The Biotechnology Sector: "Bounds" to Market Structure

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Motivation

- **Evidence for biotechnology sector consolidation in terms of patent and firm ownership (Harhoff *et al*., 2001; Graff *et al*., 2003)**

- **Opposition to biotechnology partly based on concerns:**

  - **a few large firms will exercise control over food system**

  - **there will be systematic bias in product development**

- **Revolves around two well-known arguments in IO – (i) what determines market structure, and (ii) is there a causal link between market structure and innovation?**

- **Focus on process that *jointly* determines market structure and innovative activity in biotechnology**

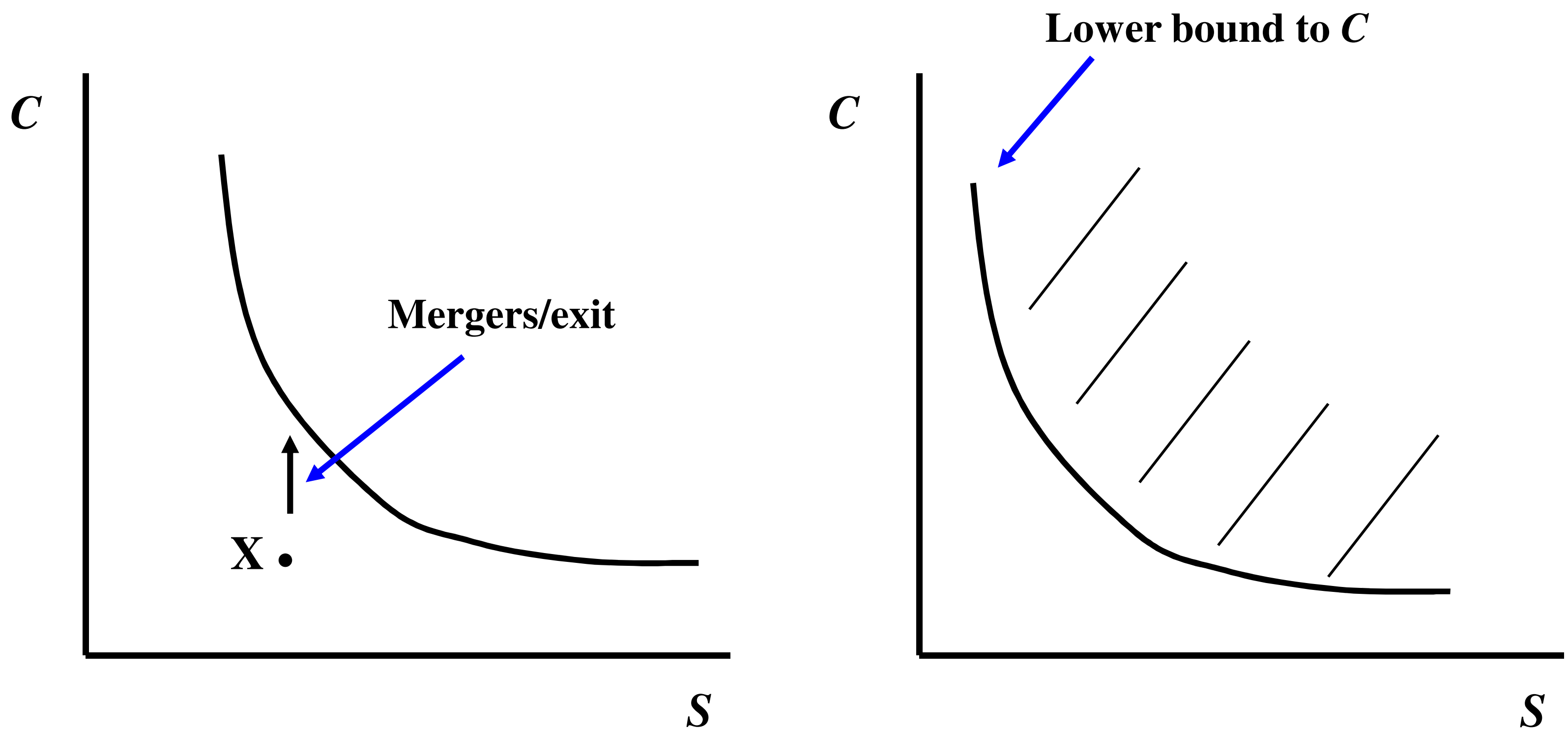
Market Structure and Innovation

- Early analysis of innovation drew on two hypotheses:
  - Schumpeterian (1947) – there is a positive relationship between innovation and market structure
  - Arrow (1962) – incentive to innovate less under monopoly than competition
- Empirical work sought relationship between R&D intensity and seller concentration with mixed results (Cohen and Levin, 1989)
- Dasgupta and Stiglitz (1980) – market structure and innovative activity endogenous
- Sutton (1996) - any link between R&D intensity and seller concentration involves a “bounds” constraint not captured in reduced-form regressions

