An Empirical Analysis of Payment Card Pricing in China[1]

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Abstract: We exploit a unique merchant-level dataset from the monopoly payment card network in China to study payment card pricing. We develop hypotheses associating payment card pricing to card penetration rate, profitability and fraud risk. Our empirical analysis uses the variations in those three factors across industries to show that the card network charges a higher merchant discount for industries with lower card penetration rate, higher profitability and higher fraud risk. Moreover, we find that the card network provides quantity discounting to merchants.

Keywords: Payment card, two-sided market, price discrimination

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1. Introduction

This paper exploits a unique dataset on the payment card industry to explore the determinants of payment card pricing. Payment card becomes more relevant to our day-to-day transactions, and raises social welfare by facilitating the exchange of goods and services. Nonetheless, this new technology differs from the existing transaction devices, such as cash, by operating in a two-sided market. On one hand, the card network needs to encourage more customers to use the card for transaction in order to gain a higher acceptance of card payment among merchants. On the other hand, it needs to encourage more merchants to accept card payment so as to increase the willingness of customer to use card to pay for their purchases. This interesting feature of two-sided markets attracts attention from economists to analyze the workings of payment card industry (see Rochet and Tirole, 2006 for an overview).

However, not much is known about the price structure adopted by card network on merchants, which is important to determine merchant acceptance and hence consumer card usage. Understanding the price structure of payment card not only extend the academic literature, it also has implications on payment policy. For instance, there was an incident in Shenzhen in year 2004 that merchants refused to accept card payment.[4] The incident attracted attentions from policy makers because about 70% of retail sales in Shenzhen was sold by the group of merchants refusing to accept card payment. Importantly, the point of conflict relates to the pricing strategies adopted by the card network, i.e. merchants compliant the merchant discount was too high. Consequently, the dispute was settled by a reduction of merchant discount in year 2004.

To fill the gap in the literature, we look into the development and structure of Chinese payment card industry and the price structure adopted by the monopoly payment card network in China. More specifically, we ask the following questions: 1) Does the card network discriminate merchants in price? 2) Do consumer card usage, industry characteristics and merchants' total transaction value with card affect merchant discount? To answer those questions, based on Armstrong (2006) and

[4] Shenzhen ranked the fourth in GDP per capita among Chinese cities in year 2004.

Rochet and Tirole (2006), we hypothesize that the card network performs the third-degree price discrimination across industries for card services with three factors: the cross-group externality that an extra merchant accepting card brings to consumers, the benefit of using card services for merchants and the cost of providing card services to merchants. Furthermore, we hypothesize that the card network exercises second-degree price discrimination across merchants in each industry.

We then test those hypotheses with a unique merchant-level dataset in which the information on total payment for merchant discount and total transaction value with card are available. We use differences in card penetration rate, profitability and fraud risk across industries to identify the effects of those three factors on payment card pricing. Our findings show that merchant discount depends inversely on card penetration rate. It suggests that the card network reduces price to attract more merchants to join the network when consumer card usage is high, which shows an implication of two-sided market. Moreover, we show that the card network charges a higher merchant discount for industries with higher profitability and higher fraud risk, which suggest that the card network adjusts the price structure according to demand and cost factors. Finally, we find that merchant discount increases less than proportional than total transaction value and the extent of such quantity discounting seems to reduce as card penetration rate rises.

This paper is related to the growing literature on payment card pricing since the seminal work of Baxter (1983) and, recently, Rochet and Tirole (2002). They provide a rationale for card network using interchange fees in a two-sided market to encourage consumer card usage and merchant acceptance, and hence to affect the transaction value that are paid by card. Recently, there are few works on analyzing the price structure of payment card. Shy and Wang (2011) examines the reasons why card networks charge fees that are proportional to transaction values instead of charging fixed per-transaction fees.

However, there is limited evidence on the price structure of payment card.[5] An

[5] A majority of empirical studies on payment card industry focuses on consumer payment choice. See Humphrey (2010) for a recent survey.

exception is Guibourg and Segendorff (2007), which find that banks tend to use two-part tariffs with the variable fee equal to zero to charge their customers of using bank card. Our work differs from theirs by using a merchant-level dataset to show how merchant discount varies across merchants. Moreover, Rysman (2007) finds a positive correlation between consumer card usage and merchant acceptance, which shows the effect of two-sided market in the payment card industry.[6] We add to this discussion by showing the card network employs the third-degree price discrimination across industries in which consumer card usage is used as a factor for setting its merchant discount.

We discuss the institutional background of Chinese payment industry in the next section. Section 3 develops our testing hypotheses. Section 4 presents the data, descriptive statistics and empirical model. Section 5 presents the empirical findings. Section 6 concludes.

2. Institutional Background

We begin with discussing the background of Chinese payment card industry, and then explaining the organizational structure of the card network.

