ENGEL’S LAW, DIET DIVERSITY AND THE QUALITY OF FOOD CONSUMPTION

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A WEEK’S FOOD

Norway

2011 GDP p.c. = $61,897
Food budget share = 10.5%

Chad

2011 GDP p.c. = $1,984
Food budget share = 51.4%

Pictures © Peter Menzel
BENEFITS OF DIVERSITY

• Usually, diversity associated with more choice, opportunities and higher incomes
• More diversified consumption patterns usually a good thing
• Nutritional benefits of a diversified diet (USDA’s Healthy Eating Index)
APHORISMS

• Variety is the spice of life
• Don’t put all your eggs in one basket
• A change is as good as a holiday
• Diversity is our strength
• Two heads are better than one
• The wisdom of crowds
• All work and no play makes Jack a dull boy
• [The law of large numbers (?)]
DRIVEN BY DIFFERENCE
HOW GREAT COMPANIES FUEL INNOVATION THROUGH DIVERSITY
DAVID LIVERMORE
MEASURING DIVERSITY

• **Count index** of diversity -- number of items consumed

• A more economic approach -- **budget shares** measure the economic importance of each item:

\[ w_i = \frac{p_i q_i}{M}, \quad 0 < w_i < 1, \quad \sum_{i=1}^{n} w_i = 1 \]
SUM OF SQUARED SHARES

• **Hirfindahl index** -- sum of squared budget shares

\[ H = \sum_{i=1}^{n} w_i^2, \quad \frac{1}{n} \leq H \leq 1 \]

• **Berry index**

\[ B = 1 - H, \quad 0 \leq B \leq 1 - \frac{1}{n} \]

• Higher value of B means more diet diversity, with less dispersion among shares
• More even spread of expenditure means more diversity
ENGEL’S LAW AND DIVERSITY

• As income rises, the budget share of food falls -- Engel’s law
• One of the most important laws in economics
• The little understood Engel-diversity nexus
CROSS-COUNTRY FOOD CONSUMPTION

FOOD AND INCOME, 155 COUNTRIES IN 2011

\[ y = -11.15 \log M + \text{constant} \]

\( (0.49) \)

Food share
\((\times 100)\)

Income p.c. ($)

Niger

Liberia

Armenia
THE LOG-LINEAR CASE

\[ w_i = \alpha_i + \beta_i \log M, \ i, \ldots, n \]

- Income part of the Almost Ideal Demand (AID) model of Deaton and Muelbauer (1980)
- Income elasticity: \( \eta_i = 1 + \frac{\beta_i}{w_i} \) \( (w_i = p_i q_i / M) \)
- Income coefficient: \( \beta_i < 0 \Rightarrow \eta_i < 1 \)
- Homotheticity: \( \beta_i = 0 \Rightarrow \eta_i = 1 \)
SHORT DIGRESSION: AID MODEL

• Angus Deaton, 2015 Nobel Laureate
  “for his analysis of consumption, poverty, and welfare”

• Almost ideal demand model:

\[ w_i = \alpha_i + \beta_i \log \left( \frac{M}{P^*} \right) + \sum_{j=1}^{n} \gamma_{ij} \log p_j , \ i, \ldots, n, \]

where \( P^* = \) price index
The Economist (2015):
“... in earlier models, demand was assumed to increase in lock-step with income, regardless of how rich the person was. The new approach allowed for different responses according to the level of income, so that a 1 percent pay boost might raise porridge demand by 2 percent for a pauper, but only 0.1 percent for a prince.”
ECONOMIST WRONG

- Porridge transforms from luxury to necessity
- Perfectly plausible behaviour, **BUT**
- Not permitted by AID as $\eta_i = 1 + \frac{\beta_i}{w_i}$, with $\beta_i = \text{constant}$ and $w_i > 0$

<table>
<thead>
<tr>
<th></th>
<th>Pauper</th>
<th>Prince</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in income</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Increase in porridge</td>
<td>2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Income elasticity $\eta_i = \frac{%\Delta q_i}{%\Delta \text{income}}$</td>
<td>$\frac{2}{1} = 2$</td>
<td>$\frac{0.1}{1} = 0.1$</td>
</tr>
</tbody>
</table>
BERRY AND ENGEL

• The Berry index of diversity again:

\[ \text{Berry} = 1 - \sum_{i=1}^{n} w_i^2 \]

