Bilateral Monopoly Revisited: Price Formation, Efficiency and Countervailing Powers

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Workshop on Market Power in Supply Chains

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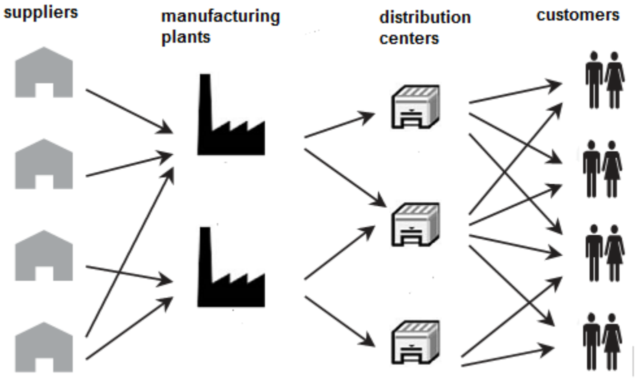
Background: CMA Research Strategy 2023-2024

Supply chains, monopsony and labour markets:

Traditionally, competition authorities have focused on horizontal product market competition. Market structure may also influence supply chains [...]. Market power may also take the form of monopsony in [...] input markets [...] harming consumer welfare. Relevant research topics include: supply chain structure, monopsony power in input markets and resilience to shocks.

Supply chains

- All products have supply chains...



Related literature I

Recent IO and trade literatures on markups/markdowns

- Decarolis and Rovigatti (2019), Lee et al. (2021), Avignon and Guigue (2022), Hahn (2023), Alviarez et al. (2023), Molina (2024)... all rely on Nash bargaining

Price formation in bilateral monopoly

- Cournot (1838)?, Menger (1871)
- Bowley (1924, 1928), Wicksell (1925), Fellner (1947), Morgan (1949), Farouker (1957), Stahl (1978)... relied on 'informal' bargaining
- Central concern: indeterminacy, market breakdown

Recurrent policy interest

- Spengler (1950) $\longrightarrow$ double marginalisation
- Galbraith (1952) $\longrightarrow$ countervailing powers
- Host of recent papers

Related literature II

Nash bargaining in bilateral monopoly

- McDonald and Solow (1981), Manning (1987) → unionised bargaining in labour
- Horn and Wolinsky (1988) → Nash-in-Nash IO literature
- Avignon et al. (2024), Demirer and Rubens (2024)...

Non-cooperative foundations

- Bjoernerstedt and Stennek (2007), Collard-Wexler et al. (2019), Abreu and Manea (2024)
- Binmore (1987), Muthoo (2008), Yildiz (2003), Dávila and Eeckhout (2008), Penta (2011)

Basic questions

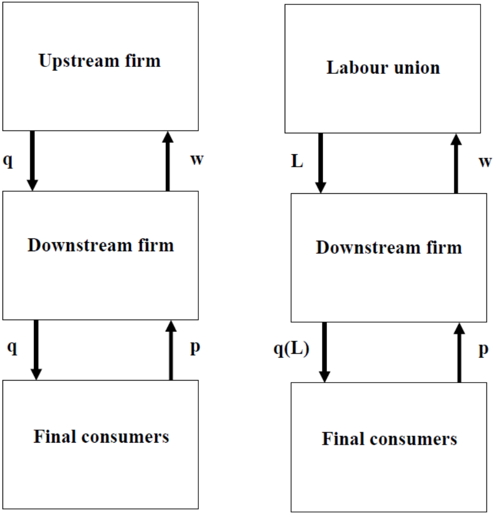
- How are prices formed in bilateral monopoly?
- How to model seller power and buyer power?
- Are seller and buyer power 'countervailing'?
- Does buyer power benefit final consumers?

Road map

- 'Informal' bargaining:
  - Price posting: traditional price setting and price taking
  - Take-it-or-leave-it offers
  - Ad hoc assignment of power
- Nash bargaining:
  - Complete bargaining (and two-part tariffs): bilaterally efficient
  - Partial bargaining with right-to-manage (labour economics): bilaterally inefficient
- Today: synthesis of these approaches
- A bit on non-cooperative foundations
- Ongoing: extension to bilateral oligopoly
  - Nash-in-Nash with two-sided multi-homing
  - Multi-channel selling and order-splitting
  - Competition in supply and demand functions
  - Free entry upstream and downstream (jointly determined)

Bilateral monopoly

- Parallel development in IO and labour economics
- Monopoly and monopsony...



Model

- **Upstream** firm produces intermediate good at cost

$$C(q) = cq + dq^2$$

- **Downstream** firm turns intermediate good into final good
- One-to-one input to output technology
- Uniform *wholesale* price w for inputs, possibly two-part tariffs
- No additional downstream costs but easy to extend to DRS
- Final goods inverse demand function

$$p(q) = a - bq$$

- Here p is *retail* price
- How do we determine (q, w, p)?

Preliminaries

- In supply chains, need to consider supply and demand functions for both intermediate and final goods
- Define revenue functions

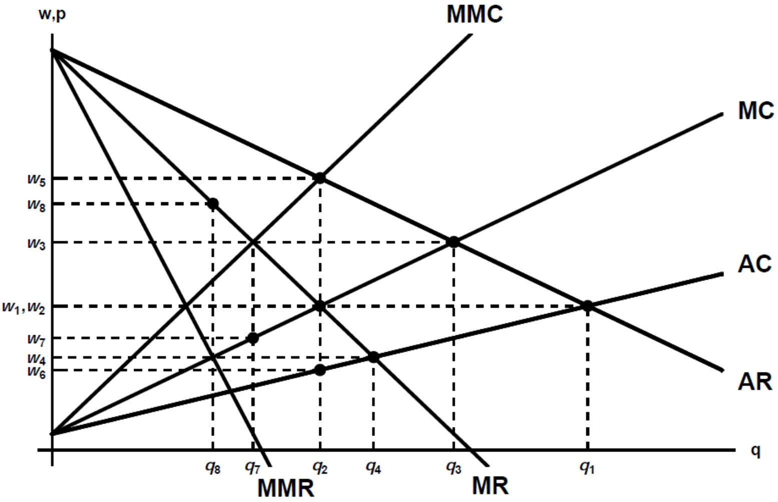
$$
\begin{aligned}
AR(q) &= a - bq \\
MR(q) &= a - 2bq \\
MMR(q) &= a - 4bq
\end{aligned}
$$

