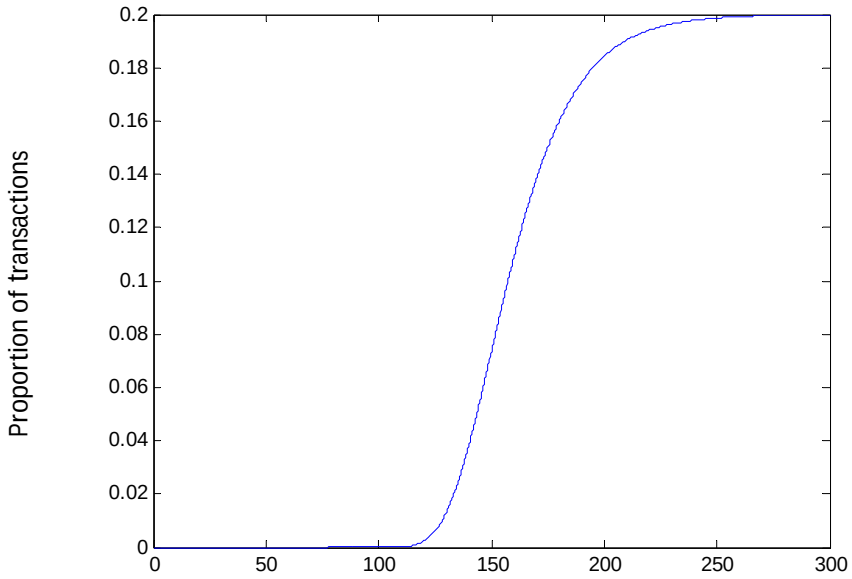
Given that any amount may be sent through SPEI, this system can be considered a substitute for direct debits, t+1 EFTs and checks. These non-cash payment options constitute the universe of transactions where SPEI’s importance is defined.

The functional form of the logistic curve is presented in equation (1) and Figure 5 shows a typical curve.

$$S_t = \frac{a}{1 + c\exp(-bt)} + e_t \tag{1}$$

Figure 5

Logistic curve



In equation (1) S_t is the proportion of transactions carried out with SPEI, calculated as the number of SPEI transactions over the total number of possible substitute payments; the latter is the sum of direct debits, electronic transfers (including both SPEI and EFT) and checks. In other words, S_t is the fraction of SPEI adopters over the total number of possible transactions (adopters plus non-adopters).

In the logistic curve presented above a is an asymptote of S_t ie $\lim_{t\to\infty} S_t = a$. This implies that as time passes, the adoption process converges to a saturation point a. Furthermore, the parameter *c* is the inflection point of the S-curve, thus it shifts the curve back and forth without changing the shape, ie it can increase or decrease the period at which the maximum rate is achieved. The parameter *b* determines the slope of the curve or the rate of adoption in the following way:

$$\frac{dS_t}{dt}\left(\frac{1}{S_t}\right) = b\left(\frac{a - S_t}{a}\right)$$

The rate of adoption showed above reaches its maximum at the inflexion point and tends to zero as the proportion of adopters approaches the saturation point.

In order to model the adoption of SPEI, we apply this methodology to two different datasets in order to obtain the three parameters described above. We test several hypotheses both, at the industry aggregated level and at the individual banks level.

The first dataset encompasses monthly aggregated information of the number of SPEI transactions. The dependant variable that we used is the fraction of the number of SPEI transactions over the total number of non-cash non-POS transactions number.

The second dataset comprises quarterly information of SPEI transactions number, disaggregated at the bank level, from March 2006 to March 2008. This data set includes eight banks that account for more than 80% of the total transactions processed in the system.[19] As it will be mentioned later, the fact that only quarterly information is available implies that we cannot test the individual impact of all the regulations that we have identified, since in some cases more than one regulation was adopted during the same quarter. With this data set we will test if the process of adoption varies across banks and if regulations affect banks in a differentiated manner.

In both types of estimations we analyze the impact that several regulations had over the saturation point (the proportion of SPEI transactions performed in the long run), the adoption rate and the inflexion point. Furthermore, in line with Snellman and Vesala (1999) we use the proportion of the number of transactions and not the proportion of the value because the efficiency of the payment system is better reflected by the number of transactions it handles. Transaction value does not bear relationship with the amount of the resources needed to process such payments.

