Managing Derived Demand for Antibiotics In Animal Agriculture

2018 AAEA Annual Meeting

Tuesday, August 7, 2018

Washington, DC

David Hennessy

Michigan State University

Motivation

- Protecting antibiotics for human medicine
- FDA Veterinary Feed Directive amendments of 2017
  - Disallows use of many for growth promotion or feed efficiency
  - Requires VFD document from veterinarian for feed use and must be for prevention, treatment or control
  - Shifts many OTC antibiotics to prescription required
- Antibiotics will still be used extensively in animal agriculture, e.g., dairying with most use for mastitis control
- If demand is to be managed then it needs to be understood

Four Main Points

1. Antibiotics present growers with a real option to use or wait [Developing observations by Jensen, Hayes (2014)]
2. Some standard monopoly theory tells quite a bit about using (*disease probability inverse takes place of price*)

    (*ex-ante*) early, as prevention + possibly growth promotion, or

    (*ex-post*) late, as treatment

3. Sub-therapeutic ex-ante use ban likely lowers environmental load
4. Demand discontinuity, with market effects & elasticity implications

Model Notation

- There is no disease with probability $1 - \theta$. Then
  - production is 1 when antibiotics are not used, and
  - production is $\mu \geq 1$ when used
- Antibiotics use is given by z at unit cost c
- If disease occurs then production is $\delta(z)$ when antibiotics aren't used and $\mu\delta(z)$ when used, with $\delta(z) \in [0, 1]$, and $\delta(z)$ increasing, concave

Model, *Ex-Ante* (FCE or growth promotion)

- Ex-ante expected profit is:

$$\pi^{ante} = (1-\theta)\mu + \theta\mu\delta(z) - cz$$

- Profit maximizing *ex-ante* antibiotics application satisfies (and this is key to model analysis):

(ea) $$\delta'(z) = \frac{c}{\theta\mu}; \qquad \theta \in [0,1]; \qquad \mu \geq 1.$$

- Solution may be above or below that solving:

(ep) $$\delta'(z) = c$$

Model, *Ex-Post*, (therapeutic)

- Were sub-therapeutic antibiotics prohibited then the herd owner only uses antibiotics in event of a disease, or *ex-post*. Then productivity gains from growth promotion are forgone and the profit function is:

$$\pi^{po} = 1 - \theta + [\delta(z) - cz]\theta$$

- Profit maximizing *ex-post* antibiotics application satisfies, from before:

(ep) $$\delta'(z) = c$$

Point 1 (opening for info roles in mgmt.)

- Central features of real options are
  - *Alternative time points for investment*, i.e., before or after learning about biotic disease in barn
  - *Temporal resolution of uncertainty*, e.g., Wilbur is off his grub (or not)
  - *Increase expected profit by waiting to condition investments on info., but at cost of losses from delay*, e.g., growth promotion benefit from moving early, and avoiding total cost of treatment from moving later
- Consider impact of any θ uncertainty, or value of waiting were waiting cost to increase because of prescription

Comparisons

- Let $z^*(.)$ be solutions where forms are the same and only difference is effective cost point of evaluation
- Bear in mind that *ex-post* application occurs only if there is a disease, with probability θ
- Question then is

$$z^*\left(\frac{c}{\theta\mu}\right) \quad > (=) < \quad \theta z^*(c)?$$

ex-ante use $>(=)<$ Expected ex-post use?

Point 2 (monopoly connection)

- Rearrange as

$$\frac{1}{\theta} z^* \left(\frac{c}{\theta\mu} \right) > (=) < \; z^*(c); \qquad \frac{d[uz^*(uc/\mu)]}{du}$$

ex-ante use > (=) < Expected ex-post use

- Here disease probability is the inverse of price: ex-ante reduces disease risk and effective cost
- Value of μ aside, the question then becomes a familiar one, that of how $P \times Q(P)$ changes with P or its inverse: the monopoly revenue maximization issue assuming away production costs