- Define cost functions

$$
\begin{aligned}
AC(q) &= c + dq \\
MC(q) &= c + 2dq \\
MMC(q) &= c + 4dq
\end{aligned}
$$

Curves and solutions

- Supply and demand in factor and product markets



First-best benchmark

- Social optimum where upstream supply equals final demand:

$$AR(q) = a - bq = c + 2dq = MC(q)$$

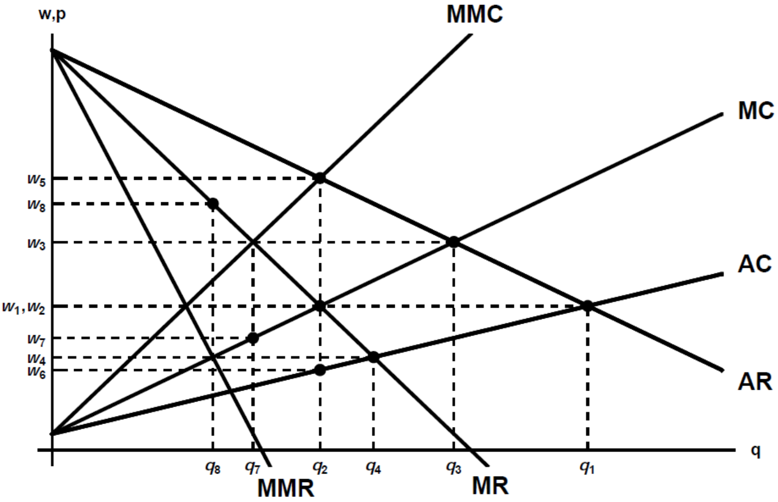
- Then

$$\begin{aligned} q^* &= \frac{a-c}{b+2d} \\ p^* &= \frac{2ad+bc}{b+2d} \end{aligned}$$

- Note: downstream firm plays no role (as no additional costs)

Solution

- Graphically:



Competitive equilibrium

- If upstream and downstream sectors perfectly competitive, sellers receive average costs and sellers charge average revenue
- Zero profit condition: average costs equal average revenues

$$AC(q) = c + dq = a - bq = AR(q)$$

- Then

$$q_1 = \frac{a - c}{b + d}$$

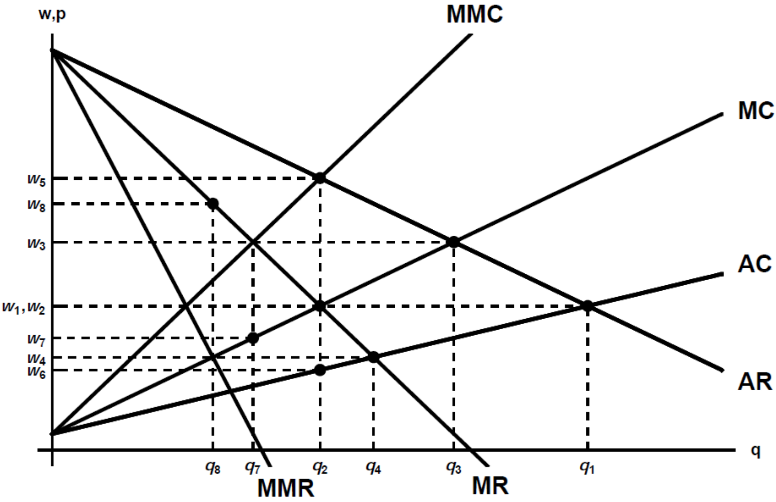
- Retail and wholesale prices are

$$p_1 = w_1 = AC(q_1) = AR(q_1)$$

- Firms earn zero profits

Solution

- Graphically:



Two-sided price taking I

- Upstream firm takes w as given and maximises

$$\pi^U = (w - c - dq)q$$

- This leads to the supply function

$$S(w) = \frac{w - c}{2d}$$

- Downstream firm takes w as given and maximises

$$\pi^D = (a - bq - w)q$$

- This leads to demand function

$$D(w) = \frac{a - w}{2b}$$

Two-sided price taking II

- Market clearing yields

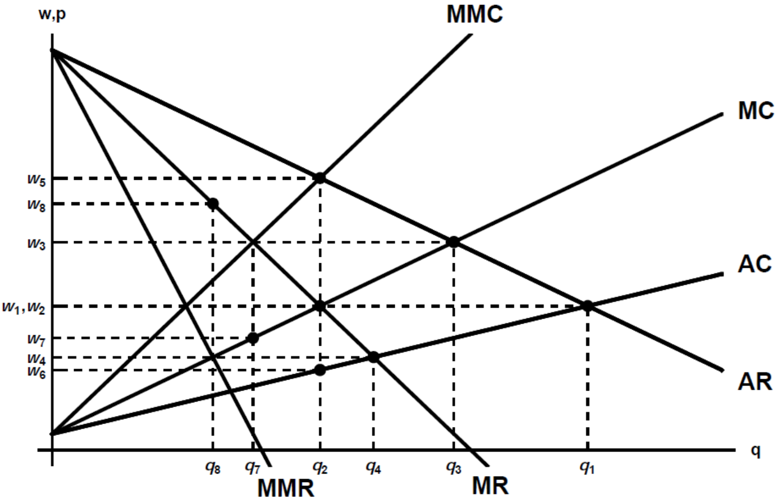
$$q_2 = \frac{a-c}{2(b+d)}, \quad w_2 = \frac{ad+bc}{b+d}, \quad p_2 = \frac{ab+2ad+bc}{2(b+d)}$$