In order to assess the effect of regulation passed by BM at the aggregate level, parameters ***a*** and ***b*** and ***c*** are estimated in the following way:

$$a = \beta_i X_i + \delta_j D_j$$
$$b = \gamma_i X_i + \varphi_j D_j$$
$$c = \phi X_i + \kappa_j D_j$$

Where, X_i are control variables obtained from the growth rate of accounts (demand control variables), and D_j is a vector of dummy variables that defines the months in which regulations were first put in place, that is:

$$D_j \begin{cases} 0 & \text{if } t < t^* \\ 1 & \text{if } t \geq t^* \end{cases}$$

where t* denotes the month when each regulation started.

At the bank level a_i (the saturation point for bank *i*) is defined in two alternative ways:

$$a_1 = a_k B_k + \beta_i X_i + \delta D$$
$$a_2 = a_k B_k + \beta_i X_i + \delta D + \lambda_k B_k D$$

And the rate of diffusion and the inflexion point are specified in the following way

$$b = b_k B_k + \delta D + \gamma X_i$$
$$c = \delta D + \phi X_i$$

At the bank's level B_k stands for dummy variables that identify each of the banks included. These parameters capture any omitted variable at the institution level related to the adoption

[19] We included the 6 largest banks plus two smaller institutions that promote the performance of transactions through the internet and that are oriented to high income clients.

of SPEI such as the degree of sophistication of clients or the Internet infrastructure offered by each institution.

In a_1 we let the effect of the regulation be the same across banks, while in a_2 the impact of the regulation could vary across institutions.

At first glance, prices seem to be a rather relevant variable for the adoption process. However, we did not include them in the models because the series of maximum SPEI prices that we have (at the bank level), does not show enough volatility to be of any relevance.

As we have mentioned, SPEI was introduced in August of 2004. Up until March 2005 SPEI and SPEUA were simultaneously functioning; therefore SPEI could not be adopted completely even for the transactions carried out by SPEUA until then, which were mainly institutional. Moreover, SPEI could not be adopted by final users until identification standards were set, in July 2005; approximately at the same time, during June and July of 2005, banks started the provision of SPEI through their internet sites.

We consider that it was not until these institutional conditions were met – identification standards and internet provision – that SPEI could be adopted by the typical bank clients. Before that, SPEI did not really have a chance to become a massively used payment mechanism. Consequently, our adoption analysis is restricted to the period March 2005 to August 2008.

During this period several institutional changes and regulations were adopted aiming at fostering SPEI's usage, as we mentioned in section 4. Some regulations were not expected to have a considerable impact on adoption, like the reduction in the fees that BM charges to banks; therefore, we mainly consider two measures empirically:[20]

1. Removal of the minimum amount to send a transaction through SPEI (starting from December 2005).

2. Banks' agreement to impose a cap on SPEI's fee (adopted in March 2006).

At the aggregated level, since we use monthly data, both measures were tested separately; nevertheless, at the bank level where we only have quarterly data, we tested the joint effect of both measures given that they occur during the same quarter.

Given the Jyrkönen (2004) criticism of the use of a logit model to represent electronic payments adoption, it is necessary to justify the usage of an S-shaped function for the analysis of SPEI's adoption in Mexico. In other words, we need to show that the process presents an S shape during the properly defined period of analysis.

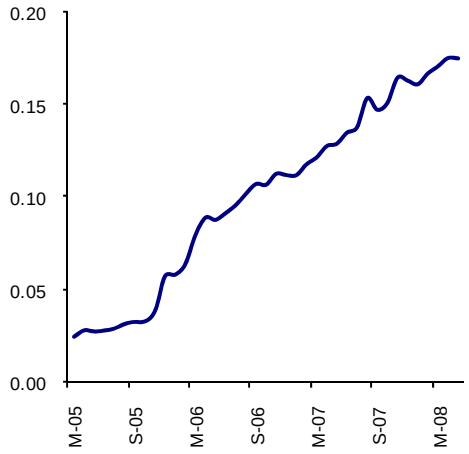
The following Figures show that starting from July 2005, when the standards of identification were properly set and clients could perform SPEI transactions over the internet, there is first a lower adoption rate and then it increases from January 2006, achieving a maximum value in July 2006. After that period the growth rate starts to decrease. This behavior is in line with the logistic model we propose.

[20] We did test all other regulations and they had no significant impact on adoption.

