Dynamic Efficiency and Pricing of Pharmaceutical Innovations

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DYNAMIC EFFICIENCY AND

PRICING OF PHARMACEUTICAL INNOVATIONS

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There is a prolonged debate over how much of the social surplus generated by an innovation should be transferred to the innovator to achieve dynamic efficiency in the innovation industry. I revisit the canonical model of pricing in innovation markets, which maximizes total surplus, and contrast it with the recently proposed alternative, which maximizes consumer surplus. I set up this optimization problem as a weighted average of consumer and producer surplus to derive the conditions under which the optimal solution deviates from the canonical corner solution, in which the full surplus is transferred to the manufacturer during the patent period to achieve dynamic efficiency. I empirically estimate a production function for innovations in the pharmaceutical market to determine the optimal transfer rate when the dynamic objective deviates from the canonical model. I then demonstrate, through simulations of innovation markets under different payment regimes, that when a large and a small country coexist, the small country has the luxury of deviating from the canonical model due to free-riding on the investments made by the larger country.

Keywords: Dynamic efficiency, surplus appropriation, innovation, monopoly, dynamic model.

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PUSH INCENTIVE SOCIAL PAYER SETS TODAY'S PROFITS EXPECTING FUTURE INVESTMENTS BY INNOVATOR

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Patents Grant Monopoly — But Don't Specify a Fair Price

The Policy Framework

Bayh-Dole Act (1980)

Universities can patent federally-funded research

Orphan Drug Act (1983)

Incentives for rare disease drugs

Hatch-Waxman Act (1984)

Balances generics with patent extensions

Large literature demonstrates that an increases in anticipated profits increase innovation

Market Size↑ Innovations ↑

Acemoglu and Linn 2004; Dubois et al. 2015; Blume-Kohout and Sood 2013; Bennette et al. 2019; Finkelstein 2004;

Total Revenue↑ Innovations ↑

Goldman et al. (2011)

Price ↑ Innovations ↑

Garthwaite et al. (2022)

All point towards a PULL INCENTIVE mechanism

None specifies how much profit is fair

Consensus: Account for dynamic efficiencies in this market to fully maximize the long-term returns of innovation

(Finkelstein 2004; Jena and Philipson 2008; Moreno and Ray 2016)

Jena and Philipson (2008)

Maximize the expected total surplus in society using pull incentives.

Claim the appropriation share of total surplus (at competitive equilibrium quantity) should be 100%

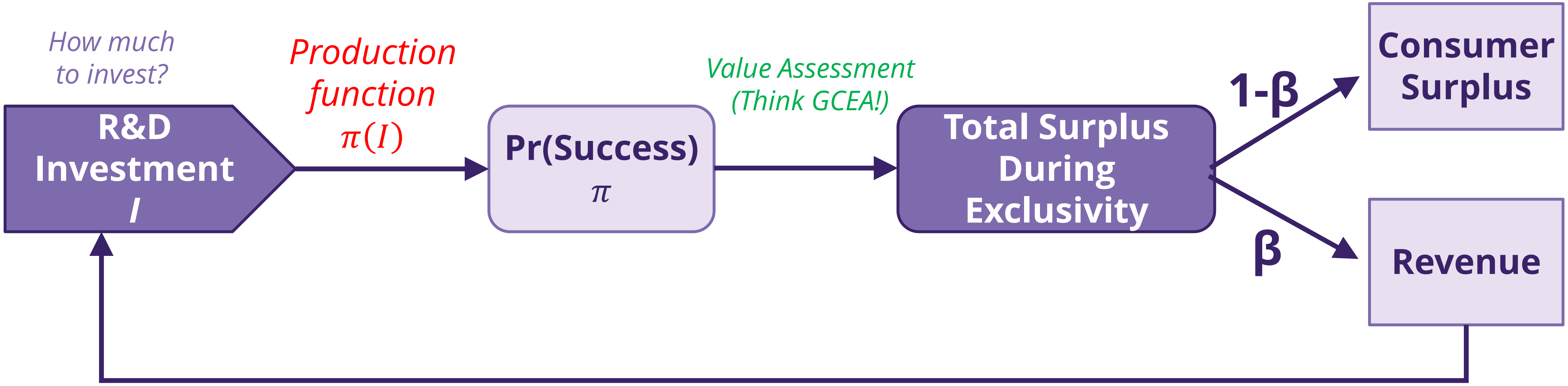
Woods et al. (2024)

Maximize expected consumer surplus in society using push incentives

Estimate this share fraction to be about 22%.