- Replicates full-integration benchmark, but not social optimum
- Walrasian: at price w_2, output on supply and demand function
- Profits shared according to "Walrasian weights":

$$\begin{aligned} \pi_2^U &= \left(\frac{d}{b+d}\right)\frac{(a-c)^2}{4(b+d)} \\ \pi_2^D &= \left(\frac{b}{b+d}\right)\frac{(a-c)^2}{4(b+d)} \end{aligned}$$

Solution

- Graphically:



Pure monopsony

- Firm acts as monopsonist on input market but sells output to perfectly competitive output sector → Robinson (1933) so

$$p = AR(q) = a - bq$$

- Taking p as given, maximises

$$pq - wq = pq - (c + dq)q$$

- The FOC gives

$$MC(q) = c + 2dq = a - bq = AR(q)$$

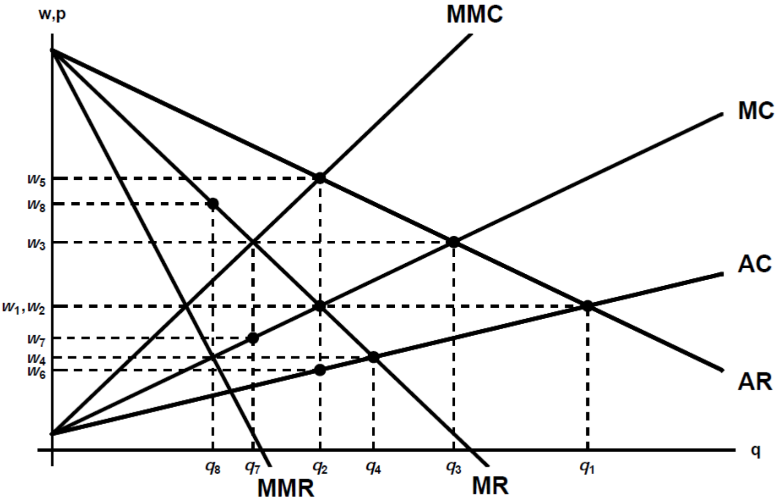
- Solution is

$$q_3 = \frac{a - c}{b + 2d}, \quad w_3 = \frac{2ad + bc}{b + 2d}, \quad p_3 = \frac{2ad + bc}{b + 2d}$$

- Note: need infinite firms downstream

Solution

- Graphically:



Pure monopoly

- Firm acts as monopolist on output market but buys input from perfectly competitive input sector so

$$w = AR(q) = c + dq$$

- Taking w as given, maximises

$$pq - wq = (a - bq)q - wq$$

- The FOC gives

$$MR(q) = a - 2bq = c + dq = AC(q)$$

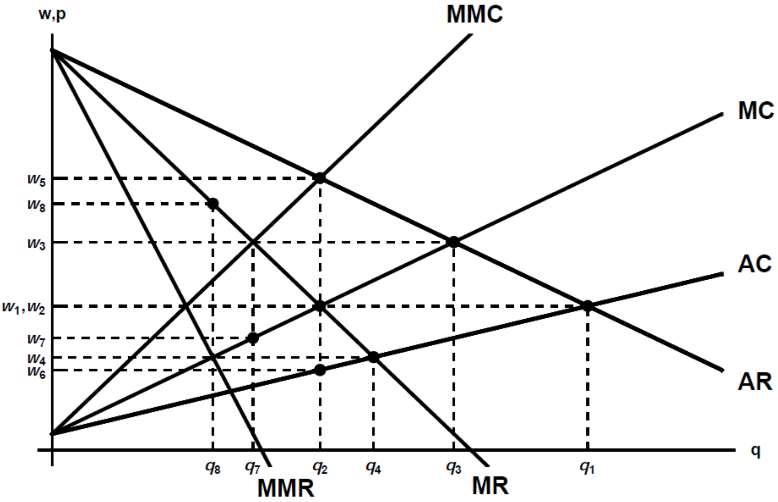
- Solution is

$$q_4 = \frac{a-c}{2b+d}, \quad w_4 = \frac{ad+2bc}{2b+d}, \quad p_4 = \frac{ab+ad+bc}{2b+d}$$

- Note: need infinite firms upstream

Solution

- Graphically:



Upstream firm makes take-it-or-leave-it offer

- Upstream firm maximises

$$\pi^U = (w - c - dq)q$$

- Must respect individual rationality constraint

$$\pi^D = (a - bq - w)q \geq 0$$

- This yields constraint

$$w \leq a - bq = AR(q)$$

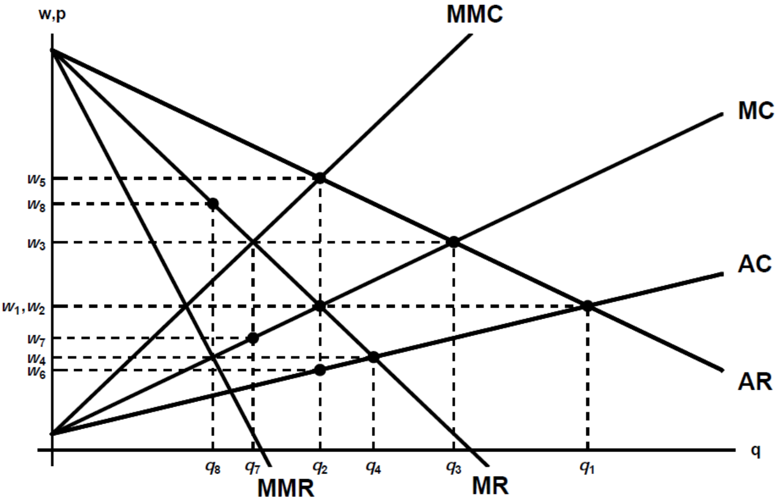
- Solution is

$$q_5 = \frac{a - c}{2(b + d)}, \quad w_5 = \frac{ab + 2ad + bc}{2(b + d)}, \quad p_5 = \frac{ab + 2ad + bc}{2(b + d)}$$

