Market Structure and Credit Card Pricing: What Drives the Interchange?

Zhu Wang

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Motivation

- Credit and debit cards have become an increasingly prominent form of payments.
  - 75% households own credit cards; 6.3 cards per household.
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  - Worldwide: EU, UK, Australia, Spain, Netherlands and etc.
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- The controversy of interchange fees.
  - The fees merchant-acquiring banks pay to card-issuing banks for transactions between merchants and cardholders.
  - Set by four-party systems: Visa and MasterCard.
  - Totals $30 billion or $270 per US household (2005).
sells good
at price $p_e$
pays $p_e(1-R)$
($R$: reward)
pays $p_e(1-S)$
($S$: discount)
Merchant Cardholder
Card Issuer Merchant Acquirer
Card Network (sets interchange $I$)

Figure: A Four-Party Credit Card System
Figure: U.S. Credit Card Interchange Fees and Transaction Volume
Credit Card Industry Trends: Costs and Competition
Puzzles

- Why have interchange fees been increasing given falling costs and increased competition in the card industry?
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- What are the causes and consequences of the increasing consumer card reward?
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- Given the rising interchange fees, why can’t merchants refuse accepting cards? Why has card transaction volume been growing rapidly?
- What are the causes and consequences of the increasing consumer card reward?
- What can government intervention do in the credit card industry? Is there a socially optimal card pricing?
Literature

- For interchange:
  - Schmalensee (2002), Rochet and Tirole (2002), Wright (2004): Interchange fees increase the value of two-sided payment systems by shifting costs between issuers (consumers) and acquirers (merchants). The profit and welfare maximizing fee likely coincide.

- Against interchange:
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- An equilibrium industry model:
  - Competing payment instruments, e.g., cards vs. alternatives;
  - Rational consumers (merchants) always use (accept) lowest-cost payment instruments;
  - Oligopolistic card networks that set profit-maximizing interchange fees;
  - Competitive card issuers that join the most profitable network and compete with one another via consumer rewards.

New findings:
- Collusive card networks demand higher interchange fees as card payment become more efficient;
- At equilibrium, consumer reward and card transaction volume also increase, while consumer surplus does not.
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- A cash store charges $p_a$, while a card store charges $p_e$:

  \[ p_a = \frac{k}{1 - \tau_{m,a}}; \quad p_e = \max\left(\frac{k}{1 - \tau_{m,e} - S}, p_a\right). \]
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- A cash store charges $p_a$, while a card store charges $p_e$:
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  p_a = \frac{k}{1 - \tau_{m,a}}; \quad p_e = \max\left(\frac{k}{1 - \tau_{m,e} - S}, p_a\right).
  \]
- The condition $p_a \leq p_e$ ensures card stores do not incur losses in case someone use cash there, so that
  \[
  S \geq \tau_{m,a} - \tau_{m,e};
  \]
  Moreover, a meaningful pricing requires
  \[
  1 - \tau_{m,e} > S.
  \]
Consumers:

- All consumers have access to cash and most own cards.

Using cash costs consumers $\tau_c$, per dollar, while using cards costs $\tau_c, e$ but receives a reward $R$ from issuers. Therefore, card consumers do not shop cash stores if and only if

$$\left(1 + \tau_c, a\right)_p > \left(1 + \tau_c, eR\right)_p$$

Given $p_a, p_e$, cash consumers prefer shopping cash stores and card consumers have no incentive to use cash in card stores.

