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Competition is bad for consumers: Analysis of an Artificial Payment Card Market ⋆

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Abstract

This paper investigates the competition between payment card issuers in an artificial payment card market. In the market we model the interactions between consumers, merchants and competing card issuers and obtain the optimal pricing structure for card issuers. We allow card issuers to charge consumers and merchants with fixed fees, provide net benefits from card usage and engage in marketing activities. We establish that consumers benefit from a reduction of competing payment cards through lower fees and higher net benefits while merchants remain largely unaffected. The two-sided nature of the market leads to the result that more competitors do actually reduce competition for customers.

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1 Introduction

Debit and credit cards - as payment cards are more commonly referred to - have become more and more important for making payments. According to Evans and Schmalensee (2003) in 2002 consumers used 1.8 billion cards to buy products and services worth more than US$ 2.7 trillion with high growth rates since then. The market consists mainly of 6 competitors, Mastercard, Visa, American Express, Discovery, JCB and Diners Club, where Mastercard and Visa dominate in terms of market share. The competition between these card issuers is not well understood in the academic literature. In this paper we develop a model of this competition by using an agent-based approach allowing us to introduce complex interactions between the various market participants which is not easily possible using other modeling approaches. We are able to derive the optimal pricing strategy for payment card issuers and compare them between scenarios with 2, 5 and 9 competing payment cards.

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 mer-

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chants, using a payment card need a subscription to this specific payment card. Modeling such markets is challenging as 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. Consumers and merchants will face network externalities as a larger number of merchants and consumers using a certain card makes the subscription more valuable and card issuers will also affect behavior by changing subscription fees and benefits associated with the cards.

Most models of the payment card market only give cursory considerations to these complex interactions and how they affect competition; the literature focuses on a peculiarity of the payment card market, the so called interchange fee, see Evans and Schmalensee (2003); Gans and King (2002); Rochet and Tirole (2002, 2007); Schmalensee (2002); Wright (2003a,b). This fee arises as follows: card issuers do not directly issue payment cards to customers but rather allow banks to distribute them in their own name; card issuers only provide a service in form of administering the payments made using these cards. Similarly, merchants do have a contract with a bank that allows them to accept payments made using a specific payment card. In the majority of cases the consumer will have been given his card from one bank with the merchant having a contract with another bank. In this case the bank of the merchant will have to pay the bank of the consumer a fee for making the payment, which is called the interchange fee. Not only is much of the academic literature focussing on the interchange fee, it is also the focus of regulators, see Chakravorti (2003); Cruichshank (2000); Commission of the European Communities (2007); Federal Reserve System (2004).

With the focus on the interchange fee the literature makes a number of very simplifying assumptions on the behavior of consumers and merchants. In contrast, our paper will explicitly model the behavior of consumers and merchants and concentrate on the competition between payment cards to attract subscribers and transactions. We abstract from the interchange fee by implicitly assuming that payment cards are directly issued by card issuers, i. e. neglecting the role of banks in the market. This approach allows us to analyze all the fees paid by consumers and merchants using payments cards rather than only the interchange fee. This will enable us to gain an understanding of the competitive forces in the payment card market and how the competition between different payment cards affects consumers, merchants and the payment card issuers themselves. So far no other paper is able to investigate this issue adequately.

The remainder of this paper is organized as follows: the coming section introduces the artificial payment card market with its elements and interactions, section 3 then briefly introduces the learning algorithm used to optimize the card issuers' strategies and discusses the parameter constellation used in the computer experiments. The results of the computer experiments are presented in section 4, where we focus on the optimal pricing structure by card issuers and how they differ for the case of 2, 5 and 9 competing payment cards. Finally section 5 concludes the findings of this paper.

2 The Artificial Market

In this section we introduce our model of an artificial payment card market by describing in detail the market participants - consumers, merchants and card issuers

- and how they arrive at their decisions through interactions with each other.

2.1 Model Elements

In this subsection we formally introduce the three key elements of the model - merchants, consumers and payment cards - with their attributes.

2.1.1 Merchants

Suppose we have a set of merchants $\mathcal{M}$ with $|\mathcal{M}| = N_{\mathcal{M}}$, who are offering a homogeneous good at a common price and face marginal cost of production lower than this price. With the elimination of price competition among merchants, we can concentrate on the competition among payment card providers and how the card choice affects merchants. The merchants are located at random intersections of a $N \times N$ lattice, where $N^2 \gg N_{\mathcal{M}}$, see figure 1. Let the top and bottom edges as well as the right and left edges of this lattice be connected into a torus.

