



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

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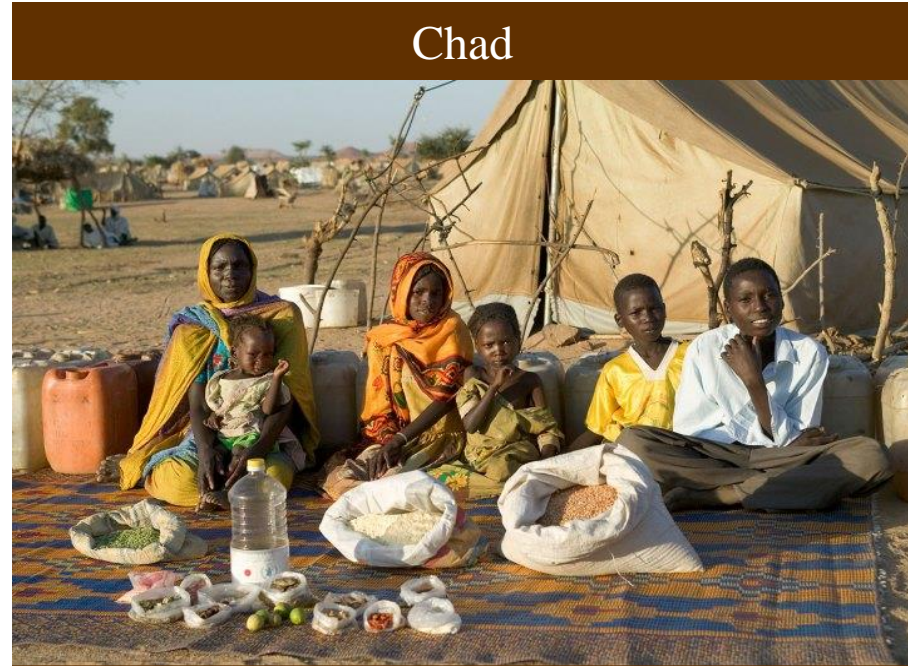
A WEEK'S FOOD

Norway



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

