Transportation Economics and Bio-Mass Transportation
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TRANSPORTATION ECONOMICS AND BIO-MASS TRANSPORTATION

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April 27, 2010
The road ahead…..

- Why Does Transportation Matter?
- Transportation Economic Fundamentals
- Bio-Fuels: The Story of Ethanol in the U.S.
- Open Discussion / Dialogue
Transportation Matters ........ a great deal!

- It always has ......
- It always will ......

Especially when considering policies on:
- Food
- Agriculture
- Energy
- Environment
- Everything else ......

Issues are often quite complicated
Why is Transportation Important?

- Affects practically all aspects of your life?
  - Where you live
  - What you eat
  - What you buy
  - What you sell

- Transportation creates time and place utility

- Creation of markets........and value that otherwise wouldn’t exist

- This isn’t a recent phenomenon
Two Examples of Markets Created

- Hay to Asia

- Dell Computers
  - Prior to 1996, computers were assembled similar to other manufacturing processes
Pre-1996 Dell Supply Chain
Net Effect

• Orders are made online

• Components are provided from supplier “Just-in-Time”

• Inventory of parts reduced:
  • 75-100 days of inventory
  • Down to 6 – 7 days of inventory

• From time of order, computers are assembled, software loaded, tested and delivered around 36 hours
After 1996 Dell Supply Chain
Transportation Influences.....

- **Product**
  - Physical characteristics

- **Pricing**

- **Supply Markets**

- **Target Markets**

- **Facility Location**
Factors Influencing Transportation Costs

- **Product-Related**
  - **Density**
    - Refers to a product's weight-to-volume ratio.
  - **Stowability**
    - The degree to which a product can utilize available space in transport vehicle.
  - **Handling Ease**
    - Uniform sizes or odd shapes.
  - **Liability**
    - Important for products with high value-to-weight ratios.
  - **Perishability**
    - Degree to which the product may be damaged in transit.
Factors Influencing Transportation Costs

- Market-Related
  - Degree of Intra- and Inter-Modal competition
  - Location of Markets
    - Distance goods must be transported
  - Government Regulation
  - Seasonality
Distance-Transportation Costs Relationships

![Graph showing the relationship between transportation cost per unit and length of haul with lines A, B, C, and D representing different cost models.](image-url)
Transportation Cost Surface

Assuming Linear Costs

Market Center

Isocost Contours

Transportation Cost Function

Length of Haul
Transportation Cost Surface
Assuming Increasing Costs at a Decreasing Rate

Market Center
Isocost Contours
Transportation Cost Function

Length of Haul

0 D₁ D₂ D₃ D₄
# Mode Comparison by Economics

<table>
<thead>
<tr>
<th>Economic Characteristic</th>
<th>Truck</th>
<th>Rail</th>
<th>Air</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>Moderate</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Market Coverage</strong></td>
<td>Point-to-point</td>
<td>Terminal-to-terminal</td>
<td>Terminal-to-terminal</td>
<td>Terminal-to-terminal</td>
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<tr>
<td><strong>Degree of Competition</strong></td>
<td>Many</td>
<td>Few</td>
<td>Moderate</td>
<td>Few</td>
</tr>
<tr>
<td><strong>Traffic Type</strong></td>
<td>All types</td>
<td>Low to moderate value, relatively high density</td>
<td>High value, relatively low density</td>
<td>Low value, High density</td>
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<tr>
<td><strong>Length of Haul</strong></td>
<td>Short to long</td>
<td>Medium to long</td>
<td>Medium to long</td>
<td>Medium to long</td>
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<tr>
<td><strong>Capacity (tons)</strong></td>
<td>10-25</td>
<td>50-12,000</td>
<td>5-125</td>
<td>1,000-60,000</td>
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## Mode Comparison by Service

<table>
<thead>
<tr>
<th>Service Characteristics</th>
<th>Truck</th>
<th>Rail</th>
<th>Air</th>
<th>Water</th>
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</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>Moderate-Fast</td>
<td>Slower</td>
<td>Fast</td>
<td>Slow</td>
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<tr>
<td><strong>Availability</strong></td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
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<tr>
<td><strong>Consistency</strong> (delivery time)</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
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<tr>
<td><strong>Loss and damage</strong></td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td><strong>Flexibility</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
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</tbody>
</table>
Freight Mode Comparison

Cargo Capacity

- One Barge: 1,500 ton, 52,500 bushels, 453,600 gallons
- One 15 Barge Tow: 22,500 ton, 787,500 bushels, 6,804,000 gallons
- Jumbo Hopper Car: 100 ton, 3,500 bushels, 30,240 gallons
- 100 Car Train: 10,000 ton, 350,000 bushels, 3,024,000 gallons
- Large Semi: 26 ton, 910 bushels, 7,865 gallons

Equivalent Units

- One Barge: 15 Jumbo Hopper Cars
- One 15 Barge Tow: 58 Large Semis

Equivalent Lengths

- One 15 Barge Tow: .25 mile
- 2.25 100 Car Trains: 2.75 miles
- 870 Large Semis: 11.5 miles (bumper to bumper)

Source: Iowa Department of Transportation, 800 Lincoln Way, Ames, IA 50010, 515.239.1520
Energy Use Per Freight Mode
Agricultural Supply Chain
Biomass Supply Chain

Biomass Supply Chain

Geographically distributed biomass feedstocks

Biomass power plant

Biomass Utilization Supply Chain

Biorefinery

Heating

Electricity grid

Distribution Terminal
Alternative Mode Cost Relationships

![Graph showing cost relationships for different transportation modes and zones.](image-url)
What Happened with Ethanol in the U.S.?

