Price competition on a buyer-seller network

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Two consumers want to go to an Irish pub on the other side of a river. (Reservation value = 1)

The road network restricts where they can cross.
There are two bridges operated by different firms who simultaneously announce prices. (Bertrand competition).
Our main question:

What is the effect of the structure of the road network on pricing strategies and welfare?
Example: A Perfectly Competitive Road Network

Pricing Strategies: $P_1 = P_2 = 0$; Firm Profits: $\pi_1 = \pi_2 = 0$

Figure: (Plain-vanilla Bertrand competition)
Our main question:

Example: A Perfectly Monopolistic Network

Pricing Strategies: $P_1 = P_2 = 1$; Firm Profits: $\pi_1 = \pi_2 = 1$
Example: A Mixed Case

Our main question:

\[ F_1 \leftarrow C_1 \]

\[ \text{The Pub} \]

\[ F_2 \leftarrow C_2 \]
Our main question:

Example: A Mixed Case

- Pricing Strategies: Involve continuous mixing over common support \([\frac{1}{2}, 1]\); with an atom at \(P = 1\).
- Firm Profits: \(\pi_1 = 1; \pi_2 = \frac{1}{2}\)
What do we learn from the example?

Increasing a Firm 2’s access to consumers (adding links) might harm it by making pricing competition more aggressive.
Our main question:

What do we learn from the example?

Firm 1’s exclusive access to "locked-in" consumers limit her ability to profit for "mobile" consumers.
Our main question:

The model

- Take any exogenous network linking consumers and firms.
- Consumers have a log-concave (increasing elasticity) demand for good: $Q(P)$.
- Firms have constant marginal cost.
- Firms simultaneously announce prices; consumers buy from cheapest firm they are linked to.
Most results for two firms.

With two firms there are three types of consumers:

- $C_1$ is the number of consumers who can only buy from Firm 1.
- $C_2$ is the number of consumers who can only buy from Firm 2.
- $C_{1,2}$ is the number of consumers who can buy from both.
Possible applications of the model

- Competition over infrastructure networks: toll-ways on roads and sea-routes; water, electricity and natural gas distribution networks.
- Competition with constraints on technological compatibility.
- Differentiated consumer: brand-loyal vs price-seeking; partially informed vs fully informed.
Our main question:

Two firms: results for pricing strategies

Proposition

Let $\max\{C_1, C_2\} > 0$ and $C_{1,2} > 0$. Then the distributions $G_1(P)$ and $G_2(P)$ are the unique mixed strategy equilibrium.\(^a\)

\(^a\)The exact functional forms are given in the paper.

- There are no pure strategy equilibrium except for pure Bertrand network or the separate monopolists networks.
- Pricing involves mixing over a continuous support and atoms at the top.
- Pricing is complicated but welfare is not.
Our main question:

Two firms: comparative statics for welfare

Some facts:

- Aggregate surplus is maximized when firms charge marginal cost.
- Higher prices generate deadweight loss by crowding out consumers.
Our main question:

Two firms: comparative statics for welfare

**Proposition**

Take any network and fix the number of consumers. Then adding a previously non-existent link between a Firm and a Consumer decreases the pricing strategies in First Order Stochastic Dominance.

**Corollary**

Adding links increase the welfare for ALL consumers and increases aggregate surplus.
Our main question:

Two firms: comparative statics for welfare

**Proposition**

- Profits for the firm with more "locked-in" consumers weakly-decreases if you add links.
- Profits for the firm with fewer "locked-in" consumers might increase or decrease by adding links.
Our main question:

Which networks are likely to arise?

■ Suppose links can be added for free.

■ Consumers welfare always increases by adding links, therefore only the firm’s incentives to add links matter.

■ In the paper we study nash equilibria for entry games: start with a network and let firms add links.

■ In general, equilibrium network are neither fully disconnected nor have separate monopolies.

■ Equilibrium networks always have $C_2 + C_{1,2} = C_1$ or $C_1 + C_{1,2} = C_2$ (subject to integer constraints).
Conclusion

- We presented imperfect price competition. Firms have restricted access to consumers as modeled by a network structure.
- We solved for the unique mixed strategy in prices and analyzed welfare.
- We found that more connected networks increase welfare.
- We find stable networks are not fully connected nor fully disconnected. (Neither pure Bertrand nor pure monopolies).
Thank you for your time.

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Price Discrimination

- Both firms are worse-off if they are able to price-discriminate.
- But each firm would prefer to price discriminate if the other cannot.
- Not a prisoner’s dilemma.
Equilibrium Pricing Strategies

Corollary

Assume \( C_1 \geq C_2 \). The unique mixed strategy equilibrium for the duopoly network pricing game are:

\( F_1 \): "Stay out" with probability \( \left( 1 - \frac{C_2 + C_{1,2}}{C_1 + C_{1,2}} \right) \) by charging the monopoly price;

\( F_2 \): Always "go in": charge below \( p^M \) with probability 1.

Both: Conditional on going-in mix according to:

\[
\sigma_j(p|p < p^M) = 1 - \frac{C_1}{C_{1,2}} \left( 1 - \frac{Q^M p^M}{Q(p)p} \right)
\]