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The Adoption Process of Payment Cards -An Agent- Based Approach*

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Abstract: We investigate the payment card's adoption rate under consumers' and merchants' awareness of network externalities, given two levels of Interchange Fees in a multi-agent card market. For the purpose of our research, in multiple instances of the model (scenarios) the investigated effects are analyzed over the complete process of adoption, until the market's saturation point is achieved. For each scenario, a comparison is made between two different levels of Interchange Fees and different degrees of consumers' and merchants' awareness. We model explicitly the interactions between consumers and merchants at the point of sale. We allow card issuers to charge consumers with fixed fees and provide net benefits from card usage, whereas acquirers can charge fixed and transactional fees to merchants.

Keywords: Two-sided markets, financial services, network formation.
JEL Classification: D7, D85, G28, L13.

Resumen: Investigamos la tasa de adopción de las tarjetas de pago considerando el conocimiento (la consciencia) de consumidores y comercios respecto las externalidades de red, usando dos niveles de Cuota de Intercambio en un mercado de tarjetas multi-agente. Para el propósito de nuestra investigación, en múltiples instancias (escenarios) del modelo los efectos investigados son analizados sobre el proceso completo de adopción, hasta que el mercado alcanza su punto de saturación. Se realiza una comparación, para cada escenario, entre los dos niveles de Cuota de Intercambio y diferentes grados de conocimiento (consciencia) de consumidores y comercios. Hemos modelado explícitamente las interacciones entre consumidores y comercios en el punto de venta. En el modelo, los emisores de tarjeta pueden cobrar cuotas fijas y entregar beneficios netos por el uso de las tarjetas, mientras que los adquirientes pueden cobrar cuotas fijas y por transacción a los comercios.

Palabras Clave: Mercados de dos lados, servicios financieros, formación de redes.

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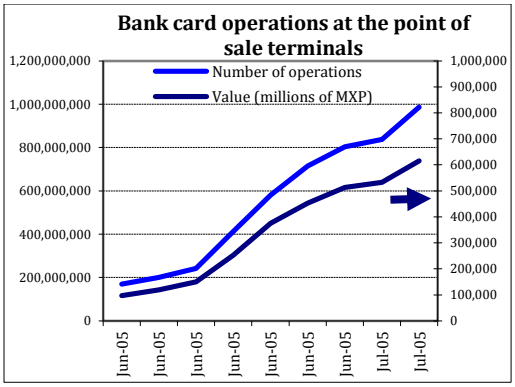
1. Introduction

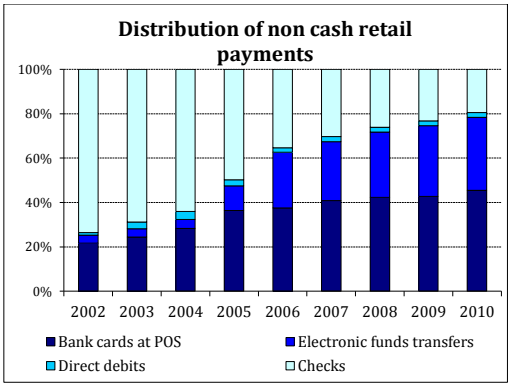
During the last decade interest on studying the retail side of the payment systems has grown. The driving factor behind this study is that electronic payment methods are of ever increasing importance for making payments. Among these instruments, payment cards - more commonly referred to as credit and debit cards - are replacing cash and check payments at a rapid rate and are competing strongly with new payment methods. In terms of relative importance, for instance in Canada and the USA payment cards are the most commonly used instruments, accounting for 68% and 58%, respectively, of all registered transactions made in 2010 (Bank for International Settlements, 2011). According to the European Central Bank (2010) in the European Union their market share is reported to be 38%, which is the highest of all payment methods available, well ahead of direct credits, direct debits and checks.

Electronic payments have also been expanding in emerging and developing countries. For example, in Mexico, the average growth rate of transactions with non cash payment instruments (payment cards, direct debits, checks and electronic funds transfers) between 2002 and 2010 was 14%. That of transactions with payment cards was 26%; they totaled almost 1 billion operations in 2010 with a value of nearly 600 billions of pesos (Figure 1(a)). In turn, electronic funds transfers (direct credit) and direct debits have grown at positive rates also, while checks have decreased. As a result of these dynamics, during that period bank card payments as a share of non cash retail payments increased from 22% to 46% (Figure 1(b)) and card payments per inhabitant per year more than duplicated from 4 to 9[1] (Figure 1(c)), still well below of what is observed at either Canada, the United States or Europe.

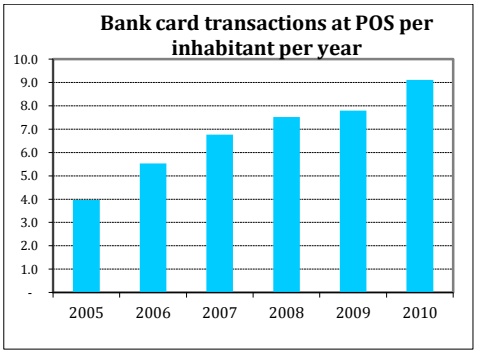
[1] For further details about credit card usage among different population segments in Mexico see the appendix.



Source: Central Bank of Mexico
(a)



Note: Estimations exclude electronic funds transfers of 100,000 pesos or more
Source: Central Bank of Mexico
(b)



Source: Central Bank of Mexico and National Population Council.
(c)

Figure 1: The growth of electronic payments

Given the prominent growth in the usage of payments cards, the line of research dedicated to study the competitive nature of the payment card market has attracted considerable attention from policy makers (e.g. Vickers, 2005, Reserve Bank of Australia, 2008, Bolt & Chakravorti, 2008, and Weiner, 2008). We have recently witnessed several regulatory initiatives such as the code of conduct for the credit and debit card industry in Canada. The aim of the code is to ensure that merchants are fully aware of the costs associated with accepting credit and debit card payments, including the interchange fee (IF). Furthermore, in order to encourage consumers to choose the lowest-cost payment option, merchants are provided with increased pricing flexibility and are able to freely choose which payment options they will accept. Another prominent example is the USA financial reform, which among others regulatory provisions, is aimed to set up a new bureau in the Federal Reserve to regulate mortgages and credit cards. In addition, the bill also includes a reduction on the fees charged on debit card transactions, including the IF that card issuers can charge to card acquirers whenever their cardholders use their cards at the merchant's point of sales terminal set by a different acquirer. On June 29, 2011, the Federal Reserve Board issued its final rule to implement the debit card IF and routing regulation rules pursuant to the "Durbin amendment" to Dodd-Frank. Among other things, the amendment sets

standards for assessing whether debit card IF received by debit card issuers are "reasonable and proportional" to the costs incurred by issuers for electronic debit transactions and a maximum permissible IF.

Let us briefly point out that both analysts and policy makers concede IFs a paramount role in the functioning of payment card systems with four parties (i. e. issuers, acquirers, cardholders and merchants). The reason is that this transfer between issuers and acquires, which can flow from either side to the other, impacts the prices charged to both cardholders and merchants, who are the final users of the payment instrument (Figure 2). For instance, the IF charged by issuers to acquires sets a minimum to the merchant service fee that acquirers can charge to the establishments for accepting card operations, which in turn permits the issuer promotes the use by means of offering rewards to cardholders. In contrast, when the issuers pay acquirers the IF, cardholders may have to pay an annual fee or a fee per transaction and merchants may receive a stimulus (we will discuss this issue further in the following section).