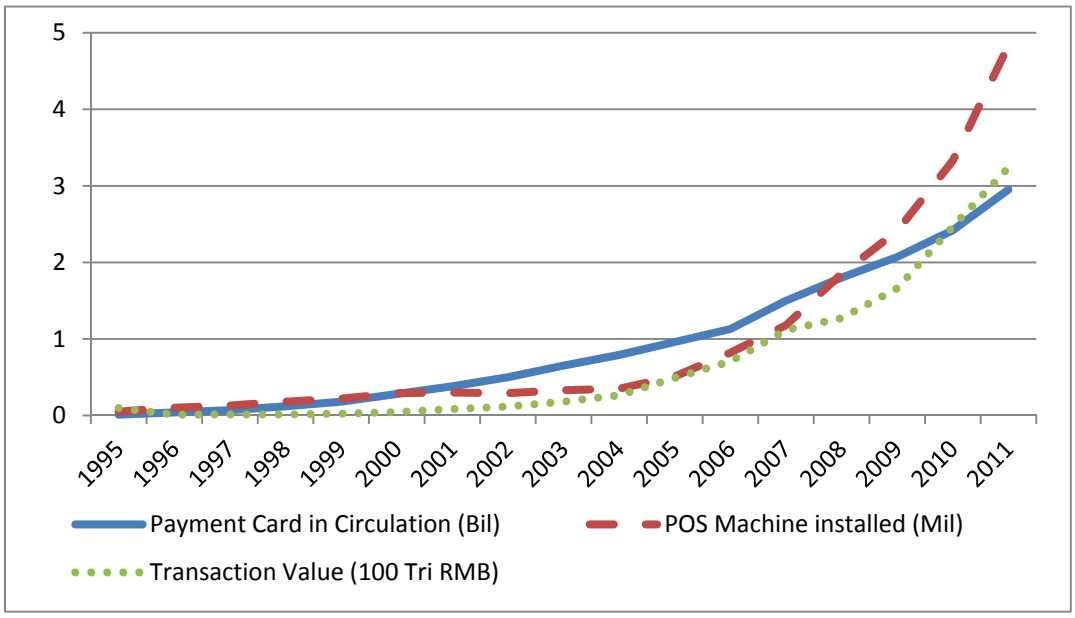
2.1.Payment Card Industry

Payment card was introduced in China in 1980s. The state commercial banks, i.e. the four largest banks, issued their first payment cards since 1985. More specifically, BOC, ICBC, CCB and ABC issued their first payment cards in 1985, 1987, 1990 and 1991, respectively. Later on, the joint stock banks started issuing their payment cards in 1990s. Since then, the payment card industry was growing rapidly. Figure 1 shows that the number of Point of Sales (POS) machine installed, the number of card in circulation and the transaction value by card grow by 99, 210 and 336 times larger over the period 1995-2011, respectively. Furthermore, the industry becomes more competitive over time. Over the period 1996-2005, among the largest 15 banks, the

[6] There are related works studying the implications of two-sided market for other industries such as Rysman (2004) on the Yellow Page market and Kaiser and Wright (2006) on the magazine industry.

HHI of card issued reduced from 0.28 to 0.13 and that of POS machine installed reduced from 0.26 to 0.17 (See Appendix 1 for data).

Figure 1: Development of Payment Card Industry



Note: See Appendix 1 for data and its sources.

The growth rates of card payment and POS machine installed are both positive over the period 1995-2011. It provides anecdotal evidence that the Chinese payment card industry exhibits a feature of two-sided market, i.e. consumer card usage for purchase and merchant acceptance of card payment reinforce each other.[7]

Table 1: Payment Card Industry in China and Europe in 2005

	China	Europe 25
No. of card issued	491 million	624 million
Transaction value	491 trillion RMB	1.37 trillion Euro
Card holding per capita	0.74	1.35
Transaction value per capita	37,655 RMB	2,970 Euro
Percentage of card purchase to GDP	5.19%	12.64%
GDP per capita	14,182 RMB	23,659 Euro

Data source for China: See Appendix 1. Data source for Europe 25: Payment and securities

[7] This nexus between card usage and merchant acceptance is also observed in a bank-level panel dataset. The related empirical results are available upon request.

settlement systems in the European Union (known as Blue Book) published by the ECB in August 2007. Note: Transaction value includes deposit, withdrawal, transfer and purchase. Exchange rate CNY/Euro ≈ 10 in 2005.

To put the descriptive statistics in a comparative perspective, we report the basic information of payment card industry in China and Europe in Table 1. In year 2005, there were 491 million card in circulation in China, i.e. 0.74 card holding per capita. The total transaction value with card was 491 trillion RMB, i.e. 37,655 RMB per capita. The fraction of GDP paid by card was 5.19%. On the other hand, in year 2005, there were 624 million card issued in Europe, i.e. 1.35 card holding per capita. The total transaction amount with card was 1.37 trillion Euro, i.e. 2,970 Euro per capita. The fraction of GDP paid by card was 12.64%.[8]

There are several interesting features deserved attention. First, the growth of POS machine installed is slower than that of card in circulation. Second, there were surges in the POS machine installed and the use of card purchase after year 2007. It suggests that the low growth in merchant acceptance may hinder consumer card usage before year 2008. Since merchant discount plays an important role in determining merchant acceptance, evidences on how the card network set its merchant discount is useful to understand the low merchant acceptance.

2.2. Card Network

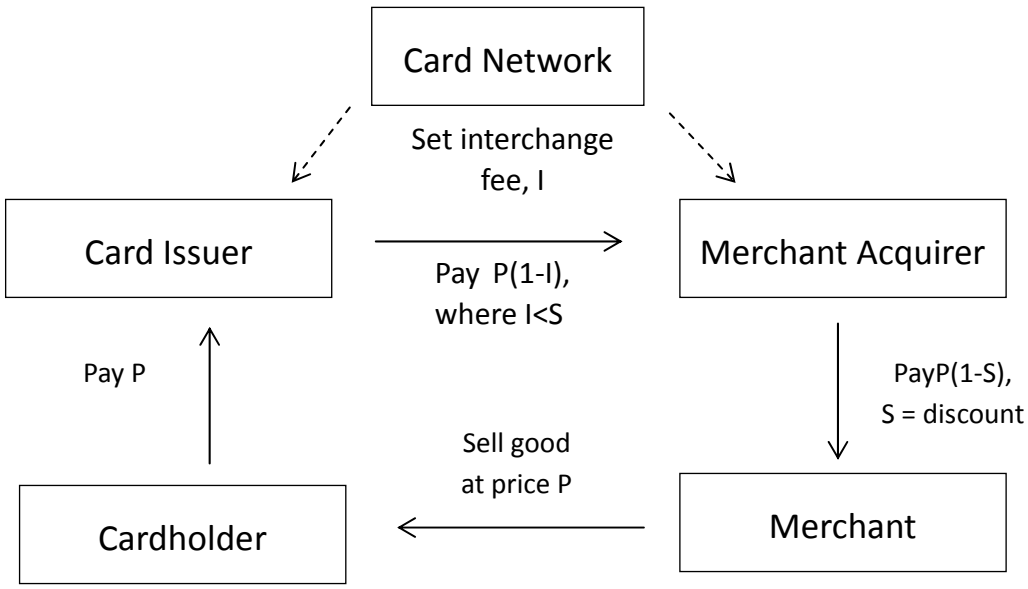
For transactions with domestic currency, i.e. RMB, there is a monopoly card network in China. As in the case of two major card networks in the globe, Visa and MasterCard, the card network in China employs an open-loop network (shown in Figure 1) in which the card network is only responsible for running the network. For example, it runs marketing campaigns for brand building. However, the card network does not issue card and handle payment, but accepts banks as its members to perform these tasks and bears the settlement risk by promising merchants to honor the payment authorized by cardholders. The issuing bank provides card services and consumer credit for cardholders to earn interchange fees, which is paid by merchants

