Oligopolistic competition with free entry

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- d'Aspremont C., Dos Santos Ferreira R., Gérard-Varet L.-A. (2000), "Contestability and the indeterminacy of free entry equilibria", *Japanese Economic Review* 51, 72-83.
- Dos Santos Ferreira R., Dufourt F. (2007), "Free entry equilibria with positive profits: A unified approach to quantity and price competition games", *International Journal of Economic Theory* 3, 75-94.

- Dos Santos Ferreira R., Dufourt F. (2006), "Free entry and business cycles under the influence of animal spirits", *Journal of Monetary Economics* 53, 311-328.
- Dos Santos Ferreira R., Lloyd-Braga T. (2008), "Business cycles with free entry ruled by animal spirits", *Journal of Economic Dynamics and Control* 32, 3502-3519.
- Dos Santos Ferreira R., Dufourt F. (2012), "Strategic indeterminacy and stabilization policy" (mimeo).

1. Introduction

Motivation

- Free entry commonly associated with zero profits

  Dynamic process of net business formation:
  Positive profits $\Rightarrow$ entry of new-born firms
  Negative profits $\Rightarrow$ exit of existent firms

  Free entry equilibrium = stationary state of this process

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- Any potential entrant is supposed to be able to perfectly reproduce the operating and marketing conditions of successful incumbents.
  This is OK if any firm operates at a negligible scale w.r.t. market size, as
  - in *perfect competition*, or
  - in *monopolistic competition* (within Chamberlin's *large group*).

Motivation

- This is no longer true if producing firms benefit from significant *internal economies of scale*. A potential entrant may then be unable to reproduce the incumbents' marketing conditions.
  Entry = *strategic* decision
  → Importance of timing and information considerations.
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  Entry = *strategic* decision
  → Importance of timing and information considerations.

- « The story [behind the use of the zero profit condition] can only be defended as an approximation. Entry and exit are complicated phenomena, involving difficult game theoretic issues that defy neat analytical formulation » (Weitzman, 1982).

Motivation

- Dilemma:
  - to transpose to oligopolistic competition an equilibrium concept devised for non-strategic forms of competition
  - to apply to macroeconomic analysis industrial organization tools that may prove too complex and too specific for that use

- Simple way out:

  → Apply the standard *Nash equilibrium* concept to a one-shot, one-stage game reproducing any standard regime of oligopolistic competition between firms, which may choose to be either *active* or *inactive* (i.e. not to produce).

Objective and main result

- To provide a general framework appropriate to the analysis of free entry equilibria,
- in particular in macroeconomic modelling.
- Our main result is that indeterminacy of free entry equilibria typically prevails under various standard regimes of oligopolistic competition,
- the zero profit equilibrium being only one particular free entry equilibrium, which often appears to be inefficient.

2.The conceptual framework

The game

- Symmetric game played by N firms, with payoff function
$$\boldsymbol{\Pi} : \mathbb{S}^N \to \mathbb{R}$$
Here, symmetry is not a simplifying assumption: it is directly determined by the notion of a *perfectly contestable market*, where all firms have equal opportunities.

- A firm is *inactive* if it chooses any element of $\mathbb{S}_0 \subset \mathbb{S}$.
It is *active* if it chooses some element of $\mathbb{S} \setminus \mathbb{S}_0$.

- If all $n-\delta$ active competitors of firm i (with $\delta \in \{0,1\}$, $\delta = 1$ if firm i is active, $\delta = 0$ if not) choose the same strategy $s_n \in \mathbb{S} \setminus \mathbb{S}_0$, the payoff $\boldsymbol{\Pi}(s_i, \mathbf{s}_{-i})$ of i can be denoted by $\Pi(s, s_n, n, \delta)$.

Equilibrium

- **Definition:**
  A non-trivial, symmetric **free entry equilibrium** is a pair (s_n, n) in $(\mathbb{S}\setminus\mathbb{S}_0) \times \{1, ..., N-1\}$ satisfying two conditions:

$$\max_{s\in\mathbb{S}} \Pi(s, s_n, n, 1) \quad = \quad \Pi(s_n, s_n, n, 1) \geq 0$$

(profitability)

and

$$\max_{s\in\mathbb{S}} \Pi(s, s_n, n, 0) \quad = \quad \max_{s\in\mathbb{S}_0} \Pi(s, s_n, n, 0) = 0$$

(sustainability).