• Using AID Engel curves \( w_i = \alpha_i + \beta_i \log M \),

\[
\text{Berry} = \Theta + \Phi \log M + \Gamma (\log M)^2,
\]

where

\[
\Theta = 1 - \sum_{i=1}^{n} \alpha_i^2, \quad \Phi = -2 \sum_{i=1}^{n} \alpha_i \beta_i, \quad \Gamma = - \sum_{i=1}^{n} \beta_i^2
\]
COROLLARY TO ENGEL’S LAW

• When $\beta_i = 0$, income elasticities are unity, budget shares constant and

$$\text{Berry} = \Theta, \text{ independent of income}$$

• More generally, diverse income elasticities drive diversity in consumption

$$\text{Engel’s law implies budget diversity increases with income}$$
INTERNATIONAL COMPARISON PROGRAM DATA

- Expenditures for 2011 in local currencies and volume measures in $US
- PPP prices
- 155 countries
- 31 items of food consumption
Structure of Food Consumption
155 countries, 2011
(% budget shares)

Total Consumption

Food
27%

Non-food
73%

Bread & Cereals
17%

Meat & Seafood
24%

Dairy
15%

Fruits & Veg
18%

Sweet things
5%

Other food
13%

Alcohol
8%

Rice
22%

Other cereals
24%

Bread
30%

Other bakery
17%

Pasta
7%

6 items

6 items

5 items

3 items

3 items

31 food items in total
# STAPLES CONSUMPTION

<table>
<thead>
<tr>
<th>Item</th>
<th>Conditional budget shares (%)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rich countries</td>
<td>Poor countries</td>
</tr>
<tr>
<td>Rice and other cereals</td>
<td>23.4</td>
<td>77.1</td>
</tr>
<tr>
<td>Bread etc.</td>
<td>76.6</td>
<td>22.9</td>
</tr>
</tbody>
</table>

Rich = countries in first income quartile; poor = countries in fourth quartile (averages)

- Rice and other cereals dominate consumption in low income countries
- Bread etc. dominates in rich countries
MORE ON MEASURING DIVERSITY

• n budget shares: \(w_1, \cdots, w_n\)

• Weighted logarithmic variance:

\[
\Pi_w = \sum_{i=1}^{n} w_i (\log w_i - \log \bar{W})^2,
\]

where \(\log \bar{W} = \sum_{i=1}^{n} w_i \log w_i\)

• \(\Pi_w\) measures dispersion of shares:

\[
\Pi_w = 0 \text{ if } w_i = \frac{1}{n}, i = 1, \cdots, n
\]
CONSUMPTION MOMENTS

- \( \Pi_w > 0 \) is the cross-commodity variance of budget shares
- Analogous variances of prices and quantities, and the price-quantity covariance:
  \[ \Pi_p > 0, \quad \Pi_q > 0, \quad \Pi_{p,q} < 0 \]
- These satisfy
  \[ \Pi_w = \Pi_p + \Pi_q + 2\Pi_{p,q} \]
- The quantity variance
  \[ \Pi_q = \Pi_w - \Pi_p - 2\Pi_{p,q} \]
  is the important component for nutrition
FOOD DIVERSITY AND INCOME

\[ \log \Pi_q = -0.29 \log M + \text{constant} \]

\[ (0.03) \]
DECOMPOSING DIVERSITY

\[ \Pi_q = \sum_{i=1}^{n} w_i (\log q_i - \log Q)^2 \]

- Divide n goods into G groups, \( S_1, \ldots, S_G \)
- Between-group variance: \( \sum_{g=1}^{G} W_g (\log Q_g - \log Q)^2 \)
- Within: \( \sum_{g=1}^{G} W_g \left[ \sum_{i \in S_g} \left( \frac{w_i}{W_g} \right) (\log q_i - \log Q_g)^2 \right] \)
- Then,

\[ \text{Total variance, } \Pi_q = \text{between} + \text{within} \]
Structure of Food Consumption
155 countries, 2011 (% budget shares)

Total Consumption
Food 27%
Non-food 73%

Bread & Cereals 17%
- 6 items
  Rice 22%
  Other cereals 24%
Meat & Seafood 24%
- 6 items
 Dairy 15%
 Fruits & Veg 18%
- 5 items
 Bread 30%
 Sweet things 5%
- 3 items
 Other bakery 17%
 Alcohol 8%
- 3 items
 Other food 13%

31 food items in total
INEQUALITY OF DIET DIVERSITY

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Ratio of diet diversity of rich to poor $\frac{\Pi_q^P}{\Pi_q^R}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total budget</td>
<td>2.3</td>
</tr>
<tr>
<td>Between group</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Rich = countries in first income quartile; poor = countries in fourth quartile

• **Conclusion:** Focusing on total variance, and ignoring between-within distinction, masks a substantial part of inequality of diet diversity
THE STEAKOUT

Fillet Steak

Rump Steak

Unit price difference $ \frac{38.00}{18.99} - 1 = 100\%$

Fillet steak twice as expensive as rump
THE MYSTERY OF QUALITY

• What exactly is “quality”?
• Fillet versus rump steak
• Business class versus economy
• Restaurant meals vs medical services
• Whole consumption basket – how to measure quality?
• Subjectivity

Quality is difficult in principle and practice
WHO SAID THIS?

