ENTRY AND DETERRENCE

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Core Industrial Organisation Course for
Postgraduate Certificate in Competition and Regulatory Policy

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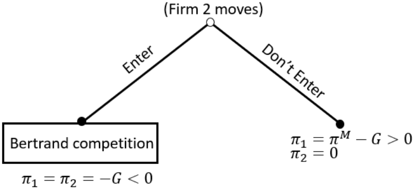
- **Questions:** If firms make positive profits in an oligopoly, why do more firms not enter an industry?
- **Questions:** Is there a relation between market size and concentration? (for this lecture we will focus on the number of firms)
    - In part, the answer depends on what happens if an entry takes place – what form of competition will ensue?
        - How brutal will be the ex post competition?
        - Are there any *sunk* costs of entry?
        - (what are *sunk* costs? are they given or do they change too depending on market size?)
    - In general, is there too little or too much entry?
        - (too little or too much compared to what?)
- **Questions:** Can incumbents take actions to discourage entry or minimize harm from it?
    - How? When? Can they take preemptive actions? Can they commit to those strategies?
    - What if they can't stop entry? What action can/do they take?
    - Do pre-entry strategies depend on type of post-entry competition?

- Entry and Concentration
  - Main issues – how many firms enter under free entry? Is there too much/too little entry? What is the relationship to market size?
    - Homogeneous Bertrand competition
    - Salop Circle - Differentiation w/ price competition
    - Cournot competition w/ Differentiated products
    - Endogenous entry costs
- Deterrence and Accommodation
  - Main issues – when/how do firms take actions to block, accommodate or deter entry? What is direct and indirect effect of incumbents actions?
    - A stylized model of entry
    - Commitment via Stackelberg model
    - Taxonomy of Business strategies
    - Applications
- Contestability and Signaling approach to deter (advanced lecture)

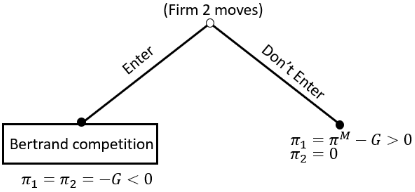
Part 1: Entry and Concentration

- Market concentration depends on, among other things, entry and exit
- Entry Barriers – are an important structural characteristic of an industry
- Bain (1956) pointed to three sources
    - Absolute cost advantage for the incumbent
    - Economies of scale
    - Product differentiation of incumbent firms (reputation, goodwill, political support)
- Other reasons we can include
    - Learning by incumbent firms
    - Brand loyalties
    - Lack of financing for startups
- A general result we will see in various models is that $\uparrow F \Rightarrow \uparrow$ concentration
- We will also focus on the relationship between market size and number of firms

- **Question:** How many firms will enter a homogenous product market when there is some sunk cost, and post entry firms compete in prices?
  - Sunk cost – all those entry costs that are not recoverable if a firm later chooses to exit the market (e.g., market analysis, licensing fees, legal costs, etc.)
  - Say there is an entry cost G and marginal cost c
  - An incumbent (firm 1) and potential entrant (firm 2)

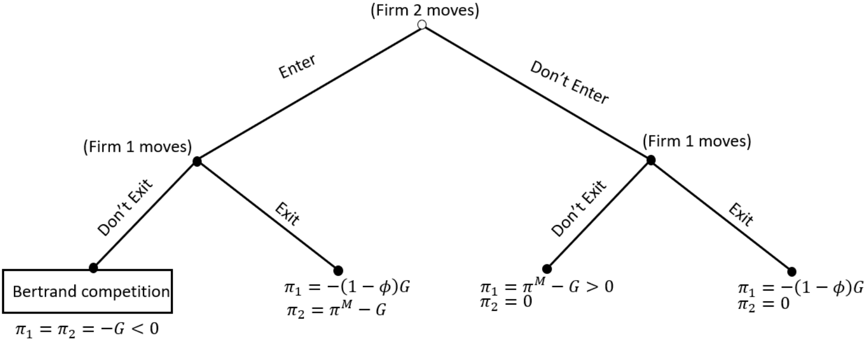


- If firm 2 enters, both make a loss equal to G
- If firm 2 stays out, incumbent charges a monopoly price and earns monopoly profit minus entry cost given by $\pi_1 = \pi^M - G$, and firm 2 continues to earn $\pi_2 = 0$

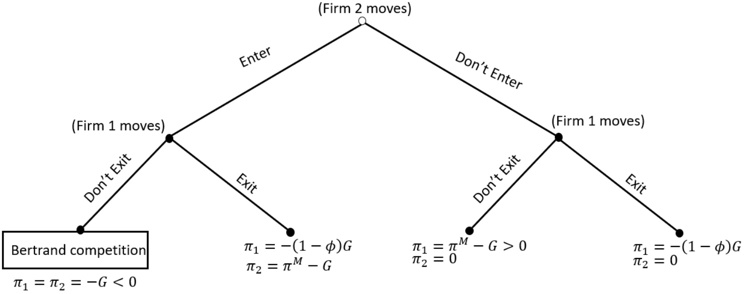


- **Result** – Unique Subgame perfect equilibrium where incumbent continues to make monopoly profit minus the entry cost G, and the entrant stays out
  - Entrant foresees that after entry, incumbent will switch to price equal to marginal cost pricing, hence in the first stage entrant will choose not to enter
  - This is a pretty stark result due to homogeneous products and firms competing in prices expost – here even a tiny bit of entry cost is enough to prevent entry
- From a social point of view, there is **too little entry**

- We can modify the game above to consider the possibility of an exit
- Suppose if a firm exits, it can recover part of the entry cost G
- A firm can recover ϕG, where $0 < \phi \leq 1$



- **Result:** A unique SPE is where firm 2 enters and firm 1 exits
  - If firm 2 does not enter (right), then NE is firm 1 does not exit
  - If firm 1 enters (left), then NE is for firm 1 to exit



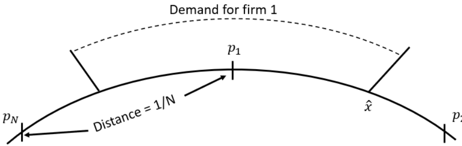
- Strong entry barriers
  - Market stays dominated by a single firm
  - One monopoly is replaced by another
  - Suppose we were to add one more stage to the game – firm 1 chooses to enter or not (not shown) – if in equilibrium it will exit, and can only recover part of the entry cost, it would not enter in the first place