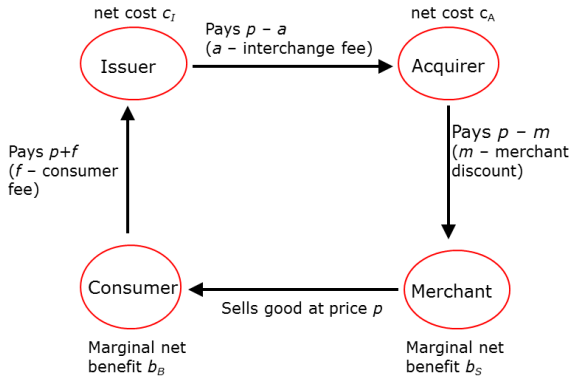


Figure 2: IF flow

Regulations to develop card payments have also been undertaken in Mexico (Negrín, 2005). The implementation of the Payment System Law (2002) and the Law for Transparent and Ordered Financial Services (2004) increased the central bank's powers to oversee payment systems in general and foster electronic payment systems in particular. In the case of bank payment cards, since Mexico's market for bank retail payment cards in Point of Sale (POS) had remained underdeveloped, both with respect to international standards and vis-à-vis other emerging economies in the region, the Mexican authorities were concerned that lack of competition may be one of the culprits and implemented measures to foster market competition and depth, including a reduction of Ifs (see Castellanos, Cordella, Medina, Mendoza, Negrín, Rochet & Solís, 2008). Another particularly important measure to promote card transactions was the launch, in November 2004, of the Electronic Payments Infrastructure Fund (Fondo de Infraestructura de Medios de Pago Electrónicos, FIMPE) by the Ministry of Finance (Secretaría de Hacienda y Crédito Público). The FIMPE was a private, non-profit-making trust

fund formed by acquirers that aimed towards promoting and extending access to the electronic payment network among small and middle size business, as well as to increase consumers' usage of them. Besides the fiscal incentive provided by the Ministry of Finance to install new electronic funds point of sales terminals, FIMPE funds were dedicated to implement a series of campaigns to advertise through multiple media the advantages of using bank cards among both consumers and merchants; that is, to increase market participants' awareness of the potential benefits of adopting this payment platform (Castellanos et al., 2008). More recently, after the financial crisis of 2008, the Law for Transparent and Ordered Financial Services has been further reformed (2009 and 2010) and the Central Bank issued the Rules for Credit Cards which regulate minimum payments and improve cardholder protection in case of card loss or robbery, among other aspects (November, 2010). Besides, it also prohibited the banks to charge commissions in the case of payment default, if they already charge delinquency interest rates, and in the case that the cardholder has not used her card during one year, if they already charge an annual fee (July, 2010).
In this context, the authorities' interest is also focused on understanding the changing nature of our payment habits. In the last years those habits have moved slowly from the use of paper-based instruments to the use of more efficient electronic payment instruments, merely payment cards. It is fair to say that the efficient use of payment instruments could have consequences beyond the payment system, i.e. the use of less expensive electronic payment means at the point of sale could results in considerable savings not only for businesses and banks, but also for the society as a whole. For instance, in Norway, where around 95% of the payments from deposit accounts are made electronically with 278 card transactions per habitant for 2010, the social cost of using and producing payment services is under half a percent of the country's GDP according to the Norges Bank (2010). Another example is Portugal, where the share of card transactions has grown from 52% in 2001 to 66% in 2009 (European Central Bank, 2010). The total costs for operations related to payment systems are estimated around 0.8% of GDP (Banco de Portugal, 2007).

In the present paper we develop a multi-agent model to simulate transactions at the point of sale between consumers and merchants in order to investigate the impact of the network externalities, such as those that FIMPE's campaigns can achieve, over the complete process of adoption. Our aim is to explore how consumers' and merchants' awareness of the network externalities modifies the adoption curve. This study is performed under two different levels of IF. The rest of the paper is organized in the following way: in Section 2 we briefly review the economic literature on payment card systems, sketching potential complementarities with the agent-based model approach. Then in Section 3 the motivation of why using a multi-agent model is presented. Brief descriptions of the model elements, which are calibrated to broadly match Mexico's payment card

market[2], are presented in Section 4. Next, in Section 5 we explain the agents' decisions and in Section 6 we present the settings of the model. In Section 7 we present our findings. Finally, in Section 8 we discuss our conclusions and suggest related lines of research.

2. Economic literature on payment card systems.

What distinguishes the market for payment cards from most other markets is that it is a two-sided market, i.e. both partners in the transaction, consumers and merchants, using a payment card need a subscription to this specific payment method. Platform operators, as Visa and Mastercard, organize their business in a four party scheme: consumers, merchants, issuers (banks that provide cards to the consumers) and acquirers (financial institutions which become creditors of transactions to the merchant and provide them electronic terminals[3,4]. Each network establishes a specific level of IF, which is charged per transaction and usually flows from acquirers to issuers (Figure 2).

The economic literature has studied payment card systems, externalities and the role of IF for some time, using the framework of two sided markets. So, for the sake of briefness we present some analytical models and discuss how an agent-based approach can be used to complement those models insights. We refer our readers to the thorough and complete surveys written by Chakravorti (2003 and 2010) for further references.

A two-sided market can be formally defined as a market where end-users are unable to negotiate prices based on costs to participate on a platform and the price structure affects the total volume of transactions (Rochet & Tirole, 2002). At first, the two-sided market literature assumed that the decision to adopt and use a payment instrument was made simultaneously; that is, if consumers adopt payment instruments they will always use them when possible. In Baxter (1983), it is argued that the equilibrium quantity of payment card transactions occurs when the total transactional demand for payment card services, which are determined by consumer and merchant demands jointly, is equal to the total transactional cost for payment card services, including both issuer and acquirer costs. A key result of this seminal model is that pricing each side of the market based on marginal cost—as would be suggested by economic theory for one-sided competitive markets—need not yield the socially optimal allocation. To arrive at the socially optimal equilibrium, a side payment –that is, an IF- may be required between the issuer and acquirer.

[2]The data used to calibrate the model is included in the appendix.

[3] It is worth noticing that in some countries the provision of terminals is not a generic acquirer tasks; nor do acquirers need to be financial institutions in all jurisdictions.

[4] In a three party payment system the same institution that issues the cards to consumers is the acquirer at merchants' shops. The best known example of the three party payment scheme is American Express.

While in Baxter (1983) issuers and acquirers are competitive and merchants cannot price discriminate between consumers who pay with cash or those who pay with cards, the model developed by Schmalensee (2002) considers that issuers and acquirers that have market power, but still assumes that merchants operate in competitive markets. This framework also supports the conclusion that the IF balances the demands for payment services by each end-user type and the cost to banks to provide them. Moreover, IF of issuers and acquirers that maximizes profits can be socially optimal. That is, given the simultaneous consumption of payment services by consumers and merchants, a side payment may be necessary to get both sides on board if there are asymmetries of demand between consumers and merchants and/or of costs to service consumers and merchants.

In contrast with the approaches described before, Rochet and Tirole (2002) studies policies set by law, card networks, or acquirers that require consumers to pay the same price regardless of the type of payment instrument used (e.g., "the no surcharge rule" or the "honor all cards rule") in a model that assumes issuers have market power, a perfectly competitive acquiring market, and merchants compete in a Hotelling framework. Consumers purchase one unit of a good and are heterogeneous in terms of net benefits received from using the payment card. Two results of these framework stand out. First, the IF that maximizes profit for the issuers may be more than or equal to the socially optimal interchange fee, depending on the issuers' margins and the cardholders' surplus. Second, merchants are willing to pay more than the socially optimal fee if they can steal customers from their competitors. However, overall social welfare does not improve when merchants steal customers from their competitors by accepting payment cards.

To summarize, the theoretical framework initially developed in Baxter (1983) and later in the models in Schmalensee (2002) and Rochet and Tirole (2002), has propelled a significant amount of research in this area. Furthermore, our understanding of the fundamental relationship among the participants of the payment card market has been straitened by the contributions of Wright (2003), Evans (2003), Evans and Schmalensee (2005, January and 2005, May), Roson (2005) and more recently of Chakravorti and To (2007) and Rochet and Tirole (2006). Those models are built on the assumption that the payment cards are accepted by all consumers and merchants and the analysis is focused on the usage externalities, which arise by the use of payment cards over the cash or other payment methods. In those studies the market dynamics are evaluated through the most representative players (namely the cardholders, the merchants, the card issuers and the acquirers) and the attention is placed on the setting of IF. These models only give cursory considerations to the interactions among heterogeneous market participants and consequently do not take into account the impact that those interactions could have on the competition in the market. For these reasons we believe that an alternative approach is required to study the social dynamic of the market under more realistic fashion, such as agent-based modeling.