Basic "Bounds" Approach

- Model developed in Sutton (1991)
- Product *homogeneous*, firms incur sunk cost ε of acquiring plant of minimum efficient scale, then compete in price
- Market structure (*C*) function of:
  - Market size *S* relative to ε
  - Intensity of price competition – Cournot, $N = \sqrt{S/\varepsilon}$
  - Markets contestable if $\varepsilon = 0$ (Baumol *et al*., 1982)
- With *horizontal* product differentiation, sunk cost of producing specific variety, and price competition mitigated – generates multiple equilibria with lower bound to *C*

Figure 1: Exogenous Sunk Costs and Market Structure

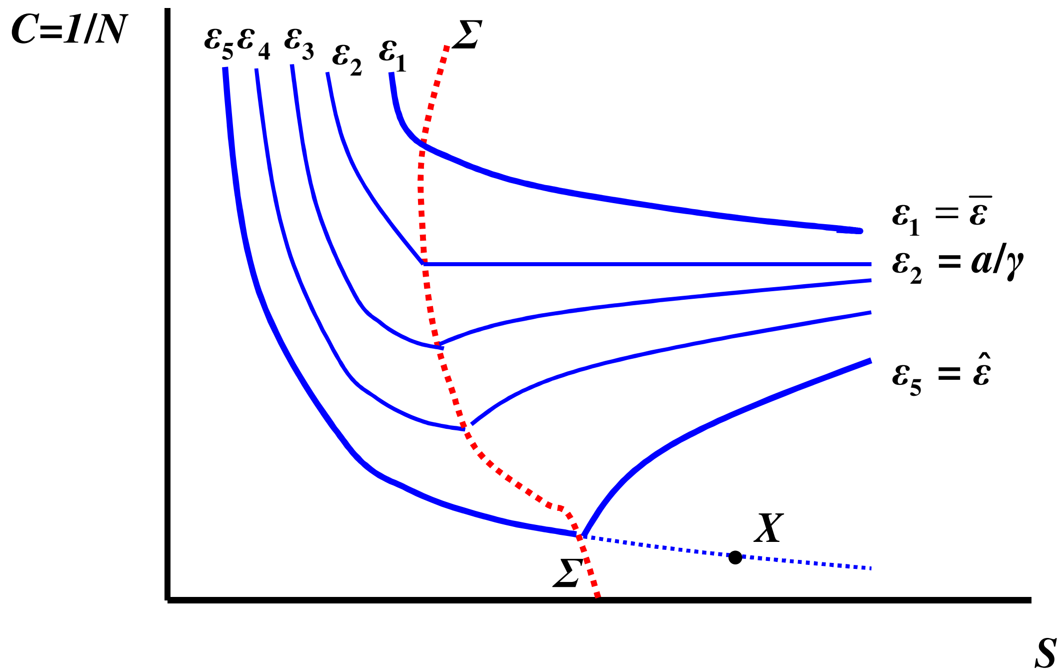


(a) Homogeneous Goods **(b) Differentiated Goods**

Basic "Bounds" Approach

- With *vertical* product differentiation, each product has single attribute *u* – quality, all consumers having same tastes
- Firms incur sunk cost *ε*, but now choose *u*, at an additional sunk cost *R*(*u*), before competing in price
- If consumer willingness to pay increases with R&D, *R*(*u*) can be thought of as an R&D response function
- Link between increased market size *S* and structure *C* is broken
- Competitive escalation of *R*(*u*), raises equilibrium level of sunk costs {*ε* + *R*(*u*)} as *S* increases, offsetting tendency toward fragmentation – R&D is an *endogenous barrier to entry*