When making a purchase decision, card consumers face the after-reward price $p_r = \left(1 + \tau_c, eR\right)_p = \left(1 + \tau_c, e\right)_k\tau_m, eS$ and have the total demand for card transaction volume $TD$:

$$TD = p_eD\left(p_r\right) = k\tau_m, eS D\left(\left(1 + \tau_c, eR\right)_p\right)$$
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\[ (1 + \tau_{c,a})p_a \geq (1 + \tau_{c,e} - R) p_e \iff \frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} - R}{1 - \tau_{m,e} - S}. \]
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- Given $p_a \leq p_e$, cash consumers prefer shopping cash stores and card consumers have no incentive to use cash in card stores.
- When making a purchase decision, card consumers face the after-reward price

$$
p_r = (1 + \tau_{c,e} - R)p_e = \frac{(1 + \tau_{c,e} - R)k}{1 - \tau_{m,e} - S},
$$

and have the total demand for card transaction volume $TD$:

$$
TD = p_e D(p_r) = \frac{k}{1 - \tau_{m,e} - S} D\left[\frac{(1 + \tau_{c,e} - R)k}{1 - \tau_{m,e} - S}\right].
$$
Acquirers:

- The acquiring market is competitive, where each acquirer receives a discount rate $S$ from merchants and pays an interchange rate $I$ to card issuers.
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- Acquiring incurs a constant cost $C$ for each dollar of transaction.
- For simplicity, we normalize $C = 0$ so acquirers play no role in our analysis but pass through merchant discounts as interchange fees to the merchants, i.e., $S = I$. 
Issuers:

- The issuing market is competitive, where each issuer receives an interchange rate $I$ from acquirers and pays a reward rate $R$ to consumers.
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- An issuer $\alpha$ incurs a fixed cost $K$ each period and faces an increasing cost $V_\alpha^\beta/\alpha$ for processing its volume $V_\alpha$, where $\beta > 1$. 
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- Issuers are heterogenous in their operational efficiency $\alpha$, which is distributed with pdf $g(\alpha)$ over the population.
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- Issuers are heterogenous in their operational efficiency $\alpha$, which is distributed with pdf $g(\alpha)$ over the population.
- Issuers pay the card network a processing fee $T$ per dollar of transaction and a share $c$ of their profits.
Issuers (continued):

- Issuer $\alpha$’s profit $\pi_\alpha$ (before sharing with the network):

$$
\pi_\alpha = \text{Max}(I - R - T) V_\alpha - \frac{V_\alpha^\beta}{\alpha} - K \implies \\
V_\alpha = \left(\frac{\alpha(I - R - T)}{\beta}\right)^\frac{1}{\beta - 1}; \quad \pi_\alpha = \frac{\beta - 1}{\beta} \left(\frac{\alpha}{\beta}\right)^\frac{1}{\beta - 1} (I - R - T)^\frac{\beta}{\beta - 1} - K.
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\]

- Free entry condition requires that the marginal issuer $\alpha^*$ breaks even, hence

\[
\pi_{\alpha^*} = 0 \implies \frac{\beta - 1}{\beta} \left(\frac{\alpha^*}{\beta}\right)^{\frac{1}{\beta - 1}} (I - R - T)^{\frac{\beta}{\beta - 1}} = K.
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  \]

- Therefore, the total number of issuers is

  \[
  N = \int_{\alpha^*}^{\infty} g(\alpha) \, d\alpha
  \]

  and the total supply of card transaction volume is

  \[
  TV = \int_{\alpha^*}^{\infty} V_\alpha g(\alpha) \, d\alpha = \int_{\alpha^*}^{\infty} \left( \frac{I - R - T}{\beta} \right)^{\frac{1}{\beta - 1}} g(\alpha) \, d\alpha.
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Network:

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- In return, the network charges its member issuers a processing fee $T$ to cover the variable costs and demands a proportion $c$ of their profits, where $c$ is determined by bargaining between the card network and issuers.
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- In return, the network charges its member issuers a processing fee $T$ to cover the variable costs and demands a proportion $c$ of their profits, where $c$ is determined by bargaining between the card network and issuers.
- As a result, the card network would like to set the interchange fee $I$ to maximize its profit

\[
\Omega = c \int_{\alpha^*}^{\infty} \pi_{\alpha} g(\alpha) d\alpha - E,
\]

which also maximizes the total profits of its member issuers.
Monopoly Network’s Problem

