Payment Industry Dynamics: A Two-Sided Market Approach

James McAndrews and Zhu Wang

Federal Reserve Bank of New York and Federal Reserve Bank of Kansas City

June 14, 2006
Motivation and Set-Up

- Payment devices convey monetary value. We model the consumer adoption of a payment innovation by consumers who value the consumption of other goods, and face alternative means of payment, each of which is costly to use.
Motivation and Set-Up

- Payment devices convey monetary value. We model the consumer adoption of a payment innovation by consumers who value the consumption of other goods, and face alternative means of payment, each of which is costly to use.

- Consumers: each maximizes utility subject to income. There are no direct utility benefits, $b_c$, to a consumer’s use of a payment device. The demand for a payment device is an indirect demand. Farrell (2006), Rochet and Tirole (2005).
Motivation and Set-Up

- Payment devices convey monetary value. We model the consumer adoption of a payment innovation by consumers who value the consumption of other goods, and face alternative means of payment, each of which is costly to use.
- Consumers: each maximizes utility subject to income. There are no direct utility benefits, $b_c$, to a consumer’s use of a payment device. The demand for a payment device is an indirect demand. Farrell (2006), Rochet and Tirole (2005).
- Producers: each sells a distinct good $a$ in a contestable market. Consumers have generalized Cobb-Douglass preferences. A village allows bids for one merchant of each category. Price coherence yields a two-sided market. Village sunk cost in facilities rules out card-only merchants.
Motivation and Set-Up

- Model is intended to capture long-run features of adoption and diffusion of innovation in two-sided market
Motivation and Set-Up

- Model is intended to capture long-run features of adoption and diffusion of innovation in two-sided market
- Fundamental to the story is the distribution of endowments and of firm size (capturing technological considerations in retailing scale economies), rather than a distribution of preferences.
Motivation and Set-Up

- Model is intended to capture long-run features of adoption and diffusion of innovation in two-sided market.
- Fundamental to the story is the distribution of endowments and of firm size (capturing technological considerations in retailing scale economies), rather than a distribution of preferences.
- We abstract from strategic richness of merchant rivalries.
Motivation and Set-Up

- Model is intended to capture long-run features of adoption and diffusion of innovation in two-sided market.
- Fundamental to the story is the distribution of endowments and of firm size (capturing technological considerations in retailing scale economies), rather than a distribution of preferences.
- We abstract from strategic richness of merchant rivalries.
- Predictions of the model are that larger firms and higher income consumers adopt the innovation soonest. How alternative card providers determine their price structure depends on the relative skewness of the income distribution compared to the firm size distribution.
Figure: Household Credit Card Adoption by Income Quintile
Figure: Payment Card Share of Transaction Volume by Merchant Type
Pre-card Equilibrium

- Merchants: each sells a distinct good $\alpha$ in a contestable market

\[(1 - \tau_m)p_\alpha = c_\alpha \implies p_\alpha = \frac{c_\alpha}{1 - \tau_m}\]

$p_\alpha$: price of good $\alpha$; $c_\alpha$: cost of good $\alpha$; $\tau_m$: merchant cash cost
Pre-card Equilibrium

- Merchants: each sells a distinct good $\alpha$ in a contestable market
  
  $$(1 - \tau_m)p_\alpha = c_\alpha \implies p_\alpha = \frac{c_\alpha}{1 - \tau_m}$$

  $p_\alpha$: price of good $\alpha$; $c_\alpha$: cost of good $\alpha$; $\tau_m$: merchant cash cost

- Consumers: each maximizes utility subject to income $I$

  $$U = \text{Max} \int_{\alpha}^{\bar{\alpha}} \alpha \ln x_{\alpha,I} dG(\alpha)$$

  s.t.  
  
  $$\int_{\alpha}^{\bar{\alpha}} (1 + \tau_c)p_\alpha x_{\alpha,I} dG(\alpha) = I$$

  $x_{\alpha,I}$: consumer $I$’s demand for good $\alpha$; $\tau_c$: consumer cash cost
An individual consumer: demand and spending on good $\alpha$

$$x_{\alpha, l} = \frac{\alpha l}{(1 + \tau_c) p_{\alpha} E(\alpha)}; \quad p_{\alpha} x_{\alpha, l} = \frac{\alpha l}{(1 + \tau_c) E(\alpha)}$$
An individual consumer: demand and spending on good $\alpha$

$$x_{\alpha,l} = \frac{\alpha l}{(1 + \tau_c)p_{\alpha}E(\alpha)}; \quad p_{\alpha}x_{\alpha,l} = \frac{\alpha l}{(1 + \tau_c)E(\alpha)}$$

