The Novelty of Innovation: Competition, Disruption, and Antitrust Policy

创新的新颖性：竞争、颠覆和反垄断政策

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汇报人：张曦尹

➢ 创新更多的来自于在位企业还是新进入企业？

Arrow(1962)(Arrow effect/replacement effect/Arrow replacement effect)

结论：垄断企业（在位企业）缺乏创新动机，反倒是那些规模较小、市场力量微弱的竞争者（新进入企业）对创新更有热情。（创新激励取决于市场竞争状态）

逻辑：阿罗指出创新在给企业带来潜在收益的同时，也可能导致企业损失现有利润。对于垄断者而言，采用创新技术和进行新技术的研发，可能意味着企业面临损失更大的现有利润的风险，这会阻碍其研发创新，而竞争者在进行创新时则没有相应的机会成本。因此，垄断者往往会局限于自己原有的技术地位，在不被外部竞争者挑战的情形下，垄断企业更倾向于保守。竞争厂商通过创新能占领更多市场份额（甚至替代在位企业），其创新动机更强。

本文的结论与之类似（Sapcial arrow effect）：在位者总是比新进入企业的创新更渐进，新进入企业创新更激进。

本文逻辑与Arrow不同，考虑**创新新颖性**的情况下，按照阿罗的逻辑推理会得到相反的结论。新产品越新颖，它对现有产品的蚕食就越少，在位者的产品组合就越能吸引广泛的客户群，跨产品协调价格获取更多的利润，所以在位企业有进行更激进创新的动机。新进入企业为了从在位者那里获取更多市场份额，新进入企业会更倾向于研发与现有产品更相近的产品（进行更渐进的创新）。

[1]Arrow K (1962) Economic welfare and the allocation of resources for invention. Nelson RR, ed. The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton University Press, Princeton, NJ), 609–626.

但为何本文还会得到“新进入企业创新会进行更激进的创新”的结论呢？

Hotelling(1929)霍特林空间竞争（Spacial Competition）理论

产品差异与产品处于直线空间上的位置有关。例子：卖冰淇淋理论。

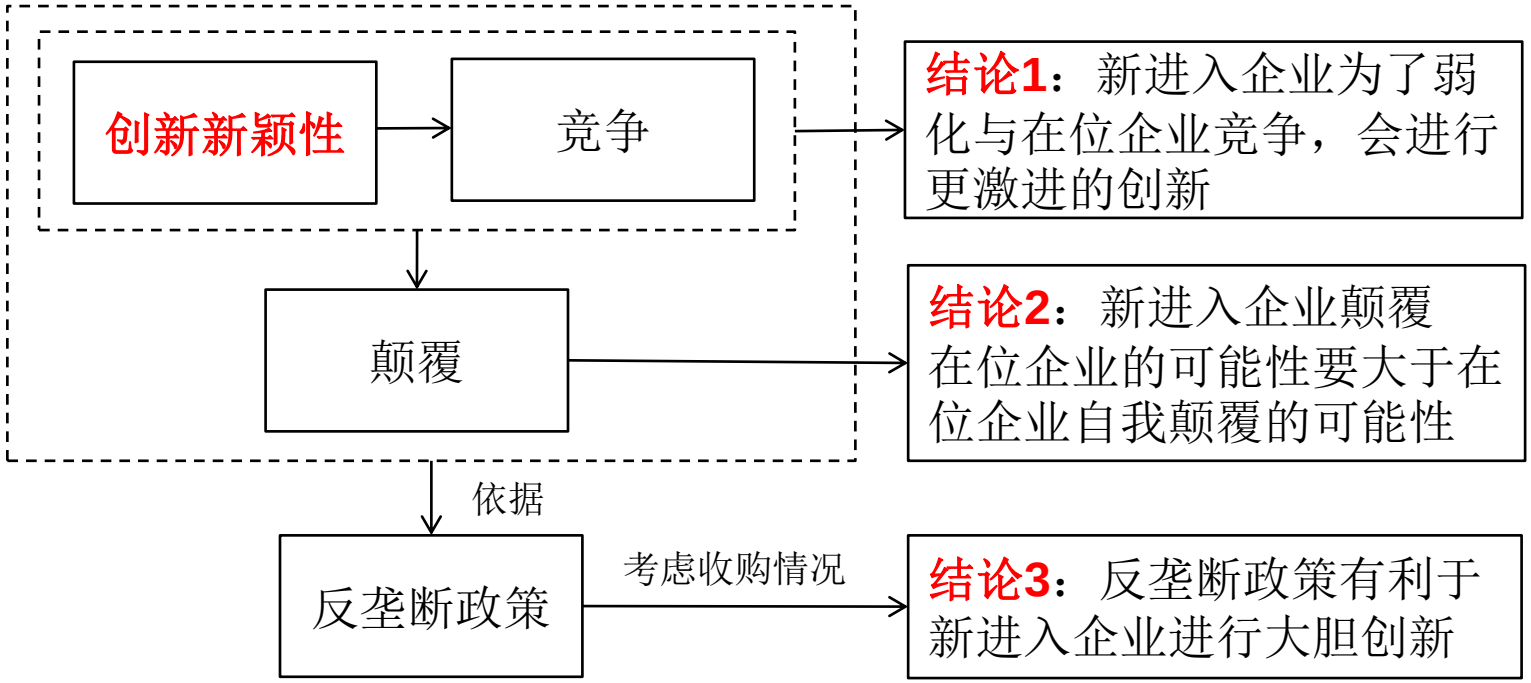
两个厂商倾向于都通过移至地理区位的中心来争取到最大的客户量，尽管这并不是社会最优解但却是纳什均衡（双方皆无动力去改变策略的状态）