Figure 2: Seller Concentration and Market Size

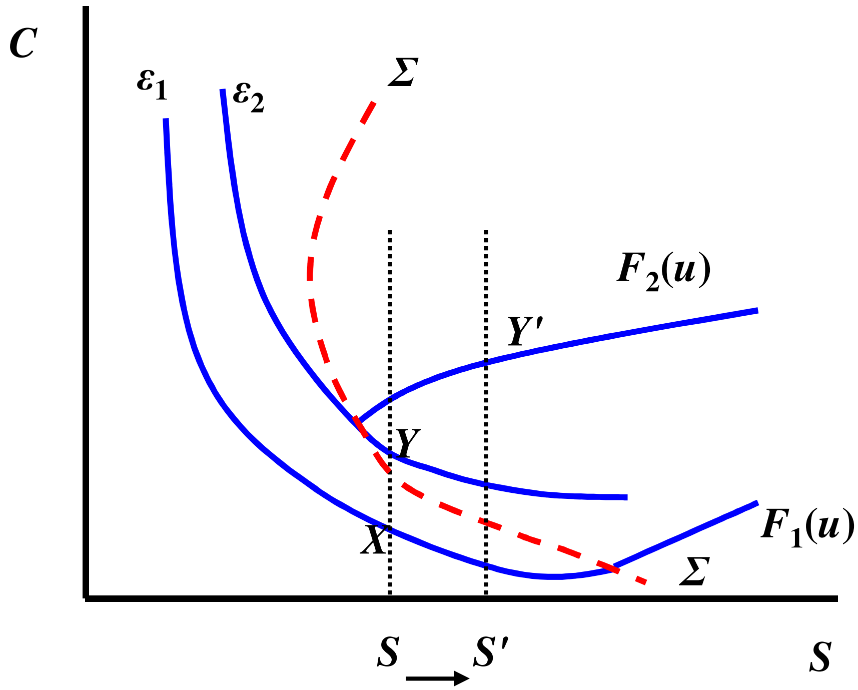


a = cost per unit of R&D, γ = returns to R&D

$\Sigma\Sigma$ = locus of points where there is a switch from no-R&D to R&D – a function of unit cost of R&D

Basic "Bounds" Approach and Biotechnology

Figure 3: Market Structure, Sunk Costs and R&D in Biotechnology Industry



X **initial market structure – early 1980s, small dedicated start-ups (Lavoie and Sheldon, 2000)**

X **to** ***Y*** **mergers/acquisitions - 1990s, life-science firms avoiding transactions costs of acquiring intellectual assets at arms' length (Graff** ***et al.*****, 2003)**

Y′ **structure with effective additional R&D – late-1990s, as market expanded in North and South America**