Point 2

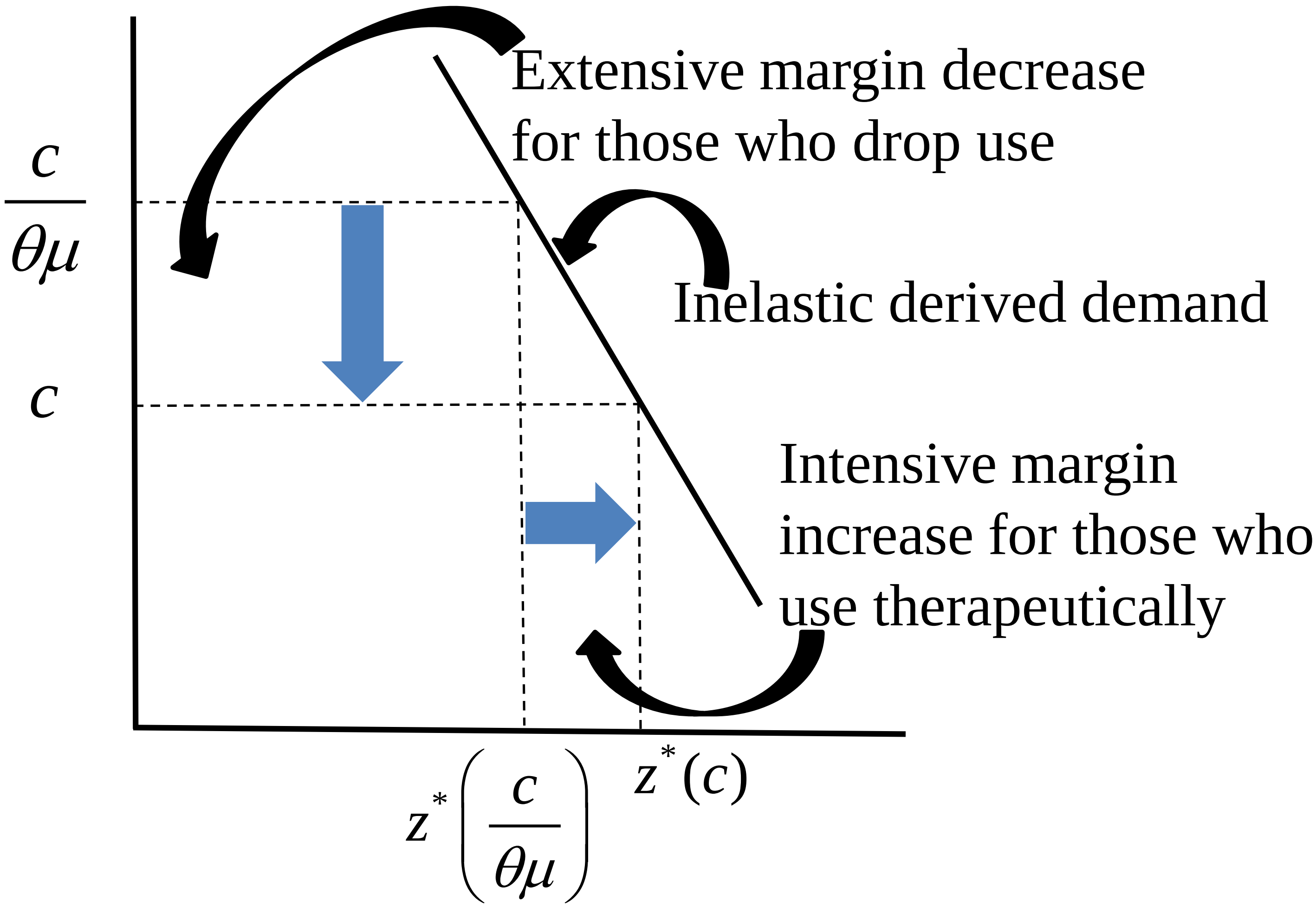

Figure 1. Why inelastic derived demand favors effectiveness of restrictions on sub-therapeutic use

Point 2

- **Proposition:** Suppose that there is
  - i) no growth promotion effect, i.e., $\mu = 1$. When compared with *ex-ante* sub-therapeutic use, mean antibiotic use under an *ex-post* therapeutic management regime is smaller (larger) whenever the input's demand is own-price inelastic (elastic)
  - ii) a growth promotion effect in that $\mu > 1$. When compared with *ex-ante* sub-therapeutic use, mean antibiotic use under an *ex-post* therapeutic management regime is smaller whenever the input's demand is own-price inelastic

  Also shown in paper, when demand is inelastic a user tax would favor a switch from *ex-ante* sub-therapeutic use to *ex-post* therapeutic use

Point 2 (inelastic, most likely)

- Antibiotics take up a small share of expenditures, e.g., for dairying in Lakes States about $30 when protecting against potential loss of about $400 (survey)
- What are the substitutes? Best substitute in many cases, to redesign equipment & buildings to make easier to clean. Hard to compare and not a substitute in many cases
- Other research has found inelastic demand for the class of pesticides in general, e.g., Finger et al. (2017), Hollis & Ahmed (2014) at -0.1 to -0.5
- So a user tax would favor a switch from *ex-ante* sub-therapeutic use to *ex-post* therapeutic use