2.1.2 Consumers

Consumers occupy all the remaining intersections of the above lattice. The set of consumers is denoted $\mathcal{C}$ with $|\mathcal{C}| = N_{\mathcal{C}}$, where $N_{\mathcal{C}} \gg N_{\mathcal{M}}$ and $N^2 = N_{\mathcal{C}} + N_{\mathcal{M}}$. Each consumer has a budget constraint that allows him in each time period to buy exactly one unit of the good offered by the merchants in a single interaction with one merchant. By making this transaction the utility of the consumer increases. In order to obtain the good any consumer $c \in \mathcal{C}$ has to travel to a merchant $m \in \mathcal{M}$. The distance imposes travel costs on consumers, which reduces the attractiveness of visiting a merchant. We have explored the case where the connections among consumers and merchants are local and the distance traveled by a consumer c to a merchant m, is measured by the "Manhattan distance" $d_{c,m}$ between the intersections on the lattice. The distance between two neighboring nodes has been normalized to one. We further restrict the consumer to visit only the nearest m_c merchants and denote by $\mathcal{M}_c$ the set of merchants a consumer considers going to.

2.1.3 Payment Cards

We consider a set of payment methods $\mathcal{P}$ with $|\mathcal{P}| = N_\mathcal{P} + 1$ and $N_\mathcal{P} \ll N_\mathcal{M}$. The first payment method is the benchmark and can be interpreted as a cash payment, whereas all other payment forms are card payments. 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 the card in question. 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 $F_p \geq 0$ is charged to the consumer, and $\Gamma_p \geq 0$ to the merchant. Cash payments do not attract any fees.

For each unit of goods sold using a payment card $p \in \mathcal{P}$, a merchant $m \in \mathcal{M}$ receives net benefits of $\beta_p \in \mathbb{R}$. Such benefits may include reduced costs from cash handling, and could differ across payment cards and are assumed to be identical for all merchants for any given card. Note that the benefits β_p could have a negative value. This means that the variable fees paid by the merchant to the card issuer is bigger than the benefits he received from the same payment card in which case they can be interpreted as a transaction fee. Cash payments do not provide any net benefits.

Consumers also receive net benefits from paying by card, $b_p \in \mathbb{R}$, but no net benefits from cash payments. Here, the benefits may arise from delayed payment, insurance cover or cash-back options. As with the benefits to merchants, the benefits to consumers can also be negative and again represent a transaction fee.

In addition, the issuer of the payment card has to decide how much he should spend on marketing effort $l_p \geq 0$, in order to increase the awareness by the consumers and the merchants for the payment card that he is providing.

The strategy employed by a payment card issuer is defined as the set of variables controlled by them: $\mathbb{S} = \{F_p, \Gamma_p, \beta_p, b_p, l_p\}$. It is this set of variables that we will be optimizing for payment cards in section 4.

2.2 Decision-making of market participants

Decisions by market participants are arrived at through interactions with each other. This section sets out how these interactions drive decisions by consumers and merchants. The decisions on the strategies chosen by card issuers are considered in sections 3 and 4.

2.2.1 Decisions by consumers

Consumers face three important decisions: which merchant to choose, which payment card to use in the transaction with the merchant, and to which payment cards to subscribe to. This section addresses each of these decisions in turn.

2.2.1.1 The consumers' choice of a merchant We assume that when deciding which merchant to visit, the consumer has not yet decided which of the cards he holds will be used. Suppose $\mathcal{P}_{c,m}$ is the set of cards consumer $c \in \mathcal{C}$ and merchant $m \in \mathcal{M}$ have in common and let $|\mathcal{P}_{c,m}| = N_{\mathcal{P}_{c,m}}$. The more payment cards the merchant and the consumer have in common, the more attractive a merchant becomes, as the consumer always carries all his cards with him. Additionally 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:

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

Each consumer $c \in \mathcal{C}$ chooses a merchant $m \in \mathcal{M}$ with probability $v_{c,m}$ as defined in equation (1). The consumers will continuously update their beliefs on the number of common payments they share with a particular merchant, by observing the number of common payments of all shops they can visit - i. e. not only those actually visited - as subscriptions change over time in the way introduced below.