Max \( \Omega^m = c \int_{\alpha^*}^{\infty} \pi_\alpha g(\alpha) d\alpha - E \) \hspace{1cm} \text{(Card Network Profit)}

s.t. \( \pi_\alpha = \frac{(\beta - 1)}{\beta}(\frac{\alpha}{\beta})^{\frac{1}{1-\tau}}(I - R - T)^{\frac{1}{1-\tau}} - K \), \hspace{1cm} \text{(Profit of Issuer } \alpha \text{)}

\( \alpha^* = \beta K^{\frac{1}{1-\tau}}(\frac{\beta}{\beta - 1})^{\frac{1}{\beta-1}}(I - R - T)^{-\beta} \), \hspace{1cm} \text{(Marginal Issuer } \alpha^* \text{)}

\( N = \int_{\alpha^*}^{\infty} g(\alpha) d\alpha \), \hspace{1cm} \text{(Number of Issuers)}

\( \frac{1 + \tau_{c.a}}{1 - \tau_{m.a}} \geq \frac{1 + \tau_{c.e} - R}{1 - \tau_{m.e} - I} \), \hspace{1cm} \text{(API Constraint)}

\( 1 - \tau_{m.e} > I \geq \tau_{m.a} - \tau_{m.e}, \) \hspace{1cm} \text{(Pricing Constraint)}

\( TV = \int_{\alpha^*}^{\infty} V_\alpha g(\alpha) d\alpha = \int_{\alpha^*}^{\infty} [\frac{I - R - T}{\beta}]^{\frac{1}{1-\tau}} g(\alpha) d\alpha \), \hspace{1cm} \text{(Total Card Supply)}

\( TD = \frac{k}{1 - \tau_{m.e} - I} D(\frac{k}{1 - \tau_{m.e} - I}(1 + \tau_{c.e} - R)), \) \hspace{1cm} \text{(Total Card Demand)}

\( TV = TD. \) \hspace{1cm} \text{(CMC Condition)}

Monopoly network:

- Assume $\alpha$ follows a Pareto distribution so that
  \[ g(\alpha) = \gamma L \gamma / (\alpha^{\gamma+1}) \],
  where $\gamma > 1$ and $\beta \gamma > 1 + \gamma$. 

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- Consumer demand function: \( D = \eta p_r^{-\epsilon} \); and pricing constraint \( 1 - \tau_{m,e} > I \geq \tau_{m,a} - \tau_{m,e} \) is not binding.
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- The monopoly maximization problem can be rewritten as

$$\max_{I} \omega^{m} = A(I - R - T)^{\beta \gamma} - E \quad \text{(Network Profit)}$$

s.t. $B(I - R - T)^{\beta \gamma - 1} = (1 - \tau_{m,e} - I)^{\varepsilon - 1}(1 + \tau_{c,e} - R)^{-\varepsilon}$,

$\frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} - R}{1 - \tau_{m,e} - I}$.

$A, B$ are functions of parameters.
Monopoly network (Continued):

- Denote the net card price \( Z = I - R \).
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s.t. $B(Z - T)^{\beta \gamma - 1} = (1 - \tau_{m,e} - I)^{\varepsilon - 1}(1 + \tau_{c,e} + Z - I)^{-\varepsilon}$, \hspace{1cm} \text{(CMC)}$

$$\frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I}. \hspace{1cm} \text{(API)}$$

- Two scenarios: elastic demand ($\varepsilon > 1$) and inelastic demand ($\varepsilon < 1$).
Monopoly network (Continued):

- Denote the net card price \( Z = I - R \).
- Rewrite the monopoly maximization problem:

\[
\begin{align*}
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\text{s.t.} & \quad B(Z - T)^{\beta \gamma - 1} = (1 - \tau_{m,e} - I)^{\varepsilon - 1}(1 + \tau_{c,e} + Z - I)^{-\varepsilon}, \\
& \quad \frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I}.
\end{align*}
\]

- Two scenarios:
  - elastic demand (\( \varepsilon > 1 \)) and inelastic demand (\( \varepsilon \leq 1 \)).
Monopoly network (Continued):