• “[A commodity] is a queer thing, abounding in metaphysical subtleties and theological niceties”
Marx and Engels (not Engel!)  
Karl Marx  
1818 – 1883  
Wrote *Das Kapital*  

Friedrich Engels  
1820 – 1895  
Wrote *The Communist Manifesto*  
(co-authored with Marx)
QUALITY AND CONSEQUENCES

- Substantial quality improvements
- Inflation measurement
- Annual CPI inflation overstated by about half a percentage point (ABS)
- Neglecting quality improvement understates volumes
CURRENT APPROACHES

- Price of product
- Hedonics
- Statistical agencies
  - Matched model
  - Package-size adjustments
  - Hedonics: Computers
ISSUES WITH CURRENT APPROACHES

• Subjectivity – need to declare what’s good for the consumer, what is quality
• Existence of “constant-quality” models
• Quality of hard-to-measure services
• Quality of basket as a whole problematic
FOODIES...

For Shannon Bennett, a Miele steam oven is not an option...
A Miele Steam Oven’s unique ability to whip up multiple dishes, without transfer of flavour, while retaining natural taste, texture and goodness, has already inspired Shannon Bennet to create a menu of amazingly innovative dishes, such as Steamed Asian Chicken…cooked simultaneously with fabulous desserts.

And the new Miele Pressure Steam Oven, which can reduce cooking time by half, has this seriously busy chef very excited indeed. For flexibility and creativity, anyone who loves authentic food, perfectly cooked, will see a Miele Steam Oven as a necessity in their kitchen too.
BACK TO FOOD IN CHAD
AND NORWAY
WHAT’S DIFFERENT?

• Volume of food very different
• Number of items very different
• **Very nature** of what’s eaten is different
• Norwegian food basket more
  o Processed
  o Packaged
  o Colourful
  o Tasty?
  o Healthy?
TWO MORE COUNTRIES

- Consumption basket in two countries “c” and “d”

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantities</th>
<th>Relative consumption</th>
<th>Budget shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>$q_1^c, \ldots, q_n^c$</td>
<td>$\log \frac{q_1^c}{q_1^d}, \ldots, \log \frac{q_n^c}{q_n^d}$</td>
<td>$w_1^c, \ldots, w_n^c$</td>
</tr>
<tr>
<td>d</td>
<td>$q_1^d, \ldots, q_n^d$</td>
<td></td>
<td>$w_1^d, \ldots, w_n^d$</td>
</tr>
</tbody>
</table>

- Share in “country” midway between the two:

$$w_{i}^{cd} = \frac{w_{i}^{c} + w_{i}^{d}}{2}$$

- Real income in c relative to d:

$$\log Q^{cd} = \sum_{i=1}^{n} w_{i}^{cd} \cdot \log \left( \frac{q_i^c}{q_i^d} \right)$$
QUALITY AND LUXURIES

• **Basic idea:** A good is of above-average quality if it’s a luxury ($\eta_i > 1$)

• **Defining quality:** Good $i$ contributes to the quality of the basket of country $c$ as compared to $d$ if

  i. It is a luxury

      \[ \eta_{i \text{cd}} > 1 \]

      where $\eta_{i \text{cd}} = \frac{w_i^c}{w_i^c + w_i^d} \cdot \eta_i^c + \frac{w_i^d}{w_i^c + w_i^d} \cdot \eta_i^d$

      and

  ii. Relative consumption of $i$ exceeds relative income,

      \[ \log \left( \frac{q_i^c}{q_i^d} \right) > \log Q_{\text{cd}} \]

      where $\log Q_{\text{cd}}$ is total consumption in $c$ relative to $d$
THE QUALITY INDEX

• Good $i$ contributes to the quality of the basket in one country relative to the other if

$$ (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) - \log Q^{cd} \right] > 0 $$

• The quality index for the whole budget is a share-weighted average:

$$ y_{q}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) - \log Q^{cd} \right] $$