A canonical pricing model

- Industry with a decreasing demand $D(P)$ for a (possibly composite) good with price P.
- N firms with the same cost function $C(y)$, s.t. $C(0) = 0$ (no sunk costs) and decreasing average cost $C(y)/y$.
- The firm strategy will always be *represented* by a price p.
- Firm i (s.t. $\delta = 1$ if active, $\delta = 0$ otherwise) has to solve the problem:

$$\max_{(p,y)\in\mathbb{R}_+^2} \{py - C(y) : y \leq d(p, p_n, n, \delta)\}$$

- Because of decreasing average cost, y is equal either to 0 or to demand, so that we get the ***canonical program***:

$$\max_{p\in\mathbb{R}_+} \{pd(p, p_n, n, \delta) - C(d(p, p_n, n, \delta))\}$$

A canonical pricing model

- The canonical program may in fact be used not only in the context of price competition games (*e.g.* Dixit-Stiglitz), possibly involving the choice of location (*e.g.* Salop), but also in the context of Cournot competition:

  Take $p_n = P$ and $y_n = D(P)/n$. Then $d(p, p_n, n, \delta)$ is equal to residual demand

  $$D(p) - (n - \delta) y_n = D(p) - (1 - \delta/n) D(p_n).$$

Assumptions

- **A1**: The *average cost* is C^2 and has a negative, non-decreasing elasticity (it is decreasing and convex in the space ($\ln y$, $\ln p$)).

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- **A3**: The elasticity of demand to the industry is non-increasing whenever smaller than -1. The elasticity of marginal cost dominates the elasticity of the inverse demand.

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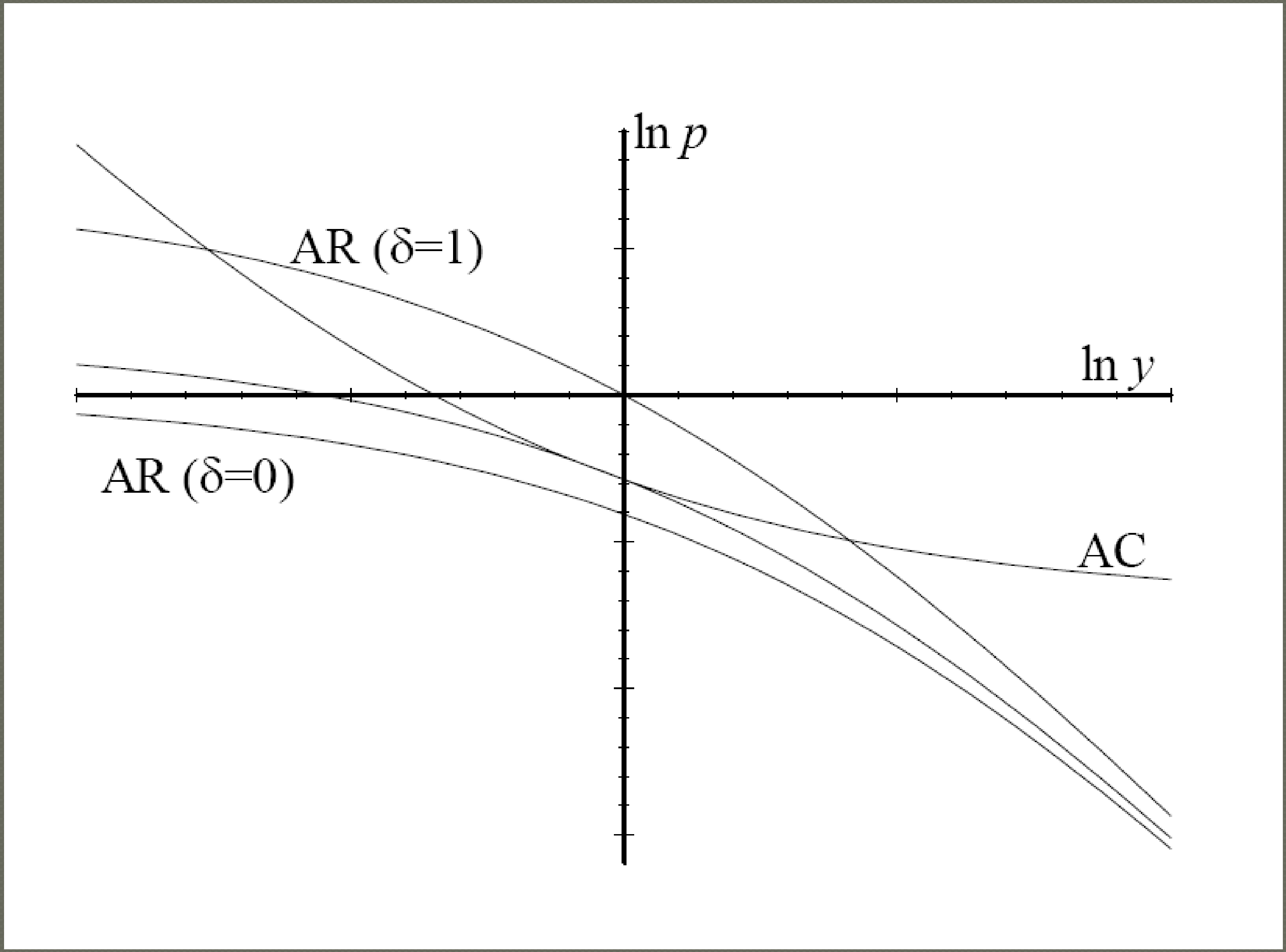
Average cost and average revenue



Definitions

- A ***critical price*** p_n^* is a price which, when simultaneously set by *n* active firms, equalizes the marginal revenue and the marginal cost of any such firm (FOC for an interior solution of the canonical program).