- Replicates full-integration benchmark
- Upstream firm keeps all profits

Solution

- Graphically:



Downstream firm makes take-it-or-leave-it offer

- Downstream firm maximises

$$\pi^D = (a - bq - w)q$$

- Must respect individual rationality constraint

$$\pi^U = (w - c - dq)q \geq 0$$

- This yields constraint

$$w \geq c + dq = AC(q)$$

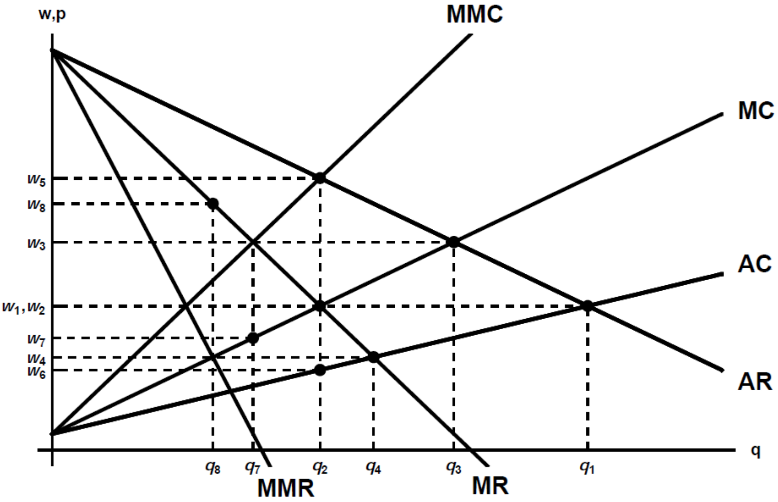
- Solution is

$$q_6 = \frac{a - c}{2(b + d)},\ w_6 = \frac{2(b + d)c + (a - c)d}{2(b + d)},\ p_6 = \frac{ab + 2ad + bc}{2(b + d)}$$

- Replicates full-integration benchmark
- Downstream firm keeps all profits

Solution

- Graphically:



Downstream firm posts price

- Downstream firm posts price, upstream firm chooses how much to supply
- Downstream firm maximises

$$\pi^D = (a - bq - w)q$$

- Chooses preferred point along inverse supply function of upstream firm

$$w = c + 2dq$$

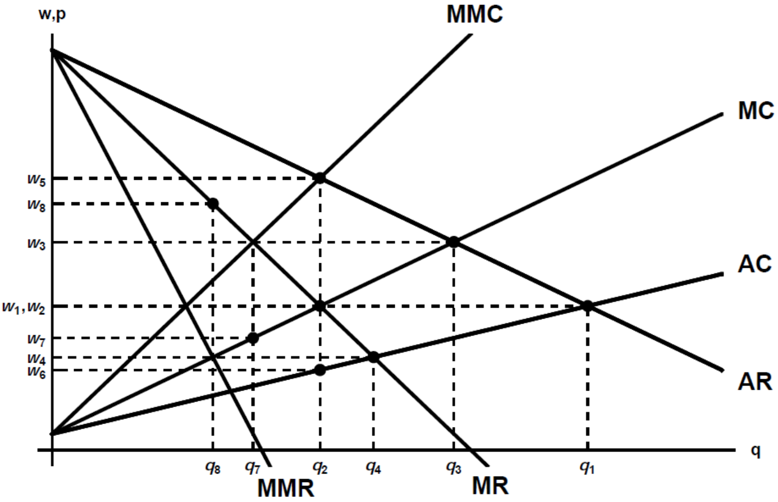
- Solution is

$$q_7 = \frac{a - c}{2(b + 2d)}, \quad w_7 = \frac{ad + bc + cd}{b + 2d}, \quad p_7 = \frac{ab + bc + 4ad}{2(b + 2d)}$$

- Downstream firm has market power upstream and downstream (sets w and p)

Solution

- Graphically:



Upstream firm posts price

- Upstream firm posts price, downstream firm chooses how much to demand
- Upstream firm maximises

$$\pi^U = (w - c - dq)q$$

- Chooses preferred point along inverse demand function of downstream firm

$$w = a - 2bq$$

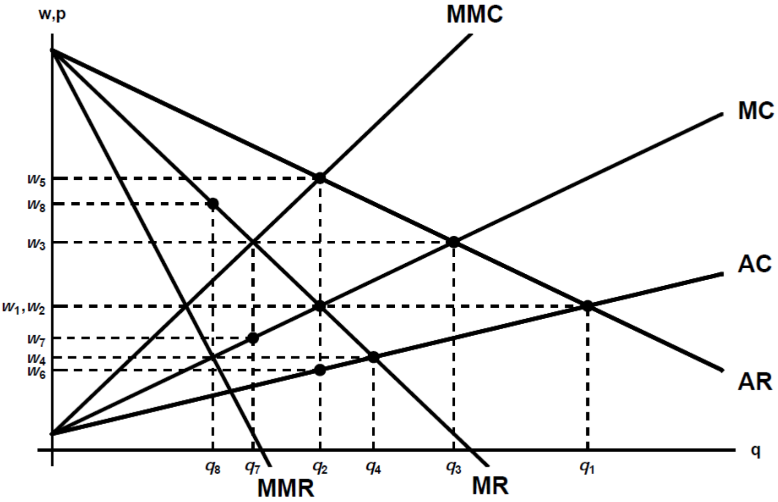
- Solution is

$$q_8 = \frac{(a-c)}{2(2b+d)}, \quad w_8 = \frac{ab+bc+ad}{2b+d}, \quad p_8 = \frac{3ab+2ad+bc}{2(2b+d)}$$

