Dynamic Games and First and Second Movers

Introduction

- **In a wide variety of markets firms compete *sequentially***
  - **one firm makes a move**
    - **new product**
    - **advertising**
  - **second firms sees this move and responds**
- **These are *dynamic games***
  - **may create a *first-mover advantage***
  - **or may give a *second-mover advantage***
  - **may also allow early mover to *preempt* the market**
- **Can generate very different equilibria from simultaneous move games**

Stackelberg

- **Interpret first in terms of Cournot**
- **Firms choose outputs *sequentially***
  - **leader sets output first, and visibly**
  - **follower then sets output**
- **The firm moving first has a *leadership advantage***
  - **can anticipate the follower's actions**
  - **can therefore manipulate the follower**
- **For this to work the leader must be able to *commit* to its choice of output**
- ***Strategic commitment has value***

Stackelberg equilibrium

- **Assume that there are two firms with identical products**
- **Marginal cost for each firm is c**
- **Firm 1 is the market leader and chooses q_1**
- **It knows how firm 2 will react and maximizes**

$$P\,[q1 + R2\,(q1)]\,q1 - cq1$$

- **Which gives the condition**
- $P + q1 \left[\frac{dP}{dQ}\right] [1 + R_2'(q_1)] = P + q_1 \left[\frac{dP}{dQ}\right]\left[1 + \frac{\partial q_2}{\partial q_1}\right] = c$
- **If demand is linear ($P = A - B.Q = A - B(q_1 + q_2)$), the Residual demand for firm 2 is:**
  - $P = (A - Bq_1) - Bq_2$

Stack n 2

$MR_2 = (A - Bq_1)$

arginal revenue

arginal cost

This is firm 2's

best re

fun

But firm 1 knows

From earlier example we know that this is the monopoly output. This is an important result. The Stackelberg leader chooses the same output as a monopolist would. But firm 2 is not excluded from the market

Firm 1 knows that this is how firm 2 will re

So firm 1 can anticipate firm 2's reaction

arginal revenue with marginal cost

his equation for ou ut q_1

$P = (A - (A-c)/2) – Bq_1/2$

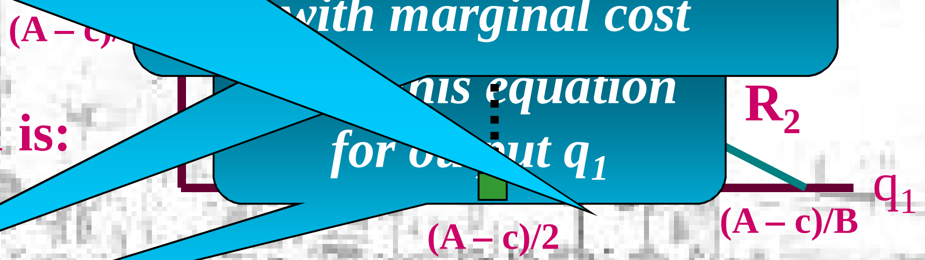
$\therefore P = (A + c)/2 – Bq_1/2$

Marginal revenue for firm 1 is:

$MR_1 = (A + c)/2 - Bq_1$

$(A + c)/2 – Bq_1 = c$

$\therefore q^*_1 = (A – c)/2$ $\therefore$ **$q^*_2 = (A – c)4B$**



Stackelberg equilibrium 3

Aggregate output is 3(A-c)/4B

So the equilibrium price is (A+3c)/4

Firm 1’s profit is $(A-c)^2/8B$

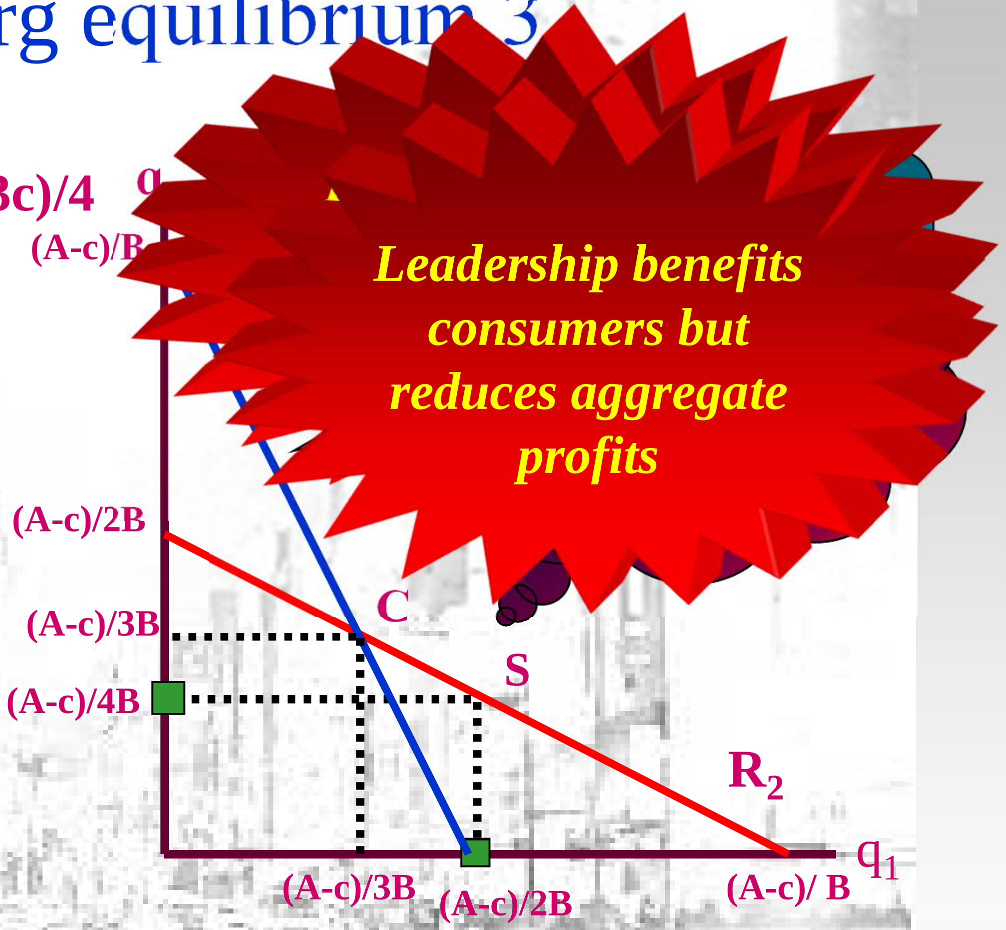
Firm 2’s profit is $(A-c)^2/16B$

We know that the Cournot equilibrium is:

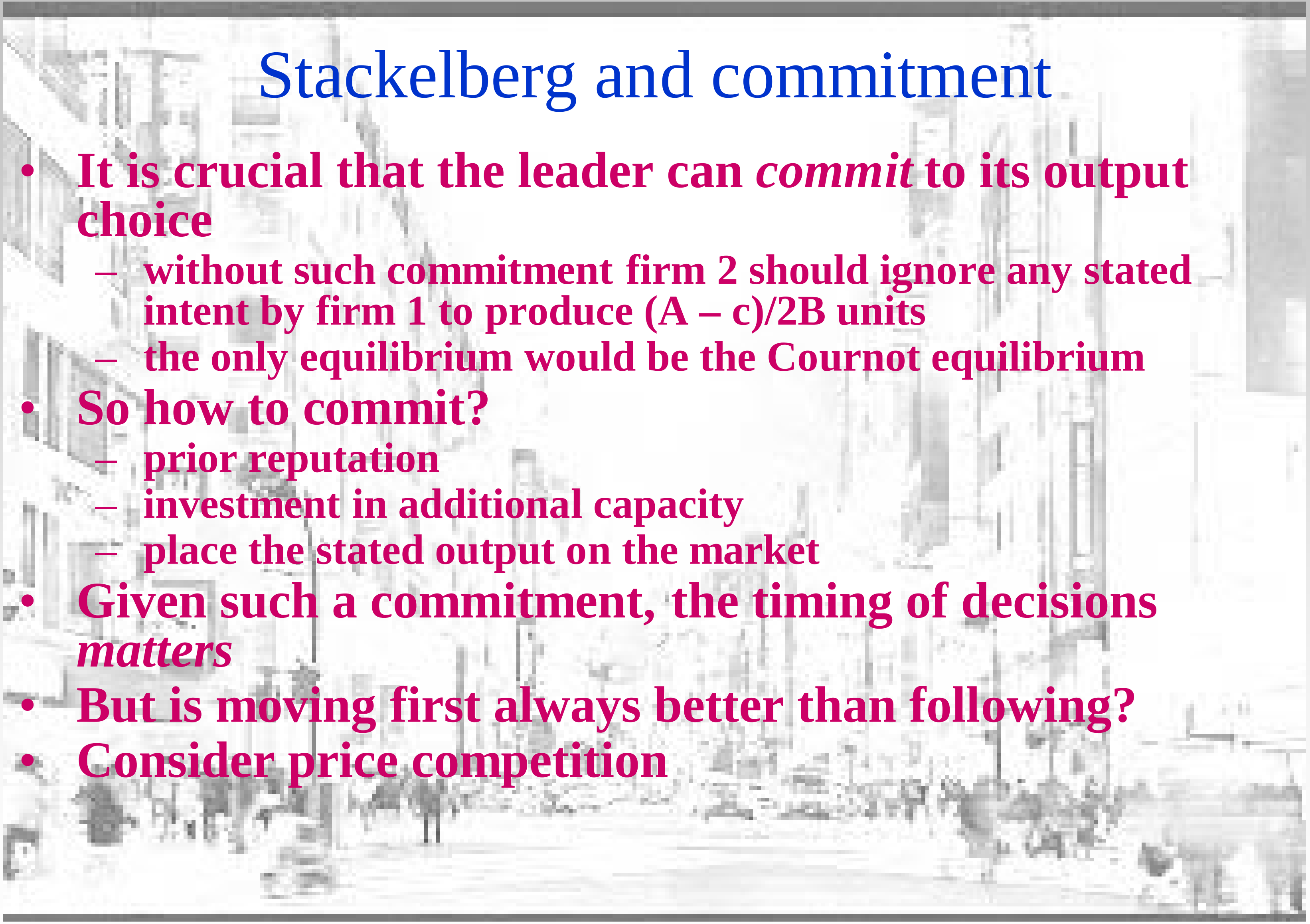
$q^C_1 = q^C_2 = (A-c)/3B$

The Cournot price is (A+c)/3

Profit to each firm is $(A-c)^2/9B$

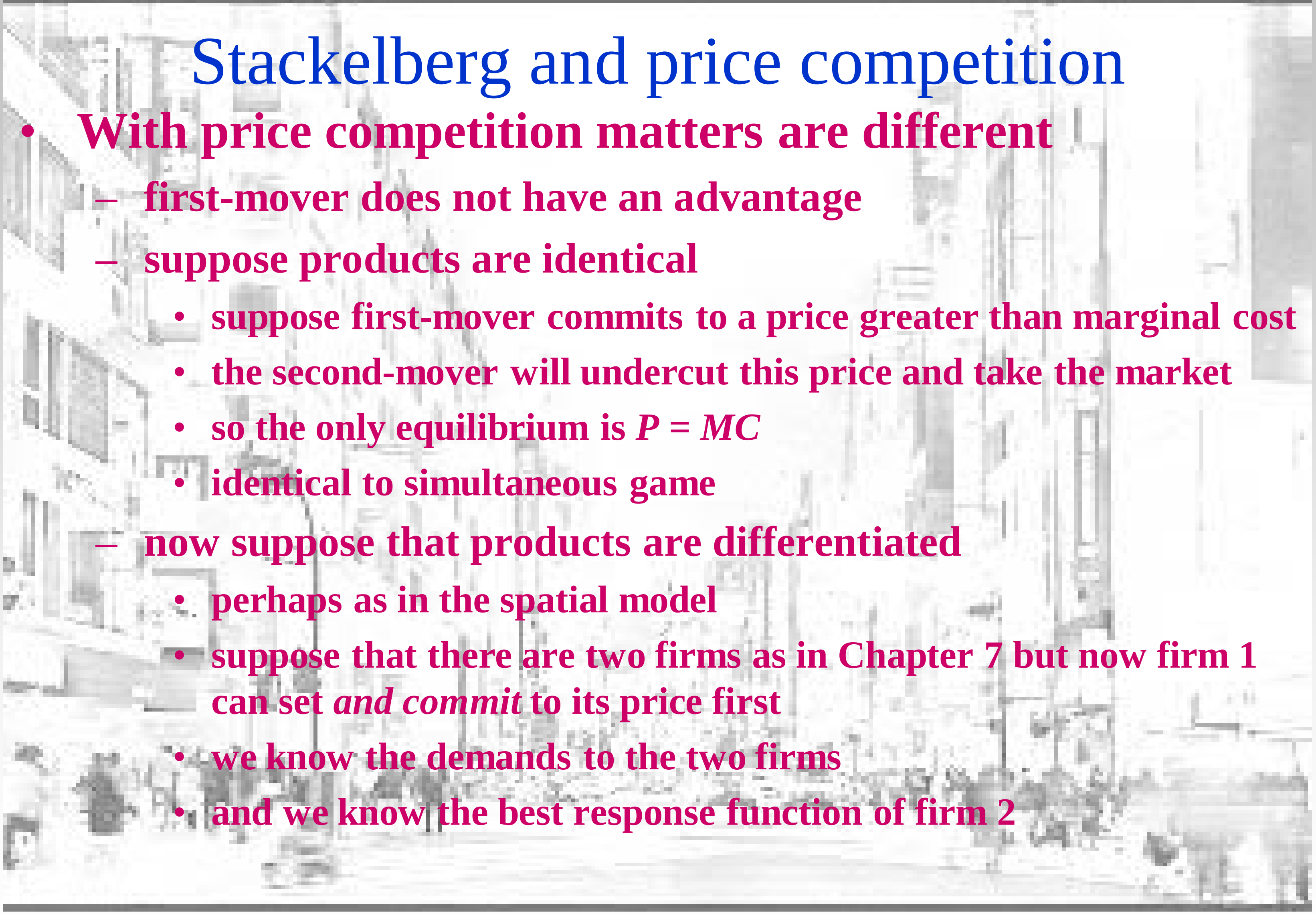


Leadership benefits consumers but reduces aggregate profits



Stackelberg and commitment

- **It is crucial that the leader can *commit* to its output choice**
  - **without such commitment firm 2 should ignore any stated intent by firm 1 to produce (A – c)/2B units**
  - **the only equilibrium would be the Cournot equilibrium**
- **So how to commit?**
  - **prior reputation**
  - **investment in additional capacity**
  - **place the stated output on the market**
- **Given such a commitment, the timing of decisions *matters***
- **But is moving first always better than following?**
- **Consider price competition**



Stackelberg and price competition

- **With price competition matters are different**
  - **first-mover does not have an advantage**
  - **suppose products are identical**
    - **suppose first-mover commits to a price greater than marginal cost**
    - **the second-mover will undercut this price and take the market**
    - **so the only equilibrium is $P = MC$**
    - **identical to simultaneous game**
  - **now suppose that products are differentiated**
    - **perhaps as in the spatial model**