- The post entry competition was in prices and products were homogeneous
  - The size of the market did not play a role here
  - We next look at a model with some product differentiation (but continue with price competition post entry)
- We consider entry in to the circular city/Salop circle – market size is fixed – and determine how many firms will enter in equilibrium
  - (Note: We already covered this model in an earlier lecture, so will skip or go over fast most of the following set up slides, and go straight to the results)

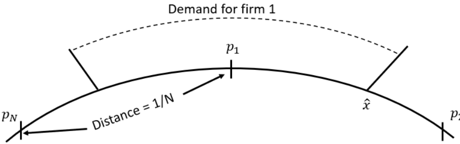
- Circular city of unit circumference
- Firms choose if they enter or not – cost is given by $cq_i + F$ where F is the fixed cost and c is the usual marginal cost
- If they enter, they place symmetrically around the circle of unit length 1
  - This model can also be given an interpretation that differs from a physical location interpretation – trains, planes and bus services provide round the clock services, so location on the unit circle can be interpreted as time of departure
- If N firms enter, the distance between any two firms is $1/N$
- Given entry (with maximal differentiation), firms set prices
- Endogenous entry – N firms choose to enter
- **Question:** How many firms will enter?

- If N firms enter, the distance between any two firms is $1/N$
  - Firms choose to enter and locate symmetrically around a unit circle
  - Marginal cost is c
  - For price p_i and quantity q_i, profit $\pi_i(q_i)$ of firm i is given by

$$\pi_i(q_i) = \begin{cases} (p_i - c)q_i - F & \text{if } q_i > 0 \\ 0 & \text{otherwise} \end{cases}$$



- Consumers are uniformly located around the unit circle
- Each firm competes with its nearest neighbour on the circle (left and right)
- Transportation cost τ is linear
- Demand for firm i
  - if firm 2 and firm N charge price $p_1 = p_n = p$, then firm 1's demand can be found by locating consumer that are indifferent between purchasing from firm 1 or its two neighbors the left/right
  - the indifferent consumer is located at $\hat{x}$ given by $p_1 + \tau\hat{x} = p\tau(1/N - \hat{x})$



  - Hence

$$\hat{x} = \frac{p - p_1}{2\tau} + \frac{1}{2N} \qquad \text{and} \qquad q_1(p_1, p) = 2\hat{x} = \frac{p - p_1}{\tau} + \frac{1}{N}$$

- Given p, each firm solves the problem

$$\max_{p_i} \pi_i(p_i, p) = p_i q_i - (cq_i + F) = (p_i - c)(\frac{p - p_1}{\tau} + \frac{1}{N}) - F$$

- The FOC give

$$(p - 2p_i + c)/\tau + 1/N = 0$$

- and with symmetric equilibrium where $p_i = p$, we get

$$p_i^* = c + \tau/N$$

- What is N in equilibrium?

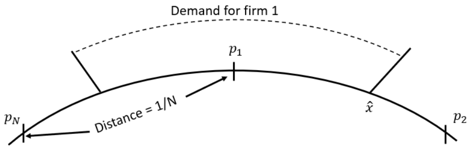
- To find equilibrium N set $\pi_i(p_i^*, p_i^*) = (p_i^* - c)\frac{1}{N} - F = 0$ and solve for N
- Hence

$$N^* = \sqrt{\frac{\tau}{F}}$$
$$p^* = c + \frac{\tau}{N^*} = c + \sqrt{\tau F}$$
$$q^* = \frac{1}{N^*}$$

- Higher transportation costs weakens price competition, increases price, and leads to higher entry
- **Fewer firms as F increases**
- Costs (skipping algebra ...)
  - cost of entry: $\sqrt{\tau/F}F = \sqrt{\tau F}$
  - transportation costs: $\tau/(4\sqrt{\tau/F}) = \frac{1}{4}\sqrt{\tau F}$
  - total: $\frac{5}{4}\sqrt{\tau F}$
- How does this compare to a social planner's problem (i.e., if we minimize the sum of entry and transportation costs)?

- From the forgoing calculations, a consumer buying from firm 1 is located 0 and $\hat{x}^* = 1/(2N)$ on each side of firm 1 – also, there are $2N$ such intervals, hence the total transportation costs with N firms were

$$T(N) = 2N\tau \int_0^{\frac{1}{2N}} x dx = \frac{\tau}{4N}$$



- A social planner would want to choose N so that the above cost plus the total entry cost $N \times F$ is minimized

$$\min_N NF + \frac{\tau}{4N}$$

- The FOC gives

$$N^*_{sp} = \frac{1}{2}\sqrt{\frac{\tau}{F}} = \frac{1}{2}N^*$$

- Thus, under free entry too many firms in equilibrium compared to socially optimal value

$$N_{sp}^* = \frac{1}{2} N^*$$

- Also, costs under social optimum are
    - cost of entry: $\frac{1}{2}\sqrt{\tau/F}F = \frac{1}{2}\sqrt{\tau F}$
    - transportation costs: $\tau/(4\sqrt{\tau/F})/2 = \frac{1}{2}\sqrt{\tau F}$
    - total: $\sqrt{\tau F}$
- Monopolistic competition circular city – **too many firms in equilibrium**

- Main findings
  - The model predicts that as fixed costs increase, there will be fewer firms in equilibrium ($\uparrow F \Rightarrow \downarrow N$)
  - Relative to a social planner's choice of number of firms, there will be too many firms in equilibrium $N^*_{sp} < N^*$
  - Note how this result differs from our initial model of Bertrand competition with no product differentiation where we found too little entry
- While the model allows for differentiation, market size is fixed (unit circle)
- We next look at a model where firms compete in quantity, products are differentiated, there is a fixed cost and a cost of entry, and we explicitly model size of the market
  - To analyze this, let's start with a given number of firms N, each facing $TC_i(q_i) = F + cq_i$ where F is the fixed cost, is the constant marginal cost and q_i is their output
  - If the products are slightly differentiated and firms engage in say Cournot competition, what are the equilibrium prices, profits etc.?