Chad



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

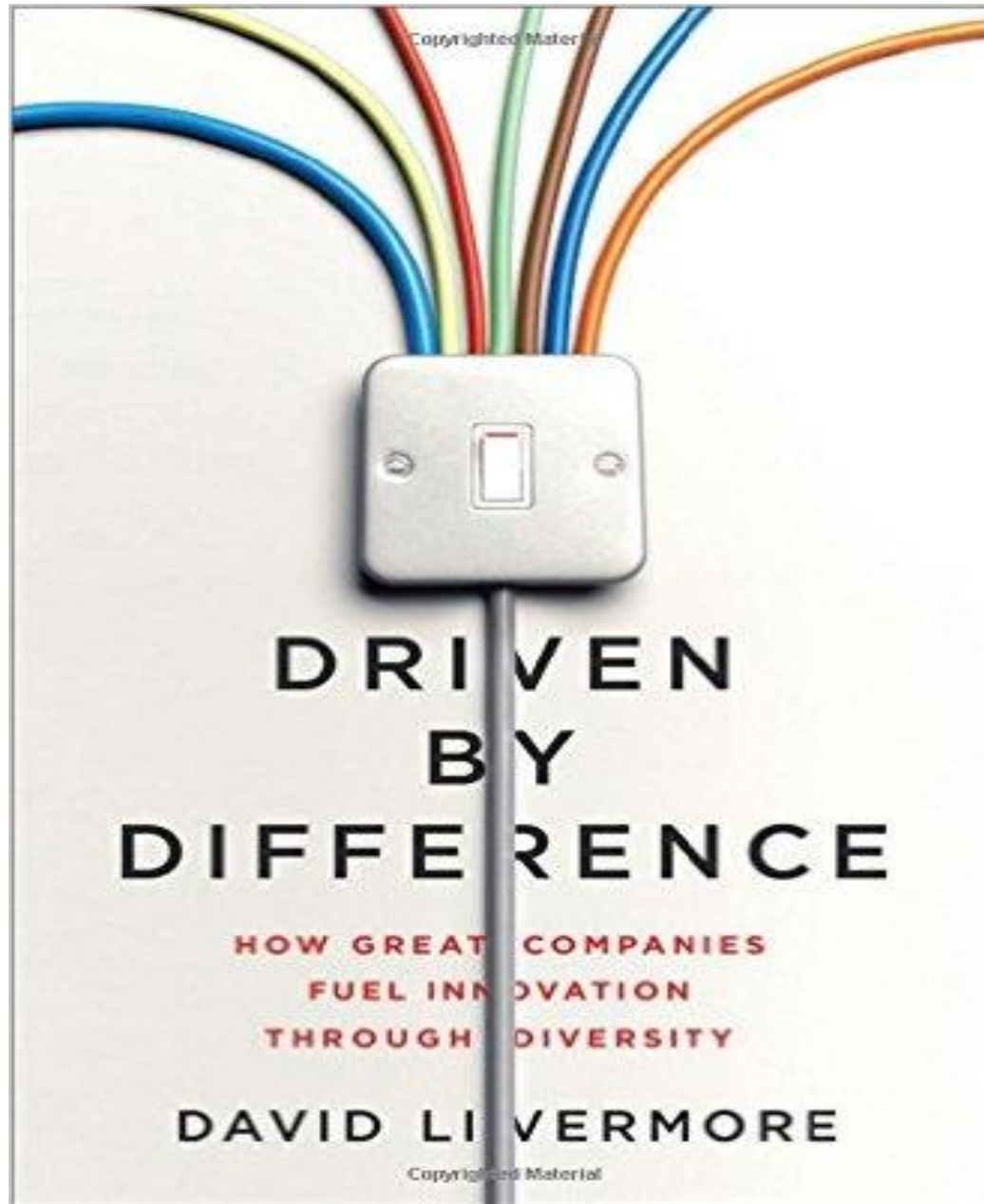
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BENEFITS OF DIVERSITY