3. The agent-based modeling – the alternative approach

If we try to visualize model's development spectrum in terms of complexity degree, those models whose creation requires high computational skills stand among the most complex ones. They challenge the conventional way of representing social phenomena and try to expand the frontier in the process of understanding reality. The agent based approach is one of these modeling techniques that use programming languages, which allows us to represent explicitly agents with bounded rationality and heterogeneous preferences. Given specific social structures, the simulation of the interaction among agents is the key strength of the agent-based modeling (ABM) (Axelrod, 2003). The representation of the behavior of the autonomous decision-making entities allows researchers to analyze emergent phenomena in order to gain a better understanding of the object of study. Inside the field of agent-based modeling, is the Agent-based Computational Economics (ACE) approach that we follow to develop our model (see LeBaron, 2000 and 2006).

One of the main purposes of ACE is to handle the complex dynamics of economic systems on a more realistic fashion (Colander, Goldberg, Haas, Juselius, Kirman, Lux & Sloth, 2009). Given the necessity imposed by the latest financial crisis to better understand the complexity of the world's economy, ACE is developing rapidly, in particular the studies related to the Agent-based Financial Economics (Kirman, 2010, and Johnson and Lux, 2011). Among the different ways of applying the agent-based approach, is the so called bottom-up modeling of market processes (Tesfatsion, 2006). The idea behind this simulation technique is to explicitly represent the participants of the market, modeling them as software programs (agents) able to take autonomous decisions. The behavior rules generally allow each agent to interact with a small fraction of agents, independent from the total number of participants built into the model. For that reason, each modeled individual exhibits significant differences with respect to the other participants. Consequently, the interactions among the agents at the micro level (locally) give rise to regularities at the macro level (globally). The intention is to observe the emerging self-organizing process for a certain period of time, in order to study the presence of patterns or the lack of them. Currently the study of this self-organizing capability is one of the most active areas of ACE research.

Regarding our object of study, the payment card market, the focus of the literature, as we said before, is on the IF and the analytical models make a number of very simplified assumptions on the behavior of consumers and merchants. Nevertheless, in reality, the behavior of market participants is determined by a set of complex interactions between consumers and merchants, as well as within the group of consumers and the group of merchants. The partners in the transaction will face network externalities as a larger number of users in one side using a certain card, makes the subscription more valuable to the other side. Card issuers/acquirers will also affect behavior by charging subscription fees and giving benefits associated with the cards.

Given the degree of complexity, modeling the payment card market is a challenge. The first attempt to tackle this issue using computational methods is presented in Alexandrova, Tsang and Krause (2008). In that study a competition among several payment card schemes is simulated through a multi agent-based approach. In particular the behavior of consumers and merchants at the point of sale is modeled using equations, whereas evolutionary computational algorithm is applied to represent the decision of issuers to price the payment cards. In this artificial market a card provider is also the entity that offers an electronic payment method to merchants. This study was further extended in Alexandrova, Tsang and Krause (2011 February and August).

In a similar setting in Alexandrova (2009) an intranetwork competition is modeled among issuers and acquirers, given that in the artificial market there is one payment card scheme. The author simulates the consumers' and merchants' decisions related to commercial transactions, in order to study the effect of IF on the payment adoption rate in a non-saturated market. In the present paper, in order to go further in the understanding of the underlying structure of the market, we implement the same model. This approach allows us to analyze all the fees paid by consumers and merchants using payments cards rather than only the IF. Thus, the contribution of the present study is that we calibrate the market, using real data of the Mexican market and analyze the complete process of card adoption, under the specified conditions.

We investigate the payment adoption rate under consumers' and merchants' awareness of network externalities, given two levels of IFs in a multi-agent card market. We acknowledge that the saturation point of the market is not only determined by network externalities and the level of Interchange Fees, but also by macroeconomic factors which we are not exploring at this stage of research. For the purpose of our research, in multiple instantiations of the model (scenarios) the investigated effects are analyzed over the complete process of adoption, until the market's saturation point is achieved. Then, for each scenario, a comparison is made between two different levels of Interchange Fees and different degree of consumers' and merchants' awareness. To this end, we model explicitly the interactions between consumers and merchants at the point of sale. We allow card issuers to charge consumers with fixed fees and provide net benefits from card usage, whereas acquirers can charge fixed and transactional fees to merchants. The IF flows from acquirers to issuers.

4. The Elements of the Intranetwork competition model

In this section we introduce the notation used to represent our model of intranetwork competition in one network payment card market. We describe the attributes of market participants - merchants, consumers, card issuers and acquirers.

4.1. Merchants

Suppose we have a set of merchants $\mathcal{M}$ with $|\mathcal{M}| = N_{\mathcal{M}}$ and a set of business sectors[5] $\mathcal{B}$. Each merchant m can belong only to one business sector b. Each subset of merchants $\mathcal{M}_b$ belonging to a specific business sector has an individual $|\mathcal{M}_b| = N_{\mathcal{M}_b}$. The merchants are located at random intersections of a $N \times N$ lattice, where $N^2 \gg N_{\mathcal{M}}$, see Figure 3. Let the top and bottom edges as well as the right and left edges of this lattice be connected into a torus. The goods offered cross business sector are heterogeneous, whereas inside each business sector merchants are offering a homogeneous good at a common price and face individual marginal cost of production lower than this price. We have adjusted the number of merchants per business sector and the merchants' marginal profit distribution ϱ according to the 2004 Economic Census performed by the National Institute of Statistics, Geography and Informatics (Instituto Nacional de Estadística y Geografía, INEGI).

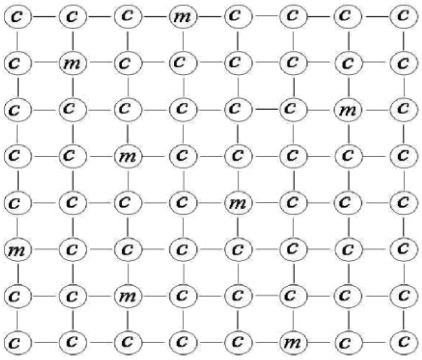


Figure 3: Sample of a lattice with consumers (c) and merchants (m)

4.2. Consumers

The set of consumers is denoted C with $|C| = N_C$. They occupy all the remaining intersections of the above lattice, where $N_C \gg N_{\mathcal{M}}$ and $N^2 = N_{\mathcal{M}} + N_C$. Each consumer has an individual budget constraint adjusted according to the income distribution obtained by the 2006 Income Census performed by INEGI. On each time period, consumers perform a single interaction with one merchant. The business sector to which the merchant belongs determines the frequency with which consumers shop at a particular merchant as well as the amount of the consumers' budget spent with it.

In order to perform commercial transactions, any consumer $c \in C$ has to travel to a merchant $m \in \mathcal{M}$. We assume that making transactions increases consumers'

[5] For more detailed information about how economic units are organized in business sectors in Mexico, please see the Appendix.

utility, whereas the travelled distance imposes costs on consumers. Given that these costs reduce the attractiveness of visiting a merchant, in this study we explore the case where the connections among consumers and merchants are local. Moreover, the distance between the intersections on the lattice is measured by the "Manhattan distance" $d_{c,m}$. The distance between two neighboring nodes has been normalized to one. We further restrict the consumer to visit only the nearest merchants and denote by $\mathcal{M}_c$, the set of merchants from all existing business sectors in the model. In subsection 4.1 we explain in detail the way this decision is designed.

4.3. Payment Methods

In the four party scheme that we have developed, we consider two sets of payment card providers: card issuers $\mathcal{I}$ with $|\mathcal{I}| = N_I$ and acquirers $\mathcal{A}$ with $|\mathcal{A}| = N_{\mathcal{A}}$. The issuers offer electronic payment cards to consumers, whereas in order to accept those cards the merchants require the electronic payment method offered by the acquirers. The payment method offered by each of the payment card providers has the same characteristics, except for the price, which may differ among issuers and acquirers.

Additionally, there is a benchmark payment method, which can be interpreted as a cash payment. Cash is available to all consumers and accepted by all merchants. For a card payment to occur, the consumer as well as the merchant must have a subscription to any of the issuing financial institutions that belong to the network. We assume that card payments, where possible, are preferred to cash payments by both, consumers and merchants. In each time period a fixed subscription fee of $F_i \geq 0$ is charged to the consumer, and $\Gamma_a \geq 0$ to the merchant.

Merchants obtain a convenience benefits b_m from accepting cards, e.g. time savings at the counter relative to cash payments, accounting facilities and fraud protection. Additionally, for each payment card transaction merchants pay a discount[6] γ_a to the acquirer. We assume that if the merchants' discount exceeds the convenience benefits, merchants will surcharge consumers that are using cards. Furthermore, the merchants' discount is established as a proportion of the IF acquirers pay to issuers[7]. Cash payments do not provide any net benefits.