- Upstream firm has market power downstream (sets w)

Solution

- Graphically:



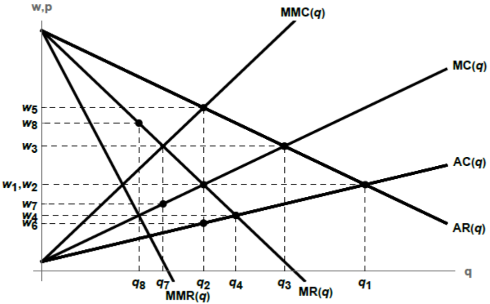
Ranking outputs

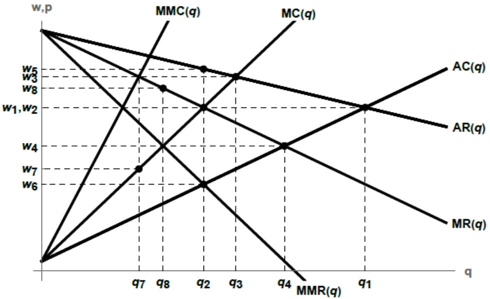
- We have that

$$\begin{aligned} \text{When } b &> d : q_1 > q_3 > q_4 > q_2 = q_5 = q_6 > q_7 > q_8 \\ \text{When } b &= d : q_1 > q_3 = q_4 > q_2 = q_5 = q_6 > q_7 = q_8 \\ \text{When } b &< d : q_1 > q_4 > q_3 > q_2 = q_5 = q_6 > q_8 > q_7 \end{aligned}$$

- Buyer and seller power *not* countervailing
- They are competing ills with different distortions
- Distortions depend on elasticities of demand and costs

Synthesis so far...





Implementation

- Bilaterally efficient output q obtained with *cost-plus* contract with transfer

$$T(q) = A + (c + dq)q$$

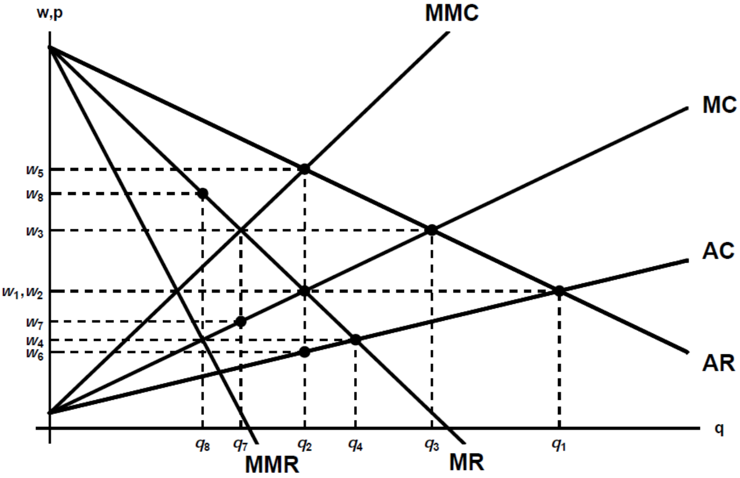
- Yields profits

$$\begin{aligned}\hat{\pi}^D &= pq - T(q) \\ &= (a - c - (b + d)q)q - A = \pi^U + \pi^D - A\end{aligned}$$

- Corresponds to joint profits of vertical structure, less A
- Under two-part tariffs, lump-sum transfer A determines distribution $\longrightarrow$ output q chosen to maximise surplus
- In special case $d = 0$, contract stipulates inputs priced at marginal cost c
- Under price posting, w determines both size and distribution of surplus $\longrightarrow$ output q distorted

Recurrent issues in classical literature

- Indeterminacy of prices and outputs and market breakdown
- Contract curve and the Walrasian equilibrium
- Assignment of roles "solves" indeterminacy, but...



Nash bargaining

- Literature has considered several possible bargaining protocols
- Complete bargaining: bilaterally efficient
- Partial bargaining (right-to-manage): bilaterally inefficient (but may be socially desirable)

Complete Nash bargaining

- Firms negotiate over terms (w, q)
- Solution to problem

$$\max_{(w,q)} \left((a - bq - w)q\right)^{\gamma} \left((w - c - dq)q\right)^{1-\gamma}$$

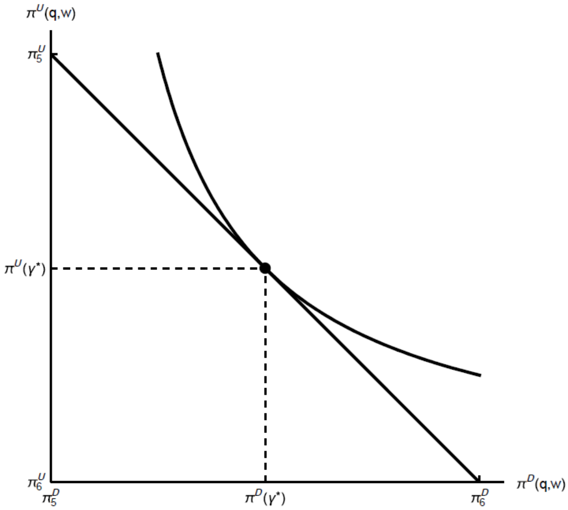
- Here, $\gamma \in (0, 1)$ bargaining power of downstream firm
- Solution is

$$\begin{aligned} q_e(\gamma) &= \frac{a - c}{2(b + d)} = q_2 \\ w_e(\gamma) &= \frac{ad + bc + [\gamma c + (1 - \gamma)a](b + d)}{2(b + d)} \\ &= (1 - \gamma)AR(q_2) + \gamma AC(q_2) \\ p_e(\gamma) &= \frac{ab + 2ad + bc}{2(b + d)} \end{aligned}$$