- Identical cost functions $TC_i(q_i) = F + cq_i$ across N firms
- Market size is S (number of consumers)
- Each consumer has a quasi-linear quadratic utility function (this gives us linear demand curves that are free of income effects)
- Products are differentiated
- Individual demand is[1]

$$p_i = \alpha - \frac{q_i}{S} - \frac{\gamma}{S} \sum_{j \neq i} q_j$$

- Firm profits given by

$$\pi_i = p_i(q_1, \ldots, q_N)q_i - c_i q_i - F$$

- Firms compete in quantities (Cournot game)

[1](Note: In an earlier lecture on differentiated duopoly, we used aggregate demand for each product as $p_i = \alpha - \beta q_i - \gamma q_j$ – it is similar to this case as the derivation is from a representative consumer's utility function with $\beta = 1$ and γ being a measure of product differentiation)

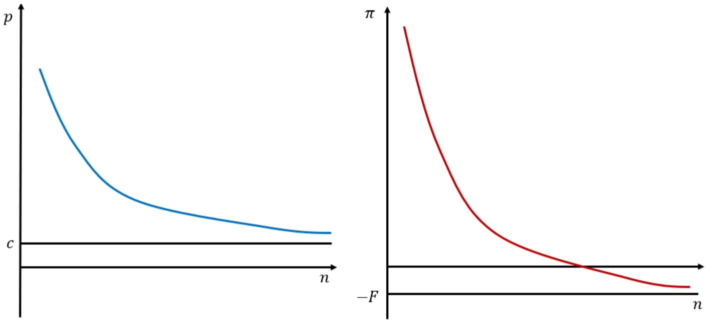
- Equilibrium (algebra skipped) under symmetry where all firms produce the same quantity

$$q^* = S(\alpha - c) \times \left[\frac{1}{2 + (N-1)\gamma}\right]$$
$$p^* = \left[\frac{1}{2 + (N-1)\gamma}\right]\alpha + \left[1 - \frac{1}{2 + (N-1)\gamma}\right]c$$
$$\pi^* = S(\alpha - c)^2 \times \left[\frac{1}{2 + (N-1)\gamma}\right] - F$$

(note: $\gamma = 1$ means homogeneous products, i.e., perfect substitutes, and $\gamma = 0$ means they are unrelated products)

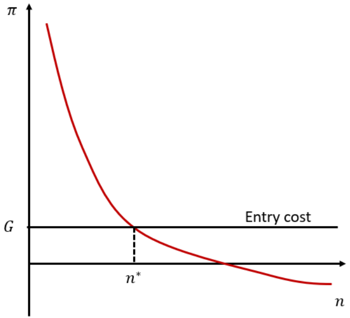
- What happens as N increases?

- What happens as N increases? Main conclusion
  - price p and price-cost margins $(p - c)$ fall
  - output per firm q falls (but $Q = N \times q$ increases)
  - profits π fall



- How many firms will enter in equilibrium?

$$\pi^* = S(\alpha - c)^2 \times \left[\frac{1}{2 + (N-1)\gamma}\right] - F$$



- Say there is an entry cost of G
- Firms will enter until profits are zero
- Entry condition: $\pi^* = G$
- Solve for N

$$N^* = \frac{\alpha - c}{\gamma}\sqrt{\frac{S}{F+G}} - \left(\frac{2-\gamma}{\gamma}\right)$$

- How many firms will enter in equilibrium?

$$N^* = \frac{\alpha - c}{\gamma}\sqrt{\frac{S}{F+G}} - \left(\frac{2-\gamma}{\gamma}\right)$$

- Answer depends on
  - market size – as S increases, so does N, and without bound
    (but not proportionally but rater in the square root of S
    if S doubles, number of firms will not double – as firms increase $(p - c)$ decreases, and hence each firm needs a larger share of the market to cover their fixed costs)
  - economies of scale – higher fixed costs F, fewer firms
  - entry barriers (entry costs) – higher entry costs G, fewer firms
  - product differentiation - as γ increase towards 1 i.e., perfect substitutes, fewer firms
    (if product differentiation is reduced, each firm makes less profit, but in equilibrium then will have fewer firms)

- In the model above, few firms in equilibrium with higher fixed costs or entry costs
- Firms also increase with market size (without bound)
  - As market size increases, additional firms would gain enough profit to cover the any sunk and fixed costs and industry concentration would reduce
  - These models predict that as market size increases, measures such as HHI or n-firm concentration ratios C_n would decrease
  - (*important caveat: sunk costs are exogenous and not growing with market size*)
- ***General lesson****: In industries with exogenous sunk costs, industry concentration decreases and approaches zero as market size grows*

- Relative to a social planners problem, too much or too little entry?
- Social planner chooses N to maximize total welfare $CS + \pi$
- Trade offs with more entry
  - more products, more variety, more competition
  - but total fixed costs (F) increase as well as entry costs (G) incurred
- Under Cournot competition, as more firms enter prices fall little (not much increase in competition as small decrease in price and increase in output) – so relatively small increase in CS
- Firm mostly steal from each other
- Thus, from a social planners view, there is **too much entry**
  (the result is driven by business-stealing effect)

- Relative to a social planners problem, too much or too little entry?
- Thus, from a social planners view, there is **too much entry** in this model (recall we had a similar result in the Salop circle considered in an earlier lecture)
- For an alternative model with too little entry, see Belleflamme and Peitz (section 4.2.4)
- What about under Bertrand competition?
  - Then we can potentially have **too little** entry
  - In the extreme case of homogeneous products, If F and G are positive then only one firm may enter
  - With small enough entry and fixed costs, entry decreases dead weight loss
- ***General lesson****: In models of monopolistic competition, the market may generate too much or too little entry – much depends on if the entrant can appropriate the surplus generated by an additional differentiated product*

- So far exogenous sunk costs – now we consider when sunk costs are endogenous
- Motivation – earlier results imply that number of firms increase with market size, albeit not proportionately, but we don't always observe that
  - US population is about 32 times larger than Portugal (328m vs. 10.3m) but there are three main producers of beer in the US (Anhauser Bush, Miller and Coors) and two in Portugal (Centralcer, Unicer)
  - In the Cournout model, firms increase in the square root of market size, so perhaps should expect 5.6 times more beer sellers in the US
  - Perhaps should not be relying on the Cournout model (for instance, in Bertrand, firms do not grow in some proportion to market size)