The Economics of Dynamic Efficiency – PULL INCENTIVE

The Innovator’s Investment Decision



The innovator invests in R&D, which determines the probability of success.

The social planner sets β — the share of total surplus the innovator keeps.

When Should Innovators Get Less Than 100%?

Standard Result (Jena & Philipson 2008)

Max Total Surplus ≈ E(CS) + E(PS)

Solution: $\boldsymbol{\beta^*}$ **= 1**.

Give innovators everything during the patent period to maximize their R&D investment.

But This Assumes:

- Consumer and producer surplus are valued equally
- Single-country setting

Non-standard Result (Basu 2026)

Max SW ≈ λ* E(CS) + (1- λ)* E(PS)

Solution: **Production function matters!**

$$\beta^* = \frac{\lambda}{(2\lambda - 1)\cdot(1 + \eta\cdot\varepsilon)}$$

$$\eta = \pi/\pi_I$$
$$\varepsilon = -\pi_{II}/\pi_I$$

When $\lambda = 1$,

$$\beta^* = 1/(1 + \eta\cdot\varepsilon)$$

Building a Pharma Production Function

Data Sources

17 major pharma companies
publicly traded on U.S. markets

R&D investment from 10-K filings
annual data from 2005–2023

Clinical trials from ClinicalTrials.gov
all industry-sponsored drug candidates

Approvals from FDA Orange Book
matched to company trial portfolios

Key Challenge

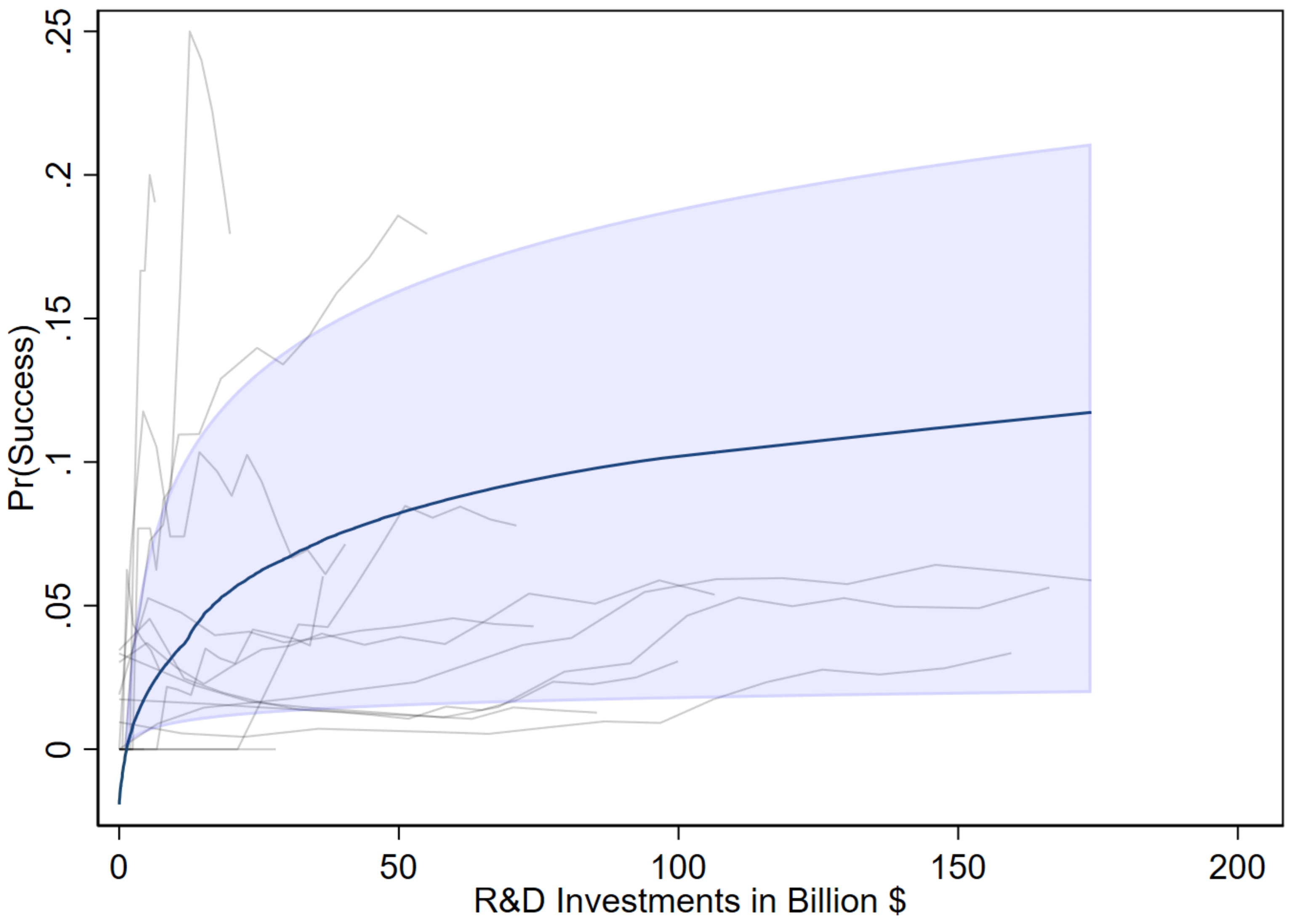
No exogenous variation in R&D spending — estimates are reduced-form associations, not causal effects.