- Complete bargaining replicates full-integration benchmark
- Output set to maximise joint profits
- Wholesale price only redistributes rents according to γ

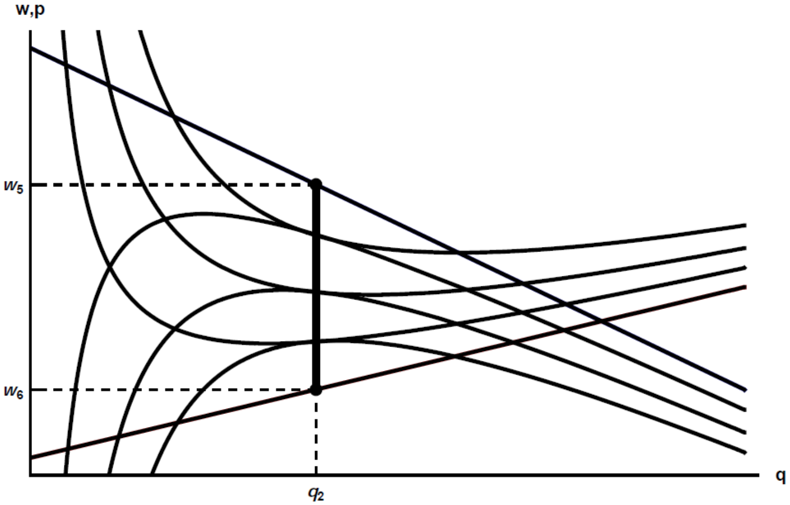
Complete Nash bargaining

- Nash bargaining solution under complete bargaining



Complete Nash bargaining

- Indifference curves and the contract curve



Complete Nash bargaining

- Efficient outcome implemented via cost-plus contract with transfer

$$\begin{aligned} T_\gamma(q) &= \pi_e^U(\gamma) + C(q) \\ &= \underbrace{\frac{(1-\gamma)(a-c)^2}{4(b+d)}}_{\approx A} + (c+dq)q \end{aligned}$$

- Contract covers costs and gives fraction of total surplus
- Yields profits

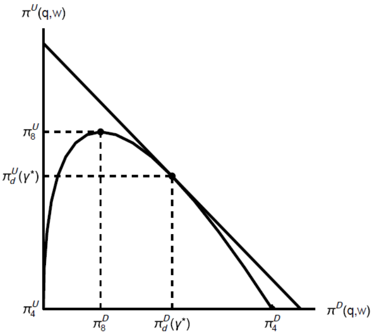
$$\begin{aligned} \hat{\pi}^D(\gamma) &= pq - T_\gamma(q) \\ &= \pi^U + \pi^D - \frac{(1-\gamma)(a-c)^2}{4(b+d)} \end{aligned}$$

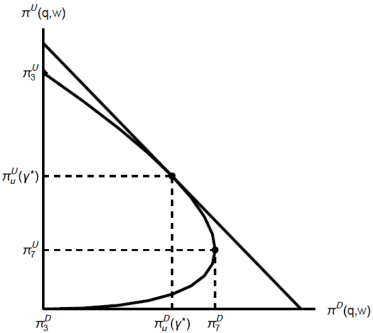
Partial Nash bargaining

- Firms negotiate over wholesale price w only
- After bargaining stage, one of the firms chooses output given agreed price w
- This is very common in labour literature
- Union and firm negotiate hourly salary, firm chooses how many hours it demands
- Two cases:
- Upstream firm chooses output
  - Relevant point along its supply function
- Downstream firm chooses output
  - Relevant point along its demand function

Partial Nash bargaining

- Restricted bargaining sets: must be on either demand or supply function





Nash bargaining: upstream firm chooses output

- Solution to problem

$$\max_{w} \left(\frac{(w-c)(2ad+bc-w(b+2d))}{4d^2} \right)^{\gamma} \left(\frac{(w-c)^2}{4d} \right)^{1-\gamma}$$

- Solution is

$$\begin{aligned} q_u(\gamma) &= \frac{(2-\gamma)(a-c)}{2(b+2d)} \\ w_u(\gamma) &= \frac{bc+2ad-\gamma d(a-c)}{b+2d} \\ p_u(\gamma) &= \frac{2a(b+2d)-b(2-\gamma)(a-c)}{2(b+2d)} \end{aligned}$$

Nash bargaining: downstream firm chooses output

- Solution to problem

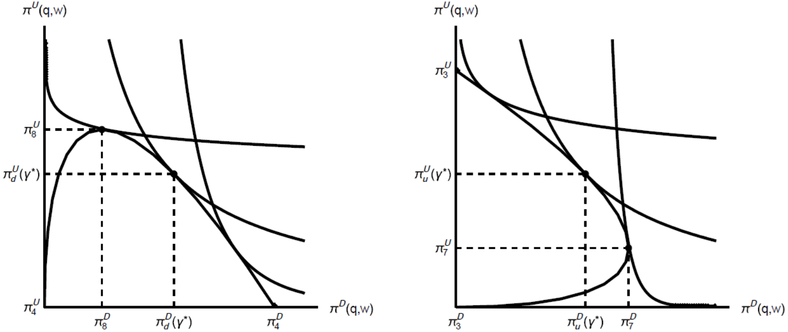
$$\max_w \left(\frac{(a-w)^2}{4b}\right)^{\gamma}\left(\frac{(a-w)(w(2b+d)-ad-2bc)}{4b^2}\right)^{1-\gamma}$$

