REMI Webinar: Epidemiological and Economic Modeling of a Pandemic

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Analysis in three parts:

*Physical, Response, and Economic*

**Tools/Data**

- **Modeling**: Epidemiological modeling, effects modeling; new drugs or countermeasures, resource modeling and machine learning.

- **Prompt Effects**: Psychosocial, morbidity/mortality.

- **Response Efforts**: Use policy responses by States.

- **Costs**: Resource modeling and countermeasures.

- **Economic Analysis**: Modeled over multiple years with REAacct^* and REMI.

The present study uses new tools and data, which raised the level of rigor.
Sandia Disease and Public Health Modeling

- Long history
- Differentiating factors
  - Problem oriented
  - Rigorous uncertainty analysis
  - Quick-turn Modeling
- Examples
  - Zoonotic diseases
  - Hospital acquired diseases
  - Healthcare system models
  - Ebola crisis response
  - Biosurveillance
Modeling for better decisions

- Quantitative guidance for decision makers:
  - Best use of resources
  - Minimizing risk

- When are models useful:
  - Insufficient data
  - Partial understanding of system
  - Need to examine alternatives

- Payoff:
  - Which interventions work best
Example of Modeling Social Distancing Workplace Policies
Targeting workplace policies to control disease

Analysis shows which policies perform best.
Pandemic Influenza Epidemiology

- A pandemic is a worldwide occurrence in which most, if not all, people are at risk for infection and illness.
- Past influenza pandemics have spread worldwide in a matter of months.
- Human influenza pandemics have occurred 3 times in the 20th century: in 1918, 1957, and 1968.
- During the pandemic of 1918–1919, influenza struck between 20 and 40 percent of the world's population, killing on average of 2 percent of the infected cases.
Typical Pandemic Pattern

Day 109

Day 139

Day 146

Day 153

Day 160

Day 190

2010 Scenario: Absenteeism, Morbidity, Mortality

- The healthcare sector is stressed
  - Increased absenteeism
  - Increased demand

- Work from Home
  - Will vary by industry
  - Likely decreased productivity

- Absenteeism
  - Some sectors more affected
  - May be nullified by WFH orders

- Morbidity
  - Increased demand for healthcare

- Mortality
  - Will change survivability within the model
2010 Scenario: Impact of Pandemic on U.S. Economy

- Two Types of Impact to U.S. Economy
  - Supply Shock
    - Employees absent
    - Lower productivity of working employees
    - Mortality
  - Demand Shock
    - Mortality
    - Consumers adjust spending due to pandemic fears (e.g., not willing to do face-to-face transactions)
    - Decreased consumer confidence

- Mitigating Factors
  - Delayed Purchases
  - Substitution
  - On-line Purchases

Epidemiological Impacts to Economic Impacts

- Key epidemiological parameters drive workplace absenteeism and mortality for the seven scenarios

- The clinical attack rate drives the pandemic’s absenteeism and is highly positively correlated to the mortality rate

- The range of GDP listed for each scenario reflected variations in the demand response,
  - Assumed a reduction for select goods and services
  - Assumed an increase of healthcare expenditures

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Clinical Attack Rate</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.26</td>
<td>0.0053</td>
</tr>
<tr>
<td>Antiviral</td>
<td>0.25</td>
<td>0.0047</td>
</tr>
<tr>
<td>Fear-40</td>
<td>0.21</td>
<td>0.0043</td>
</tr>
<tr>
<td>CMG-SE¹</td>
<td>0.10</td>
<td>0.0055</td>
</tr>
<tr>
<td>Anticipated</td>
<td>0.0092</td>
<td>0.000064</td>
</tr>
<tr>
<td>CMG</td>
<td>0.0045</td>
<td>0.000027</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pandemic Scenario</th>
<th>Year 1</th>
<th>Years 1-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$120 to $350</td>
<td>$810 to $1,100</td>
</tr>
<tr>
<td></td>
<td>1.1 % to 3.1 %</td>
<td>N/A</td>
</tr>
<tr>
<td>Fear-40</td>
<td>$140 to $400</td>
<td>$770 to $1,000</td>
</tr>
<tr>
<td></td>
<td>1.2 % to 3.5 %</td>
<td>N/A</td>
</tr>
<tr>
<td>Antiviral</td>
<td>$120 to $340</td>
<td>$710 to $960</td>
</tr>
<tr>
<td></td>
<td>1.0 % to 2.9 %</td>
<td>N/A</td>
</tr>
<tr>
<td>Anticipated</td>
<td>$140 to $400</td>
<td>$430 to $580</td>
</tr>
<tr>
<td></td>
<td>1.2 % to 3.5 %</td>
<td>N/A</td>
</tr>
<tr>
<td>CMG-SE²</td>
<td>$93 to $270</td>
<td>$310 to $410</td>
</tr>
<tr>
<td></td>
<td>0.8 % to 2.3 %</td>
<td>N/A</td>
</tr>
<tr>
<td>CMG</td>
<td>$95 to $280</td>
<td>$290 to $400</td>
</tr>
<tr>
<td></td>
<td>0.9 % to 2.6 %</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Lessons from SARS and Past Pandemic Modeling

