# Do Pharmaceutical Firms Have An Inherent Bias Against Developing Vaccines Versus Drugs?

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# Commentators on Bias

- **Vaccines and drugs alternative ways to combat disease**
- **General impression that pharmaceutical firms prefer to develop drugs**
- **Patricia Thomas (author, *Passion, Politics, and the Struggle for an AIDS Vaccine)***
  "It is not hard to understand why major pharmaceutical companies…generally invest in drugs that patients must take every day rather than shots given only occasionally. Drug company executives have investors to answer to, after all."
- **Chris Rock (comedian)**
  "Curing AIDS? That's like Cadillac making a car that lasts 50 years. You know they can do it, but they ain't gonna do nothing that f------ dumb."
- **This talk will provide several theoretical arguments for this preference being a bias**
  - Gap between social and commercial incentives
  - Can bias firms toward developing inappropriate technology (drug)

# Cataloging Preferences Toward Drugs

- **Can catalog list of reasons why firms might prefer drugs**
- **Some difficult to reconcile with neoclassical economics**
  - Thomas quote
- **Some lead to bias against drugs**
  - Risk aversion
- **Cost-side explanations**
  - Vaccines for large parasites, evolving viruses pose scientific challenges
  - Vaccines complex manufacturing process relative to molecule
  - Larger scale clinical trials needed for vaccines
  - Administering vaccines to healthy/infants raises liability issues
  - Needles hurt
  - *Don't necessarily create gap between social and commercial incentives*
- **Demand-side explanations**
  - Liquidity constraints
  - Behavioral factors (salience of treatment when sick, vaccine hesitancy)

# Two Key Demand Factors

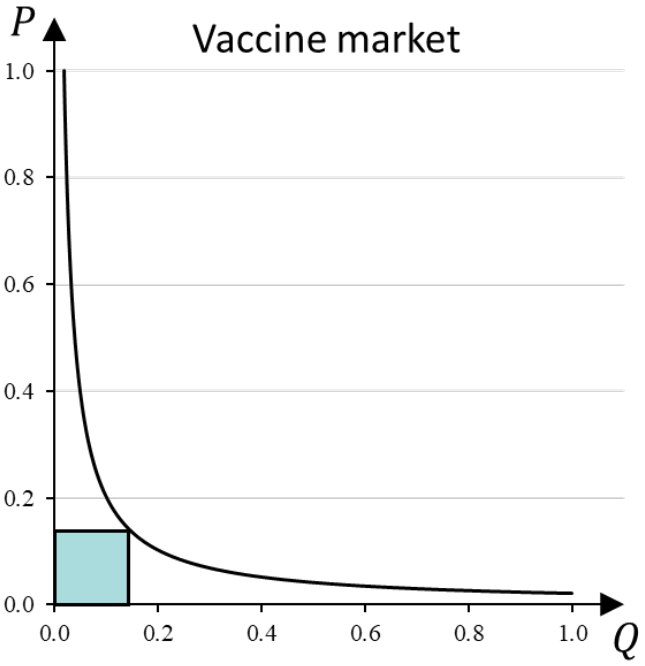
- **Free riding**
  - Vaccines that inhibit transmission generate positive externality
  - Vaccination reduces disease prevalence and remaining consumers vaccine demand
  - Potentially less important for drugs
    - ❖ Some drugs only treat symptoms rather than providing cure
    - ❖ Often taken after noticing symptoms, allowing period of asymptomatic transmission
  - Goodkin-Gold, Kremer, Snyder & Williams companion papers
    - ❖ "Optimal Vaccine Subsidies for Endemic Diseases" (*IJIO* 2022)
    - ❖ "Optimal Vaccine Subsidies for Epidemic Diseases" (*ReStat* 2023)

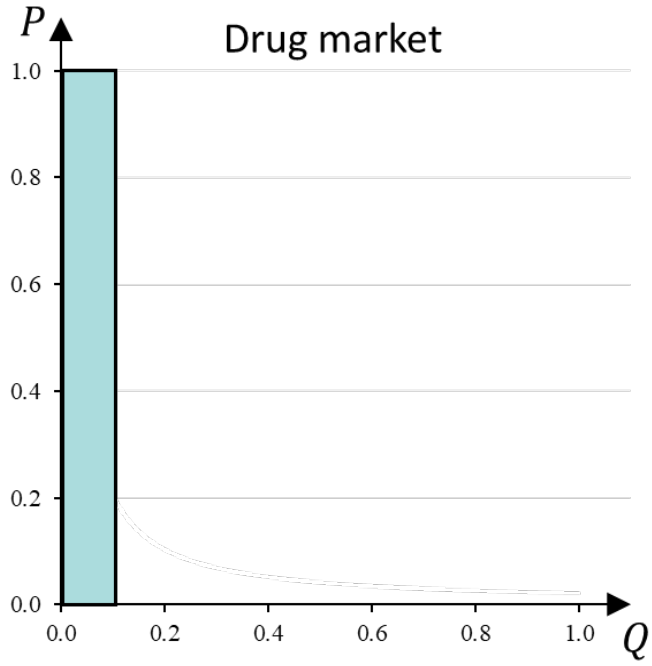
- **Consumer heterogeneity**
  - Acemoglu & Lin (*QJE* 2014): pharma market size matters for innovation
  - Kremer & Snyder (*QJE* 2015): not just level but shape of consumer demand matters
  - Demand level same for vaccine and drug addressing same disease burden
  - Different shapes because private consumer information varies with stage purchased