The aggregate market: demand and spending on good $\alpha$

$$x_{\alpha} = \frac{\alpha E(l)}{(1 + \tau_c)p_{\alpha}E(\alpha)}; \quad p_{\alpha}x_{\alpha} = \frac{\alpha E(l)}{(1 + \tau_c)E(\alpha)}$$

$E(l)$: mean of $l$; $E(\alpha)$: mean of $\alpha$
Post-card Equilibrium

- Consumers’ card adoption:

\[
U_0 = \int_{\alpha_0}^{\bar{\alpha}} \alpha \ln \left( \frac{\alpha l}{(1 + \tau_c) p_\alpha E(\alpha)} \right) dG(\alpha)
\]

\[
U_1 = \int_{\alpha_0}^{\bar{\alpha}} \alpha \ln \left( \frac{\alpha (l - k_c)}{(1 + \tau_c) p_\alpha E(\alpha)} \right) dG(\alpha) + \int_{\alpha_0}^{\bar{\alpha}} \alpha \ln \left( \frac{\alpha (l - k_c)}{(1 + f_c) p_\alpha E(\alpha)} \right) dG(\alpha)
\]

which implies that the card adoption requires

\[
E(\alpha) \ln \left( \frac{l}{l - k_c} \right) < E_{\alpha > \alpha_0}(\alpha) \ln \left( \frac{1 + \tau_c}{1 + f_c} \right)
\]

where

\[
E_{\alpha > \alpha_0}(\alpha) \equiv \int_{\alpha_0}^{\bar{\alpha}} \alpha dG(\alpha); \quad f_c: \text{comsumer card fee}
\]
It implies a threshold consumer income \( l_0 \) for adopting card

\[
l > l_0 = \frac{k_c}{1 - (\frac{1+f_c}{1+\tau_c})E_{\alpha > \alpha_0}(\alpha)/E(\alpha)}
\]

where \( \tau_c > f_c \)

More intuitively, a first-order Taylor expansion suggests

\[
\begin{align*}
\underbrace{\tau_c - f_c}_{\text{cost saving}} & \quad \underbrace{(l - k_c)E_{\alpha > \alpha_0}(\alpha)}_{\text{card transactions}} > \underbrace{k_c}_{\text{adoption cost}} \\
\end{align*}
\]
Merchants’ card adoption:

\[ p_{\alpha,d}x_{\alpha,d}^{\text{card}} = \frac{\alpha [E_{l > l_0} (I - k_c)]}{E(\alpha)(1 + f_c)}; \quad p_{\alpha,d}x_{\alpha,d}^{\text{cash}} = \frac{\alpha [E_{l < l_0} (I)]}{E(\alpha)(1 + \tau_c)} \]

Contestability imposes a zero profit condition

\[ (1 - f_m)p_{\alpha,d}x_{\alpha,d}^{\text{card}} + (1 - \tau_m)p_{\alpha,d}x_{\alpha,d}^{\text{cash}} = c_{\alpha}x_{\alpha,d}^{\text{card}} + c_{\alpha}x_{\alpha,d}^{\text{cash}} + k_m \]

\[ p_{\alpha,c} = \frac{c_{\alpha}}{1 - \tau_m} \]

Card adoption requires

\[ p_{\alpha,d} < p_{\alpha,c} \]
It implies a threshold merchant size $\alpha_0$ for accepting card

$$\alpha > \alpha_0 = \frac{E(\alpha) k_m (1 + f_c)}{[E_{I > I_0} (I - k_c)](\tau_m - f_m)}$$

which suggests that merchants’ card adoption requires

$$\tau_m > f_m$$

$$\underbrace{(\tau_m - f_m)}_{\text{cost saving}} \quad \underbrace{\frac{\alpha[E_{I > I_0} (I - k_c)]}{E(\alpha)(1 + f_c)}}_{\text{card transaction cost}} \quad \underbrace{> k_m}_{\text{adoption cost}}$$
Competitive Network without Interchange Fee:

\[
E_{\alpha > \alpha_0}(\alpha)E_{l > l_0}(l - k_c) \\
E(\alpha)(1 + d_c)
\]