- Industries that are large and concentrated are often R&D and advertising intensive
- R&D and advertising increase with market size
  - Firm choose how much adverting or R&D to do
  - They have bigger return on this investment in larger markets and hence may undertake more of it
  - Thus entry cost increase in market size ($G(S)$ and $G' > 0$)
- Shaked and Sutton (JIE, 1987)
  - Firms compete in prices and R&D or Advertising
  - There is an upper limit on number of firms as market size grows
- Sutton (1991) (or see Belleflamme and Peitz, 4.3)
  - Three stage model - (1) entry, (2) choose quality, (3) compete in quantity
  - Upper limit on number of firms as market size grows
- ***General lesson**: In markets with endogenous sunk costs, even as the size of market grows, there is a strict upper bound on the equilibrium number of firms*

Part 2: Entry Deterrence and Accommodation

- We now discuss the case where an incumbent is facing the prospect of entry, and entry cost is not so high that it is **blocked**
- In these cases, the entrant can take preemptive actions that either deter the potential entrant from entering, or if that is not possible, then take actions to minimize the harm from entry
- In the first case, entry is said to be **deterred** and in the latter case we refer to it as being **accommodated**

- Another important aspect here is **credibility** and **commitment**
  - Suppose an incumbent can threaten a firm seeking entry, that if it were to enter, it would act so aggressively post entry that it would lead to a significant loss for the entrant
    - a branded pharma firm tells a generic potential entrant that if it were to invalidate their patent and enter, the branded firm would launch it's own generic which could wipe out any profits the generic hopes to get
  - But what if upon entry, executing that threat also meant that the incumbent would make a loss, but not executing the threat would mean just lower profits? (or low profits in first case, and less low profits if threat is not carried out)
    - what if triopoly profits, even if the originator owns the psuedo-generic, are worse than duopoly profits?
  - In that case, we would say the threat is *not credible* because a rational incumbent would not carry it out – and hence the entrant would enter
    - Alternatively, it could also be that the threat is *credible* – because first mover advantages in the generic segment are very strong
  - But what if the incumbent can *commit* to this threat?
    - the patent holding drug manufacturer makes a legally binding deal with another generic that if someone later on invalidates their patent, they would authorize the first generic to enter under their licence

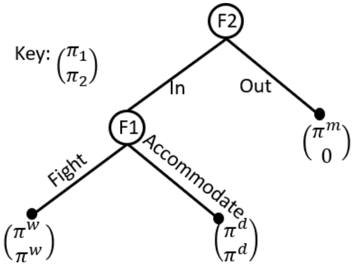
- We first look at commitment/credibilit via a simple stylized game
- We then work out a 2 stage leader/follower Stackelberg model where an incumbent can invest in capacity, followed by quantity setting competition in stage two
  - The model highlights the idea of commitment
  - It also introduces deterrence, accommodation and blocked entry
- We will than look at a more general taxonomy of business strategies when incumbent's actions increase/decrease entrants profits and if the second stage competition is in prices or quantities

- Incumbent (firm 1) facing potential entrant (firm 2)
- Entrant can choose to stay out (Out) or enter (In) – if so, payoffs are given by $(\pi_1, \pi_2) = (\pi^m, 0)$ (i.e., monopoly profit for incumbent and zero for potential entrant)
- If firm 2 enters, incumbent can fight or accommodate
- Incumbent threatens that it will fight – is this credible?
  - payoffs if fight: (π^w, π^w)
  - payoffs if accommodate: (π^d, π^d)
- Suppose payoffs such that $\pi^m > \pi^d > 0 > \pi^w$
- Normal form game is as follows

		Firm 2	
		In	Out
Firm 1	Accomodate	$(\boldsymbol{\pi^d}, \boldsymbol{\pi^d})$	$(\pi^m, 0)$
	Fight	(π^w, π^w)	$(\boldsymbol{\pi^m}, \mathbf{0})$

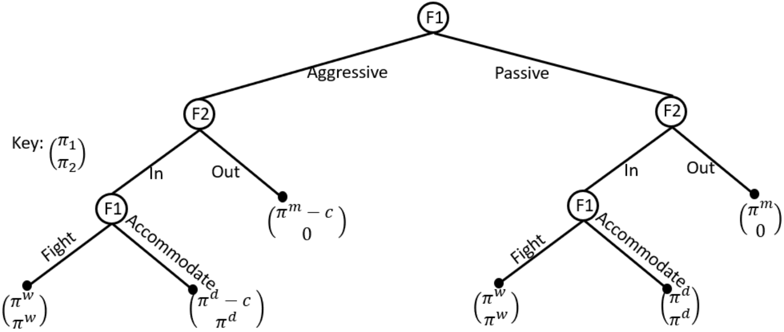
- Two Nash equilibria: (Accommodate, In) and (Fight,Out) (but this is not subgame perfect)

- The extensive form game is as shown in the tree below



  - Solving backwards, since $\pi^d > \pi^w$, incumbents profits are higher if it accommodates rather than fights if entry takes place
  - Thus incumbents threat is *incredible*
  - Knowing this, firm 2 would choose 'In' over 'out'
- Unique subgame perfect Nash equilibrim (SPNE) is (Accommodate, In)

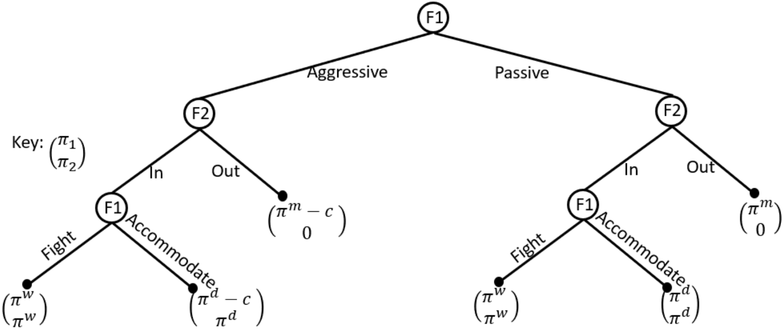
- Commitment and entry deterrence
  - Suppose the incumbent can commit to fighting – fighting costs c and it pays for it before entrant enters (advertising, capacity etc.)
  - Let $\pi^w > \pi^d - c$ and $\pi^m - c > \pi^d$ then threat is credible
  - Subgame perfect equilibrium strategies for F1 is (Aggressive, Fight if entry) and for F2 is (Out)