Figure 6

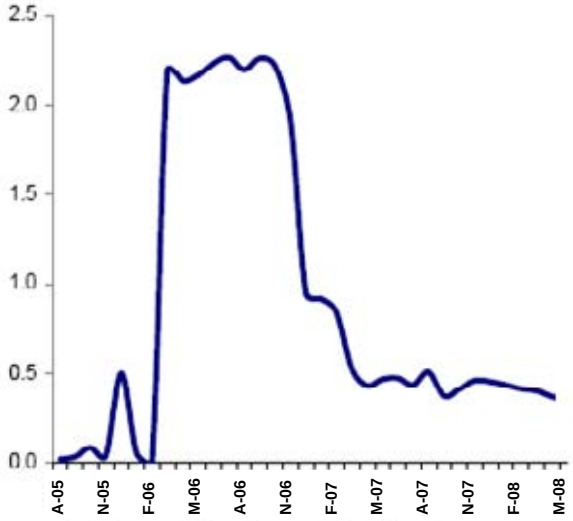
a) Proportion of Transactions Performed with SPEI

Proportion of payments



b) Growth Rate of the Proportion of Transactions Performed with SPEI

%



Source: Banco de Mexico.

Basic statistics for the variables used in the different models are shown in table 5. The variable of interest, the proportion of transactions with SPEI, has a mean of 11% and achieves a maximum value of 17.4% at the end of the period.

Table 5

Descriptive statistics of variables included in the model

Variable	Mean	Standard deviation
Proportion of Transactions with SPEI	0.11	0.04
Growth Rate of the Economic Activity (%)	3.94	1.95
Growth Rate of Accounts	0.01	0.02

Source: Own calculations with information provided by Banco de Mexico, INEGI and CNBV.

Finally Table 6 presents the variable of interest disaggregated at the bank level. From it is clear that institutions show different levels of adoption. This may be caused, among others, by the quality of the internet service provided and the degree to which banks promote SPEI transfers.

Table 6

Proportion of transactions performed with SPEI by institutions

Institution	Mean	Standard Deviation
Bank1	0.13	0.02
Bank2	0.05	0.02
Bank3	0.16	0.03
Bank4	0.03	0.00
Bank5	0.05	0.02
Bank6	0.11	0.02
Bank7	0.06	0.02
Bank8	0.17	0.05

Source: Own calculations.

6. Results

At the aggregate level we found that both the agreement that set up a cap to SPEI's price and the measure that allowed low value transfers to go over SPEI had a positive and significant effect on the proportion of transactions carried out with SPEI in the long run (saturation point). At the bank level, we found that adoption across banks is a heterogeneous process that strongly depends on banks' characteristics, such as their internet infrastructure and client type (level of income, education, etc.). We also found a positive and significant effect on the saturation point of the agreement on SPEI's price and the possibility to send low value transactions.

Tables 7 and 8 present the estimation results at the aggregate level, where the dependent variable is the proportion of transactions carried out with SPEI over the total number of transactions. The difference between both is that the model included in the latter control for demand variables. Table 7 presents in Column I the basic specification where the adoption process is only a function of time. In this model the three parameters are significant and have the expected positive signs; the saturation point (a) is reached at 17% of the total transactions and the growth rate (b) is positive. Finally, the inflexion point (c) is reached 23 months after July 2005. This model constitutes the point of reference for the rest of the estimations.

Columns II, III and IV test the separate effects of the regulations over the saturation point, the rate of adoption and the inflexion point, respectively. Model II shows that the agreements that set a price cap and removed the minimum transaction value had a positive and significant effect on the saturation point. This implies that this measure tended to increase the maximum proportion of transactions performed with SPEI from 12% to almost 24%. Additionally, as can be seen in the second column of Table 8, this result is not changed by the introduction of demand related variables.

In model III we found that both measures had a negative effect on the adoption rate, which implies that these regulations tended to slow down the process. This could be attributed to the fact that the adoption of low value transactions (favored by both measures) occurred later and at a slower pace compared to high value transactions.

Finally, model IV shows that the effect of the measures on the inflexion point is negative and significant. This implies that as a result of the agreements the maximum rate was achieved at an earlier period.

