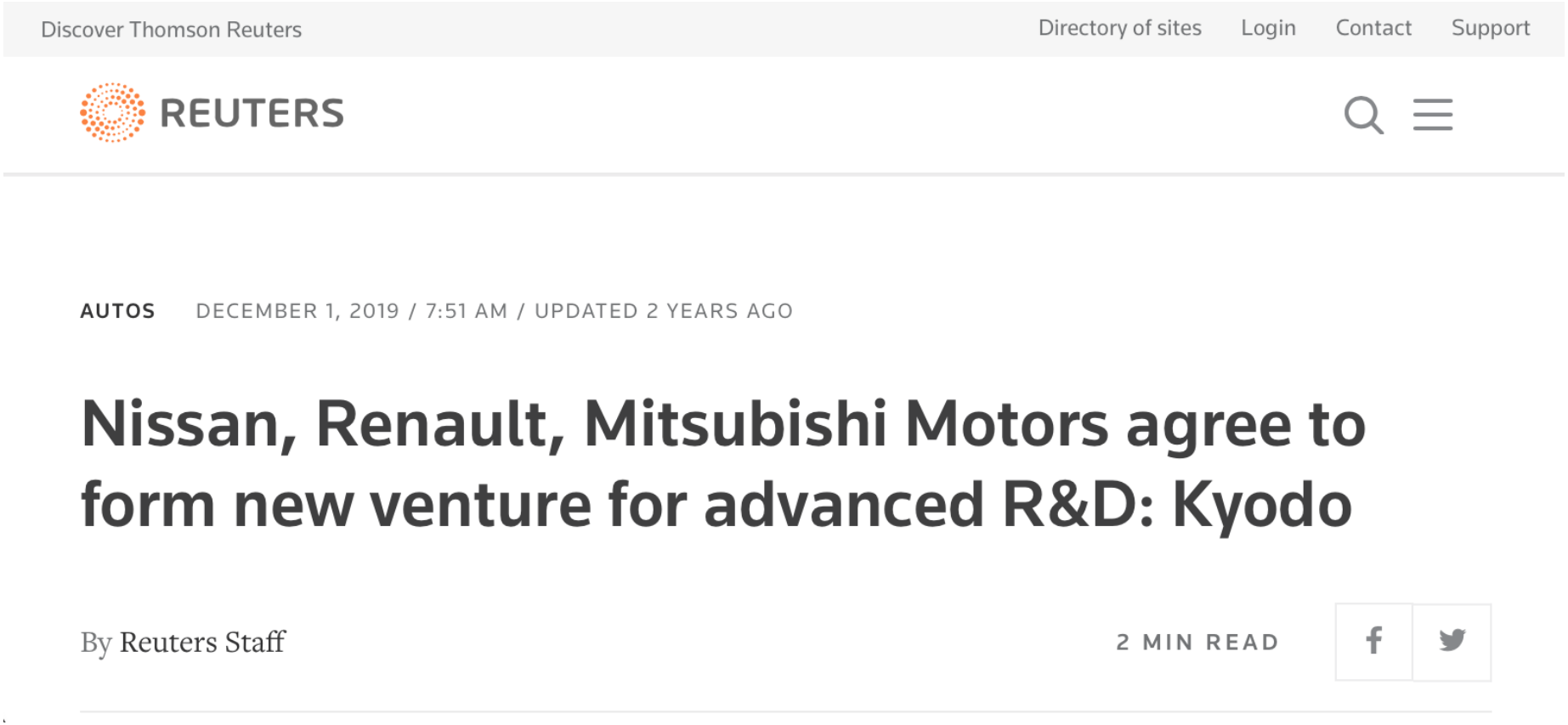
Research Joint Ventures:

The Role of Financial Constraints

Philipp Brunner, Igor Letina and Armin Schmutzler

March 15, 2023

Introduction



Introduction

- Competition policy prohibits horizontal agreements.
- Some specific exceptions are made for efficiency reasons.
- Research Joint Ventures receive lenient treatment:
  - → EU: R&D BER (set to expire Dec. '22, extended by 6 months, new draft available) and Sec. 3 of Horizontal Guidelines;
  - → US: 1993 National Cooperative Research and Production Act;
  - → CH: Art. 6 para. 1(a) CartA.
- Is this justified?