- Elastic demand ($\varepsilon \geq \frac{1+\tau_{c,a}}{\tau_{c,a}+\tau_{m,a}} > 1$):

$$\frac{1 + \tau_{c,e} + Z - l}{1 - \tau_{m,e} - l} = \frac{\varepsilon}{\varepsilon - 1},$$

(FOC)

$$B(Z - T)^{\beta \gamma^{-1}} = (1 - \tau_{m,e} - l)^{\varepsilon^{-1}}(1 + \tau_{c,e} + Z - l)^{-\varepsilon}.$$  

(CMC)
Elastic demand ($\varepsilon > 1$): 

$$\frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I} = \frac{\varepsilon}{\varepsilon - 1}, \quad \text{(FOC)}$$

$$B(Z - T)^{\beta \gamma^{-1}} = (1 - \tau_{m,e} - I)^{\varepsilon^{-1}}(1 + \tau_{c,e} + Z - I)^{-\varepsilon}. \quad \text{(CMC)}$$

Elastic ($\frac{1 + \tau_{c,a}}{\tau_{c,a} + \tau_{m,a}} > \varepsilon > 1$) or inelastic ($\varepsilon \leq 1$) demand:

$$\frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} = \frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I}, \quad \text{(API)}$$

$$B(Z - T)^{\beta \gamma^{-1}} = (1 - \tau_{m,e} - I)^{\varepsilon^{-1}}(1 + \tau_{c,e} + Z - I)^{-\varepsilon}. \quad \text{(CMC)}$$
Monopoly Interchange Pricing: Elastic Demand

Case (1)

API Constraint
CMC Equation ($\epsilon > 1$)

Case (2)

API Constraint
CMC Equation ($\epsilon > 1$)
Monopoly Interchange Pricing: Inelastic Demand

Case (3)

CMC Equation ($\varepsilon \leq 1$)

API Constraint

Case (4)

CMC Equation ($\varepsilon \leq 1$)

API Constraint
Endogenous Industry Variables

\[ R = I - Z; \]
\[ V_\alpha = \left( \frac{\alpha}{\beta} (Z - T) \right)^{\frac{1}{\beta - 1}}; \]
\[ N = \int_{\alpha^*}^{\infty} g(\alpha) d\alpha = \left( \frac{L}{\alpha^*} \right)^\gamma; \]
\[ TV = B(Z - T)^{\beta \gamma - 1} k^{1 - \epsilon}; \]
\[ p_r = \frac{(1 + \tau_c,e + Z - I)}{(1 - \tau_{m,e} - I)} k; \]
\[ A = \left( \frac{K \beta}{\beta - 1} \right) (1 - \beta)^\gamma cKL^{\gamma \beta - \gamma} \frac{\beta^{\gamma - \gamma - 1}}{\beta^{\gamma - \gamma - 1}}; \]
\[ \pi_\alpha = \left( \frac{\beta - 1}{\beta} \right) \left( \frac{\alpha}{\beta} \right)^{\frac{1}{\beta - 1}} (Z - T)^{\frac{\beta}{\beta - 1}} - K; \]
\[ \alpha^* = \beta \left( \frac{\beta K}{\beta - 1} \right)^{\beta - 1} (Z - T)^{-\beta}; \]
\[ \Omega^m = A(Z - T)^{\beta \gamma} - E; \]
\[ p_e = \frac{k}{1 - \tau_{m,e} - I}; \]
\[ D = \eta p_r^{-\epsilon}; \]
\[ B = \frac{L^{\gamma \beta - \gamma - 1} k^{\epsilon - 1}}{\eta} \left( \frac{\beta^{\gamma - \gamma - 1}}{\beta^{\gamma - \gamma - 1}} \right) \left( \frac{K \beta}{\beta - 1} \right)^{1 + \gamma - \beta \gamma}. \]
## Equilibrium Industry Dynamics under a Monopoly Network

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<td>Interchange fee</td>
<td>Consumer reward</td>
<td>Net card price</td>
<td>Issuer α profit</td>
<td>Issuer α volume</td>
<td>Number of issuers</td>
<td>Network profit</td>
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<td>Retail price</td>
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<td>Card user’s consumption</td>
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<td>( \tau_{m,a} ) merchand cash cost</td>
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<tr>
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</table>

\[ \varepsilon \geq \frac{1 + \tau_{c,a}}{\tau_{c,a} + \tau_{m,c}} > 1 \]

\[ \frac{1 + \tau_{c,a}}{\tau_{c,a} + \tau_{m,c}} > \varepsilon \geq 0 \]

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</tbody>
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Monopoly Network: What do we learn?