Measurement

P(I) = cumulative approvals / cumulative candidate products

Models the industry-average relationship between investment and regulatory success.

More R&D Yields More Innovation — With Diminishing Returns



Production function:

$\pi \sim \boldsymbol{\alpha_1} \cdot \ln(\text{R\&D expenditures})$

α_1 = 0.019 (p = 0.035)

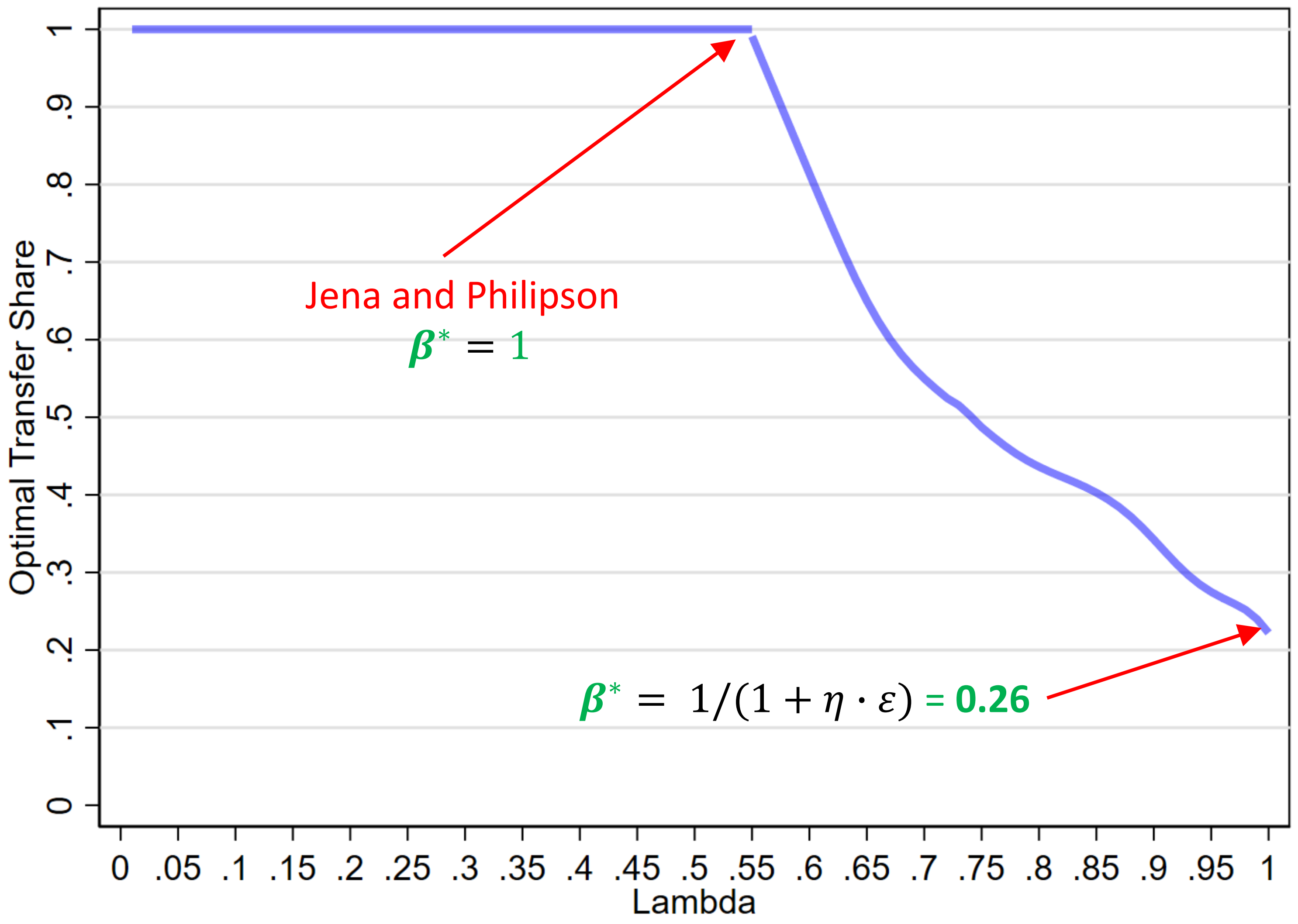
0.25 innovations per $Billion

(95% CI: 0.05 – 0.45)

~$4 Billion per approved drug

(range: $2B – $22B)

The Optimal Price Depends on Society's Values



Woods et al.: 0.22

Biases in Optimal Beta