Due to the reduced risk for cash handling and delayed payment, consumers also obtain a convenience benefits b_c from using a card. In addition they receive a transaction benefits b_i from the card issuer as cash-back points. We assume that those points are used instantaneously, i.e. the final amount spent increases. For that reason, cardholders, wherever possible prefer to use card over cash in a transaction. Nevertheless, in the case when the merchant has surcharged card

[6] In the model the value of the convenience benefits and the merchant discount is normalized to one

[7] For more detailed study of the relationship between the merchants' discount and the IF please see Alexandrova and Negrin (2009).

usage, the cardholder will use cash if the price increase exceeds the convenience and the transactional benefits that he receives. Cash payments however do not provide any net benefits

5. Decision-making of market participants

This section explains how the interactions among the consumers and merchants drive their decisions. These decisions are made under the condition that the prices charged by card issuers and acquirers are randomly assigned at time $t = 1$ and are fixed throughout the simulation.

5.1. Consumers' Decisions

In the model, there are two sets of consumer decisions. The first relates to the activities of shopping, which are performed at each time period. The second set of decisions relates to the subscription to the electronic payment instrument and is taken with certain periodicity determined by an individual Poisson distribution. This section addresses each of these set of decisions in turn.

5.1.1. Consumers' shopping decisions

We have modeled the process of shopping with four consumers' decisions. First he has to select a business sectors; then, from the set of the nearest merchants belonging to this business sector consumer chooses a merchant to visit; further, he must decide how much to spend;[8] and, finally, he selects a payment method to use in the transaction.

We assume a random consumer choice for the selection of business sectors. This decision is adjusted according to the patterns of cardholders' behavior observed in the data reported quarterly to the Mexican Central Bank during 2007.

With respect to the consumer choice of a merchant, we suppose it is driven by two factors: the payment methods that the consumer can use at the merchant and the distance between this consumer and the merchant. Regarding the possible payment methods used, we assume that when deciding which merchant to visit, the consumer has not yet decided which payment method he will use. In order to handle this relation, suppose $\mathcal{P}_c$ is the set of payment methods the consumer $c \in C$ has and $\mathcal{P}_{c,m}$ is the set of payment methods this consumer knows that can use with the merchant $m \in \mathcal{M}$. Let $|\mathcal{P}_c| = N_{\mathcal{P}_c}$, $|\mathcal{P}_{c,m}| = N_{\mathcal{P}_{c,m}}$ and $N_{\mathcal{P}_c} \geq N_{\mathcal{P}_{c,m}}$, i.e. any cardholder knows in advance which merchant in the neighborhood accepts card payments. Furthermore, in the case when a cardholder has previously visited a particular merchant, the consumer will also know that he will prefer a cash payment over card if card usage surcharge is applied and it is higher than the consumer's card benefits.

[8] The constrain on the maximum amount of budget spent varies across business sectors.

In addition, we assume that the smaller the distance $d_{c,m}$ between the consumer and the merchant, the more attractive this merchant will be to the consumer. From these deliberations we propose to use a preference function for the consumer to visit the merchant as follows:

$$v_{c,m} = \frac{\frac{1}{d_{c,m}} \frac{N_{\mathcal{P}_{c,m}}}{N_{\mathcal{P}_c}}}{\sum_{m' \in \mathcal{M}_c} \frac{1}{d_{c,m'}} \frac{N_{\mathcal{P}_{c,m'}}}{N_{\mathcal{P}_c}}} \qquad (1)$$

Each consumer $c \in C$ chooses a merchant $m \in \mathcal{M}$ with probability $v_{c,m}$ as defined in equation (1). Consumers will continuously update their beliefs on the number of payment methods they share with a particular merchant, by observing the acceptance of card payments of all shops in their neighborhood - as subscriptions may change over time in the way introduced below.

After choosing a merchant, the next decision the consumer must take is how much he will spend in his purchases. This is constrained in two ways. First, we assume that only a fraction of the consumers' income is spent, given that the higher the income the lower the fraction dedicated to consumption. This fraction is adjusted according to the data reported in the 2006 National Survey of Income and Expenses performed by INEGI. Secondly, even when the exact amount of the transaction is assumed to be a random choice, the possible maximum amount spent is exogenously determined and it is business sectors dependent. The adjustment of this decision is made by using data reported quarterly to the Mexican Central Bank regarding cardholders' transactions during 2007.

Finally, the cardholder decides which payment method he wants to use at the merchant he has selected. We assume a card is preferred in the case when the merchant has not surcharged. In the case the merchant charges for card usage, the decision is determined by the consumer's convenience benefits b_c from using card, the transactions benefits b_i received by the issuer and the surcharge rate sr_m applied by the merchant. Let b_c, b_i and sr_m are normalized to zero. If $sr_m > b_c + b_i$, then the cardholder will use cash, otherwise he will prefer a card payment. In the case when the merchant does not accept card payments, the transaction is settled using cash.

5.1.2. Consumer card subscriptions

In parallel to the shopping decisions, periodically[9] non-card consumers may decide to adopt an electronic payment method and consequently they have to choose to which issuers to subscribe to. Similarly, cardholders could decide to

[9] The periods are determinate by individual Poisson distribution

drop their card or to switch to a different card issuer.

Initially the number of cardholders is determined randomly in the market. Then payment cards, randomly selected from different issuers, are allocated to the selected cardholders. After certain number of interactions individually determined, cardholders may decide to drop their card subscription or change the card issuer they are dealing with. In a similar fashion, the rest of consumers have to decide whether to have a payment card or not and in the case they do, they must select a card issuer. The frequency with which consumers take these decisions is defined by an individual Poisson distribution with a mean of λ time periods between decisions.

In the model there are two mayor factors that drive the consumer decision to have a payment card: merchants' card acceptance and consumers' convenience benefits b_c from using an electronic payment method. For that reason, every consumer $c \in C$ keeps track of the merchants accepting cards, whereas the convenience benefits b_c are exogenously given. Let ω_c^+ be the consumer's score for merchants accepting cards. Each time the merchant $m \in \mathcal{M}_c$ that he is visiting accepts card payments, the consumer increases ω_c^+ by one. Assume that he decides to have a payment card with probability

$$\pi_c^+ = \frac{\exp\left(\alpha^+ \frac{\omega_c^+}{\omega_c} + b_c\right)}{x_c^+ + \exp\left(\alpha^+ \frac{\omega_c^+}{\omega_c} + b_c\right)} \qquad (2)$$

where ω_c denotes the number of merchants visited, a x_c^+ is a constant that accounts for the propensity of the consumer to have payment card and α^+ is another constant representing the consumers' awareness of the benefits arriving from the existing payment card network externalities[10]. For instance, suppose we have two scenarios with two different values of α^+. Ceteris paribus, in the case when the value of α^+ is smaller, the payment adoption rate on the consumers' side will be lower in comparison to the case when consumers have a higher awareness of the existing positive network externalities, i.e. α^+ has a larger value. Given the parameter constellation used below, we are able to explore the impact of the different degree of consumers awareness on the payment adoption curve by scaling the values of α^+. Those experiments have been performed under two different level of IF. On the other hand, cardholders may decide to drop their payment cards. They will do so with the probability

$$\pi_c^- = \frac{1}{x_c^- + \exp\left(\alpha^- \frac{\omega_c^+}{\omega_c} + b_c\right)} \qquad (3)$$

[10] The awareness in this case is of those consumers that do not belong to the network.

where x_c^- is a constant accounting for the consumers' inertia to abandon the payment card network and α^- is another constant representing the cardholders' awareness of the existing positive network externalities.

Finally, the cardholders' decision to which card issuer to subscript is driven by the fees F_i and transaction benefits b_i associated with the payment card. A card becomes more attractive to subscribe and existing subscriptions are less likely to be changed if the fixed fee charged is low and the benefits from each transaction are high. From these deliberations we propose to use a preference function for the consumer to select an issuer as follows:

$$v_{c,i} = \frac{\alpha_1 b_i - \alpha_2 F_i}{\sum_{i^* \in I} \alpha_1 b_{i^*} - \alpha_2 F_{i^*}} \qquad (4)$$

Where α_1 and α_2 are constants. Furthermore, with an exogenously given threshold τ_c, if $(\alpha_1 b_i - \alpha_2 F_i) < \tau_c$, the consumer will change his current subscription to a different issuer.