- The ***break-even price*** is the lowest price which, when simultaneously set by *n* active firms, allows them to get non-negative profits.

- The ***limit price*** is the highest price which, when simultaneously set by *n* active firms, prevents an entrant from getting positive profits.

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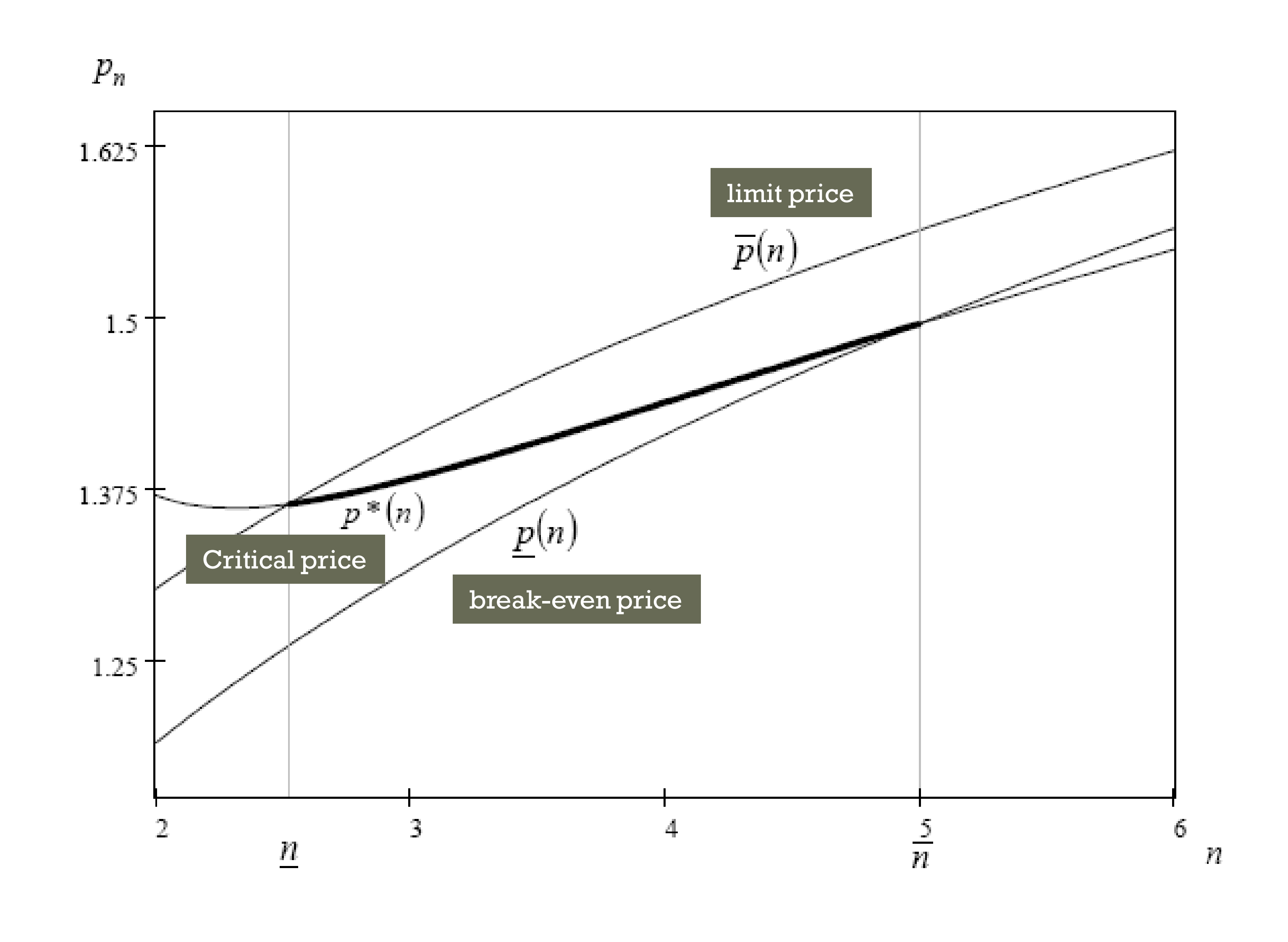
- The ***limit price*** $\overline{p}(n)$ is the highest price which, when simultaneously set by *n* active firms, prevents an inactive firm from getting positive profits.

Proposition

- Under assumptions (A1), (A2) and (A3), a symmetric strategy profile with *n* active firms setting the same price is a free entry equilibrium iff this price is a critical price p_n^* s.t.

$$\underline{p}(n) \leq p_n^* \leq \overline{p}(n) .$$



p_n
1.625
1.5
1.375
1.25
limit price
$\bar{p}(n)$
$p^*(n)$
Critical price
$\underline{p}(n)$
break-even price
2
3
4
5
6
$\underline{n}$
$\bar{n}$
n

Admissibility

- The condition on an admissible price interval translates into the condition that the number of active firms should belong to some admissible interval $[\underline{n}, \overline{n}]$.
- If this interval contains more than one integer, there is indeterminacy of the free entry equilibrium.
- Such indeterminacy is in fact quite robust, appearing in different regimes of competition and with different sources of internal economies of scale.