- 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 (?)]*



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

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

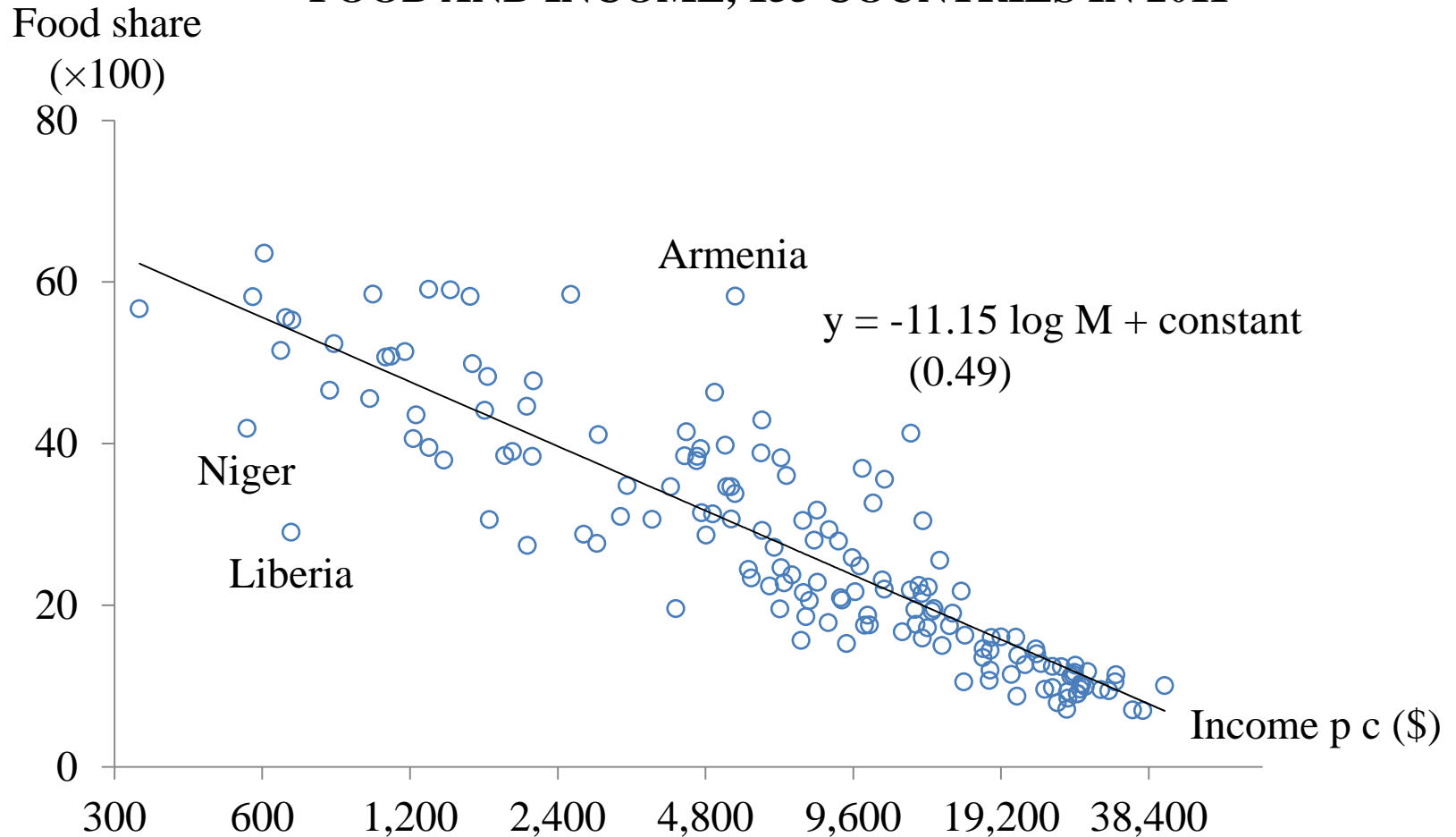
- Higher value of B means more diet diversity, with less dispersion among shares
- More even spread of expenditure means more diversity

