Assessment of Benefits and Costs of Policies to Regulate Antibiotic Use in U.S. Animal Agriculture

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Introduction

- **Antibiotic resistance**
  - Public health concern
    - 23,000 deaths/year, 2 million of patients diseased with a resistant strain
    - Increased time of hospitalization, specific measures… per case $ [15,000-135,000]
  - Mechanisms of acquisition
    - Natural
    - Selection due to antibiotic use
      - Humans (outpatients +hospitals)
      - Animals
      - Crops

Quantitative contribution of use in animals to resistance in human is unknown
FARMING
- Economic indicators

POLICIES
- Regulations

BACTERIA
- Susceptibility indicators
- Level of resistance

PUBLIC
- Consumption indicators
- Public health indicators

Market failure:
Private consumption of antibiotics
Negative externality increase of antibiotic resistance affecting people

Antibiotic use

Presence of diseases
Economic interest

Human infections
diseases
### U.S. Farming systems

<table>
<thead>
<tr>
<th>Species/production system</th>
<th>Number of animals (M., 2012)</th>
<th>Production</th>
<th>Level of integration*</th>
<th>Lifecycle time (Days)</th>
<th>Antibiotic use (Tons, % total FPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle</td>
<td>29</td>
<td>Meat</td>
<td>+++</td>
<td>500</td>
<td>6,728 (48%)</td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>9,2</td>
<td>Meat, Milk</td>
<td>-</td>
<td>950</td>
<td></td>
</tr>
<tr>
<td>Hog</td>
<td>66</td>
<td>Meat</td>
<td>+++</td>
<td>200</td>
<td>3,559 (25%)</td>
</tr>
<tr>
<td>Poultry</td>
<td>1,506</td>
<td>Meat, Eggs</td>
<td>++++</td>
<td>30</td>
<td>2,209 (16%)</td>
</tr>
<tr>
<td>Sheep, Goat</td>
<td>5,4, 2,6</td>
<td>Meat, Milk, Wool</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds others (turkeys etc)</td>
<td></td>
<td>Meat</td>
<td>++++</td>
<td>150</td>
<td>&gt;1,136 (&gt;8%)</td>
</tr>
<tr>
<td>Fish</td>
<td></td>
<td>Meat</td>
<td>++++</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Reflects the autonomy of farmers regarding input provisioning and output sales

High diversity of ABU
Time horizon: long production adjustments
Substitutions in commodities?
Objectives

- Establish an analytic framework
- BCA evaluation
  - Uncertainty regarding the attributable costs of antibiotic resistance
  - Evaluate compensations for farmers in case of policies prohibiting antibiotic use
- Dairy production as an example
Materials and methods

• Perspective
  – Primary actors
    • U.S. farmers
    • Citizens (public health)
    • U.S. consumers
  – Secondary actors
    • Retailers
    • Veterinarians
    • Pharmaceutical companies
### Scenarios

<table>
<thead>
<tr>
<th>Business as usual (BAU)</th>
<th>Prohibition</th>
<th>Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current situation of antibiotic use</strong>&lt;br&gt;No specific measure restricting use</td>
<td>Antibiotics not allowed in dairy production</td>
<td>Increased cost of antibiotics, without modifying the effectiveness of the treatment</td>
</tr>
</tbody>
</table>
# Impacts of limiting antibiotic use

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Negative effect</th>
<th>Positive effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>Farmers</td>
<td>Increase of diseases (mortality, morbidity, prevalence)</td>
<td>Decreased production Q</td>
</tr>
<tr>
<td></td>
<td>Loss of feed efficiency (growth promotion)</td>
<td></td>
</tr>
<tr>
<td>Veterinarian</td>
<td>No antibiotics sales</td>
<td>Decreased incomes</td>
</tr>
<tr>
<td>Food industry</td>
<td>Decreased milk Q to process</td>
<td>Decreased sales Increased marginal costs</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>No antibiotics sales</td>
<td>Decreased incomes</td>
</tr>
<tr>
<td>Government</td>
<td>Implementation expenses</td>
<td>Tax collection</td>
</tr>
<tr>
<td>Consumers</td>
<td>Increased prices of commodities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased food safety?</td>
<td></td>
</tr>
<tr>
<td>Citizens</td>
<td>Animal welfare?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amenities?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased antibiotic resistance</td>
<td></td>
</tr>
</tbody>
</table>
Impacts