s.t. \( l_0 = \frac{k_c}{1 - \left( \frac{1 + d_c}{1 + \tau_c} \right) E_{\alpha > \alpha_0}(\alpha)/E(\alpha)} \)

\[
\alpha_0 = \frac{E(\alpha)k_m(1 + d_c)}{[E_{l > l_0}(l - k_c)](\tau_m - d_m)}
\]

\[
f_m = d_m \quad \text{and} \quad f_c = d_c
\]

where \( d_m \) (\( d_c \)) denotes merchant (consumer) card service cost.
Competitive Network with Interchange Fee:

\[
\begin{align*}
\text{Max}_{f_c, f_m} & \quad \left\{ \frac{E_{\alpha > \alpha_0}(\alpha) E_{l > l_0} (I - k_c)}{E(\alpha)(1 + f_c)} \right\} \\
\text{s.t.} & \quad \alpha_0 = \frac{E(\alpha) k_m (1 + f_c)}{[E_{l > l_0} (I - k_c)](\tau_m - f_m)} \\
\quad l_0 & = \frac{k_c}{1 - \left( \frac{1 + f_c}{1 + \tau_c} \right) E_{\alpha > \alpha_0}(\alpha)/E(\alpha)} \\
\quad d_m + d_c & = f_c + f_m
\end{align*}
\]
Monopoly Network:

\[
\begin{align*}
\max_{f_c, f_m} \quad & \left\{ \frac{E_{\alpha > \alpha_0}(\alpha) E_{l > l_0}(1 - k_c)}{E(\alpha)(1 + f_c)} (f_c + f_m - d_m - d_c) \right\} \\
\text{s.t.} \quad & \alpha_0 = \frac{E(\alpha) k_m (1 + f_c)}{[E_{l > l_0}(1 - k_c)](\tau_m - f_m)} \\
& l_0 = \frac{k_c}{1 - \left( \frac{1 + f_c}{1 + \tau_c} \right) E_{\alpha > \alpha_0}(\alpha) / E(\alpha)}
\end{align*}
\]
Social Planner:

$$\begin{align*}
\text{Max}_{f_c, f_m} & \quad \left\{ \frac{E_{\alpha > \alpha_0} (\alpha) E_{l > l_0} (l)}{E(\alpha)(1 + \tau_c)} (\tau_c + \tau_m) - (1 - G(\alpha_0)) k_m \\
& - \frac{E_{\alpha > \alpha_0} (\alpha) E_{l > l_0} (l - k_c)}{E(\alpha)(1 + f_c)} (d_m + d_c) - (1 - F(l_0)) k_c \right\} \\
\text{s.t.} & \quad \alpha_0 = \frac{E(\alpha) k_m (1 + f_c)}{[E_{l > l_0} (l - k_c)](\tau_m - f_m)} \\
& \quad l_0 = \frac{k_c}{1 - \left( \frac{1 + f_c}{1 + \tau_c} \right) \frac{E_{\alpha > \alpha_0} (\alpha)}{E(\alpha)}}
\end{align*}$$
Findings:

- With an interchange fee, only the sum of the payment card cost $d_m + d_c$ matters;
Findings:

- With an interchange fee, only the sum of the payment card cost $d_m + d_c$ matters;
- An interchange fee improves the cost allocation and helps achieve higher card adoption and usage for the competitive network;
Findings:

- With an interchange fee, only the sum of the payment card cost $d_m + d_c$ matters;
- An interchange fee improves the cost allocation and helps achieve higher card adoption and usage for the competitive network;
- A monopoly card network maximizes the card revenue instead of transaction volume, so it prefers lower card usage than the competitive network;
Findings:

- With an interchange fee, only the sum of the payment card cost $d_m + d_c$ matters;
- An interchange fee improves the cost allocation and helps achieve higher card adoption and usage for the competitive network;
- A monopoly card network maximizes the card revenue instead of transaction volume, so it prefers lower card usage than the competitive network;
- The cost saving of using card relative to cash, i.e. $(\tau_c + \tau_m)$ relative to $(d_m + d_c)$, and the card adoption costs $(k_c, k_m)$ are only in the social planner’s calculation but not in (any of) the card network’s objectives.
Short-run Industry Dynamics

\[ \alpha_0 = \frac{E(\alpha) k_m (1 + f_c)}{[E_{I > I_0} (I - k_c)](\tau_m - f_m)} \quad (L1); \quad I_0 = \frac{k_c}{1 - \left(\frac{1 + f_c}{1 + \tau_c}\right) E_{\alpha > \alpha_0}(\alpha) / E(\alpha)} \quad (L2) \]
Appendix: Simulation Results