Point 3, ban likely lowers load

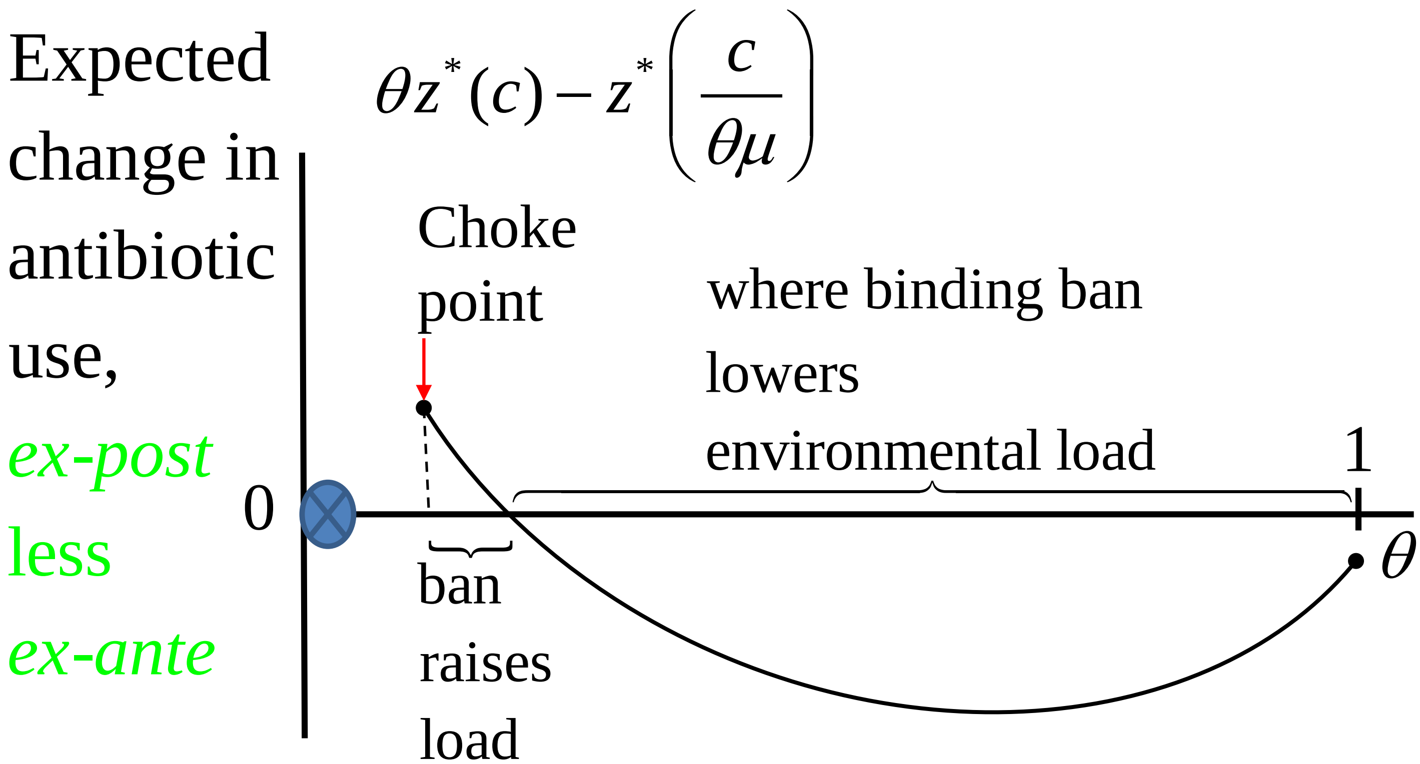

Figure 2. Aggregate demand under therapeutic use less that under a ban as infection probability changes