5.2. Merchants' Decisions

On the merchants' side, as with consumers, to a random number of retailers is assigned an initial subscription to a randomly selected acquirer. The merchants' decisions are limited to the acceptance of cards, the choice of acquirers and the application of a surcharge for the card usage in the case of high merchant discount γ_a. These decisions are taken periodically, after observing the consumers' behavior at the point of sale. A Poisson distribution specific to each individual with a common mean of λ time periods governs the frequency with which merchants review them.

Merchants that do not accept cards keep track of the number of consumers presenting a card to them. Every time a consumer wants to pay with a card the score of θ_m^+ is increased by one and the probability to join the payment card network is given by

$$\pi_m^+ = \frac{\exp\left(\delta^+ \frac{\theta_m^+}{\theta_m} + b_m\right)}{x_m^+ + \exp\left(\delta^+ \frac{\theta_m^+}{\theta_m} + b_m\right)} \qquad (5)$$

where θ_m denotes the number of transactions made and x_m^+ is a constant. The interpretation of the term δ^+ follows the same lines as for consumers, i.e. it accounts for merchants' awareness of the positive network externalities. Similarly here, in order to explore the effect of δ^+ on the merchant adoption rate, in separated experiments ceteris paribus we gradually increase its value. The observed curve of adoption is reported for each value change. These set of experiments are performed under two different level of interchange fee IF. The results are reported in section 6.

If the outcome of the above decision drives the merchant to join the payment card network, then he must select an acquirer. Similarly to the consumers, this decision is driven by the fixed fees Γ_a and the merchant's discount γ_a charged by the different financial institutions. The preference function proposed for this case is the following:

$$v_{m,a} = \frac{\frac{1}{\delta_1 \gamma_a + \delta_2 \Gamma_a}}{\sum_{a^* \in \mathcal{A}} \frac{1}{\delta_1 \gamma_{a^*} + \delta_2 \Gamma_{a^*}}} \quad (6)$$

where δ_1 and δ_2 are constants.

If the merchant $m \in \mathcal{M}$ accepts cards, every time a card is presented to him, he increases the score of θ_m^- by one. The probability to stop accepting a card then is given by

$$\pi_m^- = \frac{1}{x_m^- + \exp\left(\delta - \frac{\theta_m^-}{\theta_m} + b_m\right)} \quad (7)$$

where x_m^- is a constant that represents the merchants' inertia to leave the payment card network.

In our model merchants that accept electronic payments are allowed to surcharge card usage, i. e. they may apply price differentiation according to the payment method used in a transaction. They will do so, if the convenience benefits are lower than the merchants' discount $b_m < \gamma_a$, i.e. if consumers prefer to use a card instead of cash, they will have to pay a higher price for the good they are buying.

Finally, in Figure 4 we present a global view, which allows the reader to understand the payment card model by presenting the parameters and variables that have been used to construct agents' decisions. For instance, it can be seen that the cardholder's decision to select an issuer is directly affected by the transaction benefits for costumers, the consumer's subscription fee and the consumer decision to adopt a card. The last one is affected by the consumers' convenient benefits, which means that this parameter affects indirectly the Consumer´s decision to have a card. The diagram gracefully shows that the number of card transactions, the number of cardholder and finally the number of merchants accepting cards are the variables we have chosen to evaluate the model's results, which is the adoption of payment cards.

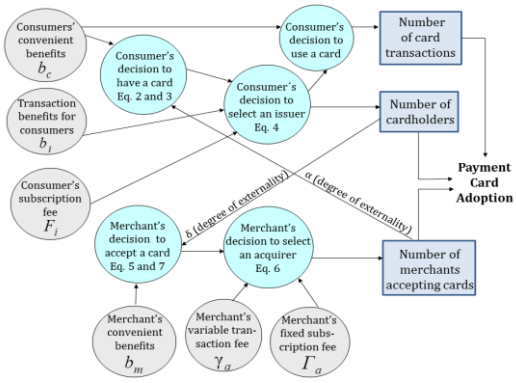


Figure 4: General view of the model

6. Experimental setting

In this section we explain the way the experiments have been conducted and how we have studied the impact that the positive network externalities have on the network's growth.

We study the effects on the payment adoption rate in a multi-agent based payment card market of the consumers' and merchants' degree of awareness of the network externalities under two levels of Interchange Fees. To this end first we have explored the parameters' search space in order to find a feasible set of scenarios, in which the emerging patterns of studied phenomenon are similar to those observed in reality. We assume that the saturation point of the market is not determined by the network externalities, but rather by other factors such as consumers' income, merchants' market power among others, which we are not exploring at this stage of research. Using the selected set of scenarios the investigated effects are analyzed over the complete process of adoption, until the saturation point in the market is achieved. For each scenario then a comparison is made between two different levels of IFs in a state where the usage/acceptance of the payment cards is at saturation point.

The criteria applied for the selection of the scenarios are the presence of a positive growth of the payment card usage/acceptance and the existence of network externalities among the two sides of the payment card market, namely among consumers and merchants. Regarding the modeling of network externalities, our research question is how aware of those positive externalities the consumers and the merchants are. In order to answer this question, we assume that any increase either of the consumers' or the merchants' awareness will have an impact on both sides of the market. We model the different degree of consumers' and merchants' awareness by scaling separately the values of α^+ and δ^+. The selected scenarios result from the combinations of values between α^+ and δ^+.

In tables 1 and 2 we present the values for the main parameters and constants,

which are kept the same for all scenarios, whereas the values of α^+ are taken from the interval [6, 7], the values of δ^+ are taken from the interval [5, 6] and the scaling of these two variables is made with a regular increase of 0.2. Figures 5 and 6 show the impact on the network growth, when the degree of consumers' or merchants' awareness of network externalities is increased. In other words, when the values of α^+ or δ^+ are gradually increased[11]. Each of these figures contains six panels (3 lines x 2 columns). The three lines that depict the impact on number of cardholders, number of merchants accepting cards and card transactions, respectively. In each of the two columns, impacts are compared across two IF environments that broadly correspond with the average values observed in Mexico in 2004, before the central bank asked the banks' association to modify the scheme to set IF, and 2010, after two rounds of reductions based on the scheme proposed by the banks' association took place (Castellanos, et al., 2008). All figures use the same scale so that the intensity of the effects can be appreciated more easily.

Symbol	Description	Value
$N_{\mathcal{M}}$	Number of Merchants	864
N_C	Number of Consumers	20745
$N_{\mathcal{I}}$	Number of Issuers	10
$N_{\mathcal{A}}$	Number of Acquirer	7
$N_{\mathcal{B}}$	Number of business sectors	5
$N_{\mathcal{M}_b}$	Total number of merchant to be visited by the consumer	23
$N_{\mathcal{M}_1}$	Number of merchant to be visited by the consumer (Sector 1-3)	1
$N_{\mathcal{M}_2}$	Number of merchant to be visited by the consumer (Sector 4)	3
$N_{\mathcal{M}_3}$	Number of merchant to be visited by the consumer (Sector 5)	1
$N_{\mathcal{M}_4}$	Number of merchant to be visited by the consumer (Sector 6)	17
$N_{\mathcal{M}_5}$	Number of merchant to be visited by the consumer (Sector 7)	1

Table 1: Parameters

7. Results

In this section we present our main results. We argue that our observations are related to the whole process of adoption. To this end we present for each side of the market two different levels of the IFs: case 1 - Interchange Fees = 1.2% and case 2 - IFs = 4.2. We compare those two cases over 121 scenarios, resulting from the combinations of values between α^+ and δ^+. We present the outcomes related to the proportion of consumers having cards, the proportion of merchants accepting cards and transactions achieved after 12000 interactions.

Let us describe the impact on network growth obtained when the degree of consumers' or merchants' awareness of network externalities is increased, in

[11] In those figures when the value of α^+ is increased, the value of δ^+ is on its lowest limit and vice versa.

other words when the values of α^+ or δ^+ are gradually increased[12].