3. Application

Application to standard regimes of competition in macroeconomics

- As an illustration, we apply the preceding framework to:

- quantity competition in a homogeneous oligopoly (Cournot);
- price competition in a differentiated oligopoly (modified Dixit-Stiglitz);
- price competition in a spatially differentiated oligopoly (Salop).

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- We assume the cost function $C(y) = c(\phi + y^{\gamma})$
  if $y > 0$, $C(y) = 0$ otherwise,
  with positive fixed cost ($\phi > 0$) and/or decreasing marginal cost ($0 < \gamma < 1$)
  and the demand function $D(P) = b/P$.

Application to standard regimes of competition in macroeconomics

- The expression for the break-even price is independent of the specific competition regime, but the expressions for the demand to the firm and for the critical and limit prices are regime-dependent.

- Using all these expressions, we determine the admissible interval for the number of active firms, which may in general have more than one integer.

- An exception is competition in the Dixit-Stiglitz setting when there is a fixed cost but the marginal cost is constant.

Example: Cournot with $\phi > 0, \gamma = 1$

- Critical price: $p^*(n) = \frac{n}{n-1}c$
- Break-even price: $\underline{p}(n) = \frac{b/\phi}{b/c\phi - n}$

  Profitability $p^*(n) \geq \underline{p}(n)$ imposes an upper bound on n:

$$\overline{n} = \sqrt{b/c\phi}$$

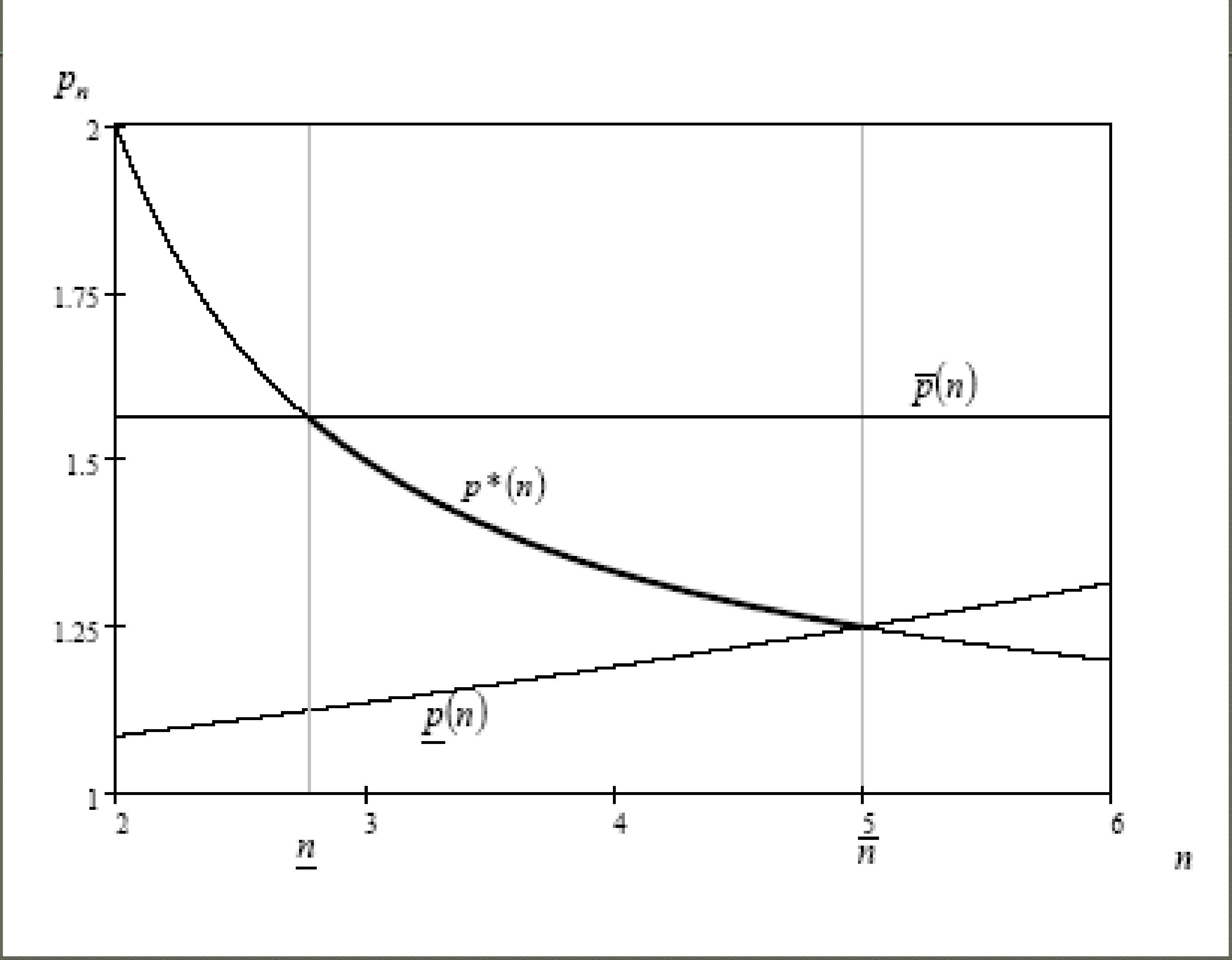
- Limit price: $\overline{p}(n) = \frac{c}{1-\sqrt{c\phi/b}} \frac{1}{1+\sqrt{c\phi/b - c\phi/b}}$