Point 4, Demand

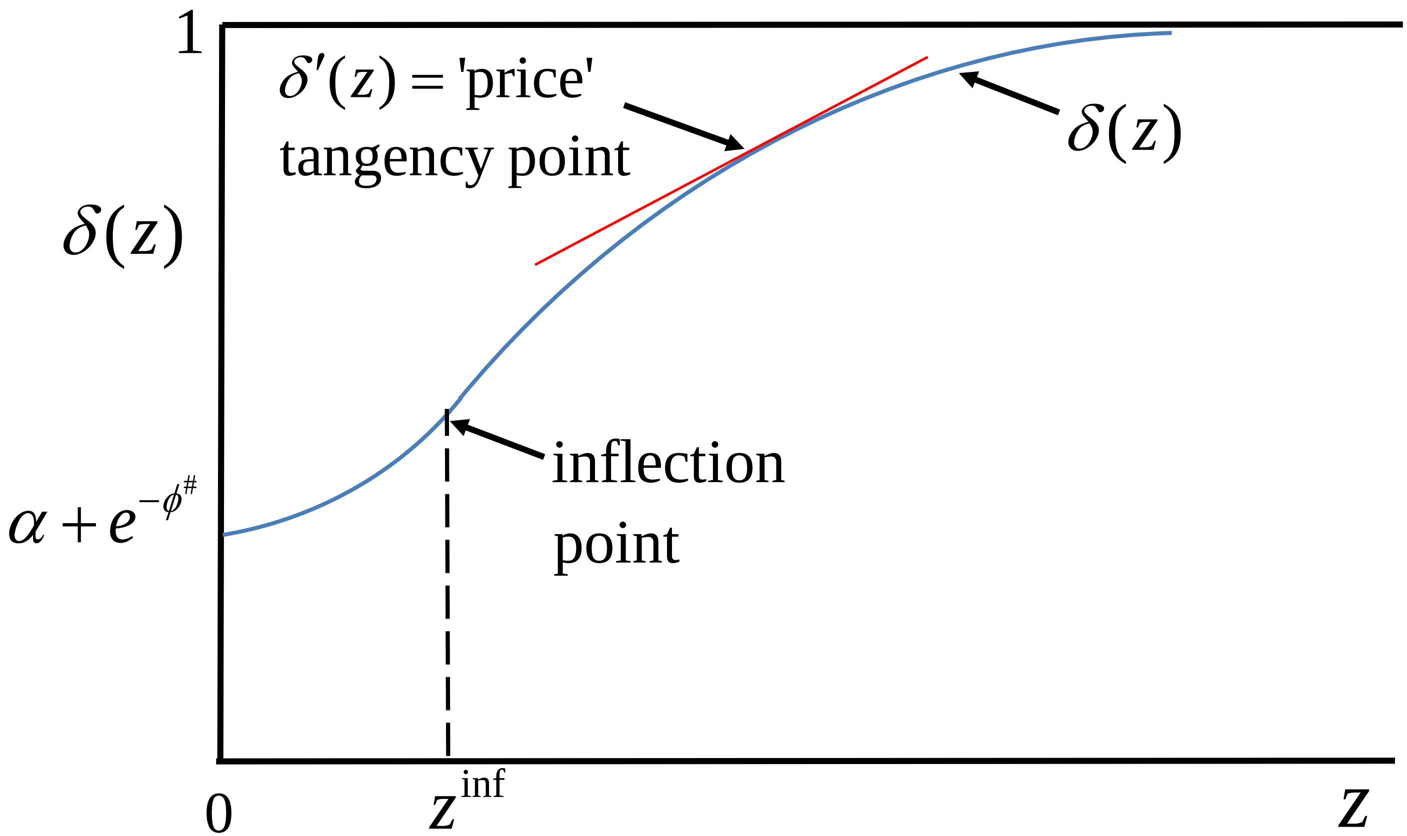

Figure 3. Locally convex reflected damage function, Lambert production technology