Introduction

- Existing literature focuses on spillovers.
  - → Katz (1986), d'Aspremont and Jacquemin (1988), Kamien, Muller and Zang (1992).
- We study a different channel through which RJVs can lead to more innovation.
  - → Reduction of duplicate R&D can relax financial constraints.
- Main differences to previous literature:
  - → budget-constrained firms;
  - → choice between many different research projects, with uncertainty about which projects are good.
- We ignore the risk of collusion (Sovinsky, 2022; Duso, Röller and Seldeslachts, 2014).

Main Results

1. Innovation Effects of RJVs
   - → With soft competition, RJVs increase variety of innovation projects and thereby innovation probability.
   - → With more intense competition, this only happens if financial constraints are sufficiently tight.
2. RJVs that increase innovation also increase consumer welfare.
3. Profitability of RJVs
   - → If RJVs increase innovation, they are typically profitable.
   - → RJVs that reduce innovation may also be profitable.

Other Results

1. RJVs can lead to more innovation and higher consumer welfare than mergers.
2. Spillovers and financial constraints are complementary reasons why RJVs could increase innovation.
3. With ex-post licensing, RJVs are less likely to increase innovation.
4. Similar results with multiple firms or multiple RJVs.

Roadmap

The Model

Innovation Effects of RJVs

Consumer Welfare

Profitability of RJVs

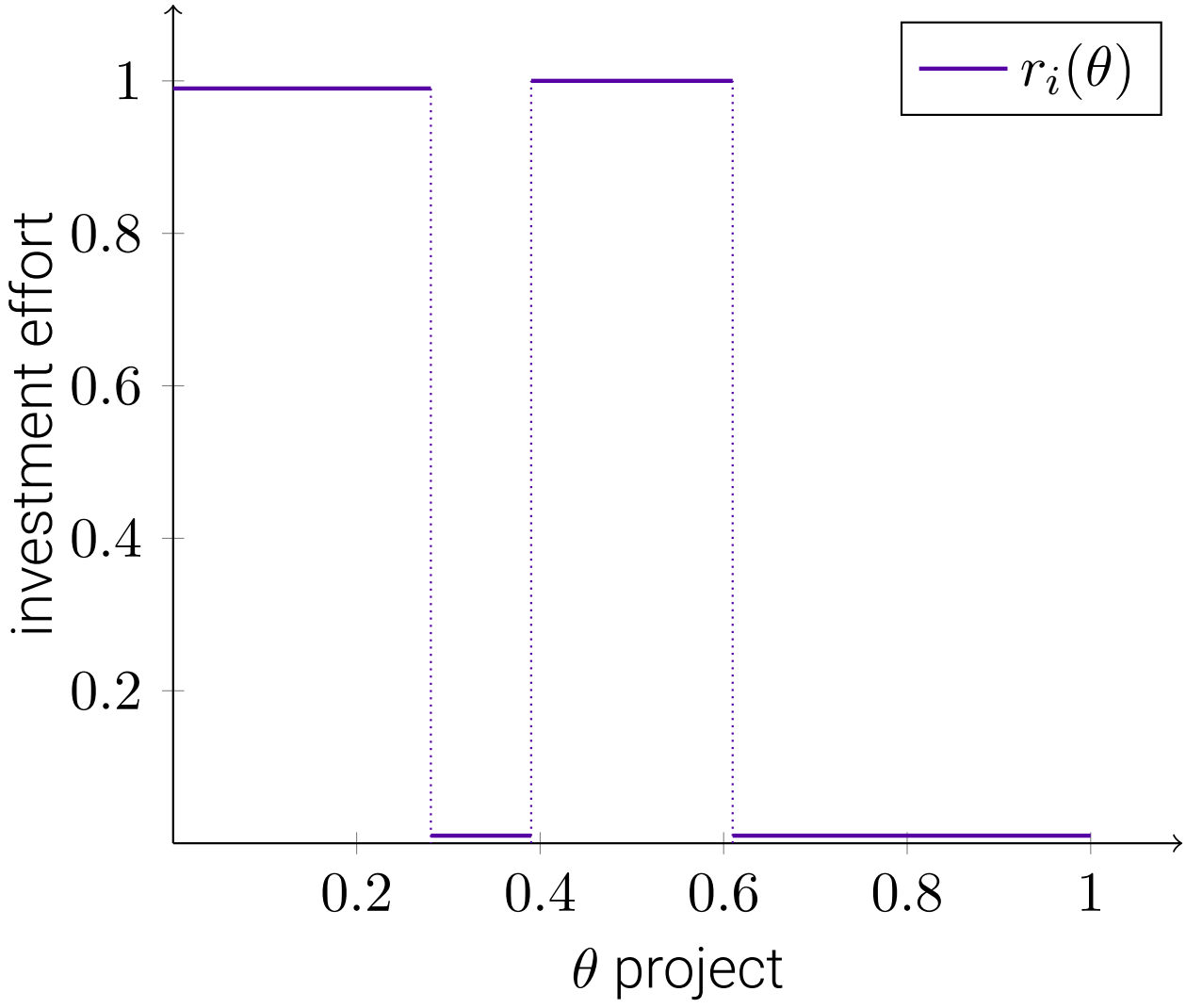
Other Results

Concluding Remarks

Assumptions

- Similar to Letina (2016) and Letina, Schmutzler and Seibel (2021).
- Two firms, each can invest in innovation.
- Two technology levels $t \in \{0, I\}$.