  Sustainability $p^*(n) \leq \overline{p}(n)$ imposes a lower bound on n:

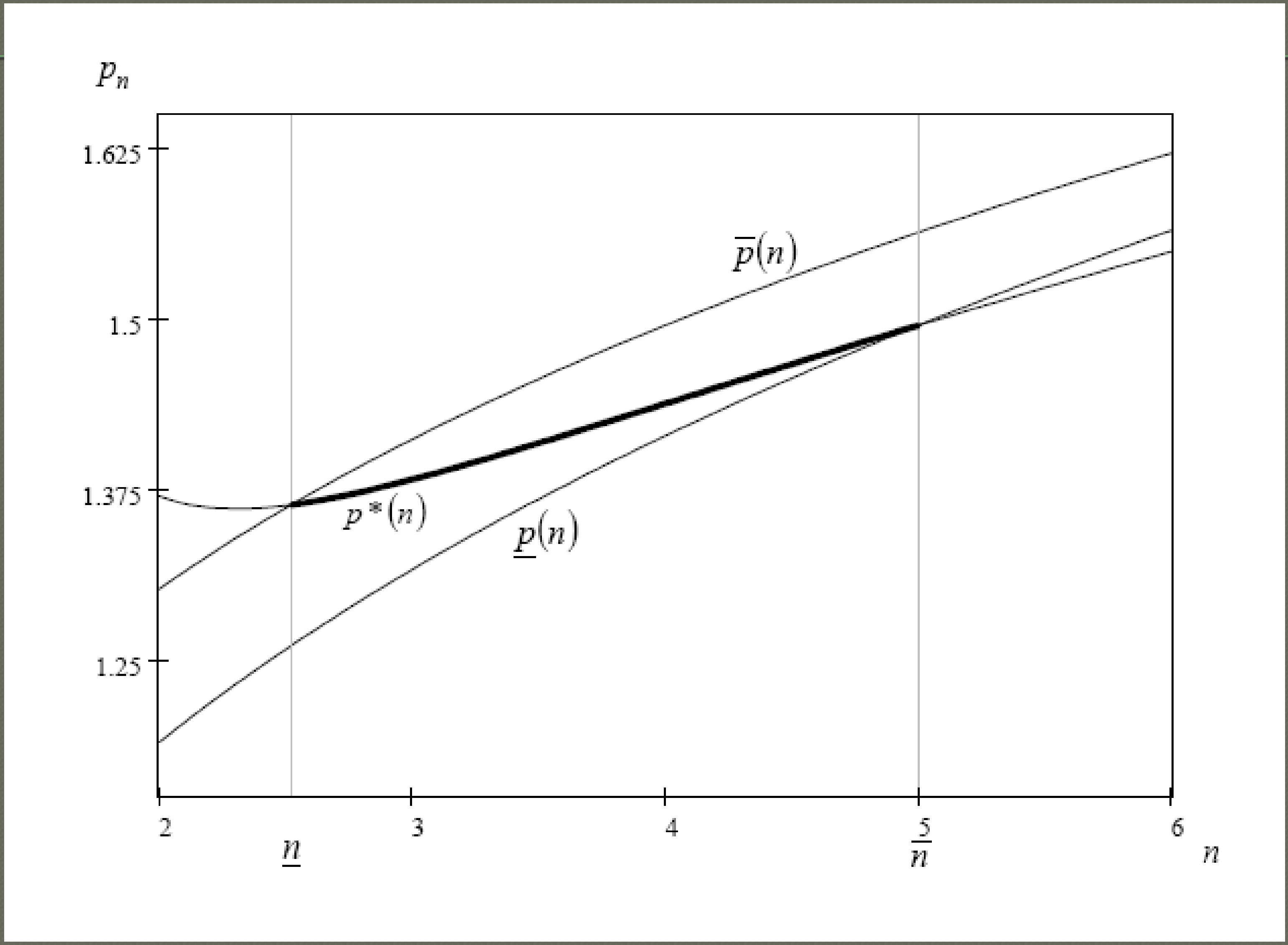
$$\underline{n} = \overline{n}/\left(2 - 1/\overline{n}\right)$$

There is indeterminacy for $\overline{n} \geq 3$ (small ϕ).