MVP

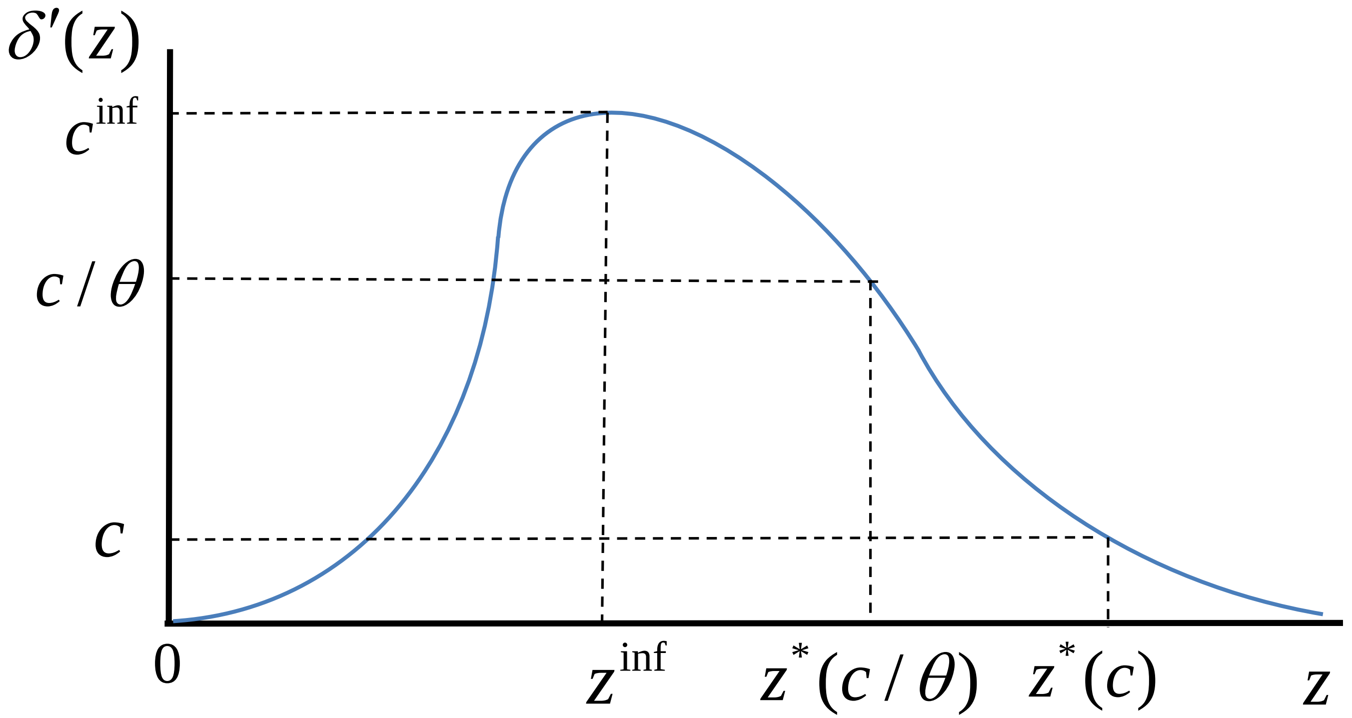

Figure 4. Marginal value product for Lambert production technology

Discontinuity, #1

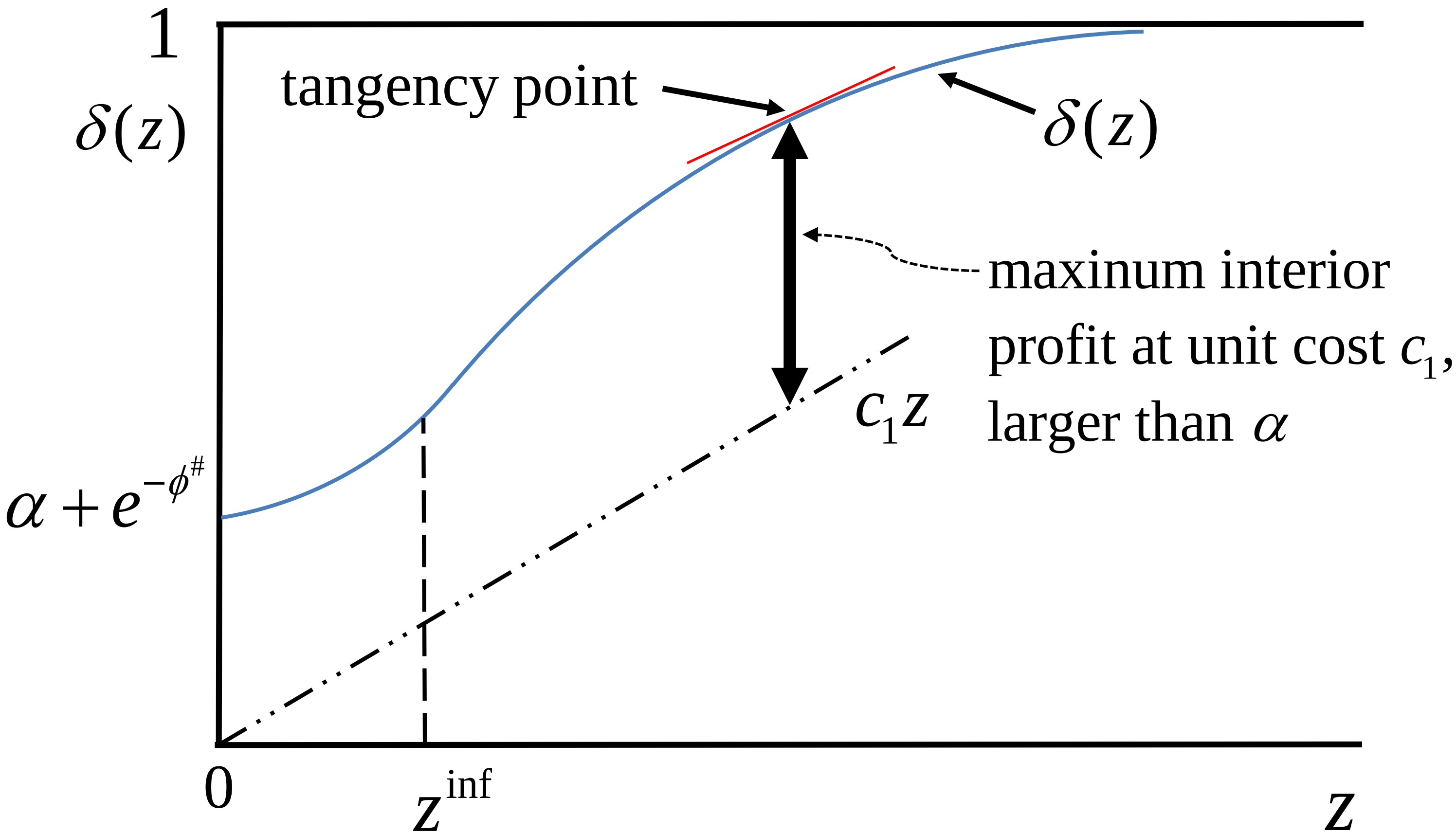