- Continuum of research projects $\Theta = [0, 1)$.
- Only one project $\hat{\theta} \in \Theta$ is correct (ex ante unclear which).
- Each firm chooses a research strategy:
  $r_i(\theta) \in \{0, 1\}$ for all $\theta \in [0, 1)$.
- Developing costs per project: $C(\theta)$, where $C(\theta)$ is differentiable, strictly increasing, and satisfies $C(0) = 0$ and $\lim_{\theta \to 1} = \infty$.

Investment Strategies



Assumptions

- Each firm has a budget B, additional funds can be borrowed externally at some interest rate $\rho > 0$.
- Profits: $\pi_i = \pi(t_i, t_j)$, where $t_i, t_j \in \{0, I\}$ is technology level.

Assumptions ctd.

Assumption 1:

(i) *Profits are non-negative:* $\pi(t_i, t_j) \geq 0$ *for all* t_i *and* t_j.

(ii) *Symmetric innovation increases profits:* $\pi(I, I) \geq \pi(0, 0)$.

(iii) *Competitor innovation reduces profits:* $\pi(t_i, 0) \geq \pi(t_i, I)$ *for* $t_i \in \{0, I\}$.

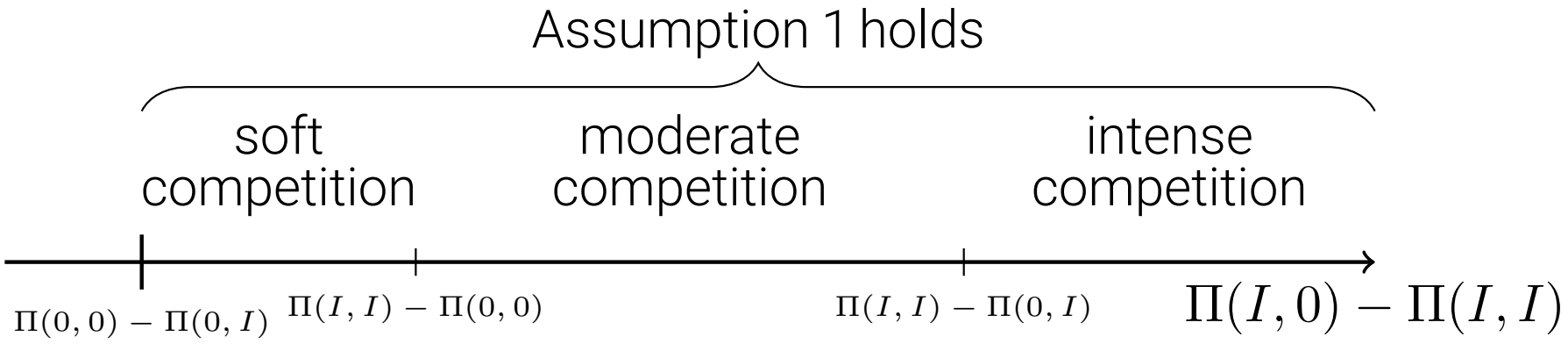
(iv) *Escaping competition is more valuable than catching up:* $\pi(I, 0) - \pi(0, 0) \geq \pi(I, I) - \pi(0, I)$.

Assumption 2: *Budget B is small enough that both firms will be financially constrained in equilibrium under R&D competition.*

Intensity of Competition

We define three different types of competition intensity:

- Competition is intense if avoiding the competitor catching up is more valuable than catching up: $\pi(I,0) - \pi(I,I) > \pi(I,I) - \pi(0,I)$.
- Competition is soft if improving together is more valuable than avoiding catching up of the competitor:
  $\pi(I,I) - \pi(0,0) > \pi(I,0) - \pi(I,I)$.
- Competition is moderate if neither of the above cases holds.