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



THE LOG-LINEAR CASE

$$w_i = \alpha_i + \beta_i \log M, \quad i, \dots, n$$

- 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:

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

where P^* = price index

AID INCOME RESPONSE

- 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

	Pauper	Prince
Increase in income	1%	1%
Increase in porridge	2%	0.1%
Income elasticity $\eta_i = \frac{\% \Delta q_i}{\% \Delta \text{income}}$	$\frac{2}{1} = 2$	$\frac{0.1}{1} = 0.1$

- 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 $w_i > 0$

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

Berry = Θ , independent of income

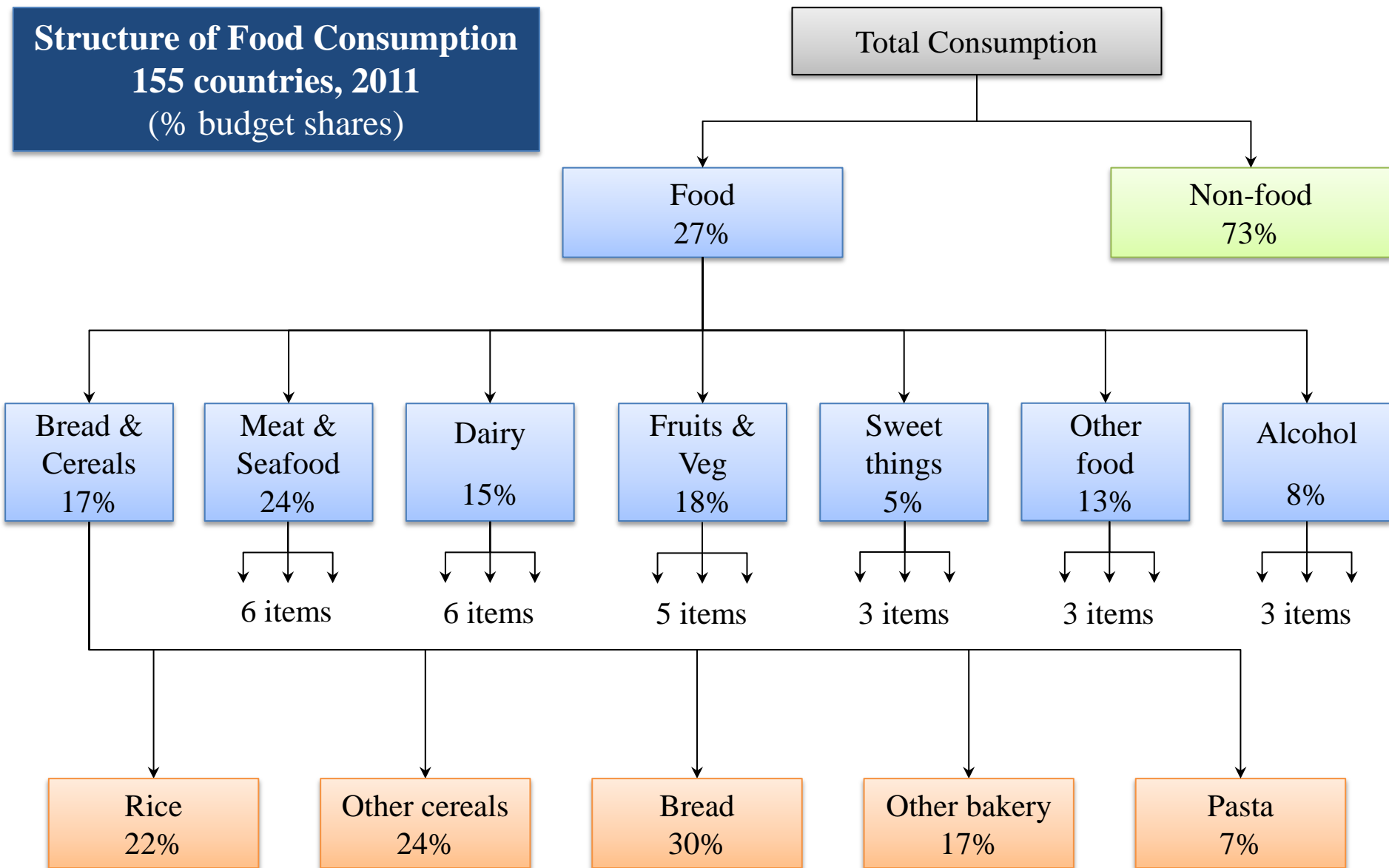
- More generally, diverse income elasticities drive diversity in consumption

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)



31 food items in total

STAPLES CONSUMPTION

Item	Conditional budget shares (%)		
	Rich countries	Poor countries	Difference
Rice and other cereals	23.4	77.1	-53.6
Bread etc.	76.6	22.9	53.6

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, \dots, w_n
- Weighted logarithmic variance:

$$\Pi_w = \sum_{i=1}^n w_i (\log w_i - \log \bar{w})^2,$$

where $\log \bar{w} = \sum_{i=1}^n w_i \log w_i$

- Π_w measures dispersion of shares:

$$\Pi_w = 0 \text{ if } w_i = \frac{1}{n}, i = 1, \dots, n$$

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

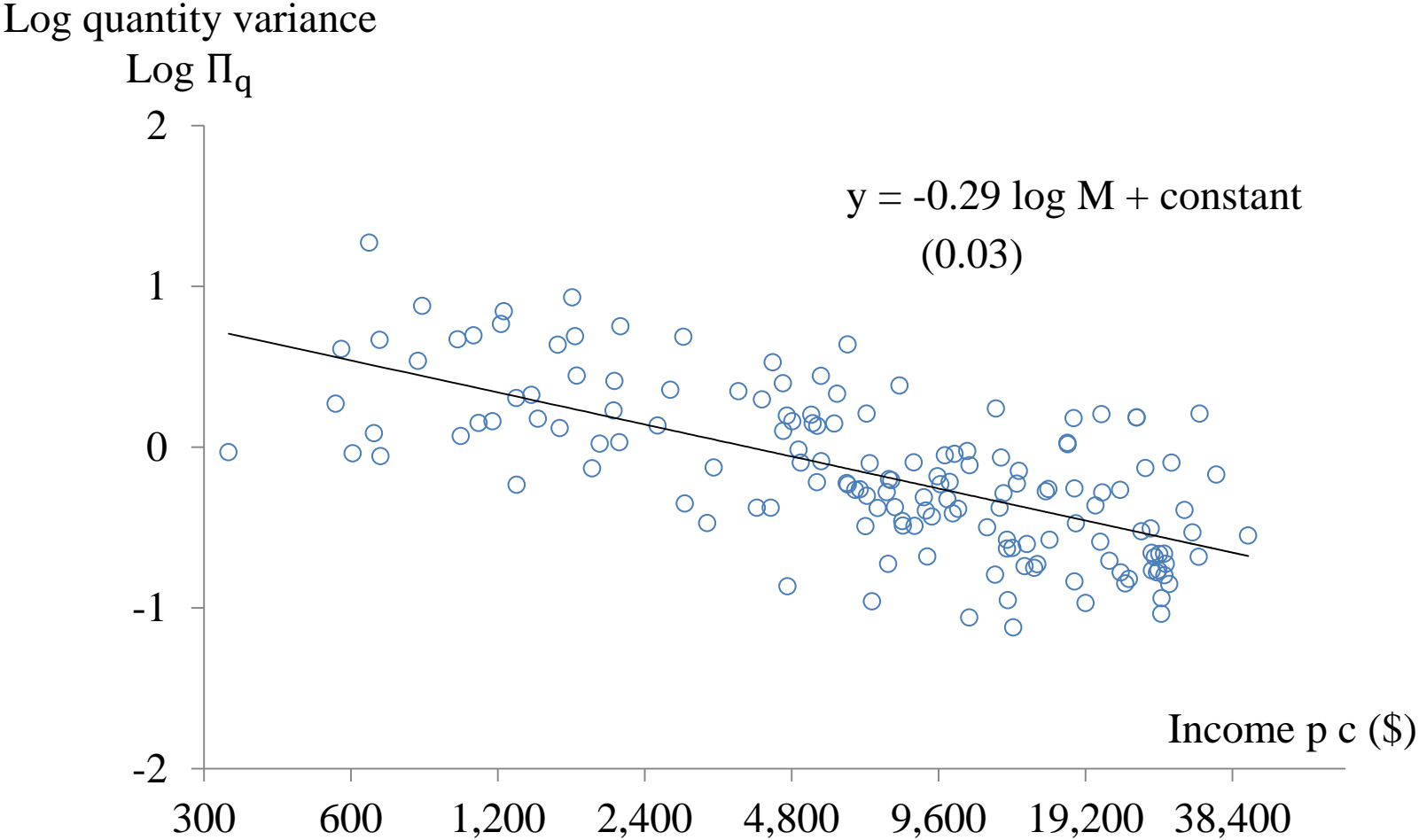
$$\boxed{\Pi_w = \Pi_p + \Pi_q + 2\Pi_{p,q}}$$