Figure 5. Profit and antibiotics price

Discontinuity, #2

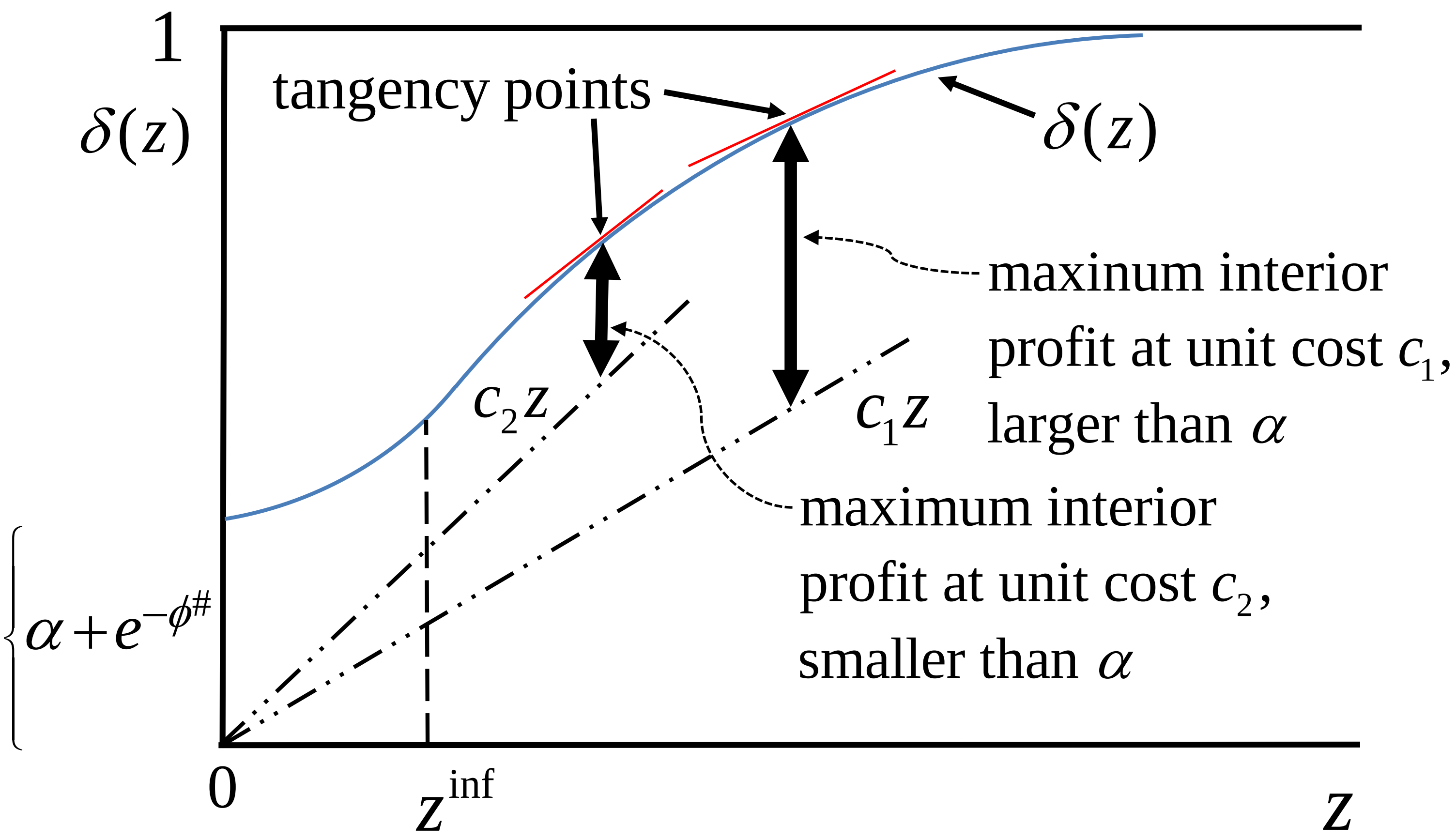

Figure 5. Profit and antibiotics price

Discontinuity, #3

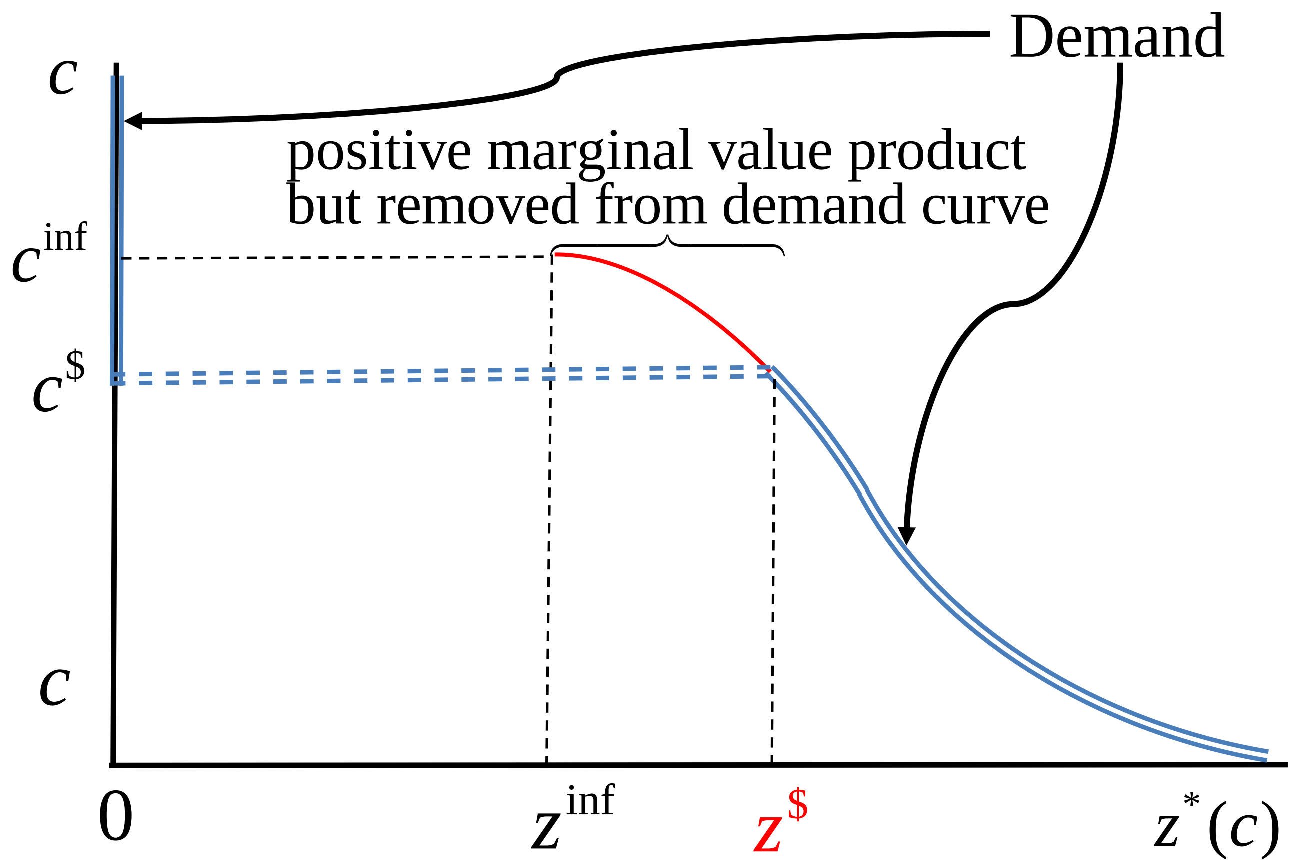

Figure 6. Antibiotic demand function as imputed from marginal value product relation

Interesting matter here is that around discontinuity point then demand becomes very ELASTIC