Card Fees:
- Competitive
- Cost: $dm+dc$
- Fees

- Monopoly
- Cost: $dm+dc$
- Fees

- Social Planner
- Cost: $dm+dc$
- Fees

Merchant Card Adoption:
- Com
- Mon
- Soc
- Adoption

Consumer Card Adoption:
- Com
- Mon
- Soc
- Adoption

Card Transaction Volume:
- Com
- Mon
- Soc
- Volume

Lambda=0.0001, Km=125, Kc=125, Tm=0.05, Tc=0.05,
Appendix: Simulation Results

Lamda=0.000075, Km=125, Kc=125, Tm=0.05, Tc=0.05,
Appendix: Simulation Results

Card fees: competitive

Card fees: monopoly

Card fees: social planner

Merchant card adoption

Consumer card adoption

Card transaction volume

Lamda=0.000075, Km=200, Kc=50, Tm=0.05, Tc=0.05,
Long-run Industry Dynamics

- At a given cost $d_m + d_c$, the monopoly network chooses the highest price level, $(f_m + f_c)$, and the lowest card adoption and usage.

As the total cost $d_m + d_c$ declines, all three market structures choose decreasing fees $f_m$ and $f_c$ and generate more card adoption and transactions.

The cost allocation is different under different market structures: the competitive network charges more on the merchants while the monopoly and social planner network charges more on the consumers.

As consumer incomes rise relative to card service costs, consumer fees tend to be decreased relative to merchant fees.

The fee allocation is influenced by the adoption cost $k_m$ and $k_c$ so that the party having a higher card adoption cost tends to bear a lower card service fee.
Long-run Industry Dynamics

- At a given cost $d_m + d_c$, the monopoly network chooses the highest price level, $(f_m + f_c)$, and the lowest card adoption and usage.

- As the total cost $d_m + d_c$ declines, all three market structures choose decreasing fees $f_m$ and $f_c$ and generate more card adoption and transactions.
Long-run Industry Dynamics

- At a given cost $d_m + d_c$, the monopoly network chooses the highest price level, $(f_m + f_c)$, and the lowest card adoption and usage.
- As the total cost $d_m + d_c$ declines, all three market structures choose decreasing fees $f_m$ and $f_c$ and generate more card adoption and transactions.
- The cost allocation is different under different market structures: the competitive network charges more on the merchants while the monopoly and social planner network charges more on the consumers.
Long-run Industry Dynamics

- At a given cost $d_m + d_c$, the monopoly network chooses the highest price level, $(f_m + f_c)$, and the lowest card adoption and usage.
- As the total cost $d_m + d_c$ declines, all three market structures choose decreasing fees $f_m$ and $f_c$ and generate more card adoption and transactions.
- The cost allocation is different under different market structures: the competitive network charges more on the merchants while the monopoly and social planner network charges more on the consumers.
- As consumer incomes rise relative to card service costs, consumer fees tend to be decreased relative to merchant fees.
Long-run Industry Dynamics

- At a given cost $d_m + d_c$, the monopoly network chooses the highest price level, $(f_m + f_c)$, and the lowest card adoption and usage.
- As the total cost $d_m + d_c$ declines, all three market structures choose decreasing fees $f_m$ and $f_c$ and generate more card adoption and transactions.
- The cost allocation is different under different market structures: the competitive network charges more on the merchants while the monopoly and social planner network charges more on the consumers.
- As consumer incomes rise relative to card service costs, consumer fees tend to be decreased relative to merchant fees.
- The fee allocation is influenced by the adoption cost $k_m$ and $k_c$ so that the party having a higher card adoption cost tends to bear a lower card service fee.
Determination of Price Structure: Competition v. Monopoly

- Compare a monopoly card network with a zero-profit network. At the same level of costs, the zero-profit network places relatively more costs on the merchant. Why?
Determination of Price Structure: Competition v. Monopoly

- Compare a monopoly card network with a zero-profit network. At the same level of costs, the zero-profit network places relatively more costs on the merchant. Why?

- The zero-profit network attempts to maximize card volume. Consider a 1 percent decrease in the merchant fees (relative to the monopolist) or a 1 percent decrease in consumer fees; which produces a larger quantity response?
Determination of Price Structure: Competition v. Monopoly

- Compare a monopoly card network with a zero-profit network. At the same level of costs, the zero-profit network places relatively more costs on the merchant. Why?