- Solution is

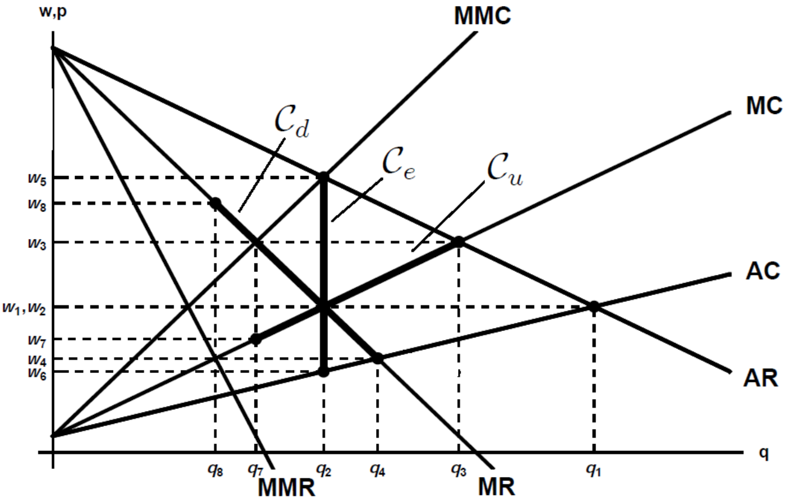
$$\begin{aligned} q_d(\gamma) &= \frac{(1+\gamma)(a-c)}{2(2b+d)} \\ w_d(\gamma) &= \frac{ab+bc+ad-\gamma b(a-c)}{2b+d} \\ p_d(\gamma) &= \frac{2a(2b+d)-b(1+\gamma)(a-c)}{2(2b+d)} \end{aligned}$$

Partial Nash bargaining

- Nash bargaining solutions under partial bargaining



Contract curves and solutions



Outputs under Nash bargaining

- Under price posting, output not bilaterally efficient and socially too low: $q < q_2 < q_1$
- Under complete bargaining, efficient output $q_e(\gamma) = q_2$
- But note that

$$\begin{aligned} q_d &\geq q_2 \Leftrightarrow \gamma \geq \frac{b}{b+d} \equiv \gamma^* \\ q_u &\geq q_2 \Leftrightarrow \gamma \leq \frac{b}{b+d} \equiv \gamma^* \end{aligned}$$

- Happens when firm choosing output has too much bargaining power over price
- Here, "too much" is relative to joint profit maximisation $\rightarrow$ may be good for welfare!

Outputs under Nash bargaining

- Can verify that

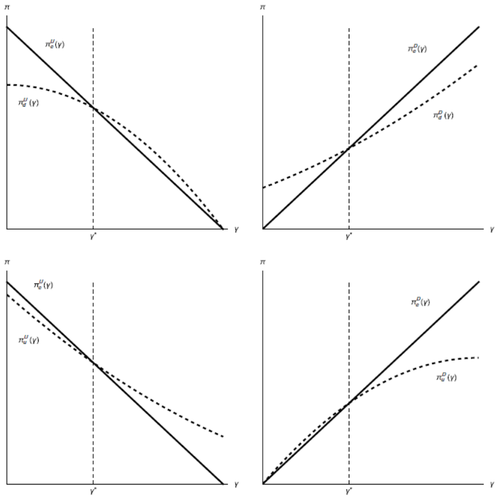
$$
\begin{aligned}
\lim_{\gamma \to 1} q_u(\gamma) &= q_7, \quad \lim_{\gamma \to 0} q_u(\gamma) = q_3 \\
\lim_{\gamma \to 1} w_u(\gamma) &= w_7, \quad \lim_{\gamma \to 0} w_u(\gamma) = w_3 \\
\lim_{\gamma \to 0} q_d(\gamma) &= q_8, \quad \lim_{\gamma \to 1} q_d(\gamma) = q_4 \\
\lim_{\gamma \to 0} w_d(\gamma) &= w_8, \quad \lim_{\gamma \to 1} w_d(\gamma) = w_4
\end{aligned}
$$

- Extreme bargaining power under partial bargaining recovers outcomes under price posting and cases of pure monopoly and pure monopsony
- Similarly, we have $q_e(\gamma) = q_2$ and

$$
\lim_{\gamma \to 0} q_e(\gamma) = q_5, \quad \lim_{\gamma \to 1} q_e(\gamma) = q_6
$$

Profits across protocols

- Comparing bargaining procedures:



Non-cooperative foundations I

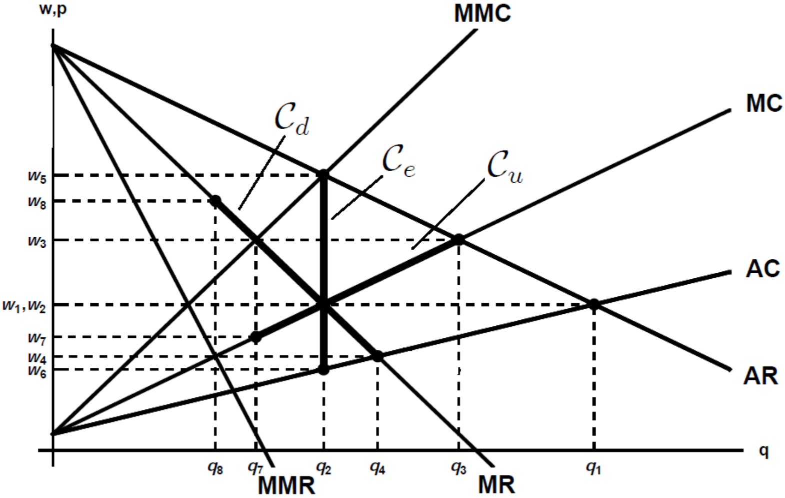
- Alternating offers: Muthoo (2008), Rubinstein (1982)
- At time $t\Delta$ with $t = 0, 2, 4, \ldots$ upstream firm offers (w_u, q_u)
- If downstream firm accepts, game ends
- If downstream firm rejects, it makes offer
- At time $t\Delta$ with $t = 1, 3, 5, \ldots$ downstream firm offers $(w_d, q_d)\ldots$
- Firms discount future at rates ρ_U and ρ_D
- As $\Delta \rightarrow 0$, unique equilibrium agreement is (w^*, q^*) with