# Consumer Heterogeneity

**Kremer & Snyder (QJE 2015)**

- Private consumer information only about disease risk
- Shut down epidemiological externality (assume neither inhibits transmission)
- Costless production
- Example with 10% prevalence
- Zipf risk distribution
- Can show vaccine profit only 21% of drug profit in this example
- Theorem mapping into worst case social loss from bias: 100% – 21% = 79%
- Concern greatest for rare but severe diseases, Zipf-similar risk distributions



# Free Riding

**Goodkin-Gold, Kremer, Snyder & Williams (*ReStat* 2023)**

- **Overview**
  - Integrate economic and epidemiological models
  - Epidemiological model: standard SIR with vaccination on recruitment
  - Economic model: rational consumers, profit-maximizing firms
  - Positive epidemiological externality from vaccine's inhibiting transmission
  - Free riding on lower infection rate from others' vaccination

- **Contribution**
  - Large literature on economic epidemiology
  - Solve simple integrated model fully
  - Use equilibrium solution to derive new insights
    - Here focus on results for vaccines vs. drugs
  - Calibrations to Covid-19

# Epidemiology

**SIR model**

- Laws of motion

$$S_t + I_t + R_t + Z_t = 1$$
$$\dot{I}_t = \beta I_t S_t - \alpha I_t$$
$$\dot{R}_t = \alpha I_t$$
$$\dot{Z}_t = 0$$
$$\dot{S}_t = -\beta I_t S_t - \dot{Z}_t$$

"vaccination on recruitment"

- Initial conditions

$$I_0 = \hat{I}_0$$
$$S_0 = \hat{S}_0 - Z_0$$
$$R_0 = 1 - \hat{I}_0 - \hat{S}_0$$
$$Z_0 = \theta Q$$

"basic reproductive number" $\mathcal{R}_0 = \beta/\alpha$

**Derive limiting susceptibles**

$$S_\infty(Q) = \frac{1}{\mathcal{R}_0}\left|\bar{L}\left(-\mathcal{R}_0(\hat{S}_0 - \theta Q)e^{-\mathcal{R}_0(\hat{I}_0+\hat{S}_0-\theta Q)}\right)\right|$$

# Economics

**Consumer demand**

- Harm $H$ from contracting disease at some point during epidemic
- Marginal private benefit

$$MPB(Q) = \theta H \Phi(Q) = \theta H \left[1 - \frac{S_\infty(Q)}{\hat{S}_0 - \theta Q}\right]$$