[8] The ratios of card purchase to GDP in the U.S. are 19% and 25% in year 2007 and 2008, respectively

to issuing banks through merchant acquiring bank. The merchant acquiring bank provides and maintains POS equipment. For each transaction, the issuing bank can be different from the merchant acquiring bank.

The Peoples' Bank of China (PBOC) set the benchmark merchant discount for each industry based on demand and cost factors. The card network then set its rate within a range around the benchmark rate. Moreover, the PBOC set the rule of dividing the merchant discount according to the principle of 8:1:1 over the period 1999-2003. To understand how interchange works under the aforementioned allocation rule, we consider the following example with merchant discount at 2%, which lies within the range that the card network in China charges its merchants. When a consumer makes a $100 purchase with a debit card, the merchant gets $98 and pays the remaining $2 to the card network, which is known as merchant discount. The issuing bank gets 80% of the merchant discount, i.e. $1.6 as interchange fees. These fees are the largest component of the merchant discount. The card network gets 10% of the merchant discount, i.e. $0.2, as service fees. The remaining 10% of merchant discount belongs to merchant acquiring bank.

Figure 1: The Open-Loop Network of Payment Card Industry



Since year 2004, the PBOC revised the allocation rule to 7:1:X. The new rule is

different from the previous one in two aspects. First, it reduces the proportion of interchange fees in merchant discount. Second, it widens the dispersion of merchant discounts across merchants because merchant acquiring bank retains different fractions of merchant discount from different merchants. The merchant acquiring bank and merchant determine the exact rate on X by negotiation. For instance, for a $100 purchase with 2% merchant discount, the merchant receives 98-98.4 depending on X.

3. Hypothesis Development

The Chinese payment card industry exhibits the necessary conditions for price discrimination, namely 1) the card network has market power; 2) the card network can identify different willingness to pay across merchants, and 3) the card network can prevent resale of the payment services among merchants. In practice, the card network exercise price discrimination across industries by proposing such pricing scheme to the PBOC as the benchmark rates across industries.

Based on the model of monopoly platform developed in Armstrong (2006) and Rochet and Tirole (2006), we hypothesize that the card network performs the third-degree price discrimination across industries for card services with three factors. The pricing decision of card network on merchant discount depends on the external benefit that an extra merchant accepting card brings to consumers, the price elasticity of merchant demand for card services and the cost of providing card services to merchants.

First, the choice of a payment instrument in any transaction involves a fundamental externality because it affects the costs and benefits of merchants and consumers to the transaction (Rochet, 2003). Therefore, the cross-group externality that an extra merchant accepting card brings to consumers depends on the consumer card usage. Consider an example of two industries with similar profitability, namely electrical appliance and supermarket. Consumers are more likely to use payment card to purchase electrical appliance than grocery in supermarket because the transaction price of electrical appliance is much larger than that of most grocery. That means the

consumers' cost of finding an ATM and withdrawing cash imposed by the refusal of card acceptance from the sellers of electrical appliance is higher than that imposed by the supermarkets. Therefore, the cross-group externality that an extra merchant in electrical appliance accepting card brings to its consumers is larger than that an extra supermarket accepting card brings to its consumers. This implication of two-sided market suggests that the card network charges the merchants of electrical appliance at a lower merchant discount in order to encourage them to accept card payment and hence to capture the consumer surplus in that industry. As a result, the card network charges merchants at a lower merchant discount for merchants operating in industries with high consumer card usage.

Second, the price elasticity of merchant demand for card services depends on the profit that can be earned from transactions. When merchants have a higher profit from transactions, they face a higher opportunity cost in losing a consumer, who potentially only use card as payment method. Thus, more profitable merchants have lower price elasticity of demand for card services. As a result, the card network charges merchants at a higher merchant discount for merchants have a higher profitability.

Third, the cost of providing card services to merchants depends on the chance that the payment is authorized by authentic cardholder. The card network faces a monetary loss if the sales of product or services is authorized by a counterfeit cardholder because the card network promises merchants to honor such payment if due diligence is exercised. As a result, the card network charges the merchants at a higher merchant discount for merchants face a higher chance in receiving fraud payment.

Hypothesis 1: The card network charges a higher merchant discount for merchants operating in industries with lower consumer card usage, higher profitability and higher fraud payment risk.

Given the card network uses the third-degree price discrimination to set its price across industries, we then hypothesize that, for each industry, the card network

provides quantity discounting to merchants with large total transaction value with card in order to encourage them to use card payment.

Hypothesis 2: For each industry, conditional on its industry-specific merchant discount, the card network charges a lower merchant discount for merchants with a larger total transaction value with card.