从空间竞争的角度：更新颖的创新在市场竞争方面也更遥远，新进入企业有差异化的动机来弱化市场竞争。在位者能够协调不同产品间的定价，没有这种动机。本文证明**新进入企业弱化竞争的动机占主导**。所以新进入企业会进行更激进的创新。

本文的核心贡献（Spacial arrow effect）：两者至于同一框架（技术距离、产品差异、消费者偏好）

[2] Hotelling H (1929) Stability in competition. Econom. J. 39(153):41–57.

本文从创新新颖性的角度，解决“**创新更多的来自于在位企业还是新进入企业？在位企业和新进入企业谁会进行更激进/渐进的创新？”这一经典问题，重新**思考创新与竞争、颠覆的关系，以及反垄断政策的意义。



2.A Model of Innovation Novelty

- **Basic settings**

two firms; technology space $\left[-\frac{1}{2},\frac{1}{2}\right]$; consumers have heterogeneous preferences over the products these technologies produce.

➢ The incumbent firm:

- product 0
- located at the center of the market
- technology $l_0 = 0$ quality v_0
- marginal cost of production is zero

➢ The entrant frim:

- product 1
- technology $l_1 \in [0, 1/2]$, quality $v_1 \sim N(v_0 + ul_1, \sigma^2 l_1)$ $(\mu \geq 0, \sigma^2 > 0)$
- marginal cost of production is zero
- development costs for new product: $c(l_1) \geq 0$; $c(0) = c'(0) = 0$; $c'(l_1) \geq 0$ for all l_1 ; convex

the quality differential between the products $\Delta \equiv v_1 - v_0$

The novelty of the innovation: distance from the technology underlying product 0.

Uncertainty of innovation quality increases in the novelty of the innovation.

2.A Model of Innovation Novelty

- **Customers**

Each consumer, s, buys at most one unit of either product 0 or 1.

The utility from product $j \in \{0, 1\}$ at price p_j
(随着消费者理想与产品技术的距离二次递减)

$$u_{sj} = v_j - t(s - l_j)^2 - p_j,$$

where $t \geq \mu \geq 0$ represents the disutility of technology distance

We assume that the quality of the incumbent's product satisfies:

$$v_0 \geq \frac{5}{4}t. \qquad (1)$$

2. A Model of Innovation Novelty

- **Compare three cases**:
  (i) the entrant is independent,
  (ii) the incumbent owns the entrant
  (iii) the entrant is independent initially but can be acquired by the incumbent after its product has been developed and before prices are set.

3.Prices, Market Shares, and Profits

- **Benchmark**

Consider the incumbent's problem if the new product did not exist.
In this case, the incumbent would charge the highest price at which all consumers are willing to buy the existing product,