- Why have interchange fees been increasing?
  - Under a monopoly card network, equilibrium interchange fees increase as card payments become more efficient (a lower $\tau_{m,e}$, $\tau_{c,e}$ or $T$) or the issuers’ mkt becomes more competitive (a lower $K$). Technology change and enhanced competition drive up consumer reward and card transaction volume, but not consumer welfare.
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- Why can’t merchants refuse cards?
  - As card payment becomes increasingly more efficient than alternatives, card networks can afford charging higher interchange fees but still keep cards a competitive payment service to merchants.

- Why are interchange lower for lower-fraud transactions?
  - Although it seems to contradict the fact that interchange fees increase as fraud costs decrease over time, the answer lies on the different API (alternative payment instrument) constraints that card networks face in different environments.
Duopoly Networks

- Starting point: monopoly vs. duopoly card markets.
Duopoly Networks

- **Starting point:** monopoly vs. duopoly card markets.

- **Nature of an infinitely repeated game:**
  - In an oligopoly producing a homogeneous product, the threat of a vigorous price war would be sufficient to deter the temptation to cut prices.
  - The oligopolists might be able to collude in a purely noncooperative manner and the monopoly price is the most likely outcome.

\[ \frac{\partial p}{\partial I} > 0 \]
Starting point: monopoly vs. duopoly card markets.

Nature of an infinitely repeated game:

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A useful theoretical result:

- Proposition: Anything else being equal, a lower interchange fee results a lower after-reward price: \( \frac{\partial p_r}{\partial l} > 0 \).
Each network’s objective:

\[ U_i = \sum_{t=0}^{\infty} \delta^t \Omega^i(l_{it}, l_{jt}). \]
Each network’s objective:

\[ U_i = \sum_{t=0}^{\infty} \delta^t \Omega^i(I_{it}, I_{jt}). \]

The payoffs \((i, j)\) for the stage game:

<table>
<thead>
<tr>
<th>j</th>
<th>Payoffs</th>
<th>(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>collude</td>
<td>(\Omega^m - E, \frac{\Omega^m - E}{2})</td>
<td>(\Omega^m, -E)</td>
</tr>
<tr>
<td>defect</td>
<td>(-E, \Omega^m)</td>
<td>0, 0</td>
</tr>
</tbody>
</table>
Consider the following symmetric strategies, also known as Forsaking Trigger (FT):

1. Phase A: set interchange fee at the monopoly level $I^m$ and switch to Phase B;
2. Phase B: set interchange fee at $I^m$ unless some player has deviated from $I^m$ in the previous period, in which case switch to Phase C and set $\tau = 0$;
3. Phase C: if $\tau \leq n$, set $\tau = \tau + 1$ and charge the interchange fee at the punishment level $I^p$ that $\Omega^i(I^p,I^p) = 0$, otherwise switch to Phase A.
Duopoly Networks (Continued)

- One-shot deviation property

\[(D, C), (D, D), (D, D), \ldots, (D, D), (C, C), (C, C), \ldots,\]

\[n\text{ times}\]

For example, if \(n=2\), the condition can be satisfied for any \(\delta > 1 + (4\Omega_m(I_m) + 4E ) / (2\Omega_m(I_m))\), which is the harshest punishment, also known as Grim Trigger (GT).