4. Data and Empirical Model

We examine payment card pricing in China with two datasets. First, we collect a unique merchant-level dataset from the card network. The dataset is compiled by the card network by aggregating the transaction data paid by card for each merchant over a year. Our dataset contains merchant ID, industry ID, total payment of merchant discount to the card network, number of transaction with card purchase and transaction value with card purchase. Our data sample covers all transactions occurred in Guangdong province in year 2004 (see Appendix 2 for the background information on the sample province). An interesting feature of our sample province is that the card penetration rate in this province is expected to be high relative to other Chinese provinces. For instance, using the data from a major city in Guangdong province, Shenzhen, we find that the percentage of card purchase in this city (16.2%) is twice more than that of national average (7.58%). Second, we utilize the industry ID of the merchant-level data to match it with the industry statistics from the Economic Census 2004 of Guangdong province, which provides the industry-specific information on operating income and operating cost.

4.1. Variable Construction

We denote the merchant discount as Discount, which is the total merchant discount paid to the card network. We also define the average merchant discount as Rate, which is the ratio of merchant discount paid to the card network to total transaction value. The merchant discount and total transaction value have variations at merchant-level.

We construct four variables at the industry-level, namely card penetration rate, gross margin, HHI and fraud risk. We define Penetrate as card penetration rate, the ratio of total transaction value paid by card to operating income, i.e.

$$Penetrate_i = \frac{\sum_{j=1,..,J} Transaction\ value\ by\ card\ \ payment_j}{Operating\ \ Income_i},$$

where J is the total number of merchants in industry i. This variable is computed at industry-level with the numerator calculated from the merchant-level data and the denominator collected from the Economic Census. The variable Penetrate measures the consumer card usage of each industry.

We define Margin as gross margin, i.e.

$$M\ \text{arg}\ in_i = \frac{Operating\ Income_i - Operating\ Cost_i}{Operating\ Income_i},$$

of the main business at industry-level. The operating income and operating cost of each industry are collected from the Economic Census. Furthermore, we define HHI as the HHI of transaction values across merchants at industry-level, which is computed from the merchant-level data for each industry. Merchants operating in a more concentrated industry are expected to have a higher profit. The variables Margin and HHI measures the profitability of each industry.

To measure fraud risk, we collect the internal rating for fraud risk from the card network. There are two steps to construct the internal rating. First, it employs the fraud transaction value across industries over the years 2004-2005. Then, it calculates the industry-specific fraud risk of card payment with the share of fraud transaction value of an industry to total fraud transaction value of all industries, i.e.

$$Fraud\ \ Risk_i = \frac{Fraud\ transaction\ value_i}{\sum_{n=1,..,N} Fraud\ transaction\ value_n},.$$

where N is the total number of industry. After computing the fraud risk of each industry, it defines the variable Fraud as a categorical variable taking the values from 1 to 5 with increasing fraud risk.[9] For an industry with Fraud taking the value 1 (such

[9] We use the share of defaulted transaction value of an industry to total defaulted transaction value to define those five groups. Group 1 contains the industries with the share lower than 0.01%; Group 2 contains the industries with

as bakery), it is belong to the group with the lowest fraud risk. For an industry with Fraud taking the value 5 (such as beverage), it is belong to the group with the highest fraud risk.

There is a caveat of using the variable Fraud because the internal rating only uses information relating to the payment denominated in foreign currency instead of domestic currency. This variable may inflate the fraud risk for industries with high usage of payment card in foreign currency (such as department store), and may deflate the fraud risk for industries with low usage of payment card in foreign currency (such as online store and mail-order house).

Since the variable Fraud does not cover all industries, the second step of variable construction employs the tractability of transaction and the total transaction value to assign the value of Fraud for the remaining industries contained in the transaction-level data. More specifically, they assign a more important role to the tractability of transaction for assigning the value of Fraud because a higher tractability reduces the cost for enforcing the payment authorized by card holders, which reduces the fraud risk of card payment. For a given level of tractability, a larger transaction value raises the benefit of fraud payment, which increases the fraud risk of card payment.

4.2. Descriptive Statistics

We report the descriptive statistics in Table 2. The average merchant discount in our sample is about 0.8% of the total transaction value with the minimum and maximum equal to 0 and 3.0%, respectively. To put our estimates into context, we compare our estimates with those in the U.S., Canada and Europe. For the U.S., Hayashi (2009) documents the average merchant discount for accepting signature debit cards and credit cards is about 1.8-2.4% of total transaction value, and that for accepting debit card is about 0.69% of total transaction value. For Canada, based on the Bank of Canada's survey of merchants on their accepted means of payment in year

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the share between 0.01% and 0.1%; Group 3 contains the industries with the share between 0.1% and 1%; Group 4 contains the industries with the share between 1% and 10%; and Group 5 contains the industries with the share higher than 10 %

2006, Arango and Taylor (2008) report that the average merchant discount for accepting credit cards and debit cards are about 2% and 0.24% of total transaction values, respectively. For Europe, Jones and Jones (2005) show that the average merchant discount for accepting credit cards is about 0.7-2.8% of total transaction value and that for accepting debit card is about 0.6% of total transaction value. Since most of the payment cards in China were debit card, the average merchant discount in our sample is close to that of debit card in other developed economies.[10]

Table 2: Descriptive Statistics at Merchant and Industry Levels

Variables at merchant-level	**Obs**	**Mean**	**SD**	**Min**	**Max**
Rate	10619	0.008	0.006	0	0.030
Discount (1000 Yuan)	10619	9.087	52.54	0	2293
Transaction value (1000 Yuan)	10619	3145	15000	0.100	468000
Variables at industry-level	**Obs**	**Mean**	**SD**	**Min**	**Max**
Penetrate	72	0.058	0.106	0.000	0.536
HHI	72	0.293	0.291	0.012	0.972
Margin	72	0.327	0.199	0.031	0.870
Fraud (Categorical; Max = 5)	72	1.889	1.157	1	5

Source for the variables at merchant-level and HHI at industry-level: The card network in China; Source for the variables at industry-level: Economic Census 2004 of Guangdong province. There are about 2-3% of observations for Rate and Discount are censored at zero. Unit: %/100, except for transaction value, HHI and Fraud.