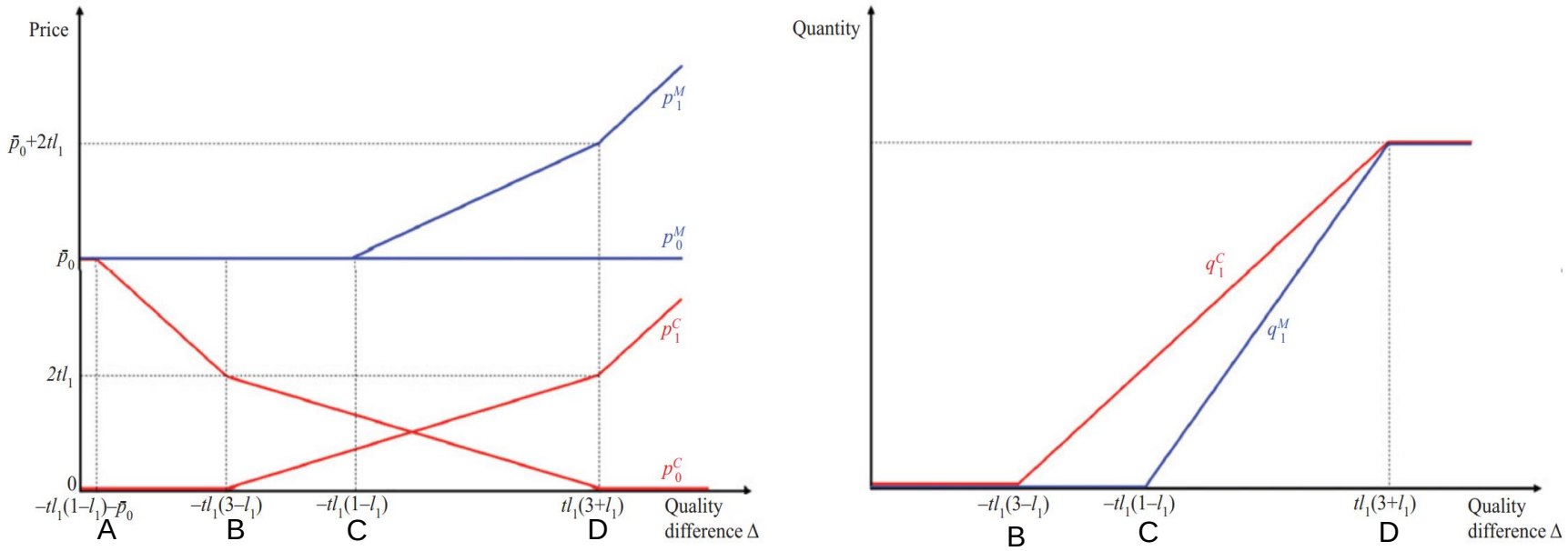
$$\bar{p}_0 = v_0 - \frac{1}{4}t.$$

Since there is a unit mass of consumers and zero marginal cost of production, we have $\bar{\pi}_0 = \bar{p}_0$.
Refer to $\bar{p}_0$ and $\bar{\pi}_0$ as the status quo price and profits.

3. Prices, Market Shares, and Profits

- **Suppose now the new product does exist** and is either owned by the independent entrant or the incumbent.
  Fixing the entrant's location at $l_1 > 0$, Figure 1 illustrates equilibrium prices and the implied market share for the new product for the two cases.

Figure 1. (Color online) Equilibrium Prices and Market Shares for Fixed $l_1 > 0$



Proof. The consumer indifferent between consuming products 0 and 1 is located at

$$x = \frac{1}{2}l_1 - \frac{1}{2tl_1}\Big((v_1 - p_1) - (v_0 - p_0)\Big). \qquad \text{(A.1)}$$

The firm's profit maximization problem is then given by

$$\max_{p_0,p_1} p_0\left(x + \frac{1}{2}\right) + p_1\left(\frac{1}{2} - x\right),$$

which, after substituting x gives, $p_0 = \overline{p}_0$,

$$p_1 = \left(\frac{1}{4}\Big(2(v_1 + v_0) - t + 2tl_1(1 - l_1)\Big)\right),$$

and

$$x = \frac{1}{4tl_1}\Big(v_0 - v_1 + tl_1(l_1 + 1)\Big).$$

This results in three different regimes: (i) $x \geq 1/2$ when $\Delta \geq tl_1(3 + l_1)$, where the entrant captures the entire market, (ii) $x \in (-1/2, 1/2)$ when $\Delta \in (-tl_1(1 - l_1), tl_1(3 + l_1))$, where both incumbent and entrant have positive market shares, and (iii) $x \leq -1/2$ when $\Delta \leq -tl_1(1 - l_1)$, where the incumbent captures the entire market. □

3. Prices, Market Shares, and Profits

- **Lemma 1** describes the **the incumbent's profit** if the incumbent owns the entrant.