As the length of punishment increases, the lower bound on \(\delta\) decreases, and as \(n \to \infty\), the bound converges to \[\frac{\Omega_m(I_m) + E}{2\Omega_m(I_m)}.\]
Duopoly Networks (Continued)

- One-shot deviation property

\[(D, C), (D, D), (D, D), \ldots, (D, D), (C, C), (C, C), \ldots,\]

\[n \text{ times}\]

- No profitable one-shot deviation in the collusion phase iff

\[
\frac{1}{2}\Omega^m(I^m) + \frac{1}{2}E < \delta\left(1 - \delta^n\right)\left[\frac{1}{2}\Omega^m(I^m) - \frac{1}{2}E\right].
\]
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- For example, if \(n = 2\), the condition can be satisfied for any \(\delta > \left\{ \left[ 1 + (4\Omega^m(I^m) + 4E)/(\Omega^m(I^m) - E) \right]^{1/2} - 1 \right\} / 2.\)
Duopoly Networks (Continued)

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\]

- For example, if \( n = 2 \), the condition can be satisfied for any \( \delta > \left\{ [1 + (4\Omega^m(I^m) + 4E)/(\Omega^m(I^m) - E)]^{1/2} - 1 \right\}/2. \)

- As the length of punishment increases, the lower bound on \( \delta \) decreases, and as \( n \to \infty \), the bound converges to \( (\Omega^m(I^m) + E)/(2\Omega^m(I^m)) \). which is the harshest punishment, also known as Grim Trigger (GT).
Duopoly Networks: Remarks

- The collusion can be supported at equilibrium only if $\delta$ is large enough, which implies any price cut by a player can be quickly observed and punished by its competitors.
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- The assumption of infinite horizon is crucial. It is known that collusion cannot be sustained even for a long but finite horizon due to backward induction. However, this requires no more than that at each period there is a probability $\theta$ in $(0, 1)$ that the market survives.
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- An infinitely repeated game may have multiple equilibriums, as suggested by Folk Theorems. Naturally, we assume the two networks coordinate on a Pareto-optimal equilibrium, that is the monopoly outcome. In addition, we choose a symmetric equilibrium given the symmetric nature of the game.
## Top Eight Credit Card Issuers in 2004

<table>
<thead>
<tr>
<th>ISSUERS</th>
<th>VISA</th>
<th>MASTER CARD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rank</td>
<td># Cards (M)</td>
</tr>
<tr>
<td>JP Morgan Chase</td>
<td>2</td>
<td>48.1</td>
</tr>
<tr>
<td>Citigroup</td>
<td>3</td>
<td>28.9</td>
</tr>
<tr>
<td>MBNA</td>
<td>5</td>
<td>24.4</td>
</tr>
<tr>
<td>Bank of America</td>
<td>1</td>
<td>58.1</td>
</tr>
<tr>
<td>Capital One</td>
<td>4</td>
<td>26.9</td>
</tr>
<tr>
<td>HSBC</td>
<td>7</td>
<td>10.3</td>
</tr>
<tr>
<td>Providen</td>
<td>8</td>
<td>10.1</td>
</tr>
<tr>
<td>Wells Fargo</td>
<td>10</td>
<td>7.1</td>
</tr>
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</table>
## Visa and MasterCard Comparison 2004

<table>
<thead>
<tr>
<th></th>
<th>Visa</th>
<th>MasterCard</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merchants (M)</td>
<td>4.6</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Outlets (M)</td>
<td>5.7</td>
<td>5.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Cardholders (M)</td>
<td>96.2</td>
<td>96.3</td>
<td>118.5</td>
</tr>
<tr>
<td>Cards (M)</td>
<td>295.3</td>
<td>271.5</td>
<td>566.8</td>
</tr>
<tr>
<td>Accounts (M)</td>
<td>215.5</td>
<td>217.6</td>
<td>433.1</td>
</tr>
<tr>
<td>Active Accts (M)</td>
<td>115.2</td>
<td>120.1</td>
<td>235.3</td>
</tr>
<tr>
<td>Transactions (M)</td>
<td>7,286.8</td>
<td>5,286.2</td>
<td>12,573.0</td>
</tr>
<tr>
<td>Total Volume ($B)</td>
<td>722.2</td>
<td>546.7</td>
<td>1,268.9</td>
</tr>
<tr>
<td>Outstandings ($B)</td>
<td>302.9</td>
<td>293.7</td>
<td>596.48</td>
</tr>
</tbody>
</table>
Policy and Welfare Analysis