2.2.1.2 The consumers' choice of a payment card The consumer decides which payment card he wants to use with the merchant he has selected. We assume a preferred card choice in which he chooses the card with the highest benefits b_p from the set $\mathcal{P}_{c,m}$; if there are multiple cards with the highest net benefits the card is chosen randomly from them. In cases where the merchant does not accept any of the consumers' cards, the transaction is settled using cash payment.[1]

[1] Please note that even for a negative b_p consumers prefer to use payment cards. Without changing the argument we also could associate a large transaction fee with cash payments

2.2.1.3 Consumer subscriptions

Initially consumers are allocated payment cards such that each consumer is given a random number of randomly assigned payment cards. Periodically consumers have to decide whether to cancel a subscription to a card they hold and whether to subscribe to new cards. The frequency with which consumers take these decisions is defined by a Poisson distribution with a mean of λ time periods between decisions. For that reason, every consumer $c \in \mathcal{C}$ keeps track of whether the cards he owns, $\mathcal{P}_c$, are accepted by a merchant or not. If a card $p \in \mathcal{P}_c$ is accepted by the merchant $m \in \mathcal{M}_c$ he is visiting, the consumer increases the score of the card $\omega^-_{c,p}$ by one.[2]

Assume that he cancels his subscription to a card with probability[3]

$$\pi^-_{c,p} = \frac{x^-_c k}{x^-_c k + e^{\frac{\omega^-_{c,p}}{\omega_c}}}, \tag{2}$$

where ω_c denotes the number of merchants visited and $x^-_c k$ accounts for the propensity of the consumer to cancel his subscription of the payment card. We define $k = 1 + F_p + N_{\mathcal{P}_c} + \frac{\varepsilon}{\kappa + b_p}$, ε and x^-_c are constants and κ is another constant with the restriction that $\kappa + b_p > 0$. A larger value for $x^-_c k$ implies that for a given number of merchants accepting the card, the consumer is more likely to cancel his subscription. As long as $x^-_c k < 1$ we can interpret the influence of this term as the inertia to cancel a subscription. The parameter constellation used below ensures that with optimized strategies we find $x^-_c k < 1$ and obtain the realistic case of inertia in consumers with

to justify our previous assumption that card payments are preferred.

[2] Please note that here consumers only take into account the merchant he actually visits. This is in contrast to the decision which merchant he visits where he is aware of the number of common cards for potential merchants.

[3] The probabilities defined in equations (2) and (3) are also affected by the marketing effort of each payment card provider. Its role is explained in section 2.2.3.

respect to changing their *status quo*.

The decision to cancel a subscription is also affected by the fees and benefits associated with a payment card. A card becomes more attractive to subscribe and existing subscriptions are less likely to be canceled if the fixed fee charged is low and the net benefits from each transaction are high. Furthermore, the more cards a consumer holds, the less attractive it becomes to maintain a subscription as the consumer has many alternative payment cards to use with merchants.

Let $\mathcal{P}_c^- = \mathcal{P} \setminus \mathcal{P}_c$ denote the set of cards the consumer does not subscribe to, with $|\mathcal{P}_c^-| = N_{\mathcal{P}_c^-}$. If the merchant and the consumers have no payment card in common, i. e. $\mathcal{P}_{c,m} = \emptyset$, and the merchant accepts at least one payment card, i. e. $\mathcal{P}_m \neq \emptyset$, the consumer increases the score $\omega_{c,p}^+$ by one for all $p \in \mathcal{P}_m \cap \mathcal{P}_c^-$.

With x_c^+ a constant, the probability of subscribing to a card not currently held by the consumer is then determined by

$$\pi_{c,p}^+ = \frac{e^{\frac{\omega_{c,p}^+}{\omega_c}}}{x_c^+ k + e^{\frac{\omega_{c,p}^+}{\omega_c}}}. \tag{3}$$

This probability uses the inertia of consumers to subscribe to new cards through the use of $x_c^+ k$. A large value of this term implies that consumers are less likely to subscribe to new cards for a given number of merchants accepting the payment card.

2.2.2 Decisions by merchants

The decisions of merchants are limited to the choice of card subscriptions. Similar to consumers the frequency with which merchants review their subscriptions is governed by a Poisson distribution specific to each individual with a common mean of λ time periods, the same as for the subscription decisions of consumers. As with consumers the initial subscriptions of merchants are a random number of randomly selected payment cards.