Lemma 1. *If the incumbent owns the entrant, its gross profit is*

$$\pi_0^M+\pi_1^M=\begin{cases}\overline{\pi}_0+\Delta-tl_1(1+l_1) & if\ \Delta\geq tl_1(3+l_1)\\ \overline{\pi}_0+\dfrac{1}{8tl_1}\left(\Delta+tl_1(1-l_1)\right)^2 & if\ -tl_1(1-l_1)\leq\Delta\leq tl_1(3+l_1)\\ \overline{\pi}_0 & if\ \Delta\leq -tl_1(1-l_1).\end{cases}$$

3. Prices, Market Shares, and Profits

- **Lemma 2** describes the profit from **competition for the two firms**.

Lemma 2. *If the entrant is independent, the incumbent's gross profit is*

$$\pi_0^C = \begin{cases} 0 & if\ \Delta \geq tl_1(3+l_1) \\ \frac{1}{18tl_1}\left(\Delta - tl_1(3+l_1)\right)^2 & if\ -tl_1(3-l_1) \leq \Delta \leq tl_1(3+l_1) \\ -\Delta - tl_1(1-l_1) & if\ -tl_1(1-l_1) - \overline{p}_0 \leq \Delta \leq -tl_1(3-l_1) \\ \overline{\pi}_0 & if\ \Delta \leq -tl_1(1-l_1) - \overline{p}_0 \end{cases}'$$

and the entrant's gross profit is

$$\pi_1^C = \begin{cases} \Delta - tl_1(1+l_1) & if\ \Delta \geq tl_1(3+l_1) \\ \frac{1}{18tl_1}\left(\Delta + tl_1(3-l_1)\right)^2 & if\ -tl_1(3-l_1) \leq \Delta \leq tl_1(3+l_1) \\ 0 & if\ \Delta \leq -tl_1(3-l_1). \end{cases}$$

随着Δ增加，新产品的价格和市场份额都在上升，而现有产品的价格和市场份额都在下降，进入者有大胆创新的动机。

4. Innovation

- **At the beginning of the game, the entrant chooses the location of the new product**.

To maximize profit, the incumbent **maximizes the expected gain from innovation**,where the gain is $G^M = \pi_0^M + \pi_1^M - \bar{\pi}_0$, minus the cost of product development, $c(l_1)$.

Thus, when the incumbent owns the entrant, the optimal location l_1^M maximizes

$$\mathrm{E}[G^M] - c(l_1). \qquad (6)$$

If the entrant is independent, the gain from innovation is simply $G^C = \pi_1^C$ (创新收益全部来自于进入者), and the optimal location is the l_1^C that maximizes

$$\mathrm{E}[G^C] - c(l_1). \qquad (7)$$

4. Innovation

- 固定l_1和Δ时，将两种情况的创新收益差(innovation gains)进行分解

$$G^C - G^M = \underbrace{(\overline{\pi}_0 - \pi_0^C)}_{\text{replacement}} - \underbrace{[(\pi_0^M + \pi_1^M) - (\pi_0^C + \pi_1^C)]}_{\text{gains from coordinating prices}} . \quad (8)$$

- 独立进入者损失了协商价格的收益，却避免了现有产品的利润损失
- the replacement effect dominates so that $G^C - G^M \geq 0$

4. Innovation

- **The Spatial Arrow Effect**

Proposition 1. *The new product is more differentiated from the existing one if the entrant is independent than if it is owned by the incumbent, that is,*

$$l_1^C > l_1^M.$$

- 为证明命题1，对创新收益差求导，对于所有的$l_1 \in \left[0, \frac{1}{2}\right]$

$$\frac{\mathrm{d}}{\mathrm{d}l_1}(G^C - G^M) = \frac{\mathrm{d}}{\mathrm{d}l_1}(\overline{\pi}_0 - \pi_0^C) - \frac{\mathrm{d}}{\mathrm{d}l_1}[(\pi_0^M + \pi_1^M) - (\pi_0^C + \pi_1^C)] \geq 0. \quad (9)$$