$$\begin{aligned} q^* &= q_2 \\ w^* &= (1-\gamma)p_2 + \gamma(c + dq_2) \\ &= (1-\gamma)AR(q_2) + \gamma AC(q_2) \end{aligned}$$

where

$$\gamma = \rho_U / (\rho_U + \rho_D)$$

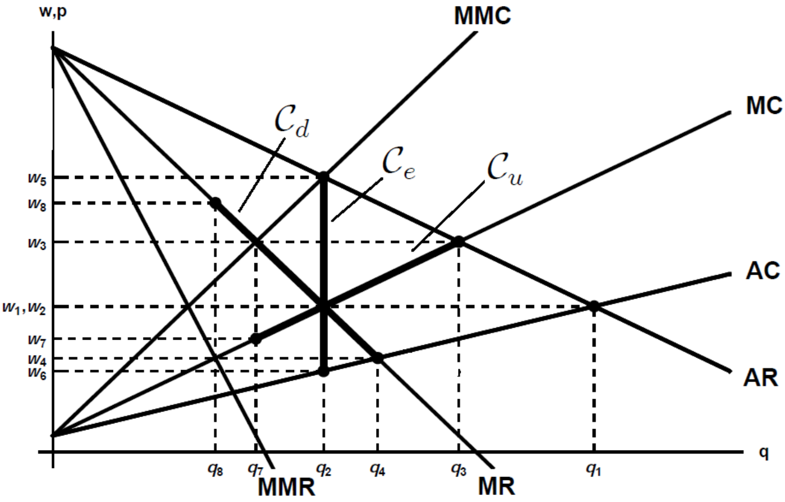
Non-cooperative foundations I



Non-cooperative foundations II

- Alternating offers: Yildiz (2003) $\longrightarrow$ "Walrasian bargaining"
- At time $t\Delta$ with $t = 0, 2, 4, ...$ upstream firm offers w_u
- Downstream firm then chooses output q_d
- If upstream firm accepts, game ends
- If upstream firm rejects, downstream firm offers w_d
- At time $t\Delta$ with $t = 1, 3, 5, ...$ downstream firm offer w_d,...
- Firms discount future at rates ρ_U and ρ_D
- **Argument:**
- Firms make offers on *each others'* offer curves
- Due to indifference conditions, in limit we are on both offer curves (at intersection)
- Outcome therefore Walrasian equilibrium

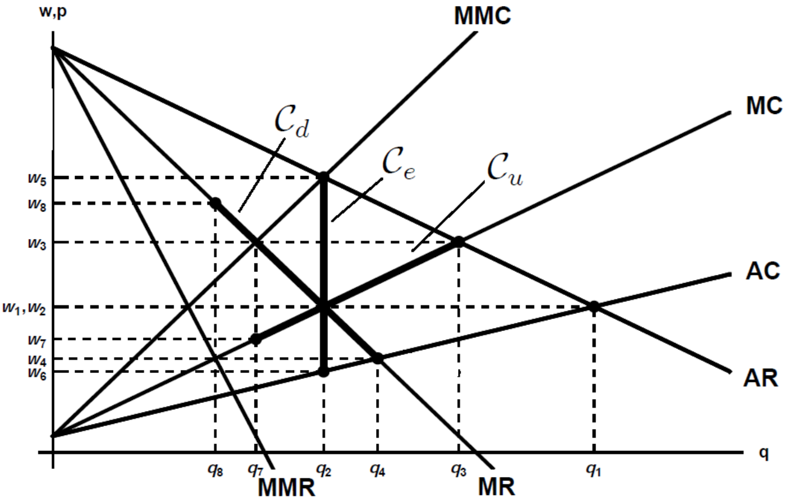
Non-cooperative foundations II



Non-cooperative foundations III

- At time $t\Delta$ with $t = 0, 2, 4, \ldots$ firm $i = U, D$ makes offer w_i
- If firm j rejects offer, it makes counteroffer w_j
- If firm j accepts, quantity is chosen by a designated firm $k = U, D$
- Under this protocol, upstream and downstream firm both choose points on the offer curve of firm k
- **Conjecture:**
- Outcomes trace contract curves under partial bargaining

Non-cooperative foundations III



Countervailing powers

DG COMP definition of buyer power:

Ability of one or more buyers, based on their economic importance on the market in question, to obtain favourable purchasing terms from their suppliers. Buyer power is an important aspect in competition analysis, since powerful buyers may discipline the pricing policy of powerful sellers, thus creating a "balance of powers" on the market concerned. However, buyer power does not necessarily have positive effects. When a strong buyer faces weak sellers, for example, the outcome can be worse than when the buyer is not powerful. The effects of a buyer's strength also depend on whether the buyer, in turn, has seller power on a downstream market.

Buyer power

Global Dictionary of Competition Law:

- *Buyer power describes the bargaining position of a buyer with respect to its supplier(s) of goods or services. Through purchasing strategies, the buyer, unilaterally or through coordination with other buyers, can decrease the purchasing price of its input below the supplier's standard selling price, above or below the competitive level.*
- *Two sub-types of buyer power are distinguished: first, monopsony power, which implies a withholding effect, being inefficient and dubbed the reverse of monopoly power; and second, bargaining (or countervailing) power, in which tactics other than withholding may be used to the benefit of the buyer to reduce the input's price. Bargaining power tends to be welfare enhancing as supra-competitive profits kept by the supplier are passed on to the buyer and eventually to the end consumers if there is competition in the retailing market.*

Random proposer

- Suppose that upstream and downstream firms propose w.p. $(1 - \gamma)$ and γ
- If proposer can make take-it-or-leave-it offer, ex ante expected output and profits same as under complete bargaining
- If proposer can only set price, expected output convex combination of price posting solutions