Changes in Technology in the U.S. Beef Industry: Welfare Analysis and Trade Implications

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Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium’s (IATRC’s) 2015 Annual Meeting: Trade and Societal Well-Being, December 13-15, 2015, Clearwater Beach, FL.

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Part 1: Motivation, Background, and Literature Review
US cattle industry declining over time

- 132 million head of cattle January 1, 1975 (peak)
- 89.8 million head of cattle as of January 1, 2015
Technology used to enhance beef production

• Hormone implants
• Beta-agonists
Domestic and international consumer’s preferences
• Concerns about hormone and Beta-agonist use in beef production
Trade disruptions because of production practices

- Concerns about protectionist or discriminatory/retaliatory policies
- Consumer driven?
Objectives

• To build a detailed theoretical model to describe the US beef industry to analyze welfare changes due to technology use
  • Incorporating all stages from the farm to the plate
  • Including the use of hormones and Beta-agonists in production

Model to be used to:

• Calculate and compare the cost of US beef production with and without the use of hormones and Beta-agonists

• Calculate welfare changes for producers and consumers if hormones and Beta-agonists were banned in US beef production
  • Determine how the supply curve would shift
Background

70-80% of US cattle produced using Beta-agonists in 2013 (Cargill)
Beta-agonists are veterinary drugs used as feed supplements to increase weight gain in cattle

- Used to improve feed conversion – more beef per animal
- Two approved in the United States
  - Ractopamine hydrochloride (Optaflexx, Elanco) approved in 2003
  - Zilpaterol hydrochloride (Zilmax, Merck) approved in 2006, released in 2007 and removed in 2013 (animal welfare concerns)
- Fed last 20 – 40 days before slaughter
Hormone implants increase growth rate and feed conversion efficiency

- FDA has approved steroid hormone drugs for beef since 1950s
- Implanted as pellets under skin in ear
- Usually at entrance into feedyard, approx. duration 100 – 120 days
  - Can be re-implanted
Consumer preferences changing

• Consumers willing to pay 17% higher prices for hormone-free beef (Lusk and Fox 2002)

• Approximately 160 countries ban or restrict the use of Beta-agonists
  • European Union, China, Russia
Current trade agreement negotiations with countries that ban the use of hormones and/or Beta-agonists

- Transatlantic Trade and Investment Partnership
- Trans-Pacific Partnership
The literature on the welfare effects of technological change in the beef industry

• Most studies fail to fully characterize many stages of the cattle industry

• Ban on the use of antimicrobial feed additives in the US pork industry (Hayes, Jensen and Fabiosa 2001)

• Economic impact of Zilmax adoption in the US cattle and beef industry (Schroeder and Tonsor 2011)

• Economic impact of E. coli vaccination for feedlot cattle in the US cattle industry (Tonsor and Schroeder 2015)
Genetic testing technologies – economic impact of using the technology

- Tenderness: Weaber & Lusk 2010
Lots of work on market concentration in the US cattle industry
Part 2: Model and Welfare Measures
Long-time Challenge in ag econ: to measure the effects of technological change on producer welfare

• Hybrid corn
• Green Revolution
• Genetically modified crops
• Precision agriculture
Traditional Method:

- Estimate where the supply curve was under the old technology
- Estimate where the supply curve is under the new technology
- (Possibly) Estimate a demand curve
- Figure out the effect of tech $\Delta$ on price
- Measure a producer surplus area behind the supply curve, for both the old and the new technology
Get some (quantity, price) data points:
Estimate supply and demand curves:
Use estimated curves to get producer surplus measurements:

$$\Delta PS = A - B$$

$PS_{\text{new}}$
But there are well-known problems of statistical reliability:

• The observed (quantity, price) points take up a small part of the diagram
• But the $\Delta$PS measure requires measurement of the entire length of supply curves
• “Extrapolation” beyond the observed range of the data
Have a pretty good idea about what the supply curve looks like up here, because we have data up here.