Deterrence & Accommodation

A Stylized Entry Game

- If either of $\pi^w > \pi^d - c$ and $\pi^m - c > \pi^d$ is not true then equilibrium is F1 is (Passive, Accommodate if entry) and for F2 is (In)



- We now want to consider a simple two stage game of quantity choice and see that the first mover can take steps to keep the second mover less active
- In this model the incumbent can take steps, i.e., invest in capacity, to keep the second mover less active
- The model is essentially a sequential Cournot quantity setting game (i.e., a Stackelberg game) where the incumbent *commits* to a certain quantity by investing in capacity in the first stage – this sets the choices for the incumbent in the second stage
- Along the way we consider two cases
    - **Accommodate entry** – if entry cannot be stopped, then make it small
    - **Deter entry** – take actions so that potential entrant cannot enter
- Whether the incumbent accommodates or deters will depend on the fixed cost/cost of entry

- Two firms, Firm 1 incumbent, firm 2 entrant/follower
- Firm i chooses level of capital K_i (how much to invest)
- Firm 1 moves first. Firm 2 after observing K_1, chooses what quantity to set (i.e how much to invest)
- Profit functions are given by

$$\Pi_i(K_1, K_2) = K_i(1 - K_1 - K_2)$$

- Note that each firm dislikes capital accumulation by the other; $d\Pi_i/dK_j < 0$
- Capital levels are strategic substitutes; $d^2\Pi_i/dK_j dK_i < 0$

- **Result:** Assume there is no cost of entry for firm 2 – then in the unique subgame perfect equilibrium of the two stage game, we get the following results
  - a) The first mover chooses a higher level of capital and obtains higher profits than in Nash equilibrium if both firms were to move simultaneously
  - b) The first mover acts in such a manner that the second mover does enter the market (produces a positive quantity)
- In this case, firm 1 limits entry but does not actually deter it

- We use Backward induction to solve the game – firm 1 will pick K_1 by anticipating 2's response in stage 2, so we start by finding $\widetilde{K}_2(K_1)$

- *Step 1* Keeping fixed K_1, firm 2 picks K_2 to maximize $K_2(1 - K_1 - K_2)$. Firm 2's optimal quantity given K_1 satisfies FOC, i.e.

$$1 - K_1 - 2K_2 = 0$$

which rewrites as

$$K_2 = \frac{1 - K_1}{2}$$

- *Step 2* Firm 1 picks K_1 by taking into account 2's reaction function

$$\widetilde{K}_2(K_1) = \frac{1 - K_1}{2}$$

So it maximizes

$$\begin{aligned} & K_1(1 - K_1 - \widetilde{K}_2(K_1)) \\ = \quad & K_1(1 - K_1 - \frac{1 - K_1}{2}) \end{aligned}$$

Now, taking FOCs of the above, we obtain $K_1 = \frac{1}{2}$
Substituting back into the earlier equations, we can then find that

$$K_1 = \frac{1}{2} \qquad K_2 = \frac{1}{4}$$
$$\Pi_1 = \frac{1}{8} \qquad \Pi_2 = \frac{1}{16}$$

- We see that despite being identical, firms behave differently in equilibrium
  - Firm 1 makes more profit than 2 (first mover advantage)
  - Firm 1 sets an "artificially high" quantity in stage and thereby profitably discourages firm 2's capital investment in stage 2
- *Step 3* Let us check the outcome if firms move simultaneously
  - An equilibrium is given by a profile (K_1, K_2) s.t. each firm is maximizing profits given the equilibrium investment of the other – we thus solve the system of best responses:

$$K_1 = \frac{1 - K_2}{2} \qquad K_2 = \frac{1 - K_1}{2}$$

    We obtain

$$K_1 = K_2 = \frac{1}{3}$$
$$\Pi_1 = \Pi_2 = \frac{1}{9}$$

  - Note that firms have converged to identical quantities, that are located the two quantities chosen in the Cournot game – the same thing goes for profits

- What is at play here? Why are the identified equilibria of our game different?
- There are two aspects:
  - a) investments are strategic substitutes
  - b) commitment: each firm has a commitment problem under simultaneous moves
- Each firm i would benefit if the other firm j invested less – but this would only happen if j's marginal value of investing were lower, which requires that i invests more. But i cannot commit to that in the simultaneous move game
- In the Stackelberg game, by acting first and in a non-reversible manner, firm 1 gains the ability to strategically increase its investment in order to deter investment by the other
  - Note that in the Stackelberg game, firm 1 would want to invest less ex post
  - Given $K_2 = \frac{1}{4}$, it would want to invest $K_1 = \frac{3}{8}$ instead of $\frac{1}{2}$!
  - But it cannot, investment being irreversible!
  - That's exactly the meaning of commitment!

- We will now show that if we slightly change the cost function and keep the dynamic nature of the game, then we obtain entry deterrence instead of accommodation
- We add an assumption of increasing returns to scale
- Assume that the profit function of firm 2 is

$$\Pi_2(K_1, K_2) = \begin{cases} K_2(1 - K_1 - K_2) - F & \text{if } K_2 > 0 \\ 0 & \text{otherwise} \end{cases}$$

- The new element is the 'cost of entry' F incurred by entrant only
- **Result:** Let $F \in (0, \frac{1}{16})$ and suppose If F is sufficiently close to $\frac{1}{16}$, then
  - In the unique subgame perfect equilibrium of the two stage game, the first mover (firm 1) acts in such a manner that the second mover does not invest (i.e. does not enter the market) – firm 1 deters entry

- To solve, we consider Firm 1's options
  - Either set a quantity that does not deter entry
  - Or set a quantity that deters entry
- We can compare the profit of each option, conditional on that option being "executed" optimally, i.e., by picking the optimal quantity that yields the corresponding objective (deter entry or not)
- We first consider the option of not deterring entry
  - Conditional on not deterring entry by 2, the optimal K_1 is $\frac{1}{2}$ as in the original Stackelberg game
  - Given this, firm 2 chooses $K_2 = \frac{1}{4}$ (as in the original game)
  - It is immediate that F does not affect quantity setting by 2, if it enters
  - In this scenario, firm 1 obtains a profit of $\frac{1}{8}$