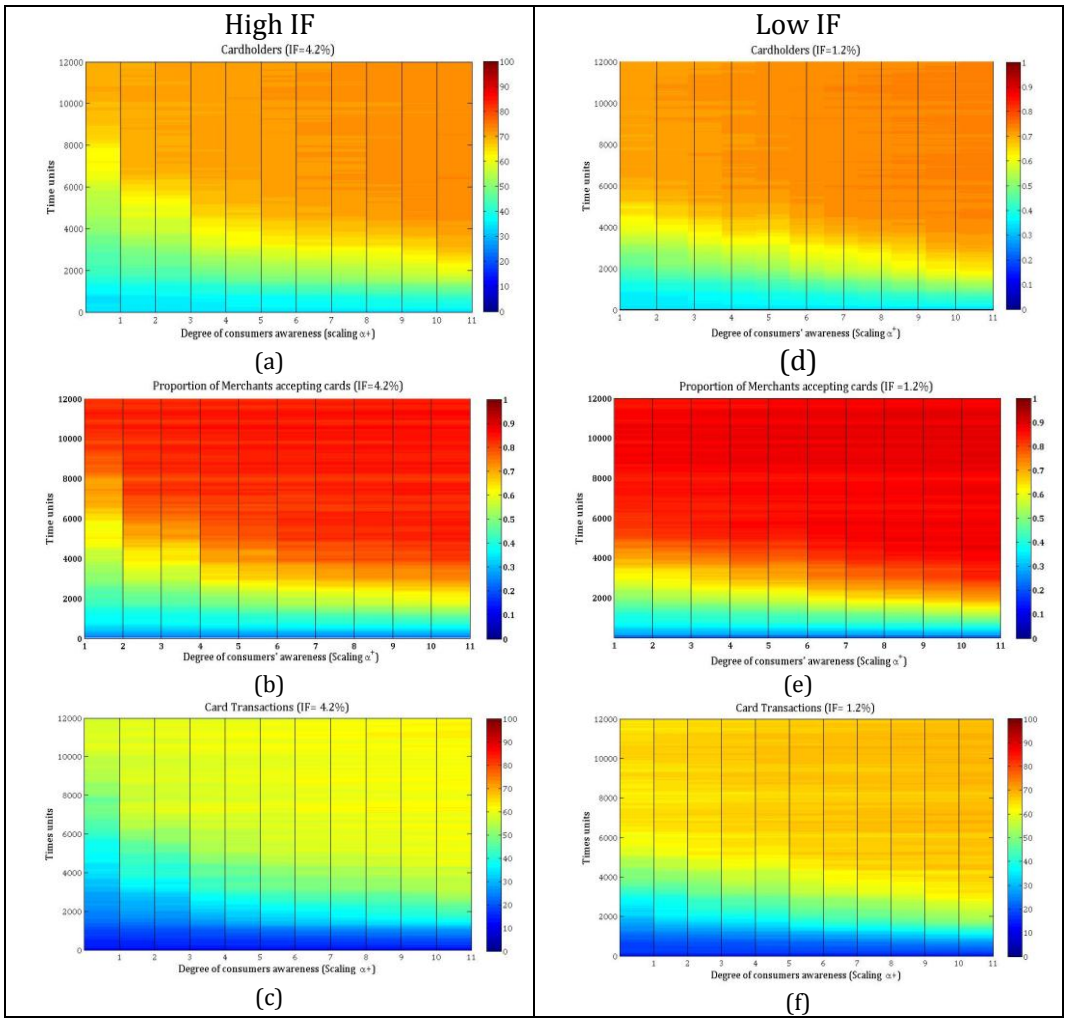


Figure 5: The impact of consumer awareness on number of cardholders, number of merchants accepting cards, and number of card transactions: high vs low IF environments

First we show the effects of increasing consumers' awareness. In panel (a) of Figure 5 we observe that low degrees of consumer awareness correspond to slower growth in the number of cardholders. Besides, for low degrees of consumer awareness, a higher IF slows down cardholder growth even further (see, for example, the dynamics for a value of 1 of consumer awareness depicted in panels 5(a) and 5(d)). But these differences in the speed of growth become less important for higher degrees of consumer awareness (see, for example, the dynamics for a value of 9 of consumer awareness depicted in panels 5(a) and 5(d)). But when 12000 iterations have elapsed, differences are practically negligible, regardless of the initial degree of consumer awareness.

Figure 5(b) show the effects on the number of merchants that accept credit cards. As before, a lower degree of consumer awareness is associated with a slower growth in the number of accepting merchants and growth speed differences

[12] In those figures when the value of α^+ is increased, the value of δ^+ is on his lowest limit and vice versa.

across IF levels become less important as the degree of consumer awareness increases (see, for example, the dynamics for a value of 9 of consumer awareness depicted in panels 5(b) and 5(e)). But even after 12000 iterations have elapsed, there is a noticeable difference in the final number of accepting merchants across the two IF scenarios considered. Clearly, in the low IF scenario the number of accepting merchants is higher than in the high IF one. This suggests that the degree of consumer awareness weights more on the merchants' side than on the consumers' side. According to panel 5(c) and 5(f), as a result of the aforementioned dynamics, the number of card operations grows at a faster pace in the low IF scenario, for any degree of consumer awareness considered.

Now let us show the impact of increasing merchants' awareness, depicted in Figure 6. As before, the higher is the degree of merchants' awareness, the larger are the proportions of cardholders, accepting card merchants and transactions (see panels 6(a), 6(b), and 6(c)). But the comparison with the case of increasing consumers' awareness shows that in this case the adoption rates among cardholders are slightly lower and among merchants are higher. As before the comparison of the high and low IF environments show that under the latter the network evolves faster than under the former.

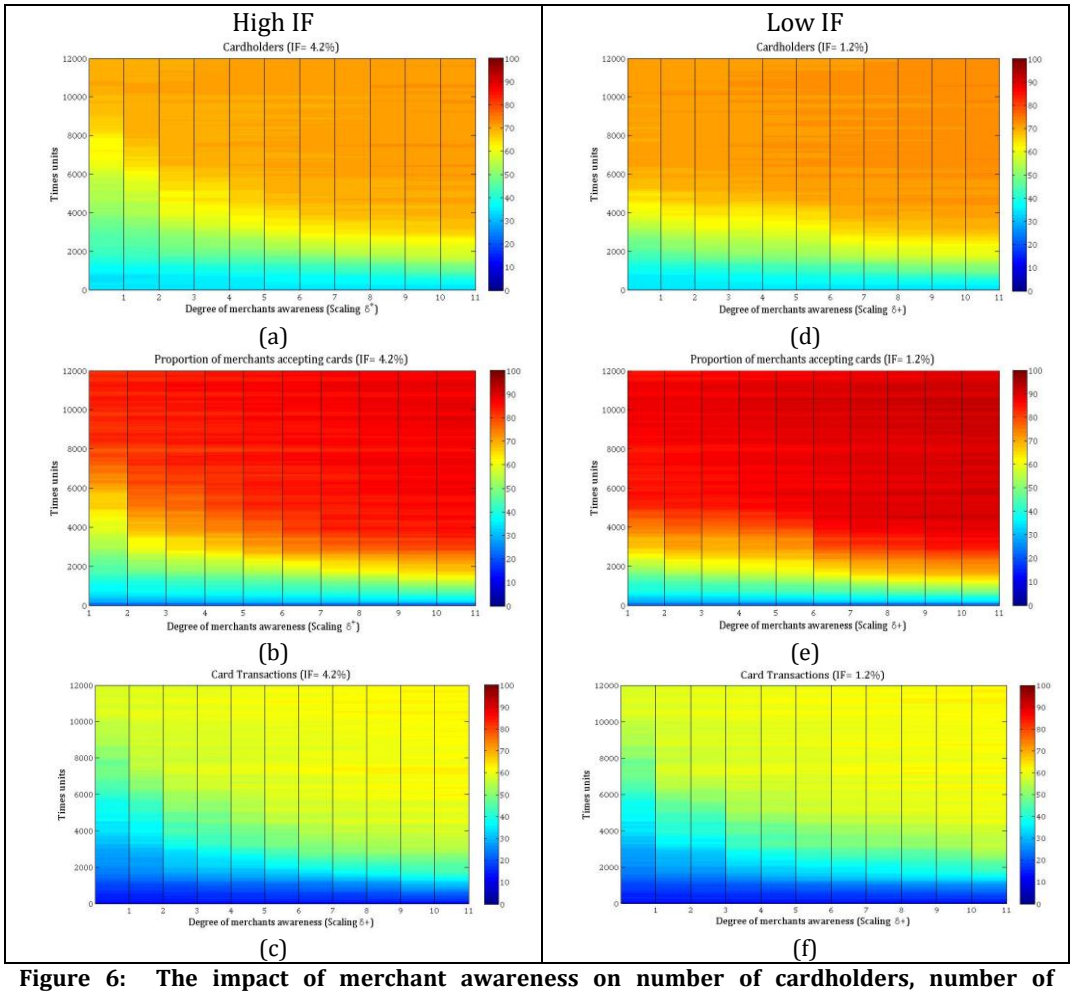


Figure 6: The impact of merchant awareness on number of cardholders, number of merchants accepting cards, and number of card transactions: high vs low IF environments