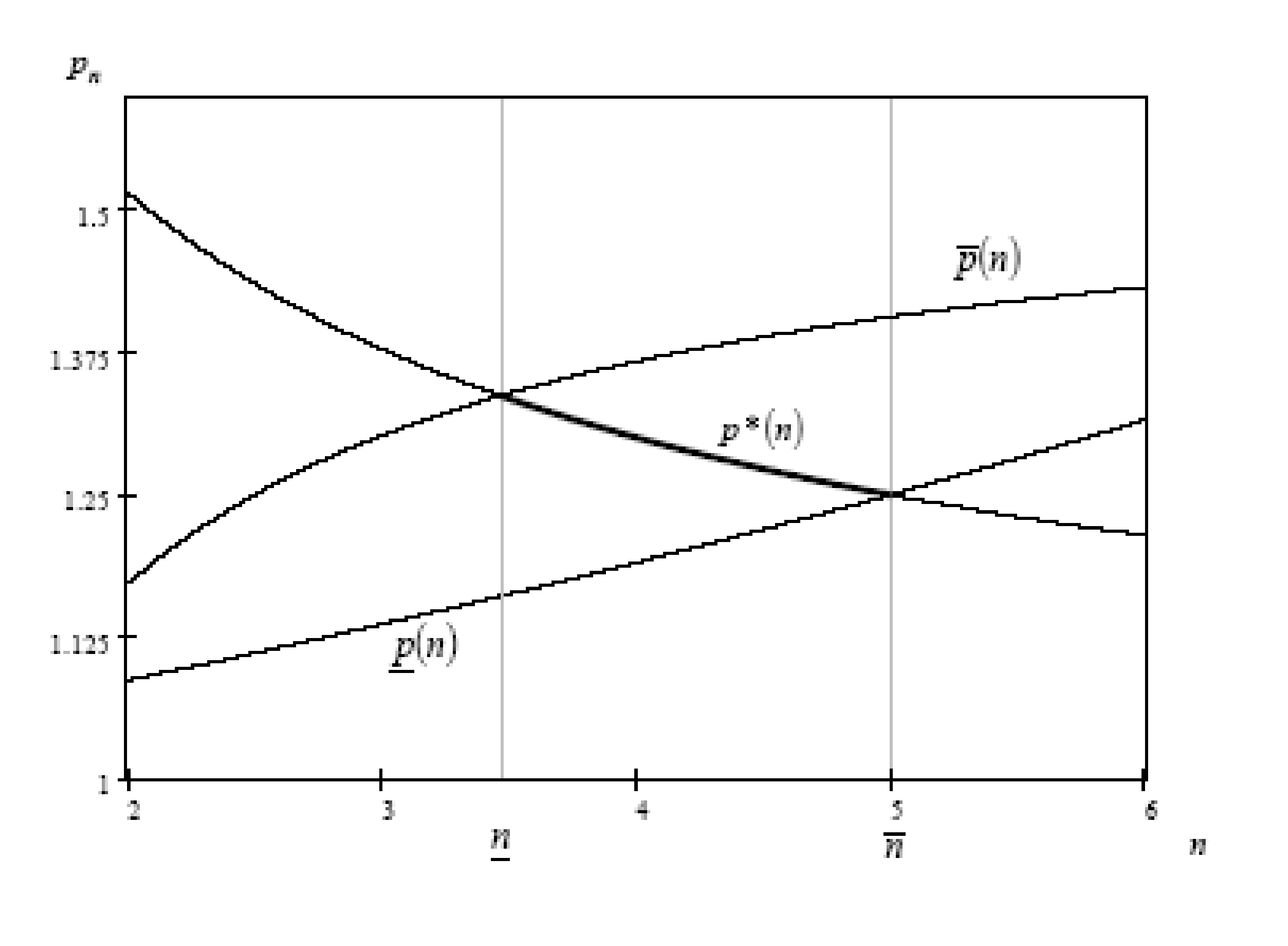
Quantity competition with a fixed cost (Cournot homogeneous oligopoly)



Price competition with decreasing marginal cost (modified Dixit-Stiglitz model)



Price competition with a fixed cost (Salop model of spatial differentiation)



4. Macroeconomic and policy implications

Some macroeconomic implications

- Multiplicity of equilibria requires some selection procedure, allowing coordination of firms conjectures and resulting decisions.

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- Multiplicity of equilibria requires some selection procedure, allowing coordination of firms conjectures and resulting decisions.
- When adopting the *zero profit condition*, one implicitly assumes that firms always coordinate on the *least profitable* of all possible equilibria.
- The *zero profit condition* does not necessarily select a Pareto-dominant equilibrium. Because of the trade-off between the inefficiency generated by market power (decreasing as n increases) and technological inefficiency (increasing with n), consumers may well prefer some equilibrium with a lower number of active firms, in spite of the corresponding higher degree of monopoly.

