Economic Growth and World Food Demand and Supply

Emiko Fukase and Will Martin

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Economic Growth & Food Markets

• Per capita income growth raises food demand
  – Primarily through diet shifts to animal products
    • Food Engel Curves are concave
    • Higher growth in poorer countries raises demand more
      – Theories of convergence suggest higher growth in poorer countries

• Long run per capita income growth is driven by productivity growth
  – Agricultural output grows less than proportionately

• Population growth raises demand proportionately & reduces land per person
Convergence potentially important

• The Solow model suggests that followers should be able to grow more quickly than economies at the frontier
• Some have pointed to high growth in developing countries as potential causes of food price rises
• Higher growth in developing countries has certainly been evident recently
• If higher growth in developing countries is needed to meet the SDGs, do we need to take into account impacts on food demand?
Recent higher growth in developing countries
Per capita demand growth
Food demand

• One way to capture food demand growth is through multi-product simulation models
  – Rising demand for superior products creates demand for inputs such as grain & oilseeds
    • This requires a huge amount of information and many assumptions

• Is there a simple, econometric alternative?
  – Like the widely-used gravity model of trade
Econometric Approach

• Draw on work by Yotopoulos & by Rask
  – Based on the experience of 155 countries

• Calculate the cereal equivalents required to produce diets as incomes grow

• Estimate reduced-form relationship between real income & cereal equivalent consumption
Some cereal equivalents

<table>
<thead>
<tr>
<th>Products</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine Meat</td>
<td>19.8</td>
</tr>
<tr>
<td>Pork</td>
<td>8.5</td>
</tr>
<tr>
<td>Poultry</td>
<td>4.7</td>
</tr>
<tr>
<td>Fish, Seafood</td>
<td>3.3</td>
</tr>
<tr>
<td>Eggs</td>
<td>3.8</td>
</tr>
<tr>
<td>Milk</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Why so high?

• Cattle take 7kg of feed for a kilo of beef
  – But this is live weight
    • The FAO numbers we use are carcass weight

• In addition, need to maintain a herd of breeding cows & calves
  – This takes the feed equivalent even higher

• Pork & poultry are more efficient
  – In feed conversion & cost of the breeding herd
CE Demand equation

\[ y = A_1 - A_2 e^{-kx} \]

where \( y \) is consumption per capita; \( A_1 \) is peak potential consumption; and \( x \) is income in PPP terms. Cross-sectional regression results:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>( A_1 )</td>
<td>2.2***</td>
<td>(.17)</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>1.7***</td>
<td>(.16)</td>
</tr>
<tr>
<td>( K )</td>
<td>( 4.6 \times 10^{-5}*** )</td>
<td>( (9.5 \times 10^{-6}) )</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.74</td>
<td></td>
</tr>
</tbody>
</table>
Estimated demand

GDP per capita, PPP (constant 2005 int. $)
Calorie vs CE demand

Fitted Calorie Consumption Curve
Fitted CE Consumption Curve

GDP per capita, PPP 2005 $

(tons/capita/year)

(kcal/capita/day)
Changes in food demand: 1992-2009
Concavity of the Engel curve important

- Consumption grows rapidly at low income levels
  - Eventually, the growth rate slows

- Global growth depends on whether poorer economies are growing faster than richer
  - ie whether income levels are converging

- Population growth elasticity is unitary
Explaining changes in consumption


Regions: China, EA, ECA, High, LAC, MENA, SA, SSA, Global

Bar chart showing the comparison of actual and estimated changes in consumption for different regions from 1992 to 2009.
Supply per person
Production

\[ z = B_0 + B_1 X^{B_2} H^{B_3} \]

where \( z \) is CE production per capita, \( X \) is PPP GDP per capita, \( H \) is ha of agric land per capita

<table>
<thead>
<tr>
<th>( B )</th>
<th>Value</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B_0 )</td>
<td>.27** (.11)</td>
<td></td>
</tr>
<tr>
<td>( B_1 )</td>
<td>( 8.9 \times 10^{-4} ) (1.5 \times 10^{-3})</td>
<td></td>
</tr>
<tr>
<td>( B_2 )</td>
<td>0.77*** (.16)</td>
<td></td>
</tr>
<tr>
<td>( B_3 )</td>
<td>0.33*** (.036)</td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.56</td>
<td></td>
</tr>
</tbody>
</table>
Regression rationale

• Even the poorest countries need some agricultural output
• Agricultural output higher in countries with greater land per person
• Assume sector-neutral productivity growth drives GDP growth
  – And agricultural growth
    • But with a less-than-unitary elasticity
Agric CE prodn vs income

China CE Consumption
China CE Production
CE Production adjusted at China Land Level
CE Production (China: land=.21 ha)

GDP per capita, PPP 2005 int. $
Explaining changes in production
Baseline and projections
Baseline and projections

• Baseline: 1992 to 2009
  – After the entry of the Warsaw Pact countries into the market-oriented trading system
  – Examine the extent of convergence & its impacts

• Projections from 2009 to 2050 from the IIASA Shared Socioeconomic Pathways
### Income convergence testing

\[ d\ln y = \alpha + \beta \cdot \ln y_{\text{initial}} \]

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<tbody>
<tr>
<td>( \beta )</td>
<td>0.0028 (1.19)</td>
<td>0.0025 (1.34)</td>
<td>-0.0043** (-2.33)</td>
<td>-0.0085*** (-17.20)</td>
</tr>
</tbody>
</table>

- Wrong sign and insignificant the first two periods
- Small & significant the third period (1/4 the Dowrick-Nguyen estimate for OECD)
- Strongly significant in the projection
How important is convergence?

• Change in total food demand
  \[ \hat{x} = \sum \hat{w}_i \cdot \hat{B}_i \cdot y_i \]
  where \( w_i \) is the share of ctry i in consumption; \( \hat{B}_i \cdot y_i \) is the income elasticity; and \( y_i \) is income growth

• If income growth is uniform or is independent of the elasticity, we can use the average elasticity & the average income change

• More generally, we can calculate the effect of a correlation using

  \[ \hat{x} = \hat{B} \cdot y + \sum \hat{w}_i \cdot [\hat{B}_i - \hat{B}] \cdot [y_i - y] \]
Only very rapid convergence has a big impact

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</tr>
</thead>
<tbody>
<tr>
<td>$\sum w_i \cdot B_i \cdot y_i$</td>
<td>0.0604</td>
<td>0.0622</td>
<td>0.0967</td>
<td>0.4756</td>
</tr>
<tr>
<td>$\hat{B} \cdot y$</td>
<td>0.0785</td>
<td>0.0707</td>
<td>0.0902</td>
<td>0.4394</td>
</tr>
<tr>
<td>$\sum w_i \cdot [\hat{B}_i - \hat{B}] \cdot [y_i - y]$</td>
<td>-0.0181</td>
<td>-0.0085</td>
<td>0.0065</td>
<td>0.0362</td>
</tr>
</tbody>
</table>
Conclusions

• Basic econometric framework for food supply/demand provides some powerful insights

• Concavity of the Engel relationship affects countries’ supply/demand balances
  – & means economic convergence affects aggregate demand

• Supply a race between improving technology and declining land endowments