But down here, we can say very little with statistical confidence.
One of two kinds of shifts is often assumed: 1) Parallel:
One of two kinds of shifts is often assumed: 3) Pivotal:

Long-time Challenge
Long-time Challenge

Which means that the statistical accuracy of the change-in-welfare measure can be very poor:
Alston, Norton, and Pardey published an excellent book detailing this methodology, but also recognizing its shortcomings:

(It’s been cited about a million times.)
Despite the traditional methodology’s frequent use, the concerns about statistical inaccuracy remain:
Beattie (1995, p. 1065) in general was complimentary in his review of Alston, Norton, and Pardey (1994), but he also wrote,

*If total benefits from a research-induced supply shift are halved when that shift is deemed to be pivotal rather than parallel, and if producer benefits disappear when the supply shift is pivotal against an inelastic demand, then it seems to me that we have a rather big problem here.*
Our Objectives

Build detailed theoretical model of US beef industry to analyze welfare effects of technology change

• Model from farm to plate
• Model use of hormones and Beta-agonists
New ideas for measuring the change in producer welfare due to technology change (Bullock)

• Trying to avoid estimation far beyond the range of the data
• So that increased statistical confidence can be placed on the estimation of the change in producer welfare
Key idea: use data from input markets to measure producer welfare change
The U.S. beef complex in initial equilibrium
Figure. Effect of β-agonist ban \( (p_b^1 = \infty) \) on feedlot welfare

Calves Markets: See next slide
Changes in Profits in the Calves and Cattle Industries

\[ \Delta \Pi_f = \Pi_f(\phi(t^N)) - \Pi_f(\phi(0)) \]

\[ = \int \left( \frac{\partial \Pi_f(\phi)}{\partial p_a} dp_a + \frac{\partial \Pi_f(\phi)}{\partial p_d} dp_d + \frac{\partial \Pi_f(\phi)}{\partial p_f} dp_f + \frac{\partial \Pi_f(\phi)}{\partial p_h} dp_h + \frac{\partial \Pi_f(\phi)}{\partial p_l} dp_l + \frac{\partial \Pi_f(\phi)}{\partial p_s} dp_s \right) \]

\[ = -\int D_a(\phi) dp_a - \int D_b(\phi) dp_b - \int S_f(\phi) dp_f - \int D_h(\phi) dp_h - \int D_i(\phi) dp_i - \int D_j(\phi) dp_j \]

\[ = \Delta \Pi_f = \int S_f(\phi) dp_f - \int D_i(\phi) dp_i \]
Why we want to focus on the welfare measure in the beta-agonist market instead of the fed cattle market or the final beef market:
Beta agonist expenditures take a share of about 0.005 of fed beef revenues:

- Size of fed steer market: \((1.55/\text{pound}) \times (34 \text{ billion pounds}) = 53 \text{ billion per year}\)

- Size of beta-agonist market: \((15.4/\text{head}) \times (16.6 \text{ million head per year in U.S.}) = 256 \text{ million per year}\)
Beef producers’ DDG expenditures take a share of about 0.04 of fed beef revenues:

• Size of DDGs-to-beef market: ($120/short ton) \times (18 \text{ million short tons per year in U.S.}) = $2.16 \text{ billion per year.}
So size-wise, the diagram looks more like this:
The difficult “$K_b$” area can only be so big, so maybe it doesn’t make sense to look at its effect in the much bigger fed cattle market.

A and B are much skinnier than shown here:
And because of close substitution between beta-agonist and feed grain market, we might have a pretty good idea about the beta-agonist choke price, and so size of triangle $K_b$:

Choke price

$D_\beta(p_\beta, p_d^1, p_f^1, p_g^1, p_h^1, p_l^1, p_\sigma^1)$

$D_\beta(p_\beta, p_d^0, p_f^0, p_g^0, p_h^0, p_l^0, p_\sigma^0)$
Part 3. Next steps...

1. Calculate and compare the cost of US beef production with and without the use of hormones and Beta-agonists

2. Determine how the supply and demand curves would shift if hormones and Beta-agonists were banned in US beef production

3. Quantify consumer and producer welfare changes with and without the use of Beta-agonists and hormones
Implications

• Trade restrictions have caused major disruptions to the US beef industry
  • Accurate estimates of welfare effects are scant
• Disease issues and controversial production practices have the potential to abruptly disrupt trade for an indefinite time
• Importance of understanding the consequences of changing US beef producing practices to address international concerns
• Importance of having accurate estimates of the welfare changes for producers and consumers if US beef practices are to be changed
  • TTIP and TPP
Thank you!

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