Coordination failures

- Coordination on extrinsic signals that are correlated across industries naturally leads to the possibilty of
  - coordination failures
  - sunspot fluctuations

- Multiplicity of free entry equilibria broadens the scope for coordination failures as compared to the framework of Cooper and John (1988).

  Contrary to this framework, we impose symmetry at equilibrium only within each class of active and inactive firms. As a consequence, we do not rely on strategic complementarity, allowing the critical price to be a multi-valued function of n.

Taxation as a selection device

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- Considered policy :$\{\tau(n/n^*), T(n/n^*)\}$

  - $\tau(n/n^*)$ is a tax rate on sales : $(1-\tau(n/n^*))p(n)y_n$

  - $T(n/n^*)$ is a lump-sum subsidy (reducing fixed costs)

  - n/n^* is the ratio between the effective and the targeted numbers of active firms

Taxation as a selection device

- Ideally, we want such a policy to be a strict selection instrument avoiding any ex-post distortions or redistribution among sectors or among types of agents (firms and consumers).

- **Definition** : The set of desirable fiscal policies is the set of proportional taxes on sales at rate $\tau\,(n/n^*)$ and lump-sum subsidies $T(n/n^*)$ satisfying:

  (i) the sectoral balanced budget condition : $T(n/n^*)n = \tau\,(n/n^*)b$;

  (ii) the inoperativeness at the efficient equilibrium condition: $T\,(1) = \tau\,(1) = 0$.

After-tax profit function:

$$\Pi\left(y,\overline{Y},n/n^{*}\right)=\left(\frac{\left(1-\tau\left(n/n^{*}\right)\right)b}{y+\overline{Y}}-c\right)y-\left(c\phi-T\left(n/n^{*}\right)\right)$$

New *Cournotian price*:

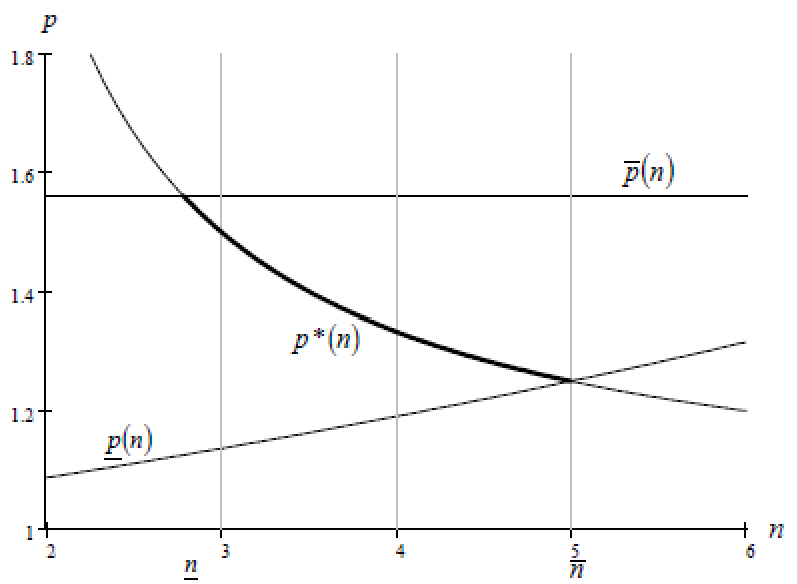
$$p^{*}\left(n,n^{*}\right)=\frac{n}{n-1}\frac{c}{1-\tau\left(n/n^{*}\right)}$$

New *limit price*:

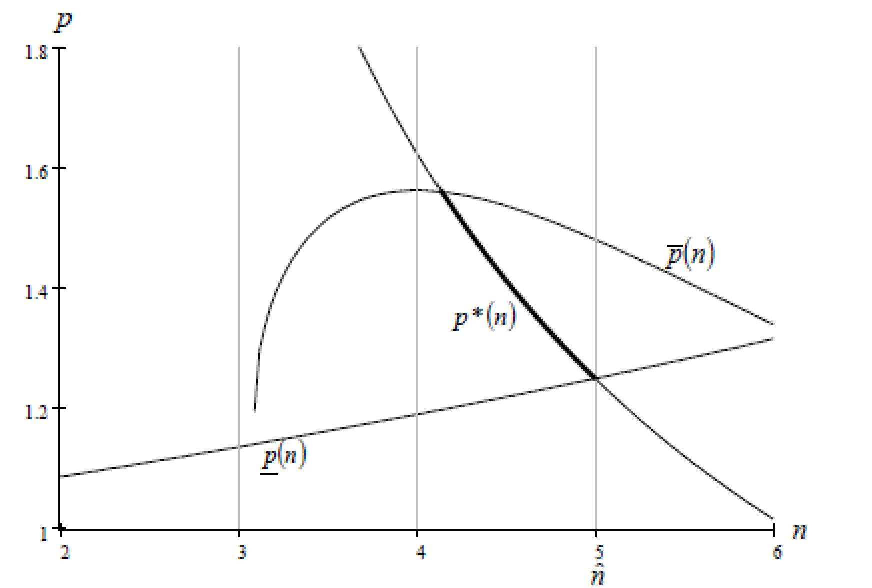
$$\overline{p}\left(n,n^{*}\right)=\frac{c}{\left(\sqrt{1-\tau\left(\left(n+1\right)/n^{*}\right)}-\sqrt{\left(c\phi-T\left(\left(n+1\right)/n^{*}\right)\right)/b}\right)^{2}}$$

Break-even price $\underline{p}(n,n^*)$ unchanged
under the sectoral balanced budget condition

Proposition 1: Any free entry equilibrium with $n < n^*$ in the 'laissez-faire' economy can be ruled out by the choice of a high enough taxation rate $\tau\,(n/n^*)$.

