Introduction to the Spatial Price Equilibrium (SPE) Model of the Cattle and Beef Industry in South-East Asia and China

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Summary Information

• SPE model is a mathematical model that simulates the Cattle and Beef Industry in South-East Asia and China
• SPE model links supply (cattle) and demand (beef) in different sub-national regions across the countries through the stages of feeder cattle, slaughter cattle and beef
• Changes in demand and supply conditions, costs of transport and transformation and changes in trade conditions can be modeled and used to predict changes in fattening and slaughtering locations
• Model can be expanded to look at longer term trends in supply and demand
• Model has been developed, coded and tested and now we are in the process of populating the model with data and calibrating it to real world conditions.
Asia: total of 68 regions based on agroecological conditions, population and statistical availability

As more detailed data becomes available, the number of regions could be increased
Thailand, Lao PDR, Cambodia and Vietnam

Vietnam: 8 agro-ecological regions => NE, NW, RRD, NCC, SCC, CH, NES, MRD

Lao PDR: 3 regions => North, Central, South

Cambodia: 5 regions => Central, Northern, Southern, Eastern, Coastal

Thailand: 6 regions => North, Northeast, Central, East, West, South
Myanmar: 5 regions => Central, East, Lower, North, South
China

China: 33 regions including provinces, municipalities and Hong Kong and Macau
Indonesia and Timor Leste

Indonesia: 7 regions => Sumatra, Jakarta, Other Java, Bali/Nusa Tenggara, Sulewesi, Melaka/Papua

Timor Leste => single region
Model Summary

- **Household Cow-Calf**
  - 68 regions
  - Feeder cattle

- **Commercial Feedlots**
  - 30 regions
  - Feeder cattle

- **Specialized Fattening households**
  - 68 regions
  - Slaughter cattle

- **Cow-calf-finishing**
  - 68 regions
  - Slaughter cattle

- **Feeder Cattle suppliers from other parts of the world**
  - Feeder cattle

- **Slaughter Cattle suppliers from other parts of the world**
  - Slaughter cattle

- **Commercial Abattoirs**
  - 20 regions
  - Beef

- **Individual Slaughterers**
  - 68 regions
  - Beef

- **Urban Beef Consumption**
  - 68 regions
  - Beef

- **Rural Beef Consumption**
  - 68 regions
  - Beef

- **Cull Cows**
Example of modeling cattle and beef movements
Supply

The supply of feeder cattle and cull cows is dependent on the size and characteristics of the cattle herd in each region.

The number of calves born is dependent on (i) the overall herd size; (ii) the proportion of breeding females in the herd; and (iii) the fertility rate of breeding females within the herd.

The supply of cull cows (cows that are slaughtered at between 8 and 12 years of age after being used in calf production) is related to (i) the number of female calves born per year; (ii) the retention rate of female calves; and (iii) the length of time that cows are kept in the herd before being culled.

The supply of liveweight is dependent on farmers’selling prices and own-price supply elasticity.
Fattening

Fattening is defined as the transformation of feeder cattle (defined as cattle at around 280kg liveweight) into slaughter cattle (defined as cattle at 350 – 400kg liveweight) through relatively intensive feeding of rations including grass, crop residues and grains. Fattening can be done in:

a. Commercial feedlots – these are the largest scale and most intensive of the fattening operations and fatten predominately using a high proportion of grains in the feed rations.

b. Specialized fattening households – these are medium scale and medium intensity fattening operations where around 5-20 head of cattle are fattened using a combination of grass, residues and grains.

c. Cow – calf to finishing households – these are relatively small scale and low intensity operations where households raise cows and keep calves until they reach slaughter weight.
Slaughtering

Slaughtering is defined as the transformation of slaughter cattle (the outputs of the fattening transformation described above) into beef. Slaughtering can be done in:

a. Commercial abattoirs – these are “modern” large scale certified operations capable of slaughtering at least 10,000 head of cattle per year. Commercial abattoirs source slaughter cattle from commercial feedlots, specialized fattening households and also slaughter cattle imported from countries outside South-East Asia/China.

b. Individual slaughterers – these are relatively small scale household level slaughtering operations. They can operate independently, or can operate cooperatively (for example in municipal slaughter points where many small scale slaughterers work together in a common location.)
Demand

Demand for beef in the simplified model is split into rural demand and urban demand. Demand in rural and urban regions depends on the population in each region and the per capita rural demand for beef and the per capita urban demand for beef.