Merchants keep track of all cards presented to them by consumers. Every time a card $p \in \mathcal{P}$ is presented to the merchant $m \in \mathcal{M}$ and he has a subscription to this card, i.e. $p \in \mathcal{P}_m$, he increases the score of $\theta^-_{m,p}$ by one. With $|\mathcal{P}_m| = N_{\mathcal{P}_m}$ the probability of canceling this subscription[4] is given by

$$\pi^-_{m,p} = \frac{x^-_m q}{x^-_m q + e^{\frac{\theta^-_{m,p}}{\theta_m}}}, \tag{4}$$

where θ_m denotes the number of cards presented and $x^-_m q$ represents the propensity to cancel the subscription similar to that of consumers with x^-_m being a constant and $q = 1 + \Gamma_p + N_{\mathcal{P}_m} + \frac{\varepsilon}{\kappa+\beta_p}$. κ takes the same value as for consumers and has to fulfill the additional restriction that $\kappa + \beta_p > 0$. The interpretation of the term $x^-_m q$ follows the same lines as for consumers and the parameter setting ensures inertia by merchants to cancel their subscriptions with the optimized payment card strategies.

Similarly, if the merchant does not have a subscription to the card, i.e $p \in \mathcal{P}^-_m$, the score of $\theta^+_{m,p}$ is increased by one and the probability of subscribing to a card is given by

$$\pi^+_{m,p} = \frac{e^{\frac{\theta^+_{m,p}}{\theta_m}}}{x^+_m q + e^{\frac{\theta^+_{m,p}}{\theta_m}}}, \tag{5}$$

where once again x^+_m is a constant.

[4] The probabilities defined in equations (4) and (5) are also affected by the marketing effort of each payment card provider. Its role is explained in section 2.2.3.

2.2.3 Decisions by card issuers

Card issuers have to decide on all variables in their strategy space $\mathbb{S}$, i. e. decide on the fees and net benefits of consumers and merchants as well as the marketing expenses. While optimizing these variables will be the main subject of the following sections, we want to establish the impact these variables have on the profits of card issuers as well as the impact of the marketing effort on the decisions of consumers and merchants.

The total profit Φ_p of a card issuer is calculated applying the following equation:

$$\Phi_p = \Phi_{\mathcal{C}_p} + \Phi_{\mathcal{M}_p} - \mathcal{L}_p, \tag{6}$$

where $\Phi_{\mathcal{C}_p}$ are the profits received from consumers and $\Phi_{\mathcal{M}_p}$ those from merchants. These profits are given by

$$\Phi_{\mathcal{C}_p} = \sum_{t=1}^{I} N_{t,\mathcal{C}_p} F_p - \sum_{t=1}^{I} N_{t,T_p} b_p, \tag{7}$$

$$\Phi_{\mathcal{M}_p} = \sum_{t=1}^{I} N_{t,\mathcal{M}_p} \Gamma_p - \sum_{t=1}^{I} N_{t,T_p} \beta_p, \tag{8}$$

where the additional index t denotes the time period, I the number of time periods considered by the card issuer and N_{T_p} the number of transactions using card p. The fees and net benefits set by the card issuers will affect the number of subscriptions and transactions using a card, which then determine the profits for the card issuers. Thus we have established a feedback link between the behavior of card issuers on the one hand and consumers and merchants on the other hand.

The sum of all publicity cost is denoted $\mathcal{L}_p$ and is calculated as

$$\mathcal{L}_p = \sum_{t=1}^{I} l_p = I l_p, \tag{9}$$

where l_p denotes the publicity costs for each time period, which we assume to be constant.

These publicity costs now affect the probabilities with which consumers and merchants maintain their subscriptions and subscribe to new cards. The probabilities, as defined in equations (2) - (5), are adjusted due to these publicity costs as follows:

$$\xi = \tau\pi\left(1-\pi\right), \tag{10}$$

where π represents , $\pi^{+}_{c,p}$, $\pi^{-}_{c,p}$, $\pi^{+}_{m,p}$, or $\pi^{-}_{m,p}$, as appropriate and $\tau = \alpha\left(\varphi - e^{-l_p}\right)$. The constants α and φ satisfy the constraint $0 \leq \pi+\xi \leq 1$. The revised probabilities as used by consumers and merchants are then given by $\pi' = \pi + \xi$.