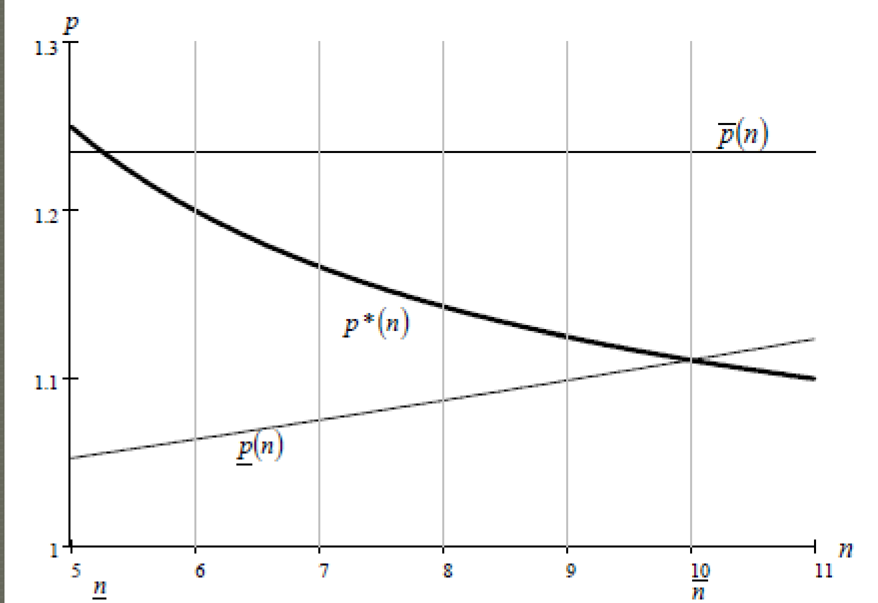


$\phi / b = 0.04; \tau = 0$

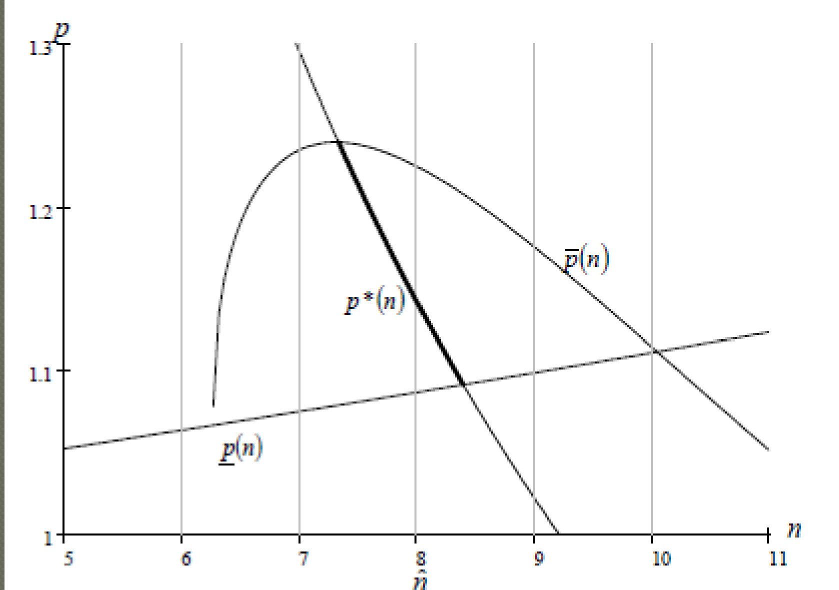


$\phi / b = 0.04; \tau = 0.18$

Proposition 2: Any free entry equilibrium with $n > n^*$ in the 'laissez-faire' economy can be ruled out by the choice of a high enough subsidization rate $-\tau\,(n/n^*)$ applied to sales (financed by a lump-sum tax equal to $-\,T\,(n/n^*)$).



$\phi / b = 0.01; \tau = 0$



$\phi / b = 0.01; \tau = 0.1$

5. Conclusion

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- The zero profit condition is just a particular selection rule, which supposes that firms always coordinate on the least profitable equilibrium.
- We can think of other coordination procedures, such as coordination on sunspots.
- This enlarges the scope for coordination failures (beyond the realm of strategic complementarities) and for existence of endogenous fluctuations (with milder assumptions on the degree of scale economies).