Per capita demand depends on income elasticity of demand and own price elasticity of demand.
Objective Function

The objective of the model is to maximize the sum of producer and consumer surplus, less the total cost of transporting and transforming the products. In addition to the standard constraints for finding the optimal value of a quadratic objective function, the model is also subject to a number of constraints that balance the flows of products between supply, transformation and demand regions.

This solution reveals equilibrium quantities of feeder cattle supplied in each region, the quantity of beef demanded in each region, quantities of cattle and beef transported between regions and the quantities of cattle fattened and slaughtered at various regions.
Running the Model

Model is developed algebraically

\[
\text{Maximize } \text{NCPS} = \sum_{j} \left( \alpha_{j} Q_{dj} + \frac{1}{2} \beta_{j} Q_{dj}^2 \right) - \sum_{i} \left( \delta_{i} Q_{si} + \frac{1}{2} \epsilon_{i} Q_{si}^2 \right) - \sum_{i} \sum_{f} (T_{if} * M_{if}) - \sum_{s} \sum_{f} (T_{fs} * M_{fs}) - \sum_{j} \sum_{s} (T_{sj} * M_{sj}) - \sum_{f} (Q_{f} C_{f}) - \sum_{s} (Q_{s} C_{s})
\]

Model is then coded into the General Algebraic Modelling System (GAMS) software

GAMS code calls input parameters from Excel worksheets and sends output to excel sheets
Data need to run the Model

- Cattle population in each region (số lượng bò của từng vùng)
- Proportion of breeding females in each region (can be estimated with herd dynamic model) (tỷ lệ bò cái sinh sản từng vùng – có thể rough bằng mô hình động vè “đàn bò”)
- Calving rate (can be estimated with herd dynamic model) (tỷ lệ sinh sản – có thể rough bằng mô hình động vè “đàn bò”)
- Post calving mortalities (tỷ lệ chết sau khi sinh sản)
- Female calf retention rates (can be estimated with herd dynamic model) (tỷ lệ bê cái được giữ lại – có thể rough bằng mô hình động vè “đàn bò”)
- Cost of fattening in commercial feedlot (chi phí vỗ béo bò tại các cơ sở vỗ béo thương mại lớn)
- Cost of fattening in specialized household (chi phí vỗ béo bò tại hộ chuyên vỗ béo qui mô lớn)
- Cost of fattening in cow-calf to finishing household (chi phí vỗ béo bò tại các hộ chăn nuôi nhỏ)
- Growth rates in different fattening / feeding systems (tỷ lệ tăng trọng ở các cơ sở/hệ thống vỗ béo khác nhau)
- Average weight of cows (culled that enter the slaughter sector), av weight of calves or feeder cattle (that exit cow-calf system) (trọng lượng trung bình của bò con bò được dẫn vào các cơ sở giết mổ; trọng lượng trung bình của bê con hay bò để vỗ béo ở các cơ sở vỗ béo)
- Carcass weight equivalent (amount of carcass weight for 1 kg of liveweight) (trọng lượng qui đổi ra “thịt xẻ”)
- Amount of bone-out beef per kg of carcass weight (lượng thịt bò đã bỏ xương “thịt xẻ”)
- Imports of feeder cattle by region (with different live and carcass weights) (lượng nhập khẩu bê con theo thị trường và thị xã)
- Imports of slaughter cattle by region (with different live and carcass weights) (lượng nhập khẩu bò thịt theo thị trường và thị xã)
- Imports of beef by region (lượng nhập khẩu thịt bò)
- Cost of slaughtering in commercial abattoir (chi phí giết mổ bò tại các lò mổ thương mại lớn)
- Cost of slaughtering in individual slaughtering (chi phí giết mổ bò tại các lò mổ nhỏ)
- Per capita consumption of beef (tiêu thụ thịt bò bình quân đầu người)
- Rural and urban population by region (dân số phân theo thành thị và nông thôn)
- Transport costs/distances between regions (chi phí vận chuyển/khoản cách vận chuyển giữa các vùng)
Example Scenarios

- Increases in per capita consumption of beef
- Changes in transportation costs/border costs
- Cattle supply changes due to disease outbreaks
- Changes in policies – import restrictions, beef production policies, cattle import restrictions etc.
- Changes in labour costs
- Changes in feed costs
Thank You