Card issuers now seek to maximize their market share as measured through the number of transactions conducted by optimally choosing their strategies. The way this optimization is accomplished by card issuers is discussed in the coming section.

3 Set-up of the computer experiments

The above model is implemented computationally and the optimization of the strategies chosen by card issuers conducted using machine learning techniques.

3.1 The optimization procedure of card issuers

Card issuers determine their optimal strategies using a Generalized Population-based Incremental Learning algorithm (GPBIL) as introduced in Baluja (1994) and extended by Kern (2006). This algorithm divides the domain of a variable x, $[a;b]$, into n sub-domains $a \leq a_1 < a_2 < \cdots < a_{n-1} < a_n \leq b$. We can now define subintervals as $\left[a; \frac{a_1+a_2}{2}\right), \left[\frac{a_1+a_2}{2}; \frac{a_2+a_3}{2}\right), \ldots, \left[\frac{a_{i-1}+a_i}{2}; \frac{a_i+a_{i+1}}{2}\right), \ldots, \left[\frac{a_{n-1}+a_n}{2}; b\right]$.

Each subinterval is equally likely to be selected, i. e. with probability $\frac{1}{n}$. The algorithm changes the location of the parameters a_i such that the subintervals with the best performance are selected with a higher likelihood. This learning is achieved through a positive and a negative feedback mechanism. Suppose we have a value of $x \in [a; b]$; we can then determine the new value of a_i with the help of a_j, the value closest to x. If the outcome associated with x is positive we then determine the updated $\widehat{a}_i$ as follows:

$$\widehat{a}_i = a_i + \zeta \nu_x h_\delta(i, j)(x - a_i), \tag{11}$$

where ζ denotes the learning rate, the role of ν_x is explained below and

$$h_\delta(i, j) = \begin{cases} 1 \text{ if } |i - j| \leq \delta \\ \\ 0 \text{ if } |i - j| > \delta \end{cases} \tag{12}$$

denotes the neighborhood in which learning occurs, where δ denotes cylinder size of the kernel. This ensures that values close to x get chosen more frequently. In the case of a negative outcome we want values on either side of x to be chosen less frequently and therefore use the following rule on updating the values of a_i:

$$\widehat{a}_i = \begin{cases} a_i + \zeta \nu_x h_{\delta'}(i, j)(a_{i-\delta'} - a_i) \text{ if } a_i \leq x \\ \\ a_i + \zeta \nu_x h_{\delta'}(i, j)(a_{i+\delta'} - a_i) \text{ if } a_i > x \end{cases}. \tag{13}$$

If $a_{i-\delta'}$ or $a_{i+\delta'}$ are not defined we set them as a and b, respectively. In our model a positive outcome is achieved if the market share of the payment card as determined by the number of transactions using the payment card is higher than the average market share, i. e. $\frac{1}{N_{\mathcal{P}}}$; otherwise it is regarded as a negative outcome.

Once it has been determined whether an outcome is positive or negative from its market share, the positive and negative outcomes are ordered ascending according to the profits achieved from the strategy. The position of a strategy x determines its weight in the updating of the values through ν_x. If we denote by ϕ the number of positive or negative outcomes, respectively, and $1 \leq \rho(x) \leq \phi$ the position, we define $\nu_x = \frac{\rho(x)}{\phi}$.

The domain of the strategy variables as well as the parameters of the learning algorithm are shown in table 1.

3.2 Parameter constellations investigated

The model is characterized by a large number of free parameters which need to be exogenously fixed in the experiments. Table 2 provides an overview of the values chosen for further analysis. An analysis of a wide range of parameter constellations has shown the results to be not very sensitive to these values and we can thus treat them as qualitatively representative examples for the remainder.

It might be noted that the inertia resulting from net benefits, ε, is relatively small compared to the fixed fee. We can justify this choice by pointing out that consumers and merchants will in many cases not be aware of the size of these benefits because they are not commonly recognized, e. g. small charges for overseas usage is hidden in a less favorable exchange rate. Empirical evidence suggests that such hidden charges and benefits are much less relevant than fees directly charged to customers. It is also for this reason that we limit the domain of the net benefits to $[-1; 1]$ such that we avoid them becoming too visible to consumers and merchants relative to the fixed fee. In doing so we willingly accept a possible corner solution in the optimal pricing strategy.