Finally, when we compare the final impact on the number of transactions, it is clear that the scenario with consumer externalities and low IF achieved the highest number of transactions (panel 5(f)). It is worth noticing that these general trends suggest the importance that implementing complementary strategies (i.e, lowering IF and use public funds to coordinate acquirers' advertisement campaigns) may have had to promote card usage, as Mexico's Central Bank and Ministry of Finance. This, given that the initial adoption rates that prevailed among both consumers and merchants were very low in Mexico.

To further illustrate this last point, in Figure 7 we compare the proportion of card transactions achieved through time under four scenarios with different initial combinations of IF, consumer awareness, and merchant awareness that allow us to "discompose" the impact of IF and the impact of the advertisement campaigns: **i)** IF=4.2% (high), δ^+= 1 (low) and α^+= 1 (low); **ii)** IF=1.2% (low), δ^+=1 (low) and α^+=1 (low); **iii)** IF=1.2% (low), δ^+= 1 (low) and α^+= 11 (high), and finally **iv)** IF=1.2% (low), δ^+=11 (high) and α^+=1 (low). We have taken from Figure 1.a two levels of the proportion of card transactions observed in Mexico in 2002 and 2010 that is 12% and 45%, respectively. Point A illustrates the initial 12% of card transactions. This point, from which all scenarios start, serves to illustrate the situation of high IF, low α^+ and low δ^+; that is, a scenario without policy interventions. Along the adoption trajectory of scenario (i), it takes 6,500 periods to reach point D with 45% on of card transactions. In the case that only the IF is lowered, that same level of adoption is reached after 3,500 periods, illustrated by point C along scenario (ii). So the speed of adoption increases by 3000 periods. In the case that the IF is lowered and either consumer or merchant awareness is increased, the level of adoption is reached after only 1,500 periods, point B scenarios (iii) and (iv). So the speed of adoption is further increased by 2000 periods. Therefore in this example 25% time reduction to reach the level can be attributed to the IF reduction and the other 15% to the advertisement campaign that raises users awareness.

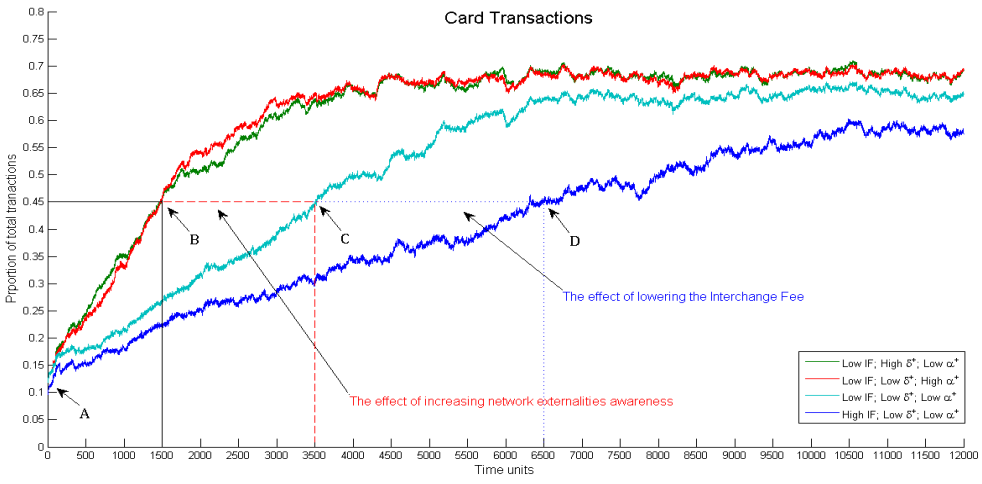


Figure 7: Comparing the impact of changes on IF levels and degrees of awareness

To complete our analysis, it is interesting to underline in Figure 7 that after 11000 periods all four scenarios exhibit stationarity. Hence, we can conclude that by then all scenarios have achieved the market saturation point. It can be seen that in the cases in which either consumers or merchants exhibit high degree of awareness (scenarios (iii) and (iv)) the adoption of the use of the payment method reaches around 70% of the market, while in case (ii) with low IF and low consumers' and merchants' awareness the cards payments are around 65% of the transactions and in case (i) with high IF y low awareness card transactions are less than 60%. In turn, we also notice that the saturation point for the cases (iii) and (iv) is achieved after only 4000 periods, which is faster than in cases (ii) and (i), where this condition is reached after 7000 periods and 11000 interactions, respectively.

In sum, rather than take these results as conclusive about what is the relative importance of the two policy instruments considered, we deem them as very suggestive of how much more intuition we can get about real policy issues by adding agent based models to the analysis toolkit and of the need to incorporate into these models real life data.

8. Conclusions

In this article we have developed an agent based economic model that allows us to understand the relative importance of IF and agents' awareness on the expansion of a card payment network. The values of the model have been chosen to broadly match the characteristics of a country, Mexico, which has undertaken several policies to promote payment card usage. Lastly, we have used the results to conduct counterfactual exercises to get a grasp of the impact of using one policy or two simultaneous policies in a fashion that is very similar to the basic economics comparative statics. These exercises besides illustrating the power of the tools of agent based modeling illustrate some interesting complementarities with other techniques of analysis.

Given the present results we consider necessary to explore in depth the scenarios we have studied. Here, we have analyzed the cases, in which consumers' and merchants' have different degree of network externalities awareness. We believe that studying the impact of the fixed and variable fees on the consumers and merchants sides may open the number of cases that need to be analyzed in detail. Furthermore, we think that exploring these possibilities through experimentation will allow us to understand better in which cases lowering the level of IF can result in a situation with high adoption of payment cards.

On the other hand, a different research question would be what may happen in a framework in which an asymmetric impact (either on the consumers or on the merchants' side) of network externalities is observed. It is worth noticing that in this paper we use advertising as a tool to raise awareness as a natural way to approach this concept. However, consumer awareness has been conceptualized as a very multifaceted phenomenon. So for deeper policy contributions, in future research it may be important to consider different mechanisms to raise awareness

(such as density of card users in consumer segment).

Symbol	Description	Value
x_c^+	Consumers' inertia to add new cards	40
x_c^-	Consumers' inertia to drop cards	2
b_c	The consumers' convenience benefits	0.03
α^-	Consumers' awareness of externalities when drop cards	0.8
x_m^+	Merchants' inertia to add new cards	45
x_m^-	Merchants' inertia to drop cards	1
δ^-	Merchants' awareness of externalities when drop cards	4
b_m	The merchants' convenience benefits	0.03

Table 2: Constants

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Appendix

In this appendix we present a brief summary of the data we have used to calibrate the multi-agent based model.

We start with the merchant side. Our data source is the 2004 Economic Census produced by the Instituto Nacional de Estadística y Geografía, INEGI. The data about economic units in Mexico is classified into the sectors and categories that match the business classification employed by acquiring banks to offer payment accepting services (Table 3). In tables 4 to 8 for each sector we have calculated the percentage of earnings for multiple subcategories of economic units that belong to each sector (i.e., for more segments than those reported in Table 3). These data could be used in a further extension of the model to introduce more heterogeneity at the merchants' side of the market.