- The quantity variance

$$\Pi_q = \Pi_w - \Pi_p - 2\Pi_{p,q}$$

is the important component for nutrition

FOOD DIVERSITY AND INCOME



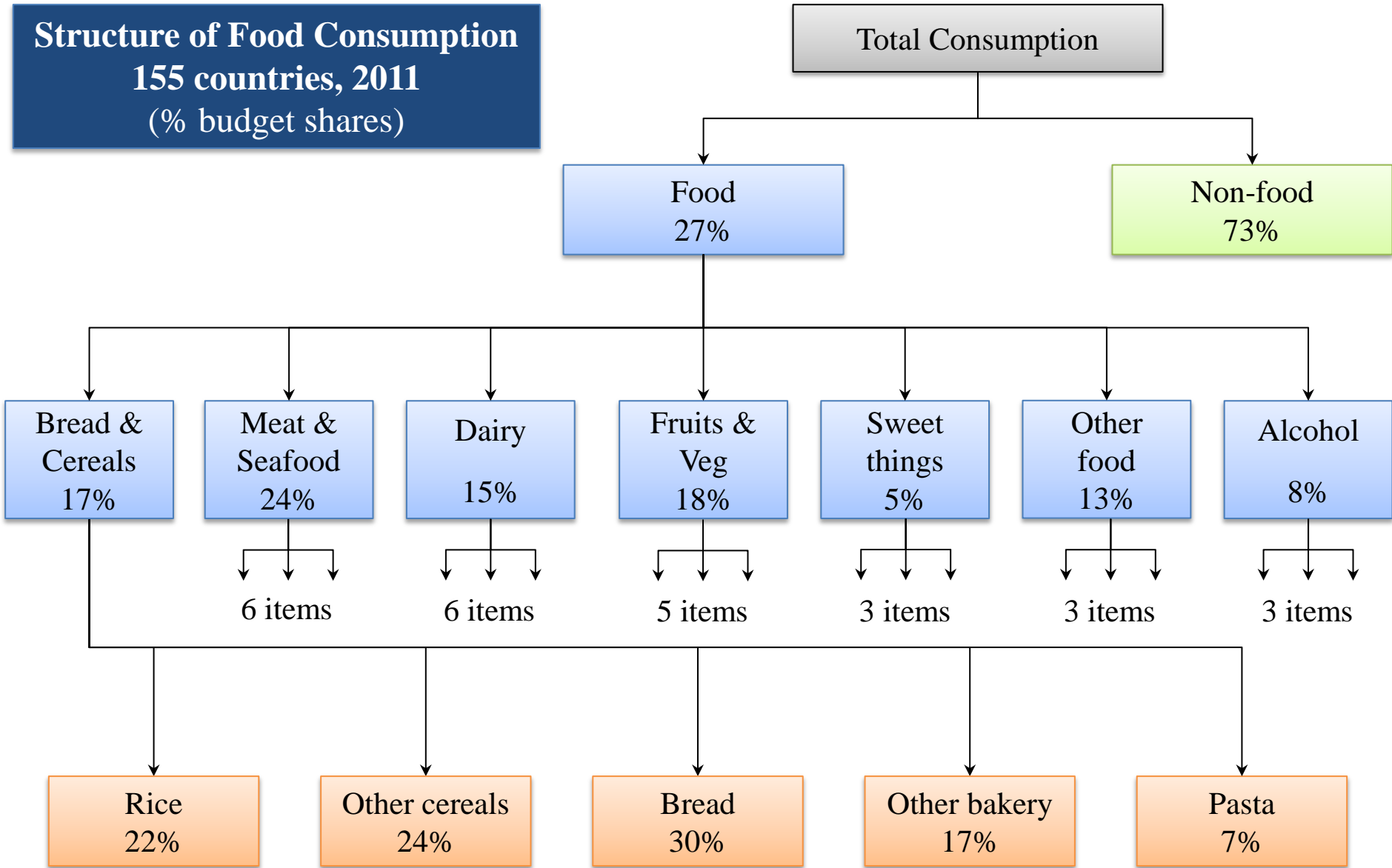
DECOMPOSING DIVERSITY

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

- Divide n goods into G groups, $\mathbf{S}_1, \dots, \mathbf{S}_G$
- Between-group variance: $\sum_{g=1}^G W_g (\log Q_g - \log Q)^2$
- Within: $\sum_{g=1}^G W_g \left[\sum_{i \in \mathbf{S}_g} \left(\frac{w_i}{W_g} \right) (\log q_i - \log Q_g)^2 \right]$
- Then,

Total variance, $\Pi_q = \text{between} + \text{within}$

Structure of Food Consumption
155 countries, 2011
 (% budget shares)



31 food items in total

INEQUALITY OF DIET DIVERSITY

Source of variance	Ratio of diet diversity of rich to poor Π_q^P / Π_q^R
Total budget	2.3
Between group	3.4

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



vs.



Fillet Steak

Rump Steak

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

Fillet steak twice as expensive as rump

THE MYSTERY OF QUALITY