Table 7

Results at the aggregate level

Variables	I		II		III		IV	
Saturation point	0.17	***	0.12	***	0.27	***	0.24	***
Rate of adoption	0.13	***	0.07	***	0.10	***	0.07	***
Inflexion point	23.44	***	30.40	***	34.08	***	43.20	***
Effect of measures on the saturation point								
No minimum value of transactions			0.04	**				
Price reduction			0.08	***				
Effect of measures on the rate of adoption								
No minimum value of transactions					-0.02	***		
Price reduction					-0.02	***		
Effect of measures on the inflexion point								
No minimum value of transactions							-4.21	**
Price reduction							-8.44	***

*Significant at the 10%, **significant at the 5%, ***significant at the 1% level.

In Table 8 we present the same model but we control for the effect that demand variables (the growth rate of the economic activity and of the number of bank accounts) may have over the three parameters of interest mentioned before.

The sign of the effect of the measures is not different to the one presented in the previous tables, since in many cases demand variables turned out to be non-significant. This result could be due to the fact that these variables may tend to affect all transactions in a very similar way leaving unchanged the ratio of transactions performed with SPEI.

Table 8

Results at the aggregate level including demand variables

Variables	I		II		III		IV	
Saturation point	0.20	***	0.16	***	0.32	***	0.29	***
Rate of adoption	0.10	***	0.06	***	0.08	***	0.06	***
Inflexion point	28.39	***	34.55	***	42.04	***	48.51	***
Effect of measures on the saturation point								
No minimum value of transactions			0.04	*				
Price reduction			0.07	***				
Effect of measures on the rate of adoption								
No minimum value of transactions					-0.02	**		
Price reduction					-0.02	**		
Effect of measures on the inflexion point								
No minimum value of transactions							-3.68	*
Price reduction							-7.84	**
Effect of demand variables on the saturation point								
Growth rate of the economic activity	-0.11		-0.35		-0.72		-0.60	
Growth rate of accounts	-0.01		-0.01		-0.02	***	-0.01	
Effect of demand variables on the rate of adoption								
Growth rate of the economic activity	-0.14		-0.18		0.12		-0.04	
Growth rate of accounts	0.01	*	0.00		0.01	***	0.00	
Effect of demand variables on the inflexion point								
Growth rate of the economic activity	-16.31		-33.54		-79.01		-63.40	
Growth rate of accounts	-1.01	**	-1.17		-2.70	***	-1.43	

*Significant at the 10%, **significant at the 5%, ***significant at the 1% level.

Results at the bank level are presented in Table 9. Colum I presents the basic model that includes dummy variables to allow for the saturation point and the growth rate of transactions to vary across institutions. In order to avoid perfect multicollinearity of dummies, we excluded one institution. The excluded institution is a small modern bank which mostly serves high

income clients. Thus we expect the customers of this bank to have a higher and faster adoption process than that experienced by the clients of other banks.

Model II adds to the first model the effect of the regulation on the saturation point as a homogenous effect on all banks controlling for demand variables. The results show that the combined effect of measures that capped the price and allowed accountholders to send low value transactions had a positive effect on the proportion of transactions performed with SPEI. Furthermore, almost all dummies included at the bank level affecting the saturation point and the rate of adoption are significant, which supports the idea that banks have different adoption curves. In this sense, banks with better infrastructure to perform transactions over the internet tend to have higher saturation points.

Columns III and IV show the effect of regulation on the rate of adoption and the inflexion point, respectively. As can be observed, the combined effects of measures tended to decrease the rate of adoption; while the effect on the inflexion point is not different from zero.

Finally, column V shows a model where the timing of measures is interacted with banks' dummies, allowing for the effect of measures on the saturation point to be different across banks. The results show, that at least for two banks, it seems plausible to assert that policy measures affected banks' saturation point in a differentiated and positive way.