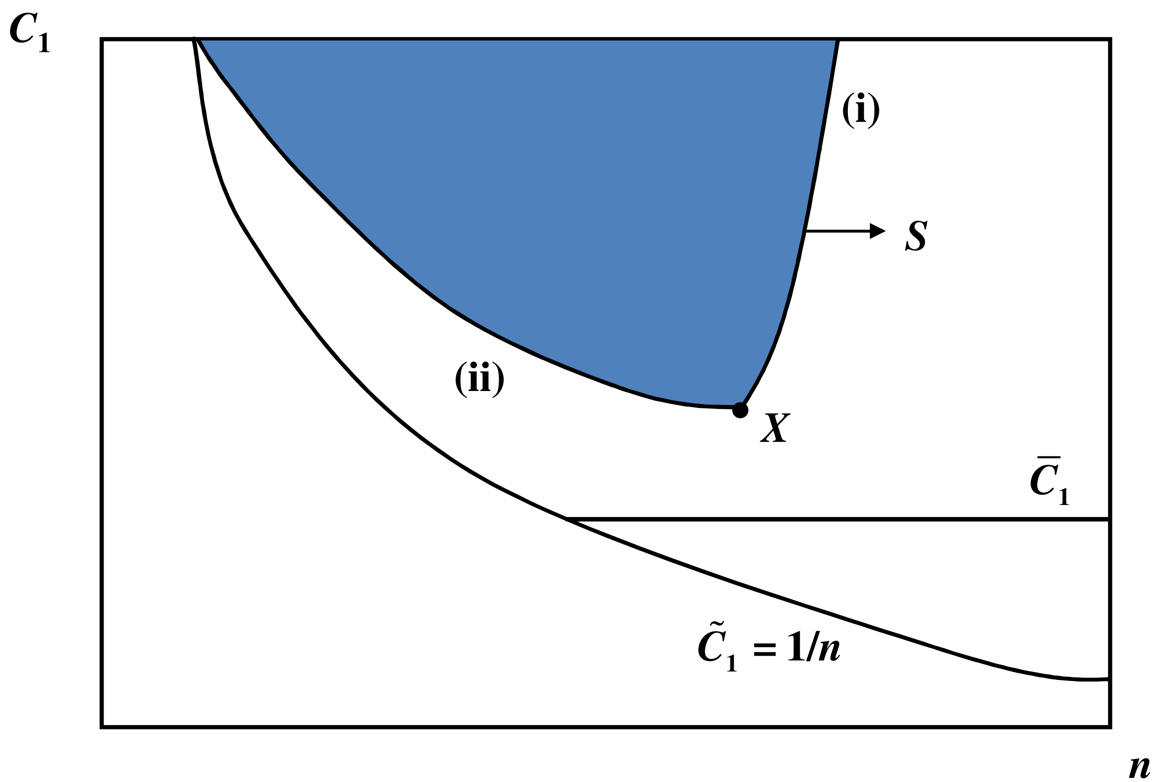
More General "Bounds" Approach

- Key assumption, firm's R&D spans *all* its products – but what if objective of R&D is to improve attributes of *specific* products
- Initial equilibrium of fragmented industry – low market share/low R&D
- An R&D escalation strategy α depends on: (i) effective R&D in a sub-market (β), and (ii) substitutability across sub-markets (σ)
- Following Sutton (1997, 1998, 2007), equilibrium configurations in (n,C_1) space, shaded area bounded by functions (i) and (ii), where:

  (i) – *viability* function based on "survivor" principle (Alchian, 1950))

  (ii) – *stability* function – a "smart" agent will fill any gap in market (Sutton, 1997)

Figure 4: Equilibrium Configurations



More General "Bounds" Approach

- **Key to more general "bounds" model:**
- **effective R&D (β) and high substitutability across sub-products (σ) – high levels of R&D and *high* seller concentration**
- **effective R&D (β) and low substitutability across sub-products (σ) – high levels of R&D and *low* seller concentration**
- **if sunk costs (ε) increase, seller concentration (*C*) increases irrespective of R&D intensity, but with low R&D intensity, *C* declines over time with *S***
- **Main result: decline in *C* with *S* bounded from zero and can even increase – explains weak correlation between R&D intensity and seller concentration in empirical work (Sutton, 1996)**

More General "Bounds" Approach

- In case of biotechnology, increase in *ε* was initial mechanism for increase in *C*, but complementarities across acquired intellectual property rights, and growth in *S*, resulted in R&D escalation (Lavoie, 2004) and further increases in *C*
- While *α* cannot be measured directly, theory places a restriction on two observables – the R&D to sales ratio, and *h*, the proportion of sales revenue accounted for by largest product class
- Future test of model's validity will be impact on market structure of introduction of GM crops (high *h*?) with stacked traits and GM products aimed explicitly at consumers (low or high *h*?)
- Conclusion: assuming direct correlation between R&D and seller concentration in biotechnology possibly misleading