- Demand $D(P)$ is $Q$ solving $MPB(Q) = P$

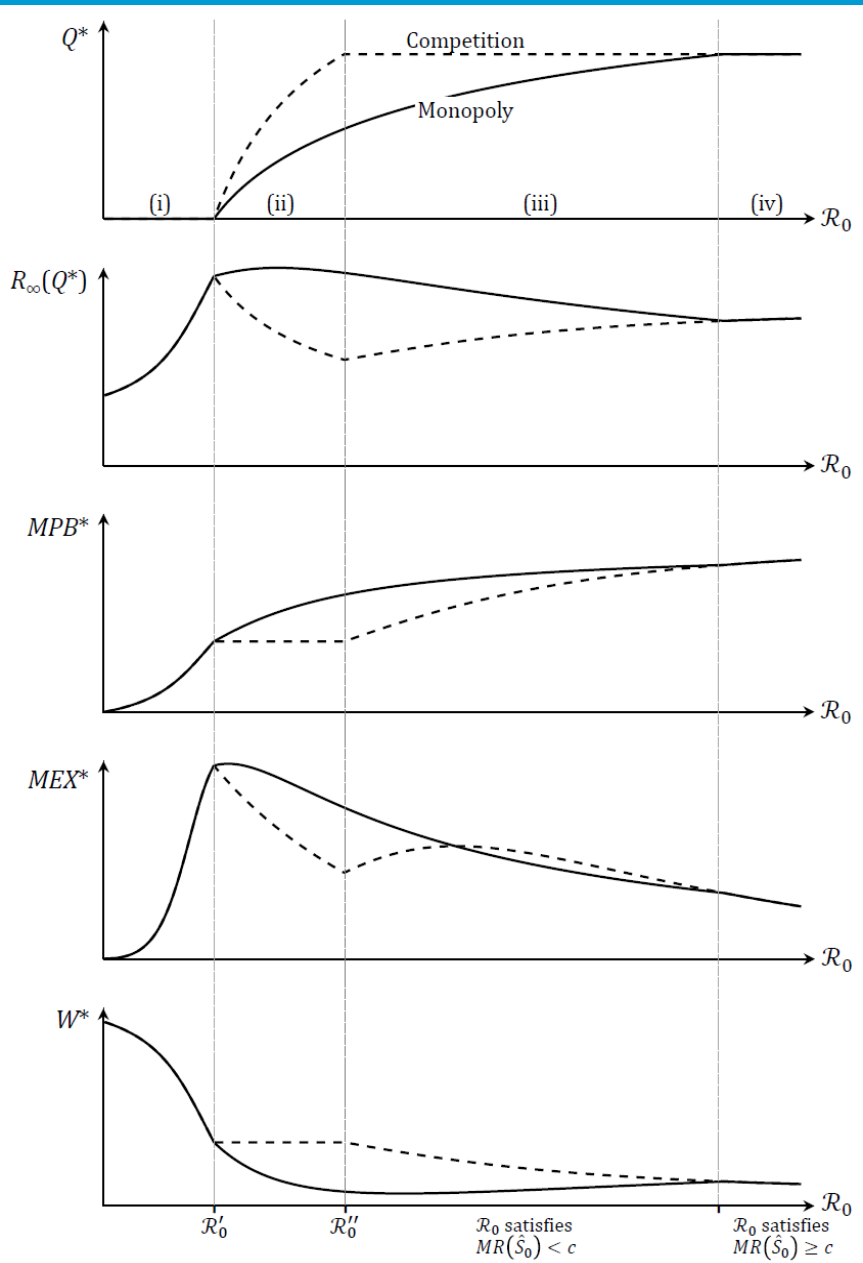
**Firm supply**

- Perfect competition: $P_c^* = c$
- Monopoly: $P_m^*$ maximizes industry profit
- Cournot: $n$ firms simultaneously choosing $q_n^*$ to maximize firm profit

**Normative measures**

- Social benefit $SB(Q) = H[1 - R_\infty(Q)] = H[S_\infty(Q) + \theta Q]$
- Welfare $W(Q) = SB(Q) - cQ$
- Marginal social benefit $MSB(Q) = \partial SB(Q)/\partial Q$
- Marginal externality $MEX(Q) = MSB(Q) - MPB(Q)$

# Equilibrium




**Comparative statics in $\mathcal{R}_0$**

- Marginal externality, optimal subsidy greatest for moderate $\mathcal{R}_0$
- Peltzman effects: infections can fall and welfare rise in $\mathcal{R}_0$ due to risk compensation

# Vaccines Versus Drugs

**Model**

- Monopoly pharma firm with perfect foresight
- Ex ante opportunity to expend fixed cost to develop vaccine or drug
- Equal efficacy $\theta$ in preventing harm
- Costless manufacturing, administration (finesse normalization)
- Vaccine cures disease, inhibiting transmission; drug only cures symptoms
- Initially infected $\hat{I}_0$ cannot benefit from vaccine but can from drug

**Results for profit wedge**

- Drug more profitable than vaccine for all $\mathcal{R}_0$
  - Initially infected part of consumer base
  - No free riding to erode demand
- Wedge greatest for moderate $\mathcal{R}_0$ (maximum free riding)

**Results for welfare wedge**

- At either extreme of $\mathcal{R}_0$ welfare higher for drug than vaccine
  - Reflecting social benefit from serving $\hat{I}_0$
- For intermediate $\mathcal{R}_0$, exist parameters for which welfare higher with vaccine
  - Reflecting positive externality on unvaccinated

# Covid Calibrations

**Ancestral variant**

- Parameters: $\mathcal{R}_0 = 2.8$, $\hat{I}_0 = 0.19\%$, $\hat{S}_0 = 93.6\%$, $\theta = 80\%$
- Drug generates more profit and higher welfare than vaccine
- Appropriate technology

**Alternative calibrations**

- Higher welfare from vaccine when efficacy lower ($\theta < 60\%$)
- Delta calibrations starker (higher welfare from vaccine for $\theta < 67\%$)
- Omicron calibrations starker still (higher welfare from vaccine for $\theta < 80\%$)
- Potentially inappropriate technology

# Conclusions

**Diseases of greatest concern**

- Kremer & Snyder (2015): rare with Zipf risk distribution
- Goodkin-Gold et al. (2023): moderately infectious

**Counterfactual model**

- Purpose of this exercise is more normative, conceptual than positive
- Sales on private market without intervention
- In practice, observe insurance
- Insurance not resolve highlighted issues
- In practice, observe subsidies, public provision
- Model helps understand role of public programs