    - **suppose that there are two firms as in Chapter 7 but now firm 1 can set *and commit* to its price first**
    - **we know the demands to the two firms**
    - **and we know the best response function of firm 2**

Stackelberg and price competition 2

Demand to firm 1 is $D^1(p_1, p_2) = N(p_2 - p_1 + t)/2t$

Demand to firm 2 is $D^2(p_1, p_2) = N(p_1 - p_2 + t)/2t$

Best response function for firm 2 is $p^*_2 = (p_1 + c + t)/2$

Firm 1 knows this so demand to firm 1 is

$$D^1(p_1, p^*_2) = N(p^*_2 - p_1 + t)/2t = N(c + 3t - p_1)/4t$$

Profit to firm 1 is then $\pi_1 = N(p_1 - c)(c + 3t - p_1)/4t$

Differentiate with respect to p_1:

$$\partial\pi_1/\partial p_1 = N(c + 3t - p_1 - p_1 + c)/4t = N(2c + 3t - 2p_1)/4t$$

Solving this gives: $p^*_1 = c + 3t/2$

Stackelberg and price competition 3

$p^*_1 = c + 3t/2$

Substitute into the best response function for firm 2

$p^*_2 = (p^*_1 + c + t)/2 \Rightarrow \quad p^*_2 = c + 5t/4$

Prices are higher than in the simultaneous case: $p^* = c + t$

Firm 1 sets a higher price than firm 2 and so has lower market share:

$c + 3t/2 + tx^m = c + 5t/4 + t(1 – x^m) \Rightarrow \quad x^m = 3/8$

Profit to firm 1 is then $\pi_1 = 18Nt/32$

Profit to firm 2 is $\pi_2 = 25Nt/32$

Price competition gives a *second mover advantage.*