- Small number of SARS infections compared to other events
- SARS provides some insight into the potential economic impact
- Demand side:
  - Less demand for goods and services
- Supply side:
  - Increased absenteeism; social distancing
- Population shock
  - Increased mortality in labor force
  - Both a demand and supply shock

### IMPACT OF SARS ON SELECTED TOURISM AND RELATED SECTORS [Exhibit 1]

<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of Establishments*</th>
<th>Employment of Sector*</th>
<th>Per Cent Fall in Sales Due to SARS**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail</td>
<td>18,372</td>
<td>85,589</td>
<td>10–50 per cent</td>
</tr>
<tr>
<td>Catering Trade</td>
<td>3,356</td>
<td>48,202</td>
<td>Up to 50 per cent</td>
</tr>
<tr>
<td>Hotels</td>
<td>196</td>
<td>26,096</td>
<td>Up to 70 per cent</td>
</tr>
<tr>
<td>Taxi Drivers</td>
<td>-</td>
<td>34,000</td>
<td>30–40 per cent</td>
</tr>
<tr>
<td>Tour operators</td>
<td>648</td>
<td>7,405</td>
<td>70–80 per cent</td>
</tr>
</tbody>
</table>

Source: Economic Survey Series 2000, Singapore Department of Statistics

#### Table 3.2 Breakdown of Consumer Spending, Selected Economies, 2001

<table>
<thead>
<tr>
<th>Category</th>
<th>PRC</th>
<th>Korea, Rep. of</th>
<th>Taipei, China</th>
<th>Thailand</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>28.1</td>
<td>14.6</td>
<td>20.9</td>
<td>25.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Alcohol &amp; tobacco</td>
<td>3.9</td>
<td>2.3</td>
<td>3.7</td>
<td>6.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Clothing &amp; footwear</td>
<td>10.1</td>
<td>3.9</td>
<td>4.1</td>
<td>11.0</td>
<td>5.1</td>
</tr>
<tr>
<td>Rent, water, fuel &amp; power</td>
<td>10.3</td>
<td>17.5</td>
<td>18.3</td>
<td>9.2</td>
<td>17.2</td>
</tr>
<tr>
<td>Household goods &amp; services</td>
<td>8.3</td>
<td>4.4</td>
<td>5.8</td>
<td>6.9</td>
<td>5.0</td>
</tr>
<tr>
<td>Health Expenditure</td>
<td>6.5</td>
<td>7.6</td>
<td>8.9</td>
<td>7.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Recreation, education, &amp; culture</td>
<td>13.0</td>
<td>13.0</td>
<td>19.2</td>
<td>8.1</td>
<td>11.5</td>
</tr>
<tr>
<td>Transport &amp; communications</td>
<td>8.6</td>
<td>16.7</td>
<td>11.9</td>
<td>16.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Other goods &amp; services</td>
<td>11.3</td>
<td>20.0</td>
<td>7.2</td>
<td>9.7</td>
<td>21.7</td>
</tr>
<tr>
<td>Total Private Consumption</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Estimate Cumulative Impacts:  
*Estimate Impact from Pandemic Event*

**Objective**
- Estimate cumulative economic impacts

**Challenges**
- Data acquisition, parameter specification, and modeling assumptions
  - Previous studies not entirely helpful

**Solutions**
- Outreach to stake-holder and subject matter experts
  - **Regional Outreach**
  - Review of methodology and assumptions
  - Identified new or state of the art models or data
  - Uncertainty quantification and sensitivity analysis
Example of Total U.S. Impact: GDP Loss Occur Over 10 Years

The economy: circular and dynamic Output (GDP) contributed by activity

Output generates employment, employment generates income, income generates demand for and spending on new output, new output generates new employment, and so on.

*Recovery efforts are likely to be funded by federal government spending, resulting in increases in output.

**Perception is based on tourism patterns observed post-Fukushima.

Relocation of economic activity within the NYC MSA. It is assumed businesses and employees will behave similar observed post 9/11 relocation patterns.

GDP impacts are not intuitive.
They can be negative or positive, but all represent economic disruption.
Economic analysis software based on inter-industry commodity flows (IO), dynamic response (general equilibrium theory), and econometrics

- Calculates temporal and spatial impacts
  - Structural relationships (goods and services)
  - Technical relationships (input-output production recipes)
  - Behavioral relationships (demand elasticities)
  - Allows for annual adjustments

- Appropriate for modeling long-term effects
Discussion

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