Table 9

Results at the bank level

Variables	I		II		III		IV		V	
Saturation point	0.22	***	0.20	***	0.22	***	0.24	***	0.22	***
Rate of adoption	0.66	***	0.61	***	0.75	***	0.39	***	0.64	***
Inflexion point	2.14	***	2.06	***	2.09	***	3.12	***	2.12	***
Effect of measures on the saturation point										
Measures			0.02	**						
Measures*bank1									0.04	**
Measures*bank2									0.02	
Measures*bank3									0.03	
Measures*bank4									-0.02	
Measures*bank5									0.02	
Measures*bank6									0.09	***
Measures*bank7									-0.04	
Effect of measures on the rate of adoption										
Measures					-0.22	**				
Effect of measures on the inflexion point										
Measures							-0.90			
Effect of demand variables on saturation point										
Growth rate of the economic activity			0.00						0.00	*
Growth rate of accounts			0.00						0.00	
Effect of demand variables on the rate of adoption										
Growth rate of the economic activity					0.00					
Growth rate of accounts					0.01	*				
Effect of demand variables on the inflexion point										
Growth rate of the economic activity							-0.04			
Growth rate of accounts							0.05			
Saturation point's dummies										
Bank 1	0.01		0.01		0.01		-0.01		-0.02	
Bank 2	-0.15	***	-0.14	***	-0.15	***	-0.16	***	-0.16	***
Bank 3	0.05	***	0.05	***	0.05	***	0.04	***	0.03	*
Bank 4	-0.16	***	-0.16	***	-0.17	***	-0.18	***	-0.15	***
Bank 5	-0.14	***	-0.14	***	-0.15	***	-0.16	***	-0.16	***
Bank 6	-0.04	***	-0.04	***	-0.04	***	-0.06	***	-0.10	***
Bank 7	-0.14	***	-0.13	***	-0.14	***	-0.15	***	-0.10	***
Rate of adoption's dummies										
Bank 1	-0.55	***	-0.52	***	-0.47	***	-0.29	***	-0.57	***
Bank 2	-0.21		-0.23		-0.14		0.00		-0.27	
Bank 3	-0.48	***	-0.45	***	-0.40	***	-0.24	***	-0.50	***
Bank 4	-0.67	***	-0.66	***	-0.57	***	-0.38	***	-0.58	***
Bank 5	-0.20		-0.23		-0.14		-0.02		-0.26	
Bank 6	-0.51	***	-0.49	***	-0.43	***	-0.25	**	-0.59	***
Bank 7	-0.32	*	-0.31	*	-0.23		-0.10		-0.22	

*Significant at the 10%, **significant at the 5%, ***significant at the 1% level.

7. Final comments

Banco de México has taken steps to set up an institutional environment free of obstacles for SPEI's adoption. As claimed by Snellman and Vesala (1999), in a favorable institutional environment, the adoption of electronic payments may advance very fast, as depicted by a sigmoid function. Moreover, the adoption process will not reach its potential unless the barriers that may exist in the market are removed. In Mexico, standards have been set,

prices have been (partially) rearranged, and barriers to participation have been eliminated in order to permit SPEI's development. These policies seem to have been quite successful.

As a consequence, SPEI has changed from being a system oriented to very large value electronic transfers (like its predecessor SPEUA) to a system also used massively for relatively small value transactions. This has increased the efficiency of general payments in Mexico and improved the benefits to users of the service. As a clear piece of evidence of the increase in efficiency, in the structure of non-cash non-POS number of payments (which includes checks, direct debit, a t+1 electronic transfers service and SPEI), SPEI went from representing 2.9% in 2005 to 13.9% in 2007; checks went in the opposite direction when they passed from representing 86.6% of such payments to 74.1% during the same period. This represents a leap in efficiency not just due to the displacement of paper based transaction (checks) but a movement to use the most efficient electronic transfer mechanism (SPEI) which reduces the risks incurred in payments.

The main result of this research is that SPEI adoption is still going to keep on growing until it reaches the 23% fraction (now is 17.5%), which the model forecasts as the saturation point. Of course this estimation may change if other regulations that affect SPEI's adoption are implemented in the future. We find that the agreements and regulations put in place by BM and other participants have been very important in SPEI's adoption process; in particular, they have moved SPEI's saturation point by 6 percentage points. Of particular significance was the agreement between banks to reduce the distortion existent between the price of SPEI and the prices of its substitutes; banks did not agree on a price, but on a cap on SPEI transactions.

In terms of the differences across banks, we find that the process of adoption of SPEI is not homogeneous; banks with better internet infrastructure and higher income clients have superior adoption rates than banks that have decided to keep on running business mainly through their branches. Additionally we found that the regulation adopted affected banks in a differentiated manner.

Finally, we found that in most cases demand variables do not seem to be significant in SPEI's adoption. What this really means is that these variables affect all payment mechanisms in the same proportion, so that SPEI's importance among its substitutes does not increase as demand variable changes.

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