- We now consider the option of deterring entry
- If firm 1 chooses this option, it chooses the minimal level of K_1 s.t. firm 2 stays OUT – denote this level by K_1^d
- So K_1^d satisfies:

$$\max_{K_2 \geq 0} \left\{ K_2(1 - K_1^d - K_2) - F \right\} = 0$$

- From the above, we obtain

$$K_1^d = 1 - 2\sqrt{F} > \frac{1}{2}$$

- K_1^d yields firm 1 profits of

$$\begin{aligned} \Pi_1 &= \left(1 - 2\sqrt{F}\right)\left(1 - \left(1 - 2\sqrt{F}\right)\right) \\ &= 2\sqrt{F}\left(1 - 2\sqrt{F}\right) \end{aligned}$$

- Note that if F is close to $\frac{1}{16}$, this profit exceeds $\frac{1}{8}$ (obtained if 'optimally not deterring')

- **Summary of results** – strategy depends on size of fixed cost of entry F
- If $F << \frac{1}{16}$ (i.e. very small), incumbent prefers to accommodate entry
- If $F \approx \frac{1}{16}$ firm 1 can increase profits by deterring entry
- If $F > \frac{1}{16}$ entry is blocked – Firm blocks entry by choosing its monopoly capacity

- An incumbent could use a variety of methods to limit or deter entry by the potential entrant
- Raising the rival's cost
  - This could be done by for example lobbying the government to increase its taxation of the potential entrant – if the entrant is a foreign firm, then higher tariffs would be one way
  - Sometimes, pushing for legislation (e.g. higher wages) that increases others' costs also implies own increased costs – but it may still be worth it
- Brand proliferation
  - Existing businesses on a given market may decide to artifially inflate its product range in order to keep other firms out
  - The product line expansion is artificial to the extent that the incumbent firm would not be offering such a wide product range if there were no potential competitors
  - A smaller product range would yield higher profits, in such a case
  - So the only motivation is to fill any niche that a potential entrant might pick
  - Example: Breakfast cereals industry in the US from the 40s to the 70s
  - Pharmaceuticals – launch additional presentations before end of exclusivity and shift patients to newer variants

- Bundling
  - Suppose there are two goods being sold, good A and B
  - There is an incumbent who produces both goods and is a monopoly on A
  - On market B, another firm considers entering
  - The monopolist might decide to bundle both goods and thereby keep the entrant out of B
  - The idea is that if consumers now want A, they have to buy the bundle (which also contains B) – leaving no demand for the potential entrant on market B
  - Effectively, the incumbent is leveraging its market power on market A in order to maintain its market power on market B
- Example of bundling: Microsoft using its monopoly of PC operating systems in order to increase its market share on the market for Media content software (Windows media player)
  - What Microsoft did was to bundle the PC operating system and Windows media player

- We now turn to a more general setting, i.e., without relying on specific functional forms, and without relying on specific form of competition to list out the effect of incumber actions and various strategies

- Two period, two firm game
  - In period 1, firm 1 choose some investment level K_1 – could be capacity, advertising, investing in brand loyalty programs, product proliferation etc.
  - The potential entrant, firm 2, observes this investment, and then decides whether to enter or not
- If firm 2 does not enter, the incumbent enjoys a monopoly profit of $\Pi_1^m(K_1, x_1^m(K_1))$ and takes it's second period action $x_1^m(K_1)$ based on the investment K_1 in period 1
  - Note that x_1 can represent any strategic variable in period 2, for instance it could be price or the quantity that the monopolist sets based on its first period choice of K_1
  - Note that choice of K_1 can effect the second period monopoly profits directly – for instance advertising, hence it enters the profit function directly – as well as through the choice the firm makes about x_1 based on the value of K_1 (for instance, quantity given level of capacity)

- If firm 2 enters, then a duopoly ensues – firms make simultaneous choices of $x_1(K_1)$ and $x_2(K_1)$ and earn profits

$$\text{firm 1:} \qquad \Pi_1(K_1, x_1^*(K_1), x_2^*(K_1))$$
$$\text{firm 2:} \qquad \Pi_2(K_1, x_1^*(K_1), x_2^*(K_1))$$

  - Note that $x_1^*(K_1)$ and $x_2^*(K_1)$ are Nash equilibrium values of these strategic variables (and the equilibrium exists and is unique by assumption, i.e., we will be restricting ourselves to models where that is so)
  - If firm 2 incurs any entry costs, they are part of the profit listed above

- A strategic incumbent chooses K_1 such that it either deters entry, or accommodate it in the least harmful way to itself
- Wether it accommodates or deters depends on which of the two leads to higher profit (deterrence may very expensive)
  - Entry is **deterred** if K_1 chosen so that entrants profits are not positive

$$\text{firm 2:} \qquad \Pi_2(K_1, x_1^*(K_1), x_2^*(K_1)) \leq 0$$

  - Entry is **accommodated** if K_1 chosen so that entrants profits are positive

$$\text{firm 2:} \qquad \Pi_2(K_1, x_1^*(K_1), x_2^*(K_1)) > 0$$

  where incumbent chooses K_1 so as to maximize its own profit $\Pi_1(K_1, x_1^*(K_1), x_2^*(K_1))$

Entry Deterrence

- Suppose there was no threat of entry – then monopolist would choose some level of K_1^m that maximizes its second period profits
- Now suppose there are some potential entrants, but the monopoly choice of K_1^m leads to negative profits for the entrant – then in that case we say entry is **blocked**
- We study the case when entry is not blocked, and incumbent has to distort away from the optimal monopoly level K_1^m
- Distortion is costly – in the absence of threat of entry, a monopolist would choose K_1^m, and deviation from that level would only lower incumbents profits
- Thus, incumbent would choose K_1 just sufficient to deter entry, i.e., choose K_1 such that

$$\Pi_2(K_1, x_1^*(K_1), x_2^*(K_1)) = 0$$

- Thus, incumbent would choose K_1 just sufficient to deter entry, i.e., choose K_1 such that

$$\Pi_2(K_1, x_1^*(K_1), x_2^*(K_1)) = 0$$

- Which direction would K_1 distort towards – compute the impact of change of K_1 on the *entrant's* profit – take total derivative with respect to K_1

$$\frac{d\Pi_2}{dK_1} = \underbrace{\frac{\partial \Pi_2}{\partial K_1}}_{\text{direct effect}} + \underbrace{\frac{\partial \Pi_2}{\partial x_1}\frac{dx_1^*(K_1)}{dK_1}}_{\text{strategic effect (sed)}} + \underbrace{\frac{\partial \Pi_2}{\partial x_2}\frac{dx_2^*(K_1)}{dK_1}}_{=0}$$