- Price cut $I < I_m$.

\[ B(Z - T)^{\beta \gamma^{-1}} = (1 - \tau_{m,e} - I)^{\epsilon^{-1}}(1 + \tau_{c,e} + Z - I)^{-\epsilon}. \]

(CMC)

The effects:

<table>
<thead>
<tr>
<th></th>
<th>$Z$</th>
<th>$R$</th>
<th>$\pi_\alpha$</th>
<th>$V_\alpha$</th>
<th>$N$</th>
<th>$\Omega$</th>
<th>$TV$</th>
<th>$p_e$</th>
<th>$p_r$</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I$</td>
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<th>$p_r$</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I$</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
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</tbody>
</table>

- Price ceiling $I^c < I^m$.

\[ B(Z - T)^{\beta \gamma^{-1}} = (1 - \tau_{m,e} - I^c)^{\varepsilon^{-1}}(1 + \tau_{c,e} + Z - I^c)^{-\varepsilon}. \]

(CMC)
Interchange Ceiling: Elastic/Inelastic Demand

Case (5)

API Constraint

CMC Equation ($\varepsilon > 1$)

Case (6)

API Constraint

CMC Equation ($\varepsilon \leq 1$)
## Equilibrium Industry Dynamics under a Binding Interchange Ceiling

<table>
<thead>
<tr>
<th></th>
<th>I Interchange fee</th>
<th>R Consumer reward</th>
<th>Z Net card price</th>
<th>$\pi_a$ Issuer $a$ profit</th>
<th>$V_a$ Issuer $a$ volume</th>
<th>N Number of issuers</th>
<th>$\Omega$ Network profit</th>
<th>TV Network volume</th>
<th>$P_e$ Retail price</th>
<th>$P_r$ After-reward price</th>
<th>D Card user’s consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_{c,e}$ consumer card cost</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$T$ network card cost</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$K$ issuer entry cost</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$\tau_{m,a}$ merchand cash cost</td>
<td>0</td>
<td>0</td>
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<tr>
<td>$\tau_{m,e}$: merchand card cost</td>
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<tr>
<td>$\varepsilon &gt; 1$</td>
<td>0</td>
<td>+</td>
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<td>-</td>
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<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$\varepsilon = 1$</td>
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<td>0</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$0 &lt; \varepsilon &lt; 1$</td>
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<td>-</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</tbody>
</table>
Social Planner's Problem

\[
\begin{align*}
\text{Max } \Omega^s & = \int_{\alpha^*}^{\infty} \pi_\alpha g(\alpha) d\alpha + \int_0^{Q^*} D^{-1}(Q) dQ - \frac{k(1 + \tau_{c,e} - R)}{1 - \tau_{m,e} - I} \cdot Q^* - E \\
\text{(Social Surplus)}
\end{align*}
\]