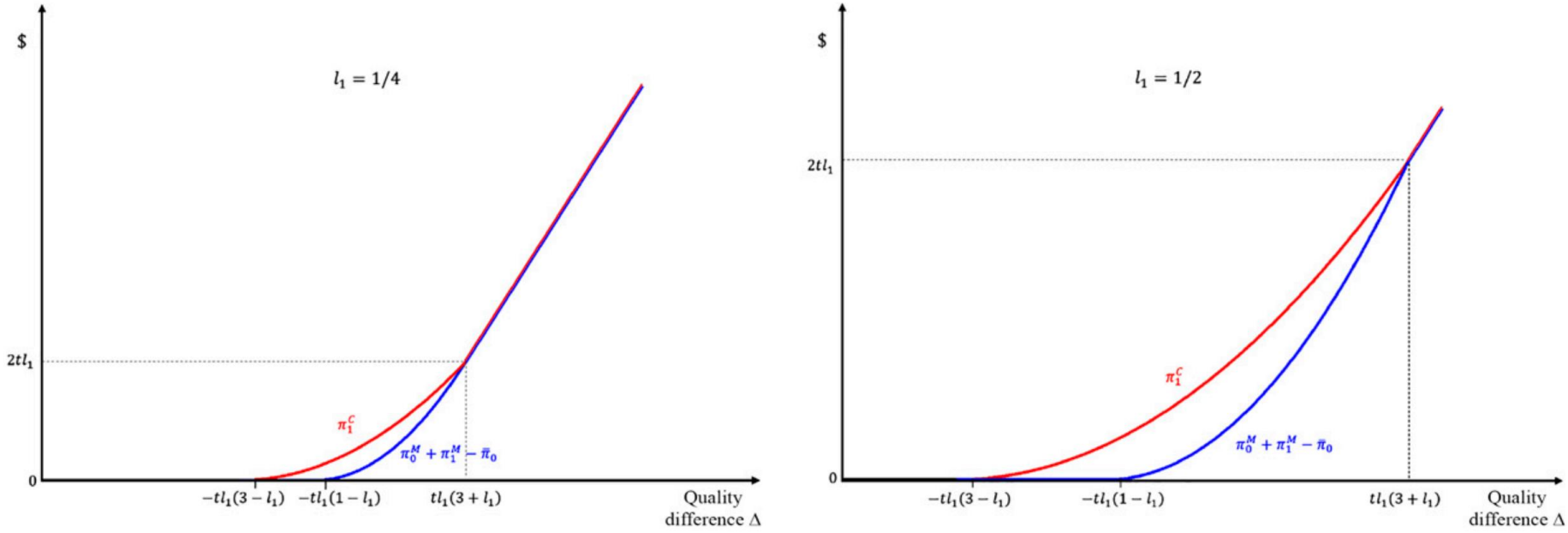
- 考虑不确定性不影响顺序

$$\frac{\mathrm{d}}{\mathrm{d}l_1}\mathrm{E}(G^C - G^M) \geq 0 \quad (10)$$

- 考虑研发成本

4. Innovation

Figure 2. (Color online) Gains from Innovation



Note. In the graph on the left, $v_0 = \frac{3}{2}$, $t = 1$, and $l_1 = \frac{1}{4}$; on the right, $l_1 = \frac{1}{2}$.

- 独立的进入者从创新中获益更多，这与阿罗的经典论点一致。
- l_1越大时，创新收益差越大(空间阿罗效应)。

4.1. Disruption

- **创新新颖性对颠覆的影响取决于两种力量**:突破性创新颠覆可能性越大；创新越新颖与现有产品**竞争**越不激烈

$$\Pr(\Delta \geq \delta) = 1 - \mathrm{F}(\delta) \qquad \frac{\mathrm{dPr}(\Delta \geq \delta)}{\mathrm{d}l_1} = \frac{\delta + \mu l_1}{2\sigma l_1 \sqrt{l_1}} \mathrm{f}(\delta) > 0.$$

设f(Δ)和F(Δ)表示均值μl_1和方差$\sigma^2 l_1$的正态分布的概率密度函数（PDF）和累积密度函数（CDF）。

---This captures the intuition that **bolder innovations having more chance of a breakthrough.**

the probability of disruption is

$$\Delta \geq t l_1(3 + l_1). \qquad (3)$$

$$\Pr(q_0^j = 0) = 1 - \mathrm{F}\left(t l_1(3 + l_1)\right) \text{ for } j = C, M.$$

$$\frac{\mathrm{dPr}(q_0^j = 0)}{\mathrm{d}l_1} = -\frac{\mu + 3t l_1(1 + l_1)}{2\sigma l_1 \sqrt{l_1}} \mathrm{f}\left(t l_1(3 + l_1)\right) < 0.$$