1. The current model maximizes some surplus during the exclusivity period only. After the exclusivity period, all surpluses can be thought to accrue to the consumer (i.e., the current estimate is biased downward).

2. Presence of multiple social planners (e.g., different countries). One planner's action may affect another's investment decisions (i.e., potential for current estimate to be biased upward)

A ONE-COUNTRY AND A TWO-COUNTRY (DIFFERENT SIZES) SIMULATION

Two countries

Large Country, $\beta^* = 1$;

Small Country, $\beta^* = 1 \; vs \; \beta^* = 0.26$

One country

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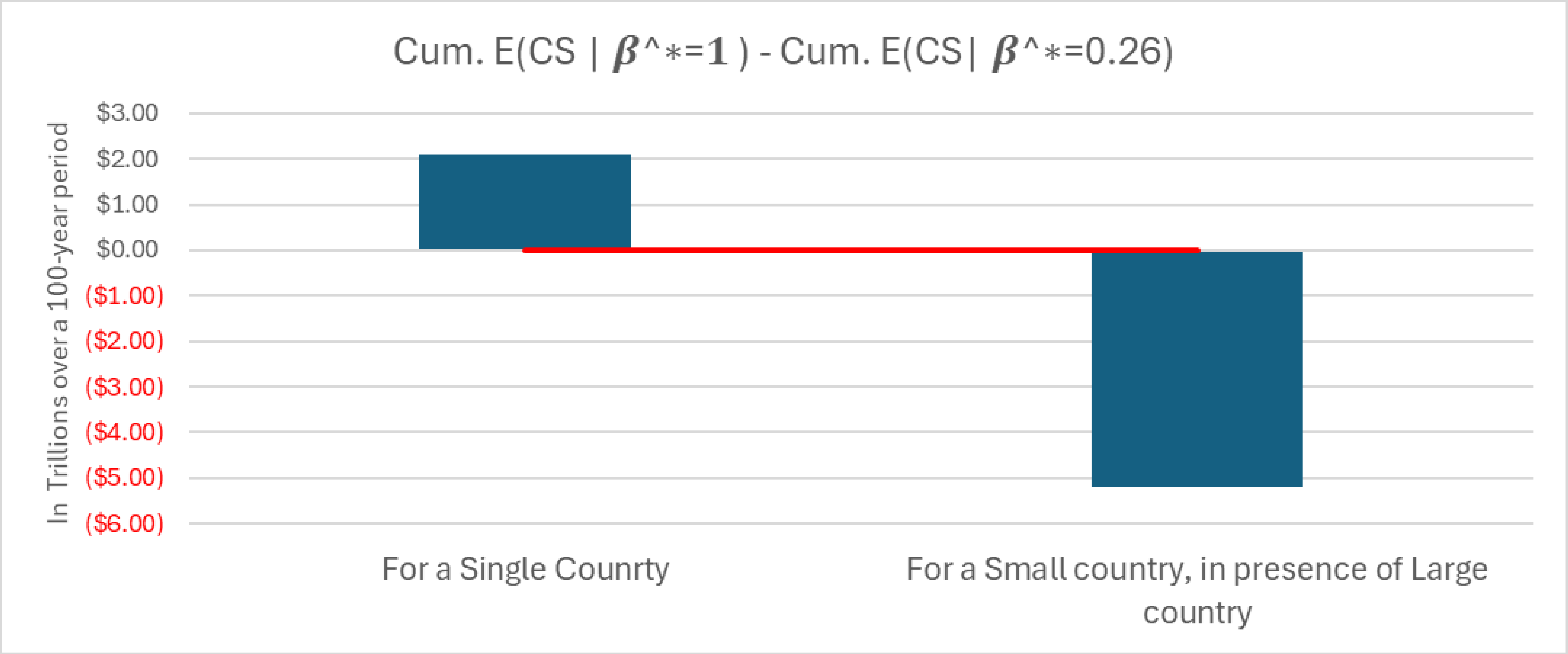