There are 72 industries in our sample (see Appendix 3 for the industry classification). Penetrate shows that about 5.8% of purchase in our sample is made by payment card, which is lower than the aggregate level (10.15%). The HHI ranges from 0.012 to 0.972, which shows that the competition intensity among merchants varies across industries substantially. Margin shows that the gross margin of our sample industries is 32.7% on average. Fraud indicates that the fraud risk across industries is skewed towards right. The average fraud risk is moderate, but few industries have high fraud risk in card payment. The low average fraud risk relates to the fact that most of the payment card are debit cards in the sample period. Those four variables have substantial variations across industries, which provide necessary

[10] The fraction of debt card to total payment card was 95.3% in year 2002.

information to identify the differences of price structure adopted by the card network across industries.

4.3. Empirical Model

We employ the reduced form regression model proposed in Busse and Rysman (2005) to examine the merchant discount across industries. Suppose the schedule of merchant discount for merchants in each industry is $Discount_{ij} = A_j Q_{ij}^{bj}$. The variable $Discount_{ij}$ is the merchant discount paid by merchant i in industry j. The variable Q_{ij} is the total transaction value of merchant i in industry j. The parameter A_j is the industry-specific effect on merchant discount, which captures the demand and cost factors of each industry. The parameter b_j captures the curvature of merchant discount schedule over total transaction value, which characterizes the extent of second-degree price discrimination across merchants in each industry. The parameter $b_j < 1$ means the card network provides quantity discounting to merchants, i.e. the merchant discount increases less than proportional to the total transaction value with card. The parameter $b_j = 1$ means the card network provides a linear pricing in total transaction value with card. The parameter $b_j > 1$ means that the card network provides quantity premium to merchants. To utilize this model to analyze second-degree price discrimination in each industry, we need to assume the marginal cost of card network for providing services is the same across merchants in each industry.

To estimate our model, we specify the parameter $b_j = b_0 + v_j$, where the error term v_j is assumed to be independent and identically distributed with mean zero. Then, we log-linearize the model and estimate the following equation with a full set of industry dummies (lnA_j):

$$\ln(1+Discount_{ij}) = \ln A_j + b_0 \ln Q_i + (v_{ij} \ln Q_{ij} + \varepsilon_{ij}) \quad (1)$$

Using the functional form $Discount_{ij} = A_j Q_{ij}^{bj}$, we assume that each industry-specific merchant discount schedule passes through the origin, thus we normalize each observation by subtracting off the lowest price and total transaction value at each industry separately. Furthermore, the variance-covariance matrix Ω has

the form that $\Omega(j,k) = \sigma_v^2*(\ln Q_{ij})^2+\sigma_{ie}^2$ for k=j and $\Omega(j,k) = \sigma_v^2*(\ln Q_{ij})(\ln Q_{ik})$ for k≠j. Since there is only one observation for each merchant in our sample, we cannot follow procedure proposed in Busse and Rysman (2005) to perform a regression for each merchant to estimate σ_{ie} and hence construct a covariance matrix to estimate Equation (1) with feasible GLS. Therefore, we estimate Equation (1) with heteroskedasticity-robust standard error.

We then perform two industry-level regressions (with 72 observations) to investigate the determinants of third-degree price discrimination. These two regressions are different in their measures for profitability. First, we regress the industry dummies ($\ln A_j$) on card penetration rate, HHI and fraud risk.

$$\ln A_j = a_0 + a_1 \ln Penetrate_j + a_2 \ln HHI_j + a_3 Fraud_j + e_j \quad (2)$$

Second, we regress the industry dummies ($\ln A_j$) on card penetration rate, gross margin and fraud risk.

$$\ln A_j = a_0 + a_1 \ln Penetrate_j + a_2 \ln Margin_j + a_3 Fraud_j + e_j \quad (3)$$

5. Empirical Results

We report the empirical results of Equations (1), (2) and (3) under Model 1 in Table 2. The left panel reports merchant-level regression of Equation (1). The coefficient on lnQ is about 0.8 and significant at 5% level. It indicates the merchant discount increases less than proportional to total transaction value, i.e. a 10% increase in total transaction value increases merchant discount by about 8%. In other words, conditional on the industry-specific merchant discount, the card network provides quantity discounting to merchants in each industry.

[Insert Table 2 here]

The right panel reports the industry-level regression of Equation (2) under Model 1-1. The coefficient on lnPentrate is negative and significant at 5% level. We show that merchant discount depends inversely on card penetration rate, which suggests that the card network reduces price to attract more merchants to join the network when consumer card usage is high. The coefficients on lnHHI and Fraud are positive and

significant at 5% level, which suggest that the card network charges a higher merchant discount for industries with higher industry concentration and higher fraud risk.

Turning to the industry regression of Equation (3) reported under Model 1-2, the coefficients on lnPenetrate and Fraud are consistent with those of Equation (2). The coefficient on lnMargin is positive but insignificant, which provides suggestive evidences to confirm that the card network charges a higher merchant discount for industry with higher profitability. In summary, these results lend support to Hypotheses 1 and 2.