• Weighted covariance between the $n$ income elasticities and the relative quantities consumed
INTERPRETATION

\[ y_{q}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) - \log Q^{cd} \right] \]

- When we move from d to c, the overall size of the basket changes by \( \log Q^{cd} \)
- When the composition moves in the direction of more luxuries, on average, then quality improves
- Same if we move away from necessities
- Revealed preference measure of quality
QUALITY AND AID MODEL

• Quality index

\[ y_{q}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) - \log Q^{cd} \right] \]

• AID Engel curves: \( w_{i} = \alpha_{i} + \beta_{i} \log M \)

• Quality consumption in “c”, compared to “d”, is:

\[ y_{q}^{cd} = \sum_{i=1}^{n} \beta_{i} \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) \]

• A fixed weighted sum in AID case

• Recall \( \beta_{i} > 0(\leq 0) \) means i is a luxury (necessity)
ADVANTAGES

\[ y_{qd}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{q_{i}^{c}}{q_{i}^{d}} \right) - \log Q^{cd} \right] \]

1. Objective as compared to hedonic methods (or, perhaps, less subjective)
2. Applicable to all types of goods and services, not just those with clearly identifiable physical characteristics
3. Comparable across goods. Use for the whole budget
DISADVANTAGES

\[ y_q^{cd} = \sum_{i=1}^{n} w_i^{cd} (\eta_i^{cd} - 1) \left[ \log \left( \frac{q_i^c}{q_i^d} \right) - \log Q^{cd} \right] \]

1. Need values of the income elasticities \( \eta_i \)
2. Some “high-quality” goods might come with some downside.
3. ???
## INCOME ELASTICITIES
(Selected food items)

<table>
<thead>
<tr>
<th>Food item</th>
<th>Conditional income elasticities</th>
<th>Rich countries</th>
<th>Poor countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs and egg-based products</td>
<td>0.02</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>0.18</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>Other cereals and flour</td>
<td>0.18</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>Beef and veal</td>
<td>0.18</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Fresh milk</td>
<td>0.21</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Fresh or frozen fish and seafood</td>
<td>0.45</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Beer</td>
<td>0.87</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>0.91</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Bread</td>
<td>0.99</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td>Fresh or chilled fruit</td>
<td>1.45</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>Jams, marmalades and honey</td>
<td>1.57</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Other bakery products</td>
<td>2.09</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>Cheese</td>
<td>2.12</td>
<td>1.63</td>
<td></td>
</tr>
<tr>
<td>SD over 31 food items</td>
<td>0.73</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

Rich = countries in first income quartile; poor = countries in fourth quartile (averages)
MULTILATERAL QUALITY INDEX

- Quality index is bilateral -- country c relative to country d
- Transform into a multilateral index by averaging over all countries $d = 1, \ldots, C$:

$$\text{Multilateral quality index for } c = \frac{1}{C} \sum_{d=1}^{C} y_{qd}^{cd}$$
FOOD QUALITY AND INCOME

\[ y = 12.06x + \text{constant} \]

\[ \text{(0.68)} \]
THE DUAL PRICE OF QUALITY

• Quality of spending
  \[ y_{pq}^{cd} = \text{weighted covariance of income elasticities and spending} \]

• Deflate spending to get back quality index: \[ y_{pq}^{cd} - y_{p}^{cd} = y_{q}^{cd}, \text{ where} \]

\[
y_{p}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{p_{i}^{c}}{p_{i}^{d}} \right) - \log P^{cd} \right]
\]

is the price of quality. Another weighted covariance
QUALITY AND INEQUALITY

- Index of the price of quality

\[ y_{p}^{cd} = \sum_{i=1}^{n} w_{i}^{cd} (\eta_{i}^{cd} - 1) \left[ \log \left( \frac{p_{i}^{c}}{p_{i}^{d}} \right) - \log P^{cd} \right] \]

- \( y_{p}^{cd} > 0 \) if, on average, relative prices of luxuries in c are higher than in d; and those of necessities lower

- As rich consume proportionately more luxuries and less necessities, \( y_{p}^{cd} > 0 \) means a pro-poor structure of prices in c as compared to d
PRICE OF QUALITY AND INCOME

\[ y = -0.92x + \text{constant} \]

(0.15)
FOOD PRICES \nREGRESSIVE

• More luxurious foods cheaper in richer countries; necessities more expensive

• Structure of food prices has \textit{regressive impact} on income distribution

• \textbf{Rule}: Don’t live in a rich country if you are poor; don’t live in a poor country if you are rich

• Significant but \textit{quite small}
REFERENCES