✓ Rising conventional fossil fuel prices
✓ Too dependent on foreign oil sources
✓ If Brazil can do it.......we can too!

Let’s grow our way out of this energy problem!!
U.S. Ethanol Production

Million Gallons

Total Number of Ethanol Plants

New Plants Under Construction
# RFS Mandated BioFuel Schedule

(Discounted Gallons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RFS, All Fuel</th>
<th>Actual Corn Ethanol</th>
<th>RFS Corn Ethanol</th>
<th>Cellulosic Ethanol</th>
<th>Other Advanced Biofuels</th>
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<tbody>
<tr>
<td>1998</td>
<td>1.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1999</td>
<td>1.47</td>
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<tr>
<td>2000</td>
<td>1.63</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2001</td>
<td>1.77</td>
<td></td>
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<tr>
<td>2002</td>
<td>2.13</td>
<td></td>
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<td>2003</td>
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<td>2005</td>
<td>3.90</td>
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<td>2008</td>
<td>9.00</td>
<td>9.00</td>
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<td>2009</td>
<td>11.10</td>
<td>10.5</td>
<td>0.5</td>
<td>0.1</td>
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<td>2010</td>
<td>12.95</td>
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<td>0.10</td>
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<td>2011</td>
<td>13.95</td>
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<td>0.3</td>
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<td>2012</td>
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<td>13.2</td>
<td>0.50</td>
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<td>2013</td>
<td>16.55</td>
<td>13.8</td>
<td>1.00</td>
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<td>2014</td>
<td>18.15</td>
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<td>2015</td>
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<td>2016</td>
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<td>36.0</td>
<td>15.0</td>
<td>16.0</td>
<td>5.0</td>
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</table>

1 Advanced biofuel includes any biofuel from “renewable biomass,” except corn starch, with lifecycle greenhouse gas emissions at least 50% less than baseline. In contrast, cellulosic biofuel is defined as fuel derived from “cellulose, hemicelluloses, or lignin” that is derived from renewable biomass and has lifecycle GHG emissions 60% less than baseline.

2 The RFS also requires increased use of biodiesel, up to 1 billion gallons in 2012. Therefore corn and cellulosic ethanol volumes are not equal to total RFS volumes.

3 The VEETC changed from 51 cents to 45 cents in the US Farm Bill. This change will take effect when 7.5 billion gallons of ethanol are produced or imported.

4 When referring to “pure” or “neat” ethanol, we are generally referring to denatured, fuel-grade ethanol (with a small percentage of gasoline).

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2007 Estimated Corn Production-Consumption Surplus/Deficit for Animal Feed Utilization and Corn Export Ports

Density of Annual Alcohol and Co-Product Shipments by Rail, 2006
Status of Unit Train Destinations, December 2009

Existing Ethanol Facilities
Capacity in Million Gal.
- 5 to 55
- 56 to 99
- 100 +

Alcohol and Co-Products
Tons
72,520 254,024 653,824 1,734,480

Source: Ethanol Plants: U.S. Department of Agriculture, Economic Research Service; Waybill Sample, 2006;
U.S. Department of Transportation, Federal Railway Administration; Rail Destinations: Railroad Websites for Tariff Rates
Ethanol Challenges

- Grew too fast, too soon........over expansion

- Ethanol Plants that are long distances from source, will face competitive disadvantages
  - Cost Risk
  - Dealing with the Railroad

- Many of the smaller plants may struggle due to lack of economies of scale

- Food vs. Fuel?

- Doesn’t score well from environmentalist (LCA) perspective

- May be an important part of the solution, but certainly not the total Energy solution
Other Bio-Fuels?

- Switchgrass
- Canola
- Forest Residue
- Municipal Waste
- Animal Waste
- Others…….

Many Difficult Questions
Such as:

- **Where to put a plant?**
  - Economically viable
  - Water Availability
  - Consistent low-cost supply
  - Proximity to feedstock supply and fuel demand markets
  - Access to transportation

- **How big should it be?**

- **Conversion technology?**

- **By-Products?**
Processing Versus Transportation Costs

Total Costs ($/gallon)

- Processing Costs
- Transportation Costs

Total Costs

Optimal Plant Size

Plant Processing Capacity (million gallons/year)
Site Identification
Vancouver/Longview Plant

[Graph showing the relationship between feedstock transportation distances (miles) and annual ethanol processing (million gallons) with various feedstock types, including Forest Residue (MGY), Crop Residue (MGY), Animal Waste (MGY), Paper (MGY), Wood residue (MGY), Food Waste (MGY), and Feedstock Transportation Costs ($/ton).]
The energy road ahead......

- Competition between two paths
What will the energy of the future look like?

- Some behavioral changes are likely to occur

- Multiple feed stock sources that allows for regional specialization

- Regional bio-fuel plants that generate electricity and supply the grid that then supplies our automobiles
Questions?
Discussion Questions:

- Why hasn’t the U.S.’s reliance on fuel not declined, (in terms of consumption per capita)?

- If fuel is more expensive, why not just ship everything on more efficient modes such as railroads?

- Why don’t we have better passenger rail service in the U.S.? (High speed rail projects)