5.1. Robustness Check

As we discuss before, the empirical model requires the merchant discount sequence passing through the origin. As a robustness check, we look into the average merchant discount, Rate, with the same empirical model. The advantage of this model is that there is no requirement that the variable Rate passes through the origin. The empirical model for this robustness check is specified as follows

$$\ln(1+Rate_{ij}) = \ln A_j + b_0 \ln Q_i + (v_{ij} \ln Q_{ij} + \varepsilon_{ij}) \quad (4)$$

We report the empirical results of Equation (4) under Model 2 in the left panel of Table 2. The coefficient on lnQ is negative and significant at 5% level. It indicates the average merchant discount decreases with total transaction value, which is consistent with Model 1. A 10% increase in total transaction value reduces average merchant discount by about 0.2% of total transaction value (equivalent to about 1/4 of the sample average merchant discount).

We report the results of corresponding industry-level regression in the right panel of Table 2 under Model 2-1 and Model 2-2. The coefficients on lnPentrate, lnHHI, lnMargin and Fraud are consistent with those reported under Model 1. The coefficient on lnMargin becomes significant but the coefficient on lnHHI becomes insignificant. Nonetheless, the alternative measures on profitability consistently suggest the card

network charges a higher merchant discount for industry with higher profitability. In summary, these results are consistent with those of Model 1 and lend further support to Hypotheses 1 and 2.

5.2. Further Analysis

In this sub-section, we explore the relationship between the extent of second-degree price discrimination and card penetration rate. We postulate the model: $b_j = b_0 + b_1 \ln Penetrate_j + v_j$, where the error term v_j is assumed to be independent and identically distributed with mean zero. Thus, we estimate the following empirical model with an interaction term:

$$\ln(1+Discount_{ij}) = \ln A_j + b_0 \ln Q_i + b_1 \ln Q_{ij} * \ln Penetrate_j + (v_{ij} \ln Q_{ij} + \varepsilon_{ij}) \qquad (5)$$

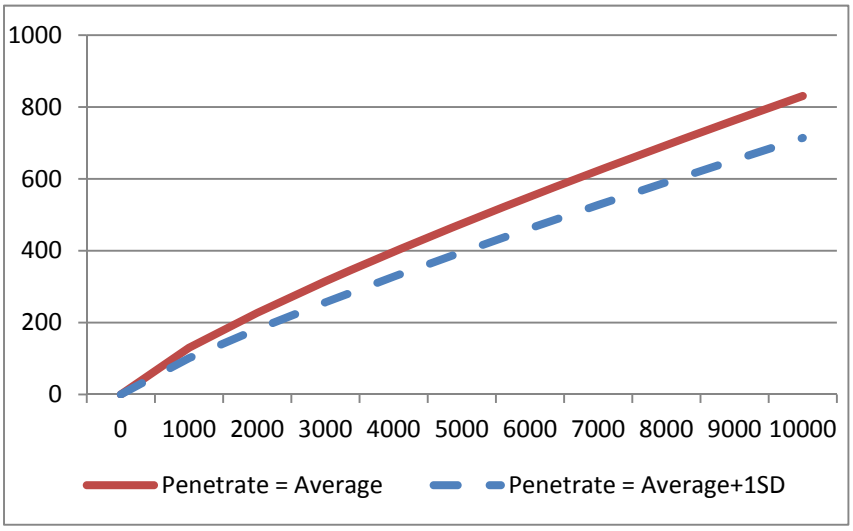
The coefficient estimates for this empirical model are reported under Model 3 in Table 2.[11] For the merchant-level regression, the coefficients on lnQ and that on the interaction term between lnQ and lnPenetrate are positive and significant at 5% level. The coefficient estimate b(j) increases with card penetration rate, which indicates that the card network exercises a smaller extent of price discrimination for industries with higher card penetrate rate. After estimating Equation (5), we perform regressions of the industry dummies ($\ln A_j$) according to Equations (2) and (3). The coefficients on card penetration rate, HHI, gross margin and fraud risk are consistent with the previous results.

According to Equation (5), a higher card penetration rate produces two opposing effects on merchant discount through reducing the concavity and the industry-specific effect of merchant discount schedule. Finally, we analyze the net effect of card penetration rate on merchant discount by examining two cases in which one case uses the average card penetrate rate, i.e. 0.058 and the other case uses the card penetrate rate at one SD above the average, i.e. 0.162. Figure 2 plots the schedule of merchant discount for those two cases over the range of transaction value from 0 to 10,000

[11] For the regression with average merchant discount as dependent variable, the coefficient on interaction term between lnQ and lnPenetrate does not show statistical significance at any conventional levels.

given the variables HHI and Fraud taking their average values. The plotted merchant discount schedule shows that a higher card penetration rate associates with a lower merchant discount.

Figure 2: Merchant Discount Schedule



Note: This figure plots Discount = $AQ^{b(j)}$. The y-axis is Discount and the x-axis is Q ranges from 0 to 10,000. The value of A is computed by A = $\exp(a_0 + a_1\ln(\text{Penetrate}) + a_2\ln(\text{HHI}) + a_3\text{Fraud})$ and b(j) is computed by $(b_0 + b_1\ln(\text{Penetrate}))$. For the average case, (Penetrate, HHI, Fraud) = (0.058, 0.293, 1.889); For the average+1 SD case, (Penetrate, HHI, Fraud) = (0.162, 0.293, 1.889).

6. Conclusion

Payment card industry in China has been growing rapidly since 1980s in which a monopoly card network has been operating with an open-loop network. This paper looks into this industry and shows that the card payment and merchant acceptance reinforces each other. Exploiting a unique merchant-level dataset, we provide evidence that the payment card pricing in China exercises the third-degree price discrimination across industries; in particular it charges a higher merchant discount for industries with lower consumer card usage, higher profitability and higher probability in receiving fraud payment. It suggests that the card network reduces price to attract more merchants to join the network when consumer card usage is high, and adjusts the price structure according to demand and cost factors. Furthermore, the card network exercises second-degree price discrimination across merchants in each

industry. We find that, conditional on the industry-specific merchant discount, merchant discount increases less than proportional to total transaction value with card across merchants in each industry. We also provide suggestive evidence that the extent of such quantity discounting reduces as card penetration rate rises. Finally, we show that our results are robust to using average merchant discount as an alternative dependent variable.