Premium on Non-Use

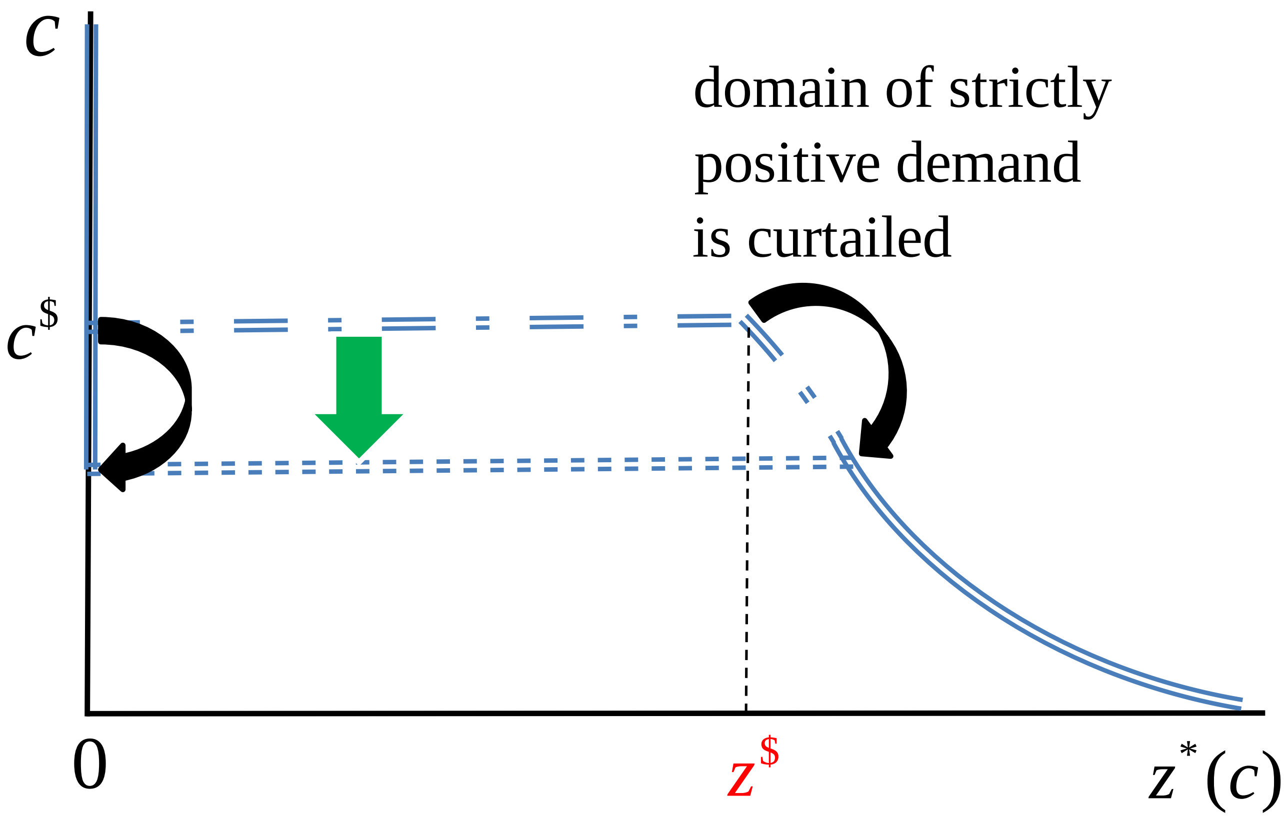

Figure 7. Antibiotic demand function when there is a premium on non-use

User Fee/ Tax

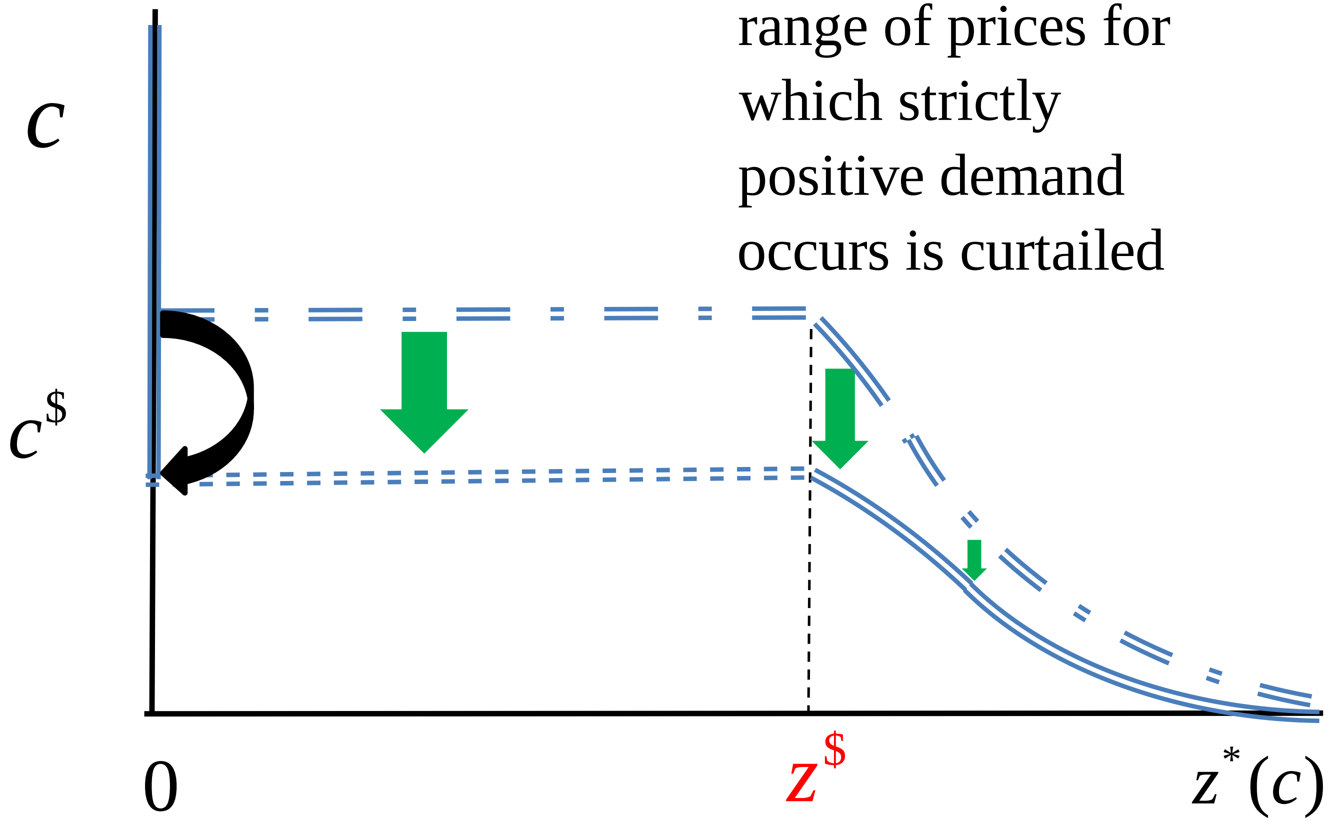

Figure 8. Antibiotic demand function, impact of a tax

Aside: a user fee will be ineffective *per se* as antibiotics costs are so low and benefits from use so high. Much more effective will be bureaucracy (Hennessy 2007)

Final Comments

*Resistance issues aren't going away in agriculture

Drugs and antibiotics

Weed and insecticide resistance

Food safety

*Managing the commons (with dynamics, externalities, etc.) is important, but so also is understanding basic micro

THANK YOU