Roadmap

The Model

Innovation Effects of RJVs

Consumer Welfare

Profitability of RJVs

Other Results

Concluding Remarks

Plan

We will compare two regimes:

- R&D competition: firms independently choose R&D strategies and compete on the market.
- RJV: firms jointly choose R&D strategy, share R&D costs and results, but compete on the market.

R&D Competition: Two cutoffs

- Define cutoffs θ_1 and θ_2 as solutions to:

$$(1+\rho)C(\theta_1) = \pi(I,0) - \pi(0,0)$$
$$(1+\rho)C(\theta_2) = \pi(I,I) - \pi(0,I).$$

- θ_1: incentive to invest in project variety.
- θ_2: incentive to invest in duplication.

R&D Competition: Equilibrium Portfolio

Lemma 1:

(i) The research competition game has multiple equilibria. A profile of double-cut off strategies (r_i^*, r_j^*) *is an equilibrium if it satisfies*

(a) $r_i^*(\theta) = r_j^*(\theta) = 1$ *for* $\theta < \theta_2$ *and* $r_i^*(\theta) = r_j^*(\theta) = 0$ *for* $\theta > \theta_1$ *and*

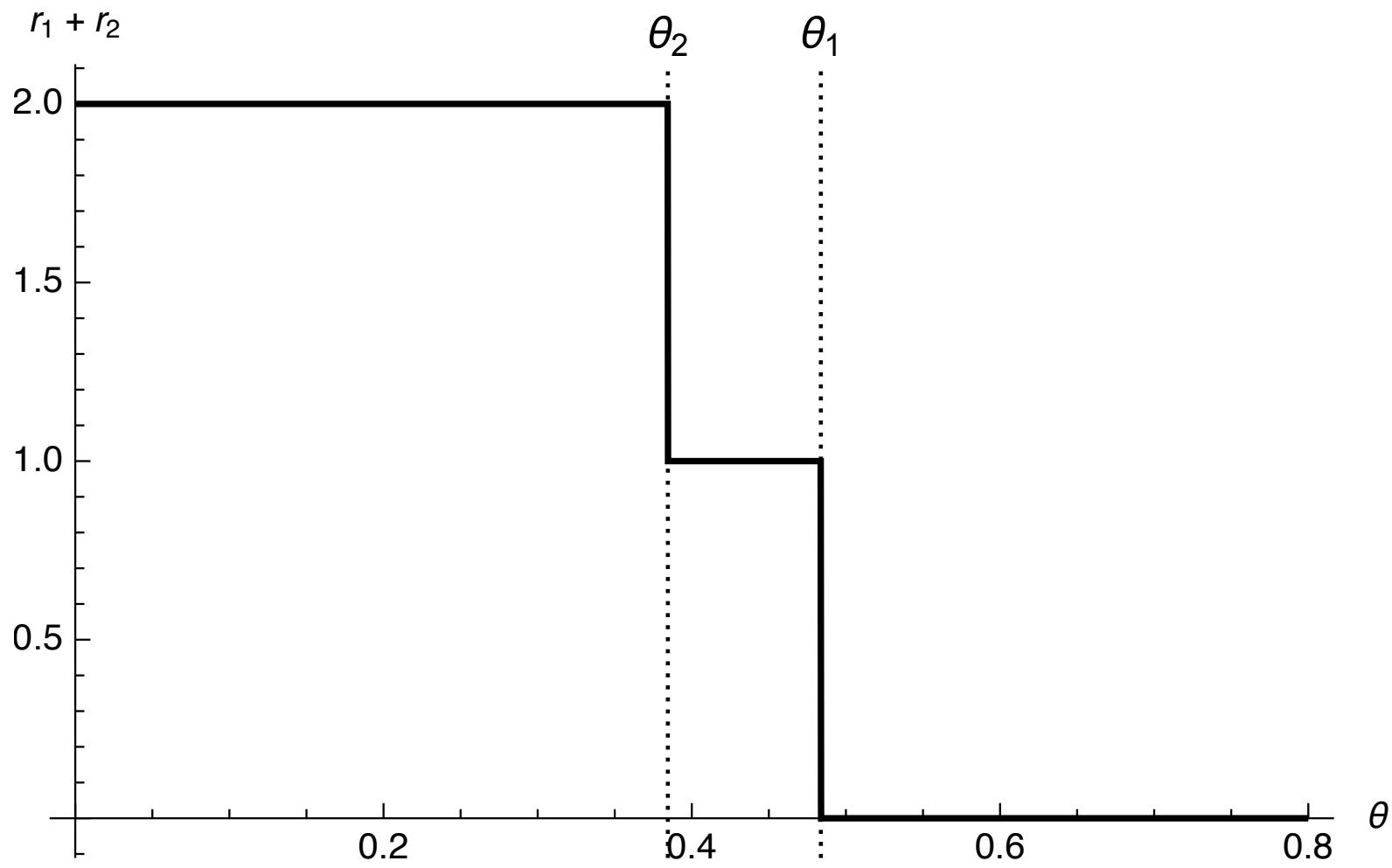
(b) for each $\theta \in (\theta_2, \theta_1)$ *either:*