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Table 2: Empirical Results for Model 1 and 2

Variable	Model 1	Model 2	Model 3	Variable	Model 1-1	Model 1-2	Model 2-1	Model 2-2	Model 3-1	Model 3-2
lnQ_{ij}	0.7933*	-0.00019*	0.9270*	lnPenetrate	-0.1187**	-0.1762**	-0.0007*	-0.0007*	-0.5374*	-0.5916*
	[0.0098]	[0.00002]	[0.0237]		[0.0626]	[0.0620]	[0.0003]	[0.0003]	[0.0642]	[0.0629]
lnQ_{ij}*lnPenetrate			0.0423*	lnHHI	0.2827*		0.0007		0.2471*	
			[0.0070]		[0.1047]		[0.0005]		[0.1073]	
				lnMargin		0.1524		0.0016**		0.0874
						[0.1973]		[0.0009]		[0.2000]
				Fraud	0.2434*	0.1875	0.0015*	0.0015*	0.2282**	0.1729
					[0.1132]	[0.1180]	[0.0005]	[0.0005]	[0.1160]	[0.1198]
				Constant	-1.9761*	-2.4724	0.0005	0.0012	-1.9761*	-5.3514*
					[0.4337]	[0.4598]	[0.0020]	[0.0021]	[0.4337]	[0.4598]
R-Squared	0.691	0.667	0.694	R-Squared	0.239	0.165	0.206	0.224	0.629	0.601
Obs	10619	10619	10619	Obs	72	72	72	72	72	72

LHS: Merchant-level regression with industry-level dummies, i.e. Equation (1), (4) and (5). RHS-1: Regression of industry dummies on constant, ln(Penetrate), ln(HHI), and Fraud with industry-level data, i.e. Equation (2). RHS-2: Regression of industry dummies on constant, ln(Penetrate), ln(Margin) and Fraud with industry-level data, i.e. Equation (3). Penetrate is the ratio of operating income paid by card. HHI is the HHI of transaction value with card across merchants. Margin is the gross margin. Fraud is the categorical variable for measuring fraud risk. Standard errors are shown in [] below the coefficient estimates.* Significant at 5% level, ** significant at 10%.

Appendix 1: Summary Statistics at Aggregate-level

In this appendix, we tabulate the aggregate card statistics and the distribution statistics of card in circulation and POS machine installed among the largest 15 banks in China. The following table reports the summary statistics over the period 1995-2011:

Year	Transaction Value (100 Tri RMB)	Card in Circulation (Bil)	POS Machine installed (Mil)	Transaction Value per capita (RMB)	Card in Circulation per capita (Card)	Card Purchase in Retail Sales (%)	Card Purchase in GDP (%)	Populatio n (Mil)	GDP (Tri RMB)	Retail Sales (Tri RMB)
1995	0.096	0.01	0.05	798	0.01			1205	6.08	2.36
1996	0.010	0.04	0.10	852	0.03			1218	7.12	2.84
1997	0.013	0.07	0.13	1054	0.06			1230	7.90	3.13
1998	0.013	0.12	0.18	1063	0.09			1242	8.44	3.34
1999	0.024	0.18	0.22	645	0.14			1253	8.97	3.56
2000	0.045	0.28	0.29	3587	0.22			1263	9.92	3.91
2001	0.084	0.38	0.30	6626	0.30	3.45	1.35	1272	10.97	4.31
2002	0.116	0.50	0.29	9031	0.39	4.68	1.87	1280	12.03	4.81
2003	0.180	0.65	0.33	13962	0.50	7.17	2.77	1288	13.58	5.25
2004	0.264	0.79	0.35	20353	0.61	10.15	3.78	1296	15.99	5.95
2005	0.491	0.96	0.51	37655	0.74	14.29	5.19	1304	18.49	6.72
2006	0.706	1.13	0.82	53837	0.86	17.00	6.01	1311	21.63	7.64
2007	1.115	1.50	1.18	84575	1.14	21.90	7.35	1318	26.58	8.92
2008	1.272	1.80	1.85	95970	1.36	24.20	8.85	1325	31.40	11.48
2009	1.660	2.07	2.41	124718	1.55	32.00	12.47	1331	34.09	13.27
2010	2.468	2.42	3.33	184027	1.80	35.10	13.74	1341	40.12	15.70
2011	3.238	2.95	4.83	240408	2.19	32.60	14.81	1347	47.16	18.10

Source: Various issues of Almanac of China Finance and Banking, 1995-2006 for the data up to year 2005. Since then, the data source is switched to various issues of Report on the Development of China's Bankcard Industry, China Payment System Development Report (2006-2010) and The overall situation of China Payment System in 2011. Card purchase data for all years is obtained from the Report.

Turning to the distributional statistics, we employ a bank-level panel data containing 15 financial institutions. More specifically, it includes 4 state commercial banks (Agricultural Bank of China, Bank of China, China Construction Bank and Industrial and Commercial Bank of China), 10 joint stock banks (Bank of Communication, CITIC Industrial Bank, China Everbright Bank, China Huaxia Bank, China Minsheng Banking Corp., China Merchant Bank, Guangdong Development Bank, Shenzhen Development Bank, Shanghai Pudong Development Bank and Fujian Xinye Bank) and Postal saving system. Those 15 financial institutions are the most active in the payment card industry in terms of issuance and POS machine installation; in particular, they have more than 90% of market shares in card issuance and POS machine installation.