• Change in supply
  – Milk market
    • Quantities and prices
    • Consumers’ and Producers’ surplus
  – Secondary markets
Impact of a potential policy on the dairy market

• Milk market
  – Constant elasticities Ed = 0.65 Es= 0.89
  – BAU values: average 2012-2016
  • Milk production
  • Milk price
  • Production costs

• Policy impacts
  – Increase of marginal production costs
  • Estimated from a farm model
Farm model

- Modeling of a 1000 cows herd
  - Average use of antibiotics
  - Comparison of scenario
    - Prohibition vs BAU
    - Taxes vs BAU

<table>
<thead>
<tr>
<th>Production costs</th>
<th>BAU</th>
</tr>
</thead>
<tbody>
<tr>
<td>($/cow/year)</td>
<td></td>
</tr>
<tr>
<td>Prohibition</td>
<td>60.88</td>
</tr>
<tr>
<td>Tax X 1.5</td>
<td>8.30</td>
</tr>
<tr>
<td>Tax X 2</td>
<td>16.59</td>
</tr>
<tr>
<td>Tax X 3</td>
<td>33.18</td>
</tr>
<tr>
<td>Tax X 4</td>
<td>49.77</td>
</tr>
<tr>
<td>Tax X 5</td>
<td>66.36</td>
</tr>
</tbody>
</table>
## Costs – market level

<table>
<thead>
<tr>
<th>Scenario</th>
<th>BAU</th>
<th>Tax X 1.5</th>
<th>Tax X 2</th>
<th>Tax X 3</th>
<th>Tax X 4</th>
<th>Tax X 5</th>
<th>Prohibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilibrium milk price (S/kg)</td>
<td>0.423</td>
<td>0.423</td>
<td>0.424</td>
<td>0.424</td>
<td>0.425</td>
<td>0.426</td>
<td>0.425</td>
</tr>
<tr>
<td>Equilibrium quantity sold (million kg)</td>
<td>93,345.7</td>
<td>93,297.0</td>
<td>93,248.3</td>
<td>93,151.3</td>
<td>93,054.7</td>
<td>92,958.5</td>
<td>92,990.2</td>
</tr>
<tr>
<td>Δ quantity sold (million kg)</td>
<td>-</td>
<td>-48.7</td>
<td>-97.4</td>
<td>-194.3</td>
<td>-291.0</td>
<td>-387.2</td>
<td>-355.5</td>
</tr>
<tr>
<td>Δ quantity sold (% of initial value)</td>
<td>-</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>Δ PS (million $)</td>
<td>-</td>
<td>-5.23</td>
<td>-10.45</td>
<td>-20.87</td>
<td>-31.27</td>
<td>-41.65</td>
<td>-38.22</td>
</tr>
<tr>
<td>Δ PS (% of initial value)</td>
<td>-</td>
<td>-0.03</td>
<td>-0.06</td>
<td>-0.11</td>
<td>-0.17</td>
<td>-0.22</td>
<td>-0.21</td>
</tr>
<tr>
<td>Δ CS (million $)</td>
<td>-</td>
<td>-31.71</td>
<td>-63.38</td>
<td>-126.63</td>
<td>-189.73</td>
<td>-252.70</td>
<td>-231.92</td>
</tr>
</tbody>
</table>

Mild changes associated with any policies
Secondary markets, retailers and pharmaceutical system

• Organic production
  – Conventional market might advocate close quality standards
  – Organic production has an internal secondary market: the conventional market!

• Meat production
  – Substitution between species

• Antibiotics
  – 20% of drugs sales in the U.S., total market for food animals B$8.5 in 2016

Secondary not so secondary
Pharmaceutical system likely to be impacted
Regulations should not target one species
Absence of costs for the externality

1. How much should we compensate the farmers so that they do not use?
   - $60 in dairy production

2. Estimate the costs of resistance
   - Antibiotic use in a complex social-ecological system
   - Evaluating impacts of resistance in humans
     - VSL
     - QALYS
   - Attributable risk and risk analysis

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