- The zero-profit network attempts to maximize card volume. Consider a 1 percent decrease in the merchant fees (relative to the monopolist) or a 1 percent decrease in consumer fees; which produces a larger quantity response?

- Considering first-order effects, the 1 percent decrease in merchant fees increases card transactions by the amount of all existing card-holder transactions at the marginal store (which is small). Alternatively, a 1 percent decrease in card-holder fees increases transactions by the marginal (low-income) cardholders conducting business using cards in all adopter-stores.
Determination of Price Structure: Competition v. Monopoly

- Compare a monopoly card network with a zero-profit network. At the same level of costs, the zero-profit network places relatively more costs on the merchant. Why?
- The zero-profit network attempts to maximize card volume. Consider a 1 percent decrease in the merchant fees (relative to the monopolist) or a 1 percent decrease in consumer fees; which produces a larger quantity response?
- Considering first-order effects, the 1 percent decrease in merchant fees increases card transactions by the amount of all existing card-holder transactions at the marginal store (which is small). Alternatively, a 1 percent decrease in card-holder fees increases transactions by the marginal (low-income) cardholders conducting business using cards in all adopter-stores.
- If the distribution of income is more skewed at that part of the distribution, then the second fee change increases transactions by a larger amount.
Determination of Price Structure: Private v. Public

- The social planner places more costs on the consumer than the private card providers. Why?
Determination of Price Structure: Private v. Public

- The social planner places more costs on the consumer than the private card providers. Why?
- The social planner puts more value on reducing the costs associated with use of cash. To gain more merchant adoption, the planner reduces (and even subsidizes) merchants. This allows society to reduce the costs of payments by eliminating cash use in the additional merchant adopters relative to the private provision. Unlike Schmalensee (2002).
Determination of Price Structure: Private v. Public

- The social planner places more costs on the consumer than the private card providers. Why?
- The social planner puts more value on reducing the costs associated with use of cash. To gain more merchant adoption, the planner reduces (and even subsidizes) merchants. This allows society to reduce the costs of payments by eliminating cash use in the additional merchant adopters relative to the private provision. Unlike Schmalensee (2002).
- Social optimum characterization similar to Farrell (2006).
Determination of Price Structure: Long-run declines in costs of providing card services or growth in consumer income

- Consider long-run technological improvements that lower the total cost of provision of card services, $d_m + d_c$, relative to income. All three market structures choose decreasing fees $f_m$ and $f_c$, typically decreasing the consumers’ fees more rapidly than merchants’ fees. Why?
Determination of Price Structure: Long-run declines in costs of providing card services or growth in consumer income

- Consider long-run technological improvements that lower the total cost of provision of card services, $d_m + d_c$, relative to income. All three market structures choose decreasing fees $f_m$ and $f_c$, typically decreasing the consumers’ fees more rapidly than merchants’ fees. Why?

- Once again, in our model, the distribution of income is more skewed (to the lower tail) than the distribution of merchant sizes. With the distribution of income more skewed, decreasing the consumers’ price by more results in a deeper penetration of consumer card adoption, and larger increases in card usage than would decreasing merchant prices.
Interchange Fee Puzzles

Why did interchange fees on debit cards in the U.S. initially flow more from consumer to merchant, and later reverse direction?
Interchange Fee Puzzles

- Why did interchange fees on debit cards in the U.S. initially flow more from consumer to merchant, and later reverse direction?
- Our model suggests that the adoption costs of new merchant terminals was greater for merchants than for consumers, who could use pre-existing ATM card at the point-of-sale, caused low fees for merchants. Later, technological progress and income growth caused interchange fees to run more from merchant to consumer.
Interchange Fee Puzzles

- Why did interchange fees on debit cards in the U.S. initially flow more from consumer to merchant, and later reverse direction?

- Our model suggests that the adoption costs of new merchant terminals was greater for merchants than for consumers, who could use pre-existing ATM card at the point-of-sale, caused low fees for merchants. Later, technological progress and income growth caused interchange fees to run more from merchant to consumer.

- Why have interchange fees on credit cards risen in the U.S. over time? Three possible reasons: the more skewed distribution of income, increasing monopoly power of the card industry, and income growth of consumers, all would predict higher merchant interchange fees.