$$r_i^*(\theta) = 1 \text{ and } r_j^*(\theta) = 0 \text{ or}$$

$$r_i^*(\theta) = 0 \text{ and } r_j^*(\theta) = 1.$$

(ii) No other equilibria of the research-competition game exist.

R&D Competition: Industry Equilibrium Portfolio



Research Joint Venture: Equilibrium Portfolio

Let θ^u, θ^ρ and θ^B, be solutions of

$$C(\theta^u) = 2[\pi(I,I) - \pi(0,0)]$$
$$(1+\rho)C(\theta^\rho) = 2[\pi(I,I) - \pi(0,0)]$$
$$\int_0^{\theta^B} C(\theta)d\theta = 2B$$

Lemma 2:

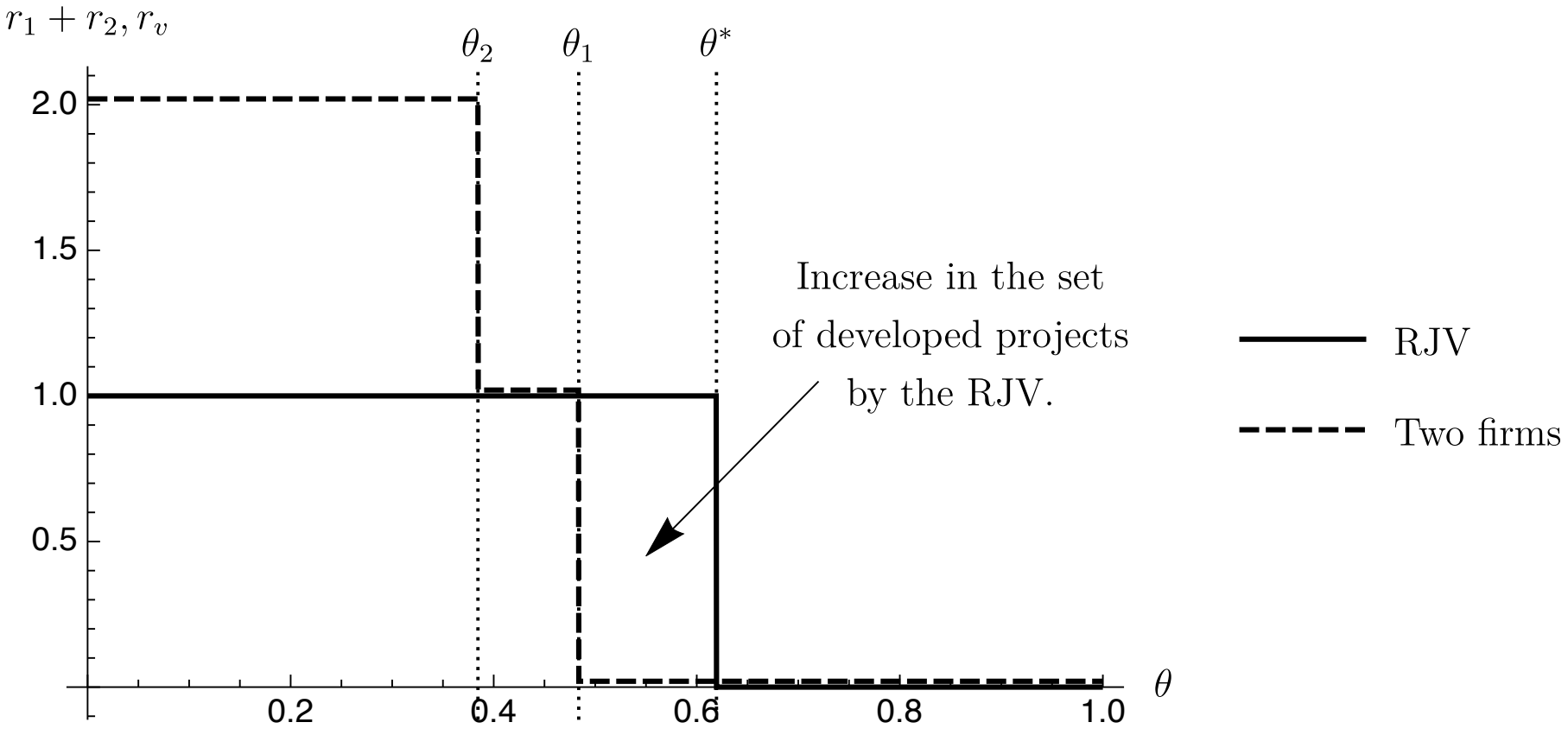
The RJV optimally applies a single cut-off strategy with $r_v(\theta) = 1$ if $\theta < \theta^*$ and $r_v(\theta) = 0$, where:

(i) $\theta^* = \theta^\rho$ if $\theta^B < \theta^\rho$

(ii) $\theta^* = \theta^B$ if $\theta^B \in [\theta^\rho, \theta^u]$

(iii) $\theta^* = \theta^u$ if $\theta^B > \theta^u$

Effect of RJV



Proposition 1 (Comparison of competition and RJV)

1. Suppose competition is soft. Then the innovation probability is strictly larger under the RJV than under R&D competition.
2. Suppose competition is moderate or intense. Then:
   (a) The innovation probability is strictly larger under the RJV than in any equilibrium under competition if and only if $B > \bar{B}(\rho)$ and $\rho > \bar{\rho}$.
   (b) If the formation of the RJV strictly increases the innovation probability, then it weakly decreases total R&D spending.

Effect of RJV: The Thresholds

The interest rate threshold is higher if product market competition is more intense:

$$\rho > \bar{\rho} = \begin{cases} \dfrac{\pi(I,0) - \pi(I,I) - (\pi(I,I) - \pi(0,0))}{2(\pi(I,I) - \pi(0,0))}, & \text{for } \pi(I,I) > \pi(0,0) \\ \infty, & \text{for } \pi(I,I) = \pi(0,0). \end{cases}$$

The budget condition requires that the RJV can finance anything inhouse that a constrained firm would want to as a sole investor:

$$B > \bar{B}(\rho) = \frac{\int_0^{\theta_1} C(\theta) d\theta}{2}$$

Roadmap

The Model

Innovation Effects of RJVs

Consumer Welfare

Profitability of RJVs

Other Results

Concluding Remarks

Consumer Welfare

- $CS(I, I)$ – consumer surplus when both firms have the innovation;
- $CS(I, 0)$ – consumer surplus when one firm has the innovation;
- $CS(0, 0)$ – consumer surplus when no firm has the innovation.

Assumption 3: *Consumers benefit from innovation.*

$$CS(I, I) > CS(0, 0) \text{ and } CS(I, I) > CS(I, 0)$$

.

Proposition 2: *If an RJV strictly increases innovation probability, then it also strictly increases expected consumer surplus.*

Roadmap

The Model

Innovation Effects of RJVs

Consumer Welfare

Profitability of RJVs

Other Results

Concluding Remarks

Profitability of RJVs

$$\Psi = \begin{cases} \dfrac{\pi(I,0) + \pi(0,I) - 2\pi(I,I)}{2(\pi(I,I) - \pi(0,0))}, & \text{for } \pi(I,I) > \pi(0,0) \\ \infty, & \text{for } \pi(I,I) = \pi(0,0), \end{cases}$$

Proposition 3 (Profitable innovation-enhancing RJV):

An RJV strictly increases net profits in each of the following constellations:

(i) *Competition is soft.*

(ii) *Competition is moderate,* $B > \bar{B}(\rho)$ *and* $\rho > \bar{\rho}$.

(iii) *Competition is intense and* $\frac{\min\{\theta^B, \theta^u\} - \theta_1}{\theta_1 - \theta_2} > \Psi$.

Total Welfare

- **An immediate corollary**: If any condition *(i)-(iii)* of Proposition 3 holds, then the RJV increases total expected welfare.