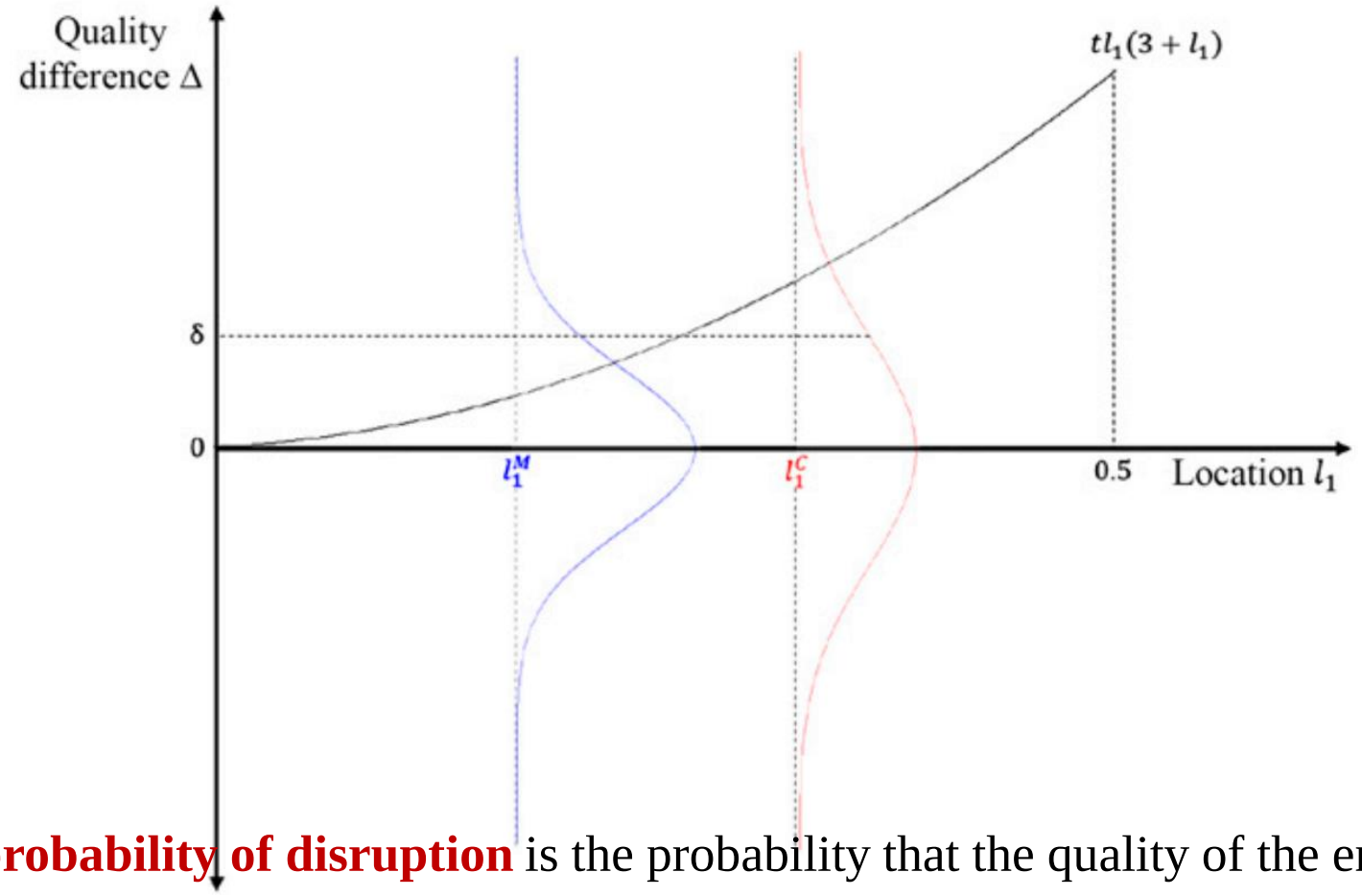
--l_1越大，颠覆的可能性越小。

- **From Proposition 1(独立进入者相比在位者拥有进入者的情况，l_1更大), the following result holds.**

Corollary 1. The existing product's market share is more likely to be zero when the entrant is incumbent owned than when it is independent. Conversely, the entrant's market share is more likely to be zero when the entrant is incumbent owned than when it is independent.

4.1. Disruption

Figure 3. (Color online) Disruption Probability, $\mu = 0$



- **The probability of disruption** is the probability that the quality of the entrant exceeds this increasing threshold.

5. Acquisitions and Antitrust（第三种情况）

- In the last case, the acquisition price is determined by Nash bargaining, where the entrant's bargaining power is given by $\alpha \in [0,1]$ and the incumbent's by$(1-\alpha)$.