  - Third term is zero (envelope theorem)
  - **Direct effect** of K_1 on firm 2's profits – could be zero (for instance if K_1 is capacity) or positive or negative if advertisement (for instance informative or persuasive advertisements)
  - **Strategic effect** of K_1 is via second period (optimal) choice of x_1 by firm 1 (so $dx_1^*(K_1)/dK_1$) in proportion to firm 2's profit being affected by x_1 (so $\partial\Pi_2/\partial x_1$)

- Under entry deterrence, objective is to reduce the entrants profits to zero – the incumbent wants to look aggressive
- An investment K_1 makes the incumbent
  - **tough** if $\frac{d\Pi_2}{dK_1} < 0$
  - **soft** if $\frac{d\Pi_2}{dK_1} > 0$
- 'top dog' – if the total effect of investment is to reduce the entrants profit, then firm should **overinvest**
- 'lean and hungry look' – if the total effect of investment is to increase the entrants profit, then firm should **underinvest**
- Over or under investment is relative to when firm 2 cannot observe K_1 prior to entry
- Capacity investment example
  - Investment in capacity does not effect entrants profits directly, but makes incumbent increase output (produce more) in period 2, more output by incumbent in period 2 reduces entrants profits and investment makes incumbent tough, thus over invest to deter entry

- Terminology
  - **tough** if $\frac{d\Pi_2}{dK_1} < 0$
  - **soft** if $\frac{d\Pi_2}{dK_1} > 0$

  - **top dog**: be big or strong to look tough or aggressive
  - **puppy dog**: be small or weak to look soft or passive
  - **lean and hungry**: small or weak to look tough or aggressive
  - **fat cat**: be big or strong to look soft or passive

- Suppose now that deterrence is too costly and so the incumbent decides to accommodate entry – meaning account for entry to take place but choose K_1 so as to maximize own profit

- The difference here is that now firm 1 takes $\Pi_2(K_1, x_1^*(K_1), x_2^*(K_1)) > 0$ as given, and choose K_1 so as to maximize $\Pi_1(K_1, x_1^*(K_1), x_2^*(K_1))$

- So instead of incumbent focusing on how K_1 changes Π_2 (as was the case in deterrence), it now focuses on how it changes Π_1

- Thus,

$$\frac{d\Pi_1}{dK_1} = \underbrace{\frac{\partial \Pi_1}{\partial K_1}}_{\text{direct effect}} + \underbrace{\frac{\partial \Pi_1}{\partial x_1}\frac{dx_1^*(k_1)}{dK_1}}_{=0} + \underbrace{\frac{\partial \Pi_1}{\partial x_2}\frac{dx_2^*(K_1)}{dK_1}}_{\text{strategic effect (sea)}}$$

- Decision by incumber to *over or under invest* depends on if increase in K_1 increases or decreases own profit, i.e., sign of $d\Pi_1/dK_1$

$$\frac{d\Pi_1}{dK_1} = \frac{\partial \Pi_1}{\partial K_1} + \frac{\partial \Pi_1}{\partial x_2}\frac{dx_2^*(K_1)}{dK_1}$$

- For the issue of over and under investment under accommodation, the direct effect $\frac{\partial \Pi_1}{\partial K_1}$ does not matter – why? because even if there was no other firm, the direct effect would be the same under profit maximization
- Strategic effect matters and originates from entrants post entry optimal value of x_2^* in response to K_1 (i.e., the term $\frac{dx_2^*(K_1)}{dK_1}$) and in proportion to firm 1's profit being affected by x_2
- What determines the sign of the strategic effect under accommodation (sea)? i.e., sign($\frac{\partial \Pi_1}{\partial x_2}\frac{dx_2^*(K_1)}{dK_1}$)

- Sign of the strategic effect under accommodation (sea) ... $\frac{\partial \Pi_1}{\partial x_2} \frac{dx_2^*(K_1)}{dK_1}$
- Suppose the sign of the cross-effect $\frac{\partial \Pi_i}{\partial x_j}$ is same for both firms, i.e., second period choices have the same effect on competitor's profits
    - $\text{sign}(\frac{\partial \Pi_1}{\partial x_2}) = \text{sign}(\frac{\partial \Pi_2}{\partial x_1}) > 0$; second period competition in prices
    - $\text{sign}(\frac{\partial \Pi_1}{\partial x_2}) = \text{sign}(\frac{\partial \Pi_2}{\partial x_1}) < 0$; second period competition in quantities
    - so that

$$\text{sign}\left(\frac{\partial \Pi_1}{\partial x_2} \frac{dx_2^*(K_1)}{dK_1}\right) = \text{sign}\left(\frac{\partial \Pi_2}{\partial x_1} \frac{dx_2^*(K_1)}{dK_1}\right)$$

- Also note that by chain rule

$$\frac{dx_2^*(K_1)}{dK_1} = \frac{dx_2^*(K_1)}{dx_1} \frac{dx_1^*}{dK_1}$$

- Sign of the strategic effect under accommodation (sea) ... $\frac{\partial \Pi_1}{\partial x_2} \frac{dx_2^*(K_1)}{dK_1}$
- If we combine the terms from above we get

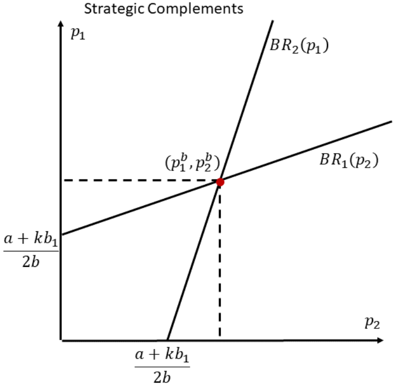
$$\underbrace{\text{sign}\left(\frac{\partial \Pi_1}{\partial x_2} \frac{dx_2^*(K_1)}{dK_1}\right)}_{\text{strategic effect (sea)}} = \underbrace{\text{sign}\left(\frac{\partial \Pi_2}{\partial x_1} \frac{dx_1^*(K_1)}{dK_1}\right)}_{\text{strategic effect (sed)}} \times \underbrace{\text{sign}\left(\frac{dx_2^*(K_1)}{dx_1}\right)}_{\text{slope reaction fn}}$$