Profitability of RJVs

Proposition 4 *(Profitable innovation-reducing RJV):*

Suppose that the following conditions hold:

(i) $2\pi\left(I,I\right)-\left(\pi\left(I,0\right)+\pi\left(0,0\right)\right)=0.$

(ii) $B\leq\bar{B}(\rho)$ or $\rho\leq\bar{\rho}.$

(iii) $\pi(I,I)>\pi(0,I).$

Then there exists some $\hat{\pi}\left(I,0\right)>\pi\left(I,0\right)$ *such that for all* $\pi'\left(I,0\right)\in\left(\pi\left(I,0\right),\hat{\pi}\left(I,0\right)\right)$ *and keeping other parameters fixed, the RJV is profitable, but reduces the innovation*

The result holds for intermediate competition, near the boundary to soft competition

Roadmap

The Model

Innovation Effects of RJVs

Consumer Welfare

Profitability of RJVs

Other Results

Concluding Remarks

Merger and RJV: Comparison

Assumption 4: $\pi(I) > \pi(0)$.

Proposition 5: (Comparison of an RJV and a merger).

1. *If* $2[\pi(I,I) - \pi(0,0)] \geq \pi(I) - \pi(0)$*, the innovation probability under an RJV is weakly higher than under a merger. The difference is strict, except when* $\theta^B \in [\theta^\rho, \theta^u_m]$ *or* $2[\pi(I,I) - \pi(0,0)] = \pi(I) - \pi(0)$.
2. *If* $2[\pi(I,I) - \pi(0,0)] < \pi(I) - \pi(0)$*, the innovation probability under an RJV is weakly lower than under a merger. The difference is strict, except when* $\theta^B \in [\theta^\rho_m, \theta^u]$.

With spillovers...

- ... but without financial constraints: Innovation probability is strictly larger under the RJV than under R&D competition if spillovers are sufficiently high and competition sufficiently soft.
- ... and financial constraints: Higher interest rate and higher spillovers both make it more likely that the RJV increases the innovation probability.

Licensing

- The innovator can license the innovation with a two-part tariff (L, η).
- After licensing, total industry profits are $2\pi(I, I) + \Delta$.
- Innovator makes a TIOLI offer and is willing to license iff $2\pi(I, I) + \Delta - \pi(0, I) \geq \pi(I, 0)$.
- If the innovator wants to license, this changes the payoff to being the single innovator to $\pi^L(I, 0) = 2\pi(I, I) + \Delta - \pi(0, I)$.
- When this is the case, competition is effectively always intense.
- Same analysis with new thresholds $\bar{B}^L(\rho) \geq \bar{B}(\rho)$ and $\bar{\rho}^L \geq \bar{\rho}$.

Multiple Firms

- Three firms $\rightarrow$ one RJV.
- Four firms $\rightarrow$ two RJVs.
- Results analogous to those of Proposition 1.

Roadmap

Concluding remarks

- We study research joint ventures in a setting where firms are financially constrained and research duplication is a concern.
- We provide a different channel through which RJVs can increase the the probability of innovation, consumer welfare and total welfare.
- In such settings, total research expenditure can be a bad proxy for innovation probability.