  The firms' joint gains from merging are always positive $\pi_0^M + \pi_1^M - (\pi_0^C + \pi_1^C) \geq 0.$

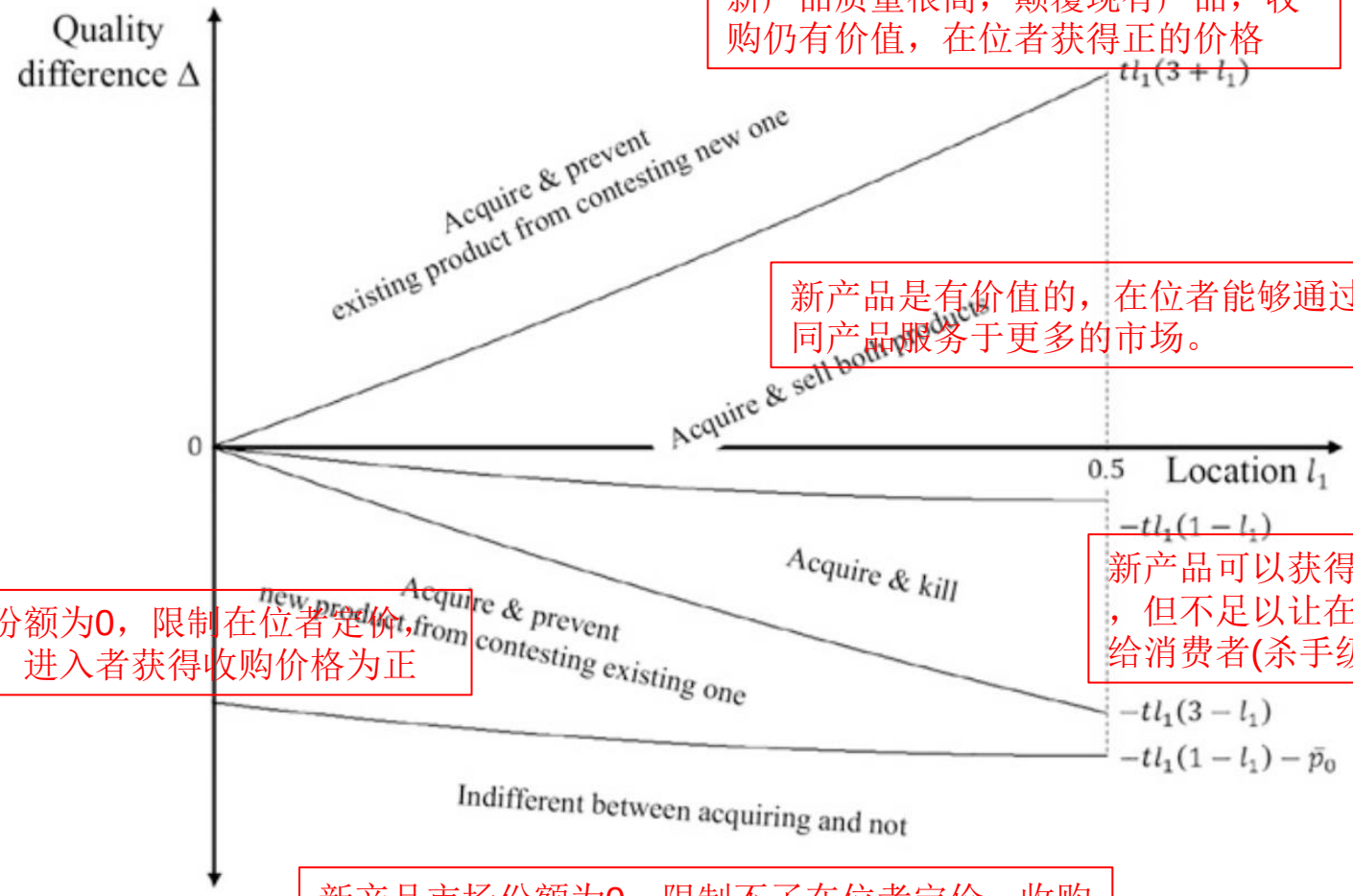
  the incumbent's expected profits are $\pi_0^C + (1-\alpha)(\pi_0^M + \pi_1^M - \pi_0^C - \pi_1^C)$

  the entrant's expected profits are $\pi_1^C + \alpha(\pi_0^M + \pi_1^M - \pi_0^C - \pi_1^C).$

- the motive and implications of the merger depend on the location and quality of the new product:(Figure 4)

