Inferring the strategy space from market outcomes

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Introduction

- Central issue in oligopoly is the identification of strategy space
- Competition in supply schedules (Klemperer and Meyer 1986 and 1989, Vives 2012, Menezes and Quiggin 2007, 2012, etc.).
- If any supply schedule is admissible, there is little definite that can be said.
  - Any market-clearing outcome where no firm makes negative profits can be supported as a Nash equilibrium (K&M, 1989)

Reducing multiplicity of equilibria

- Ex-ante approach: If demand is subject to additive shocks and supply curve defines an equilibrium for every possible value of the shock, a unique equilibrium emerges.
- Robson (1981): Linear supply curve, with slope and intercept as strategic variables + constant marginal cost = unique equilibrium is Bertrand.
- Turnbull (1983): With Quadratic costs, Robson's (1981) SFE = consistent CV of Bresnahan (1981).

Reducing multiplicity of equilibria

- K&M (1989) generalized these results to arbitrary one-dimensional manifolds in price--quantity space as supply schedules.
  - Constant marginal costs yields Bertrand as the unique equilibrium.

Ex post Approach

- Restrict the strategy space by assuming that the slope of the supply curve (β – **the competitiveness of the market**) is fixed
- Firms make strategic choices after observing shocks to demand
- Varying β yields a family of equilibria from Cournot ($\beta = 0$) to Bertrand ($\beta \to \infty$).

Our Approach (Cont'd)

- Linear supply schedules, linear demand curve is WLOG.
- Demand varies stochastically, and firms compete after the realization of demand shocks.
  - The strategy space may be inferred from market evidence.

Key ideas

- In equilibrium, each firm acts as a monopolist.
- Aggregating across firms, determine an equilibrium relationship between price and quantity for any realisation of the demand shock.
  - Equilibrium Locus (Also in Busse (2012) for Monopoly and symmetric Cournot).
- Back out the value of β or, more precisely, the value of β imputed by firms to their competitors.

Model

N firms, producing output with a convex, differentiable cost function:

$$\mathrm{c}(q_i), i = 1, \dots, N.$$

Inverse demand function:

$$p = a - b[q_1 + \cdots + q_N].$$

The strategic choice for firm i is a choice of linear supply schedules, parameterized by the strategic variable α_i:

$$q_i = \alpha_i + \beta \mathrm{p}.$$

Where α_i is a scalar representing upward or downward shifts in supply and $\beta \geq 0$ is an exogenous parameter reflecting the intensity of competition.

Model

- β is not a description of the way each firm regards its own supply decisions, but a description of how it perceives the strategic choices of others.
  - For any i, the vector α_{-i} representing the strategic choices of the other firms determines a residual demand curve.
- Given any perceived strategy space rich enough to allow the selection of any point on the residual demand curve, the firm's best response will yield the same equilibrium price and quantity.
  - This point was first made by Klemperer and Meyer (1986)

K&M (1986)

The equilibria are supported by each firm's choosing the strategic variable that its rival expects; although each firm sees its own choice between price and quantity as irrelevant, its choice is not irrelevant to its rival because the selection determines the residual demand that its rival faces.

Model (Cont'd)

- Given the market demand and the equilibrium strategies of other players, each firm picks a pair (p, q_i) from the residual (inverse) demand curve
  - The firm may conceive of itself as choosing a price, quantity, markup or any well behaved function of the market price and its own output quantity.
- The firm seeks to maximize profit, and therefore acts exactly like a monopolist faced with the same demand curve.

Inverse Residual demand

For the linear case

$$p = \theta_i - \gamma_i q_i, i = 1, \dots, N$$

Where

$$\theta_i = \frac{a - b \sum_{j \neq i} \alpha_j}{1 + b \sum_{j \neq i} \beta_j}$$

$$\gamma_i = \frac{b}{1 + b \sum_{j \neq i} \beta_j}$$

When $\beta_i = \beta, \forall i, \gamma_i = \gamma, \forall i$ and Firm *i's* profits:

$$pq_i - c(q_i) = \theta_i q_i - \gamma q_i^2 \quad - c(q_i).$$

FOCs

$$q_i = \frac{\theta_i - c\prime(q_i)}{2\gamma} \text{ and p} = \frac{\theta_i + c\prime(q_i)}{2}$$