\[
\begin{align*}
s.t. \quad \pi_\alpha & = (\frac{\beta - 1}{\beta}) \left( \frac{\Omega}{\beta} \right)^{\frac{1}{\beta}} (I - R - T)^{\frac{1}{\beta}} - K, \quad \text{(Profit of Issuer } \alpha) \\
\alpha^* & = \beta K^{\beta - 1} (\frac{\beta}{\beta - 1})^{\beta - 1} (I - R - T)^{-\beta}, \quad \text{(Marginal Issuer } \alpha^*) \\
Q^* & = D \left( \frac{k}{1 - \tau_{m,e} - I} (1 + \tau_{c,e} - R) \right) \quad \text{(Demand of Goods)} \\
N & = \int_{\alpha^*}^{\infty} g(\alpha) d\alpha, \quad \text{(Number of Issuers)} \\
\frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} & \geq \frac{1 + \tau_{c,e} - R}{1 - \tau_{m,e} - I}, \quad \text{(API Constraint)} \\
1 - \tau_{m,e} & > I \geq \tau_{m,a} - \tau_{m,e}, \quad \text{(Pricing Constraint)} \\
TV & = \int_{\alpha^*}^{\infty} V_\alpha g(\alpha) d\alpha = \int_{\alpha^*}^{\infty} [(I - R - T) \frac{1}{\beta}) \alpha^{\frac{1}{\beta}} g(\alpha) d\alpha, \quad \text{(Total Card Supply)} \\
TD & = \frac{k}{1 - \tau_{m,e} - I} D \left( \frac{k}{1 - \tau_{m,e} - I} (1 + \tau_{c,e} - R) \right), \quad \text{(Total Card Demand)} \\
TV & = TD, \quad \text{(CMC Condition)} \\
c \int_{\alpha^*}^{\infty} \pi_\alpha g(\alpha) d\alpha - E & \geq 0. \quad \text{(Ramsey Constraint)}
\end{align*}
\]
Social Planner’s Problem

- Assume $\alpha$ follows a Pareto distribution so that $g(\alpha) = \gamma L^\gamma / (\alpha^{\gamma+1})$, where $\gamma > 1$ and $\beta \gamma > 1 + \gamma$. 
Social Planner’s Problem

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- Consumer demand: $D = \eta p_r^{-\epsilon}$; constraints $1 - \tau_{m,e} > l \geq \tau_{m,a} - \tau_{m,e}$ and $c \int_{\alpha^*}^{\infty} \pi_{\alpha} g(\alpha) d\alpha - E \geq 0$ are not binding.
Social Planner’s Problem

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- For $\varepsilon > 1$, the social planner’s problem can be rewritten as

$$\begin{align*}
\text{Max } & \Omega^s = \frac{A}{c} (Z - T)^{\beta \gamma} + \frac{\eta}{\varepsilon - 1} p_r^{1-\varepsilon} - E \quad \text{(Social Surplus)} \\
\text{s.t. } & B (Z - T)^{\beta \gamma - 1} = (1 - \tau_{m,e} - I)^{\varepsilon - 1} (1 + \tau_{c,e} + Z - I)^{-\varepsilon}, \\
& \frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I} .
\end{align*}$$

(CMC) (API)
Social Planner’s Problem

- Assume \( \alpha \) follows a Pareto distribution so that
  \[ g(\alpha) = \gamma L^{\gamma} / (\alpha^{\gamma+1}) \], where \( \gamma > 1 \) and \( \beta \gamma > 1 + \gamma \).

- Consumer demand: \( D = \eta p_r^{-\varepsilon} \); constraints
  \( 1 - \tau_{m,e} > I \geq \tau_{m,a} - \tau_{m,e} \) and
  \[ c \int_{\alpha^*} \pi_k g(\alpha) d\alpha - E \geq 0 \]
  are not binding.

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  \[
  \max \quad \Omega^s = \frac{A}{c} (Z - T)^{\beta \gamma} + \frac{\eta}{\varepsilon - 1} p_r^{1-\varepsilon} - E \quad \text{(Social Surplus)}
  \]

  s.t. \( B(Z - T)^{\beta \gamma - 1} = (1 - \tau_{m,e} - I)^{\varepsilon - 1} (1 + \tau_{c,e} + Z - I)^{-\varepsilon} \),

  \[
  \frac{1 + \tau_{c,a}}{1 - \tau_{m,a}} \geq \frac{1 + \tau_{c,e} + Z - I}{1 - \tau_{m,e} - I} \quad \text{(CMC)}
  \]

  Consequently, \( I^s \leq I^m \). (Similar proofs for \( \varepsilon \leq 1 \).)
Further Considerations

- The analysis provides some justification for government interventions on interchange pricing.
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- However, several additional issues may complicate the results.
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- However, several additional issues may complicate the results.
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