4 Outcomes of the computer experiments

Using the model of the payment card market as developed in the previous sections, we can now continue to analyze the resulting properties of the market. Using the GPBIL algorithm as introduced above, we are deriving the optimal pricing strategy of the card issuers. The results of the optimization are presented in tables 3-5. We also observe that the market share of all competing payment cards are approximately equal, providing evidence for the effectiveness of the learning algorithm and the convergence of the learning.

One striking characteristic of the pricing strategy is that merchants are not charged fixed fees but rather negative net benefits, which we can interpret as a transaction fee. We have established in Alexandrova-Kabadjova et al. (2007) that the subscriptions by merchants are more sensitive to fixed fees but not much to transaction fees; this observation gives rise to this specific pricing structure for merchants. For consumers we found a similar result, but with them being less sensitive to the fixed fees than merchants, they are charged a significant fixed fee in order to generate sufficient revenue to payment card issuers. The negative impact of this fixed fee on canceling subscriptions and new subscriptions is partially offset by a high marketing effort.

From comparing the cases of 9 and 5 payment cards, we can clearly see that in the presence of only 5 cards the consumer fixed fees are significantly lower and they receive positive net benefits. For merchants we do not observe any differences in the fees charged to them. Finally, marketing costs are slightly lower in the case of 5 payment cards and the total profits made by the card issuers are significantly lower. We can conclude from these results that if there do exist only 5 cards rather than 9 cards, consumers will benefit through lower fees and higher net benefits and payment card issuers will generate less profits.

We can see that the fixed fee for consumers is reduced significantly more than the net benefits are increasing. This result is due to the property of the model established in Alexandrova-Kabadjova et al. (2007) that consumer subscriptions are reacting more sensitively to fixed fees than net benefits and therefore card issuers change this part more. The negative impact of the fixed fee on consumer subscription is partially offset by marketing efforts; with this fee now reduced we also observe the marketing costs to be diminished.

When we reduce further the number of competing payment cards to only 2, we see that competition benefits consumers even more by virtually eliminating the fixed fee. The observed slight reduction in the net benefits are less pronounced than the reduction in the fixed fee. Once again the merchants are not affected by the change in the number of competitors.

Thus competition for consumers is increasing if we reduce the number of competing payment cards. This result is very surprising at first as it is commonly surmised that the presence of more competitors increases the competition between the providers and thus benefits their customers through lower fees, higher benefits and allows the competitors to generate less profits.

This on first sight counterintuitive result can be explained with the properties of two-sided markets. Given the requirement that for a successful transaction using a payment card the consumer as well as the merchant have to subscribe to this specific payment card, we need to achieve a certain degree of coordination between all market participants. If there are less payment cards available to consumers and merchants, this coordination of subscriptions becomes easier given the reduced possibilities for subscriptions. Evidence for the improved coordination of consumers and merchants in their card subscriptions is the observation that the cash transactions observed in the presence of 9 cards is about 35%, for 5 cards it is 18% and for 2 cards only 16%.

It has been shown in Alexandrova-Kabadjova et al. (2006a,b) that payment cards tend to establish regional monopolies and with fewer cards the regions held by each card tend to be larger. If a payment card offers more favorable conditions, the reduced number of competitors will then enable card issuers to attract a significant number of new consumers and merchants. The switch of subscriptions is facilitated by easier coordination of consumers and merchants due to less cards being available to choose from. It is therefore that competition increases. Most importantly, the number of consumers and revenue generated from them by far exceeds that of merchants and it is for this reason that competition affects the pricing structure for consumers rather than merchants.

We have thus established that due to the two-sided nature of the market for payment cards a larger number of competitors does not necessarily lead to more competition between them. It can actually be that in particular consumers would benefit from less competitors in the market through lower fees and higher net benefits; merchants seem not to be affected by the degree of competition. Thus optimally the market should have a small number of competitors to ensure the best outcome for consumers, even as low as only 2 in the market investigated here.

There do exists a small number of similar results in the literature. The most commonly known result is in network industries such as telecommunications. The origin of the results in this class of models are, however, economies of scale and it is found that the presence of more competitors increases prices. Another strand of literature with a result that more competitors actually reduces competition can be found for market entry games with costly entry. More potential entrants might reduce competition among incumbents, see e. g. Nti (1989, 2000); Elberfeld and Wolfstetter (1999). In our model, however, we have neither economies of scale nor market entries, thus the result we obtained is not compatible with those strands of literature.