Monopoly

We have $\theta = a, \gamma = b$ so that FOCs yield:

$$q^M = \frac{a - c\prime(q)}{2b}, p^M = \frac{a + c\prime(q)}{2}$$

If b is constant, we can replace $a = 2p^M - c'(q)$ into the expression for q^M the locus

$$q = \frac{p - c'(q)}{b}$$

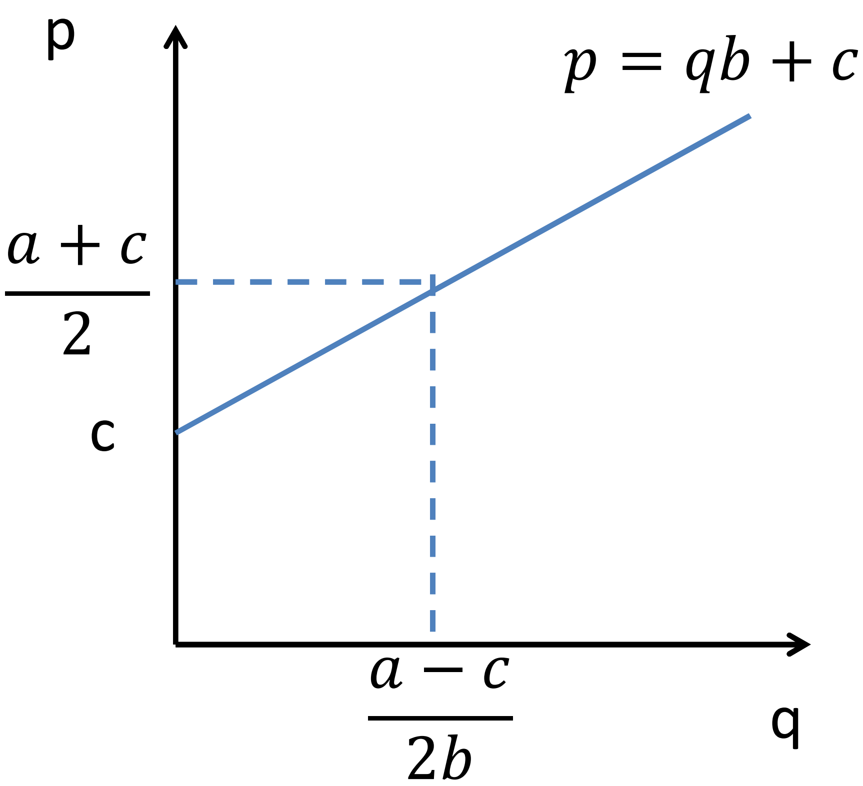
While if a is constant, it is straightforward to check that we obtain the locus

$$p = \frac{a + c'(q)}{2}$$

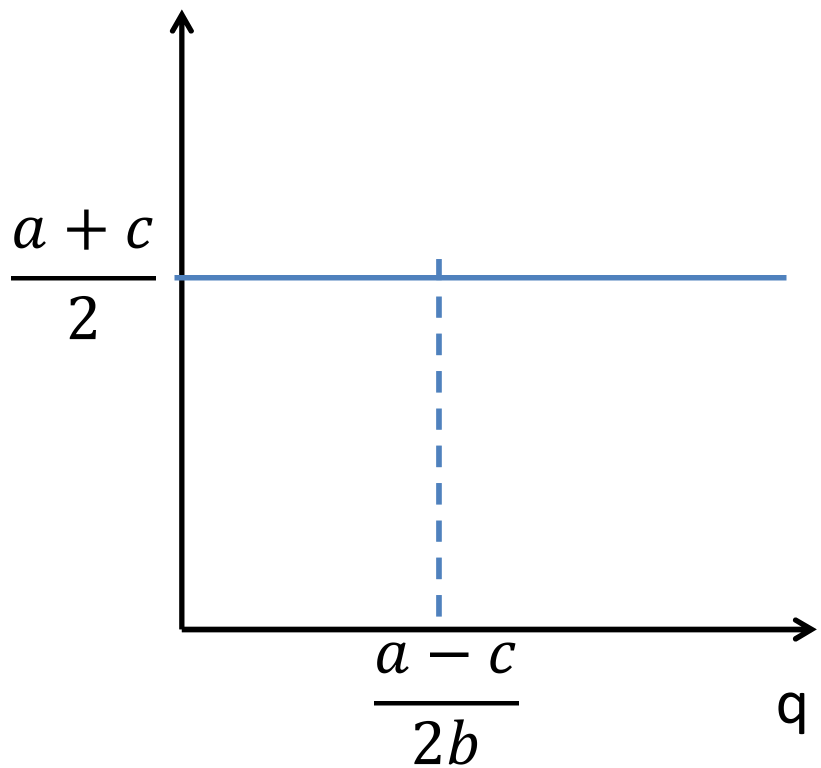
From now onwards: $c'(q) = c$

Monopoly (Cont'd)

b constant, additive a shocks



a constant, b shocks



Symmetric Oligopoly

If γ is constant, we can replace $\theta = 2p - c'(q)$ into the FOC for q to obtain the locus

$$p = c'(q) + \gamma q$$

while if θ is constant we obtain

$$p = \frac{\theta_i + c'(q_i)}{2}$$

From the expressions for θ and γ, in a symmetric equilibrium:

$$\theta = \frac{a - (N-1)b\alpha}{1 + (N-1)b\beta}, \gamma = \frac{b}{1 + (N-1)b\beta}, Q = Nq$$