Example: Differentiated Price Competition

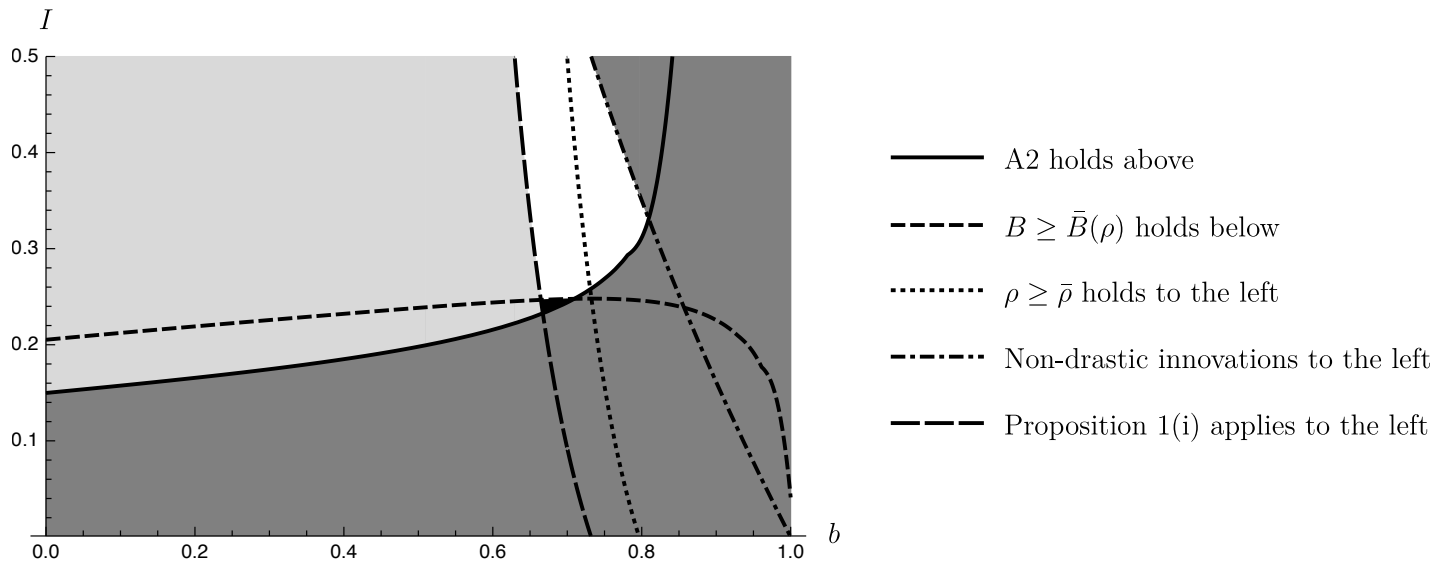


Figure: Price competition with inverse demand function $p_i = 1 - q_i - bq_j$ and constant marginal cost $c = 0.5$.

Example: Cournot Competition

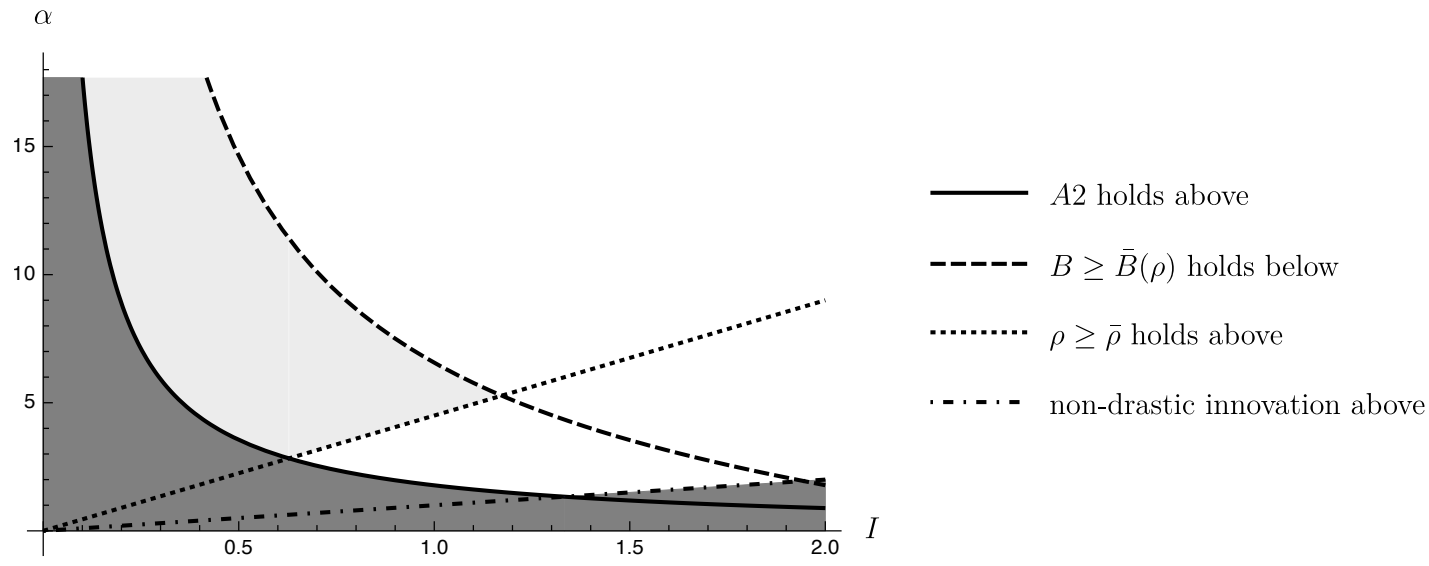


Figure: Cournot model with $P(Q) = a - bQ$, constant marginal cost c, $\alpha = a - c$, $B = 0.01$, $\rho = 0.1$.