It has to be noted, however, that with only a small number of competing payment card issuers their potential market power could be significant. It can easily be imagined that the competitors start to collude in determining their pricing strategy in order to increase their profits at the expense of consumers in particular; such collusion is becoming more and more difficult to sustain as the number of competitors increases. Even with the possibility of collusion among competitors - which we did not account for in our model - we can conclude that for consumers a small number of competitors would be the preferred market structure. In the presence of a large number of competitors they would face higher fees.

It would therefore not be in the interest of consumers for market regulators to encourage the entry of additional competitors into the payment card market. By ensuring that no collusion is sustainable between the small number of competitors consumers would benefit most.

We have also compared the performance of the optimized strategies in a market populated with otherwise random strategies and find that the optimized strategies achieve a significantly higher market share and also outperform the random strategies in terms of profits generated. This results provides evidence that the optimization of the strategies has indeed produced strategies that are performing superior to randomly generated strategies.

5 Conclusions

We have developed an artificial payment card market in which consumers and merchants are interacting with each other through payments made for purchases. Based on the usage and acceptance of payment cards, merchants and consumers continuously review their subscription to payment cards and card issuers seek to maximize their profits by setting optimal fees and marketing efforts. Using the generalized population-based incremental learning algorithm (GPBIL) we were able to determine the optimal pricing strategy for card issuers.

Comparing the case of 2, 5 and 9 competing payment cards, we found most importantly that competition for consumers between the payment cards, as evidenced by the fees charged, is highest in the case of 2 payment cards. It was observed that in this case consumers benefit from lower fixed fees and higher net benefits of card usage while the conditions for merchants remain largely unaffected by the number of competitors and the profits for card issuers were significantly lower. Hence increasing the number of competitors does not necessarily benefit consumers. The reason for this counterintuitive result was the fact that the market for payment cards is a two-sided market and the easier coordination of subscriptions by consumers and merchants in the presence of less choice, increases competitive forces and generates the described outcome. Our model therefore establishes that from the view point of consumers it is optimal to have a relatively small number of competing payment card issuers.

We have a established a first model of the payment card market that allows us to analyze the impact of competition on consumers, merchants and the card issuers themselves. The model itself offers the possibility to explore a wide variety of extensions and modifications which would allow a further analysis of the competition between payment card issuers, e. g. evaluating the impact different physical locations of merchants and consumers have on the outcome, the introduction of interchange fees into the market, or the evaluation of a regulation on the market. This latter aspect may be of particular importance given the current investigations into the payment card market by regulators.

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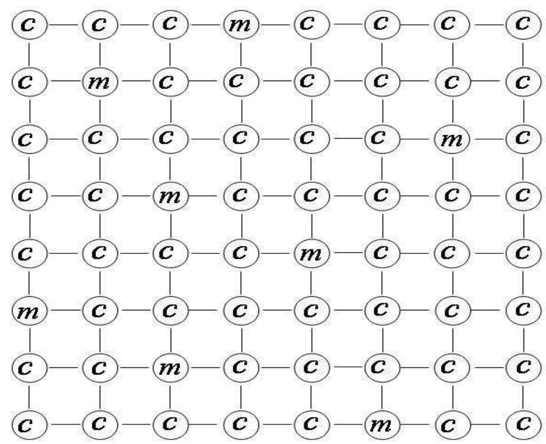

Fig. 1. Sample of a lattice with consumers (c) and merchants (m)

Description	Symbol	Value range
Consumer fixed fee	F_p	$[0; 10]$
Merchant fixed fee	Γ_p	$[0; 10]$
Net benefits of consumers	b_p	$[-1; 1]$
Net benefits of merchants	β_p	$[-1; 1]$
Publicity costs	l_p	$[0; 20]$
Number of subintervals	n	5
Learning rate	ζ	0.1
Kernel size for positive outcomes	δ	2
Kernel size for negative outcomes	δ'	1