When marginal costs are constant, and shocks are additive, we have:

$$p = c + \gamma \frac{Q}{N} = c + \frac{b}{(N + N(N-1)b\beta)} Q$$

Example

Cournot with constant marginal costs:

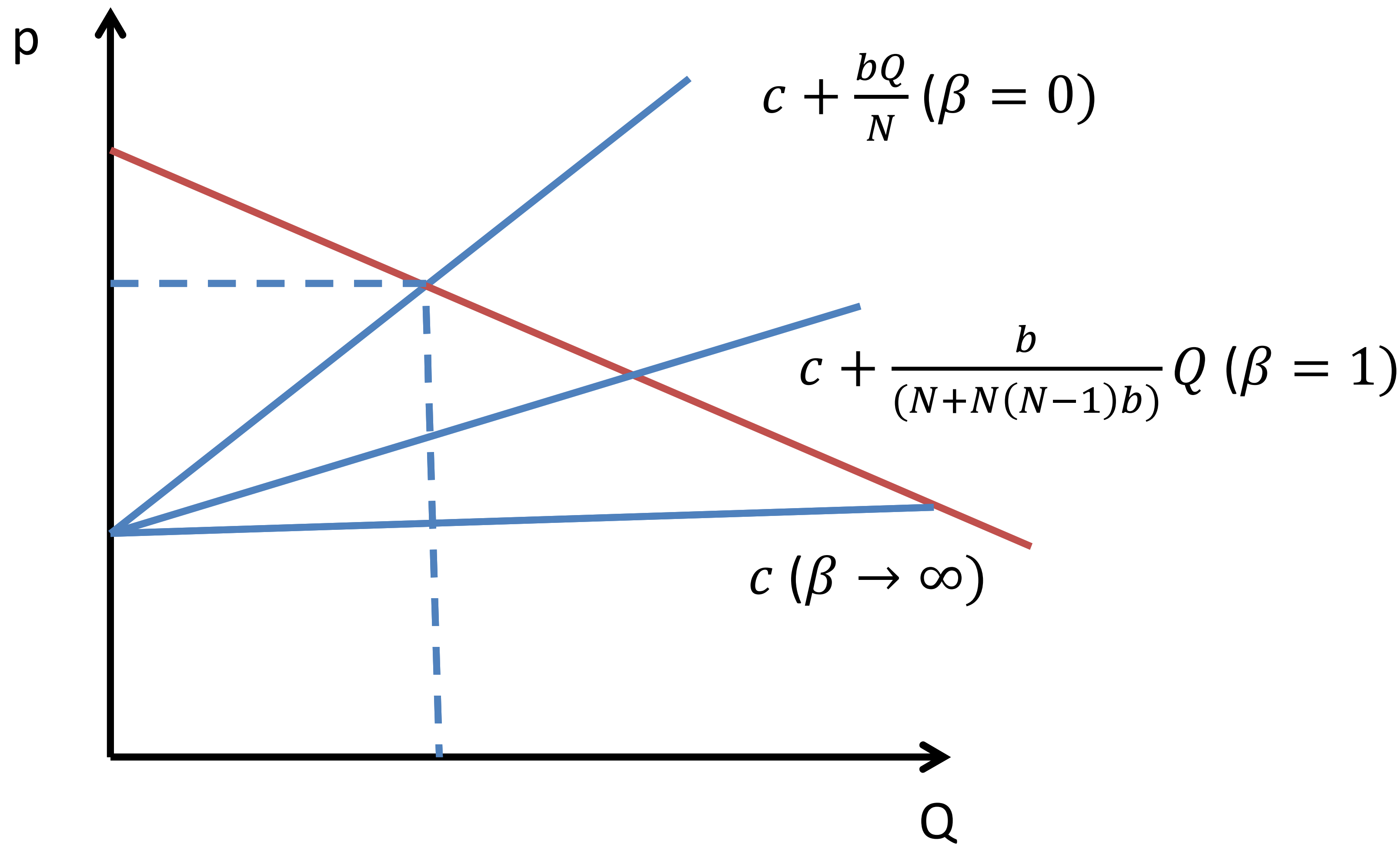
$$\gamma = b, \theta = a - (N-1)b\alpha$$

And so the case of additive shocks reduces to

$$Q = N\frac{(p-c)}{b}$$

By observing market outcomes (N, p , Q) and the realized value of shocks, estimate γ and θ to uncover the nature of competition (Cournot in this case) in a symmetric oligopoly.

Equilibrium locus for different values of Beta



Conclusion

- The problem of determining the strategy space is not unique to oligopoly.
  - E.g., the theory of contests (Menezes and Quiggin 2010):
- The equilibrium locus approach offers the possibility to recover the strategy space from observed outcomes.
- Particularly useful in the symmetric case
- More generally, numerical analysis can be undertaken to recover strategy from market outcomes