Sector	Sector Description	Category description
1	Charity	Charity
2	Special	Colleges and Universities
3	Special	Goverment
4	Strategic	Supermarkets
4	Strategic	Land passenger transportation
4	Strategic	Car rental
4	Strategic	Travel agencies
4	Strategic	Hotels
4	Strategic	Entertainment
4	Strategic	Air Transportation
5	Gasoline Stations	Gasoline Stations
6	General	Telecommunications
6	General	Insurance Companies
6	General	Hospitals
6	General	Restaurants
6	General	Retailers
6	General	Others
7	Stimulus	Fast food
7	Stimulus	Pharmacies
7	Stimulus	Tolls
7	Stimulus	Parking lots

Table 3: Description of Sectors and Categories

Sector 1-3 – Charity and Special		
% Earnings	% Economic units	Economic units
-9.81%	0.32%	105.00
8.64%	0.61%	203.00
11.84%	20.89%	6,931.00
18.49%	32.94%	10,931.00
20.85%	44.28%	14,695.00
25.10%	0.96%	320.00

Table 4

Sector 4 – Strategic		
% Earnings	% Economic units	Economic units
-8.47%	0.31%	1,716.00
4.87%	1.22%	6,698.00
12.53%	0.47%	2,577.00
17.01%	2.27%	12,452.00
23.55%	4.69%	25,723.00
27.96%	0.38%	2,085.00
50.51%	90.65%	496,841.00

Table 5

Sector 5 – Gasoline stations		
% Earnings	% Economic units	Economic units
33.57%	100.00%	13,692.00

Table 6

Sector 6 – General		
% Earnings	% Economic units	Economic units
-85.15%	0.57%	9,615.00
1.89%	0.05%	930.00
7.93%	0.15%	2,511.00
12.80%	0.77%	13,081.00
16.77%	11.40%	193,850.00
22.17%	17.91%	304,543.00
28.09%	14.60%	248,162.00
32.54%	33.37%	567,280.00
36.13%	7.23%	122,846.00
40.21%	3.26%	55,363.00
47.36%	10.62%	180,503.00
53.27%	0.08%	1,393.00

Table 7

Sector 7 – Stimulus		
%Earnings	% Economic Units	Economic units
16.85%	79.60%	185,189.00
37.50%	20.40%	47,448.00

Table 8

In the following tables we present the information related to the IF. We present in table 9 the credit card IF applied before October 2005 and in table 10 the way the credit card IF is charged afterwards. Similarly in table 11 we present the debit card IF applied before October 2005 and in table 12 the way the IF is charged

after. The source of this information is the Central Bank of Mexico.

IF was determined on the basis of merchant's monthly transaction value. (millions of MXN)					
Until Aug. 2004			Until Aug. 2005		
From	To	IF	From	To	IF
300	ABOVE	2.00%	300	ABOVE	1.80%
100	300	2.40%	100	300	2.20%
10	100	2.75%	10	100	2.50%
0.2	10	3.00%	0.2	10	2.70%
0	0.2	3.50%	0	0.2	--

Table 9: Credit Card IF

Category decription	Since Oct-05 until Jan-08	Since Jan-08
Charity	0.00%	0.00%
Gasoline Stations	1.10%	1.10%
Government	1.25%	1.25%
Colleges and Universities	1.25%	1.25%
Fast food	1.75%	1.61%
Parking lots	1.75%	1.22%
Pharmacies	1.75%	1.53%
Tolls	1.75%	1.61%
Wholesale stores	1.75%	1.64%
Air transportation	1.80%	1.62%
Car rental	1.80%	1.71%
Entertainment	1.80%	1.37%
Hotels	1.80%	1.80%
Land passenger transportation	1.80%	1.30%
Supermarkets	1.80%	1.77%
Travel agencies	1.80%	1.80%
Insurance companies	1.85%	1.66%
Retailers	1.85%	1.68%
Telecommunications	1.85%	1.56%
Hospitals	1.95%	1.74%
Restaurants	1.95%	1.91%
Others	1.95%	1.68%

Table 10: Credit Card IF

IF was determined on the basis of merchant's monthly transaction value. (millions of MXN)					
Until Aug. 2004			Until Aug. 2005		
From	To	IF	From	To	IF
300	ABOVE	2.00%	300	ABOVE	0.75%
100	300	2.40%	100	300	1.25%
10	100	2.75%	10	100	1.60%
0.2	10	3.00%	0.2	10	1.95%
0	0.2	3.50%	0	0.2	--

Table 11: Debit Card IF

Category decription	Since Oct-05 until Jan-08	Since Jan-08
Charity	0.00%	0.00%
Gasoline Stations	0.50%	0.50%
Government	0.75%	0.75%
Colleges and Universities	0.75%	0.75%
Fast food	1.10%	0.75%
Parking lots	1.15%	1.00%
Pharmacies	1.00%	1.00%
Tolls	1.40%	1.00%
Wholesale stores	1.55%	0.93 MXN
Air transportation	1.76%	0.75%
Car rental	0.75%	1.10%
Entertainment	1.15%	1.10%
Hotels	0.75%	1.10%
Land passenger transportation	1.10%	1.10%
Supermarkets	1.10%	1.10%
Travel agencies	0.90%	1.10%
Insurance companies	1.15%	1.15%
Retailers	1.00%	1.15%
Telecommunications	1.10%	1.15%
Hospitals	1.15%	1.15%
Restaurants	1.00%	1.15%
Others	1.15%	1.15%

Table 12: Debit Card IF

In table 13 we present general data related to number of consumers (from the the 2006 National Household Income and Expenses Survey performed by INEGI) and the total number of economic units and the number of units per sector (from the 2004 Economic Census, INEGI).

Next in table 14 we present some calculation we have made to obtain ratios of economic units to consumers, which allow us to calibrate the model. We have used this calibration in all scenarios presented in the present paper. In table 15 we present the parameter used in the model.

Number of consumers	59,499,202.00
Number of economic units	2,527,683.00
Number of economic units in sectors 1-3	33,185.00
Number of economic units in sector 4	548,092.00
Number of economic units in sector 5	13,692.00
Number of economic units in sector 6	1,700,077.00
Number of economic units in sector 7	232,637.00

Table 13: General information

Economic units/Consumers	0.0425
Sectors 1-3/total economic units	0.0131
Sector 4/total economic units	0.2168
Sector 5/total economic units	0.0054
Sector 6/total economic units	0.6726
Sector 7/total economic units	0.0920
Consumers/Total Economic units	23.5390
Sectors 1-3/consumers	0.0006
Sector 4/consumers	0.0092
Sector 5/consumers	0.0002
Sector 6/consumers	0.0286
Sector 7/consumers	0.0039

Table 14: Ratios of economic units and consumers

Sector	Number of economic units by sector in the ABM	Number of economic units by sector per consumer in the ABM
1-3	11	1
4	187	3
5	5	1
6	581	17
7	80	1

Table 15: Model's parameters

In table 16 we present the data used to calibrate the consumers' side of the model, which is obtained from the 2006 National Household Income and Expenses Survey, INEGI.

Monthly income level per decile	Actual percentage of the population	Income applied in the ABM	Decile
1,411.95	0.0665	1,400	I
2,013.74	0.0802	2,000	II
2,515.25	0.0847	2,500	III
2,864.20	0.0923	2,850	IV
3,348.89	0.0968	3,350	V
3,853.77	0.1013	3,850	VI
4,303.81	0.1131	4,300	VII
5,074.22	0.1208	5,070	VIII
6,780.49	0.1242	6,780	IX
16,297.80	0.1201	16,300	X

Table 16

Finally we present in figure 8 the usage of credit cards among different population segments divided by income level. The data is obtained from the 2008 National Household Income and Expense Survey produced by INEGI.

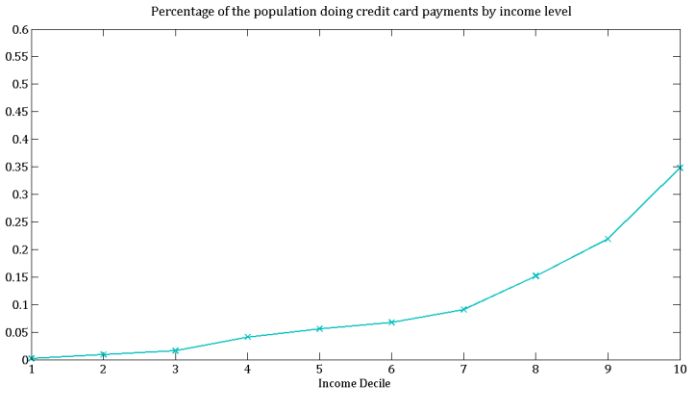

Figure 8: Credit card payments by income level