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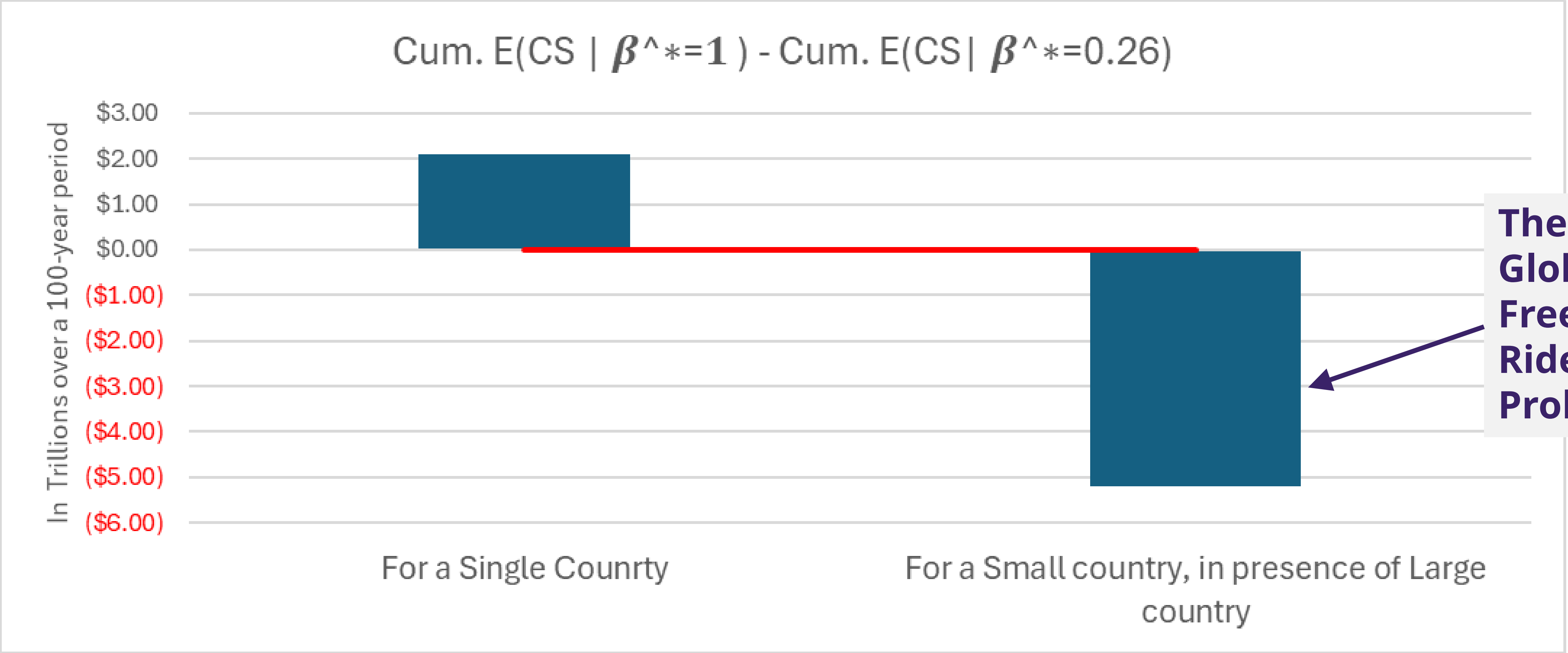

The Global Free-Rider Problem

What This Means for Drug Pricing

1. Drug pricing should not be assessed under push incentives.
2. Dynamic efficiency is typically achieved when innovators capture the full surplus during the exclusivity period.
3. Optimal innovator's share may appear <100% if the social welfare function favors consumer surplus during exclusivity — but this does NOT hold when accounting for CS accrual after exclusivity.
4. Only scenario allowing <100% innovator share: the society is free-riding on investments made by other societies.
5. 100% innovator share ≠ uniformly higher prices. Prices depend on the willingness to pay for health, which can differ.