5. Acquisitions and Antitrust

Figure 4. Acquisition Strategy of the Incumbent Firm



新产品质量很高，颠覆现有产品，收购仍有价值，在位者获得正的价格

新产品是有价值的，在位者能够通过不同产品服务于更多的市场。

新产品可以获得一定市场份额，但不足以让在位者以高价卖给消费者(杀手级收购)

新产品市场份额为0，限制在位者定价，收购有价值，进入者获得收购价格为正

新产品市场份额为0，限制不了在位者定价，收购收益为0，进入者获得收购价格为0

5. Acquisitions and Antitrust

- 考虑创新及并购决策的后果，企业家将选择一种新技术l_1来最大化盈利能力：

$$l_1^A(\alpha) = \max_{l_1 \in [0,\frac{1}{2}]} \mathrm{E}[\pi_1^C + \alpha(\pi_0^M + \pi_1^M - \pi_0^C - \pi_1^C)] - c(l_1),$$

Proposition 2. *An independent entrant that can be acquired has an optimal location $l_1^A(\alpha)$ that is decreasing in its bargaining power and satisfies $l_1^A(0) = l_1^C$ and $l_1^A(1) \in (0, l_1^M)$.*

- **如果进入者有足够议价能力，空间阿罗效应被逆转。The independent entrant** innovates more incrementally and with less novelty than would the incumbent firm if it controlled the entrant from the start. **This effect increases in the entrant's bargaining power.**

- Rewrite the entrant's gains from innovation as $\mathrm{E}[\pi_1^C + \alpha(\pi_0^M + \pi_1^M - \pi_0^C - \pi_1^C)]$

$$= \mathrm{E}[(1-\alpha)\pi_1^C + \alpha(\pi_0^M + \pi_1^M) - \alpha\pi_0^C].$$

①$\alpha = 0$(entrant has no bargaining power), expected gross profits $E[\pi_1^C]$, chooses the same location $l_1^A(0)=l_1^C$

②$\alpha = 1$(entrant has all the bargaining power), expected gross profits are $E[\pi_0^M + \pi_1^M - \pi_0^C] < E[\pi_0^M + \pi_1^M]$; $l_1^A(1) < l_1^M$

5.1. Consumer Surplus

- 创新新颖性与产品差异化的关系也会影响消费者。

----The greater novelty of the independent entrant improves consumer welfare.

----Greater novelty also imposes a cost on consumers.

Differentiation means softer price competition, and by innovating toward the fringes of the consumer distribution, any success fits less well the preferences of the average consumer.

Proposition 3. *Expected consumer surplus is larger when the entrant stays independent than when it is acquired by the incumbent.*

Proof of Proposition 3. Consumer surplus is given by

$$CS = \int_{-1/2}^{x(p_1,p_2)} v_0 - ts^2 - p_0 ds + \int_{x(p_1,p_2)}^{1/2} v_0 + \Delta - t(s-l_1)^2 - p_1 ds,$$

5.2. Disruption

- When the Arrow effect is reversed, it is **the entrant who has a higher chance of disruption**.

- **However, we should not laud such entrepreneurs.**
  For despite disrupting the incumbent, they are able to do so only because they innovate so tepidly, varying the existing product only incrementally. It is precisely because they locate so close to the existing product that only a small quality premium is needed to disrupt.
  ----increases their own pay-off, may be more likely to lead to market disruption , **lowers overall innovation and market efficiency.**

6. Conclusion

研究表明，（1）验证了阿罗替代效应（Arrow,1962），新进入者（创业企业家）比在位者（成熟企业）追求更多的创新技术，获得突破性成果的概率更高;（2）新进入者颠覆在位企业的可能性小于在位企业自我颠覆的可能性，并且在市场中失败的可能性也更小（颠覆不仅取决于进入者的技术，还取决于进入者在技术领域的距离，因为如果新技术(即使质量更高)不能满足消费者的需求，消费者可能仍然会喜欢现有产品。在位企业自我颠覆的创新可能只是一个边缘的改进，但考虑技术领域的邻近性，足以让现有产品过时。相比之下，企业家可能拥有一个明显更好的产品，但仍然不会把现任者赶出市场）;（3）通过分析在位企业收购新企业（反竞争的，具有垄断性质）对企业家创新的事前激励以及企业家选择的创新新颖性有什么影响，发现被在位者收购的前景会抑制企业家创新新颖性，选择一种比在位企业本身更渐进的创新，这逆转了阿罗效应。这表明，反垄断政策会对激励创业型企业大胆创新具有积极作用。

Thank you!