Table 1. Domains of the strategy variables

Description	Symbol	Value
Network size	N	35
Number of consumers	$N_{\mathcal{C}}$	1100
Number of merchants	$N_{\mathcal{M}}$	125
Number of payment cards	$N_{\mathcal{P}}$	2, 5 and 9
Number of merchants considered by each consumer	$N_{\mathcal{M}_{\mathcal{C}}}$	5
Inertia/propensity with respect to net benefits	ε	1
Inertia/propensity with respect to net benefits	κ	1.1
Propensity of consumers to cancel their subscriptions	x_c^-	0.05
Inertia with respect to consumers making new subscriptions	x_c^+	2
Propensity of consumers to cancel their subscriptions	x_m^-	0.05
Inertia with respect to merchants making new subscriptions	x_m^+	9
Size of the probability adjustment due to marketing effort	α	0.1
Size of the probability adjustment due to marketing effort	φ	0.05
Expected time between subscription decisions	λ	20
Number of time steps	I	20000

Table 2. Parameter settings

Experiment	Consumer fixed fee	Merchant fixed fee	Consumer net benefits	Merchant net benefits	Marketing costs	Total profits
1	7.57	0.00	-1.00	-1.00	11.11	6,048,995.23
2	5.33	0.00	-1.00	-1.00	7.66	5,275,214.86
3	3.51	0.00	1.00	-1.00	11.81	3,204,527.52
4	6.03	0.00	0.48	-1.00	11.82	4,356,514.63
5	5.46	0.00	-1.00	-1.00	10.49	5,333,885.81
6	6.03	0.00	-1.00	-1.00	13.85	5,562,761.79
7	5.98	0.00	-1.00	-1.00	8.39	5,551,276.47
8	6.48	0.00	-1.00	-1.00	9.97	5,738,453.78
9	5.38	0.00	-1.00	-1.00	10.24	5,299,438.88
10	5.66	0.00	-1.00	-1.00	10.82	5,423,793.36
Mean	5.75	0.00	-0.65	-1.00	10.62	5,179,486.23
Median	5.85	0.00	-1.00	-1.00	10.66	5,378,839.59

Table 3. Optimized payment card strategies in 10 experiments for the case of 9 competing payment cards. The results denote the converged strategies of all payment cards during the last 100 time steps.

Experiment	Consumer fixed fee	Merchant fixed fee	Consumer net benefits	Merchant net benefits	Marketing costs	Total profits
1	0.07	0.00	1.00	-1.00	7.81	83,193.46
2	3.33	0.00	0.43	-1.00	9.52	4,030,092.77
3	4.21	0.00	0.53	-1.00	10.56	4,527,125.71
4	0.00	0.00	1.00	-1.00	2.23	-5,576.79
5	1.40	0.00	0.37	-1.00	8.74	2,202,551.73
6	3.82	0.00	0.78	-1.00	10.83	4,213,727.65
7	0.00	0.93	0.10	-1.00	8.75	561,356.43
8	3.71	0.00	0.61	-1.00	10.64	4,210,577.77
9	0.37	0.00	0.71	-1.00	8.64	706,220.40
10	0.00	0.00	0.57	-1.00	7.17	203,547.22
Mean	1.69	0.09	0.61	-1.00	8.49	2,073,281.64
Median	0.89	0.00	0.66	-1.00	8.75	1,454,386.07

Table 4. Optimized payment card strategies in 10 experiments for the case of 5 competing payment cards. The results denote the converged strategies of all payment cards during the last 100 time steps.

Experiment	Consumer fixed fee	Merchant fixed fee	Consumer net benefits	Merchant net benefits	Marketing costs	Total profits
1	0.90	0.00	0.28	-1.00	7.64	2,564,890.41
2	0.18	0.00	0.10	0.03	8.13	202,368.56
3	0.00	0.00	0.12	-1.00	7.09	1,047,601.18
4	0.00	0.00	0.24	-1.00	9.40	896,259.56
5	0.00	0.00	0.12	-1.00	4.67	1,051,471.54
6	0.00	0.00	-0.18	-1.00	6.08	1,392,978.45
7	0.00	0.00	0.05	-1.00	5.22	1,140,280.84
8	0.00	0.00	-0.42	-1.00	6.06	1,585,689.79
9	0.00	0.00	1.00	-1.00	9.14	-22,840.06
10	0.00	0.00	0.04	-1.00	6.25	1,145,044.41
Mean	0.11	0.00	0.13	-0.90	6.97	1,100,374.47
Median	0.00	0.00	0.11	-1.00	6.67	1,095,876.19

Table 5. Optimized payment card strategies in 10 experiments for the case of 2 competing payment cards. The results denote the converged strategies of all payment cards during the last 100 time steps.