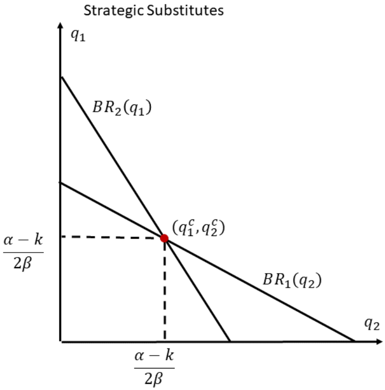
- Sign of the strategic effect under accommodation depends on the sign of the strategic effect under entry deterrence – does investment make incumbent **tough** (-ve slope) or **soft** (+ve slope) – and the sign of firm 2's reaction function, i.e., if it is **upward** or **downward** sloping – in turn, this will determine if the incumbent under or over invests

- Recall from an earlier lecture strategic complements and substitutes dx_i/dx_j

- **upward sloping BR functions (strategic complements)**
- second period competition in prices

- **downward sloping BR functions (strategic substitutes)**
- second period competition in quantities





- Sign of the strategic effect under accommodation depends on the sign of the strategic effect under entry deterrence – does investment make incumbent **tough** (-ve slope) or **soft** (+ve slope) – and the sign of firm 2's reaction function, i.e., if it is **upward** or **downward** sloping – in turn, this will determine if the incumbent under or over invests

$$\text{sign}\,\underbrace{\left(\frac{\partial \Pi_1}{\partial x_2}\frac{dx_2^*(K_1)}{dK_1}\right)}_{\text{strategic effect (sea)}} = \text{sign}\,\underbrace{\left(\frac{\partial \Pi_2}{\partial x_1}\frac{dx_1^*(K_1)}{dK_1}\right)}_{\text{strategic effect (sed)}} \times \text{sign}\,\underbrace{\left(\frac{dx_2^*(K_1)}{dx_1}\right)}_{\text{slope reaction fn}}$$

- Four cases under entry accommodation
  - Tough (-ve) & Strategic Comp (+ve) $\rightarrow$ SEA -ve, under invest to accommodate
  - Soft (+ve) & Strategic Subs (-ve) $\rightarrow$ SEA -ve, under invest to accommodate
  - Tough (-ve) & Strategic Subs (-ve) $\rightarrow$ SEA +ve, over invest to accommodate
  - Soft (+ve) & Strategic Comp (+ve) $\rightarrow$ SEA +ve, over invest accommodate

Summary of business strategies

- Let the direct effect in entry deterrence be small or zero ($\partial \Pi_2 / \partial K_1$) – see slide 55 – so that the sign of total effect ($d\Pi_2 / dK_1$) is determined by the strategic effect of deterrence (sed)

- **Result:** If the second-stage choices are *strategic substitutes* ($dx_2^* / dx_1 < 0$), then entry accommodations and entry deterrence call for the *same conduct* by the incumbent given by if investment makes firm 1 tough or soft

Strategic substitutes ($dx_2^* / dx_1 < 0$)

	Investment Makes Firm 1	
	Tough ($\frac{d\Pi_2}{dK_1} < 0$)	Soft ($\frac{d\Pi_2}{dK_1} > 0$)
To Accommodate	Top Dog (over invest)	Lean and Hungry (under invest)
To Deter	Top Dog (over invest)	Lean and Hungry (under invest)

- **Result:** If the second-stage choices are *strategic complements* ($dx_2^*/dx_1 > 0$), then entry accommodations and entry deterrence call for *different conduct* by the incumbent given by if investment makes firm 1 tough or soft

Strategic complements ($dx_2^*/dx_1 > 0$)

	Investment Makes Firm 1	
	Tough ($\frac{d\Pi_2}{dK_1} < 0$)	Soft ($\frac{d\Pi_2}{dK_1} > 0$)
To Accommodate	Puppy Dog (under invest)	Fat Cat (over invest)
To Deter	Top Dog (over invest)	Lean and Hungry (under invest)

- Applications – K_1 can be any decision taken by firm 1 in period 1, must be observed by firm 2 before taking action in period 2

- App1: Stackelberg game analyzed earlier
  - Set capacity in period 1 – makes firm 1 tough
  - Compete in *quantities* in period 2 – *strategic substitutes*

  - **Tough+Strategic Substitutes**: Firm 1 over invests (top dog) both to deter or to accommodate

- App2: Stackelberg game with a twist
  - Set capacity in period 1 – makes firm 1 tough
  - Compete in *prices* in period 2 – *strategic complements*

  - **Tough+Strategic Complements**: Firm 1 under invests to accommodate (puppy dog) and over invests to deter (top dog)
    (over investing by firm 1 sends a credible signal that it will set low price in period 2 which can deter entry but not desirable for entry accommodation)

- App3: Differentiation by choice of location
  - Choose location in period 1 – makes firm 1 tough
  - Compete in *prices* in period 2 – *strategic complements*
    - (recall in an earlier lecture we considered Hotelling model and found that moving towards center increases access to market but firms want to differentiate to minimize price competition effect)
    - (investment can be consumer goodwill, reaching out to most, being closer to the center)
  - **Tough+Strategic Complements:** Firm 1 under invests to accommodate (puppy dog) – move as far away from the center as possible
    (there is also a direct effect in this case)
- App4: Advertising by brand name firm just prior to end of marketing exclusivity, and adverting is informative (increases market size)
  - Choose advertising in period 1 – makes firm 1 soft
  - Compete in *prices* in period 2 – *strategic complements*
  - **Soft+Strategic Complements:** If entry is inevitable, then to accommodate over invest (Fat Cat) but to deter under invest in advertising (lean and hungry)

- Part 1: Entry and Concentration
  - Main issues – how many firms enter under free entry? Is there too much/too little entry? What is the relationship to market size?
    - Homogeneous Bertrand competition
    - Salop Circle - Differentiation w/ price competition
    - Cournot competition w/ Differentiated products
    - Endogenous entry costs
- Part 2: Entry Deterrence and Accommodation
  - Main issues – when/how do firms take actions to block, accommodate or deter entry? What is direct and indirect effect of incumbents actions?
    - A stylized model of entry
    - Commitment via Stackelberg model
    - Taxonomy of Business strategies
    - Applications