Our sample ended in year 2005 because the Almanac of China Finance and Banking terminated publishing the bank-level data on card in circulation and POS machines installed in year 2006 and year 2005, respectively. The following table reports the distributional statistics of card in circulation and POS machine installed over the period 1995-2009:

Year	C15-Card	C4-Card	HHI-Card	C15-POS	C4-POS	HHI-POS
1995	1	0.98	0.28	1	0.98	0.26
1996	1	0.95	0.31	1	0.95	0.24
1997	1	0.94	0.29	1	0.93	0.27
1998	0.99	0.89	0.25	1	0.90	0.23
1999	0.99	0.82	0.20	1	0.83	0.19
2000	0.99	0.78	0.19	1	0.78	0.17
2001	0.99	0.73	0.16	1	0.68	0.14
2002	0.96	0.70	0.15	0.98	0.77	0.17
2003	0.96	0.69	0.14	0.97	0.73	0.16
2004	0.94	0.66	0.13	0.96	0.69	0.16
2005	0.93	0.65	0.13	0.96	0.67	0.17

Note: Card denotes card in circulation and POS denotes POS machine installed. HHI is computed only with the data of those 15 banks without considering the remaining market share.

Appendix 2: Background Information of the Sample Province

In this appendix, we briefly describe the business and policy environments of Guangdong province and put it in a comparative perspective. First, China is a large developing country with a wide disparity in economic development across 31 provinces/municipalities. The eastern region, in which Guangdong province locates (see Figure 3), experienced preferential policy treatments on economic development since 1980s. For instance, four Special Economic Zones were established in the eastern region in year 1980, where three of them are located in Guangdong province. Moreover, the eastern region, which is proximate to ocean transport, has lower transaction costs for international trade. Finally, the institution changes from the planned to market economy benefited the coastal areas relatively more because, prior to reform, there were relatively fewer state enterprises in these areas; there were more opportunities for private enterprises to develop. (Bai et al, 2003).

Figure: Location of Guangdong Province

Second, we compare the economic development of Guangdong province to other Chinese provinces in year 2004. The following table reports the ratio of GDP per capita of each province to that of national average in year 2004. It indicates that Guangdong was one of the leading Chinese provinces in terms of economic development in year 2004. Particularly, the ratio of GDP per capita of Guangdong province to that of national average was 1.47. To put the figure in perspective, when we compute the corresponding figures for 50 U.S. states in year 2004, Delaware and Connecticut had similar ratios of GDP per capita to the national average in the U.S.

Economic Development of Selected Chinese Provinces and U.S. States in 2004

Rank	China	Ratio	US	Ratio
1	Shanghai	3.25	DC	3.29
2	Beijing	2.18	Delaware	1.52
3	Tianjin	2.17	Connecticut	1.33
4	Zhejiang	1.81	Alaska	1.27
5	Jiangsu	1.57	MA	1.18
6	Guangdong	1.47	New Jersey	1.16

Note: The Ratio is the ratio of provincial GDP to average GDP. Sources for China: National Bureau of Statistics, China. Sources for the U.S.: (GDP) Bureau of Economic Analysis, U.S. Department of Commerce and (Population) US Census.

Overall, we suggest that the market condition of Guangdong province is more competitive and more technologically advance, which is conducive to the development of payment card usage in retail and wholesale industries.

Appendix 3: Summary Statistics at Industry-level

Group	Name	GM	Group	Name	GM
1	Passenger transportation	0.23	37	Pharmacy	0.15
2	Public warehousing services	0.24	38	Sporting goods store	0.22
3	Ships and cruise route service	0.27	39	Bookstore	0.27
4	Express delivery	0.53	40	Stationery, office and school supply	0.16
5	Other transportation services	0.26	41	Photographic equipment	0.10
6	Travel agency	0.12	42	Gifts, bags and artificial limb	0.07
7	Telecommunications equipment	0.11	43	Cosmetics	0.03
8	Fixed line phone service	0.87	44	Flower shop	0.22
9	Mobile phone service	0.12	45	Tobacco	0.22
10	Computer networks and information services	0.62	46	Kiosks and newsstands	0.30
11	Cable and other pay TV services	0.46	47	Laundry services	0.48
12	Timber and building materials stores	0.15	48	Other personal services	0.51
13	Antique	0.32	49	Photography studio	0.40
14	Hotel and restaurant	0.51	50	Funeral services	0.60
15	Beverage	0.46	51	Consulting Services	0.57
16	Residential services	0.71	52	Advertising	0.25
17	Airline	0.19	53	Consumer credit report	0.60
18	Supermarket	0.14	54	Secretarial services	0.22
19	Department store	0.17	55	Commercial photography, craft and drawing services	0.41
20	Various supermarkets	0.17	56	Programming and data processing	0.35
21	Real estate	0.16	57	Management, consulting and public relations services	0.49
22	Car and truck dealers	0.05	58	Cinema	0.56
23	Wholesale	0.06	59	Electrical maintenance	0.33
24	Candy shop	0.15	60	Car rental	0.59
25	Dairy products	0.16	61	Car service	0.30
26	Car service station	0.30	62	Repair shop	0.37
27	Bakery	0.33	63	Electronic games	0.53
28	Auto-parts store	0.12	64	Optometrists and opticians	0.30
29	Gas station	0.08	65	Nursing and care services	0.67
30	Clothing	0.24	66	Hospital	0.25
31	Shoes and hats	0.24	67	Dentistry	0.62
32	Home decoration	0.23	68	Primary and secondary	0.56
33	Electrical appliance	0.10	69	University	0.25
34	Electronic equipment	0.13	70	Other educational services	0.57
35	Computer software	0.12	71	Child care services	0.62
36	Fast food restaurant	0.58	72	Construction, surveying and mapping services	0.48

Source for Gross Margin (GM) = 1- Operating Cost/Operating Income (unit = %x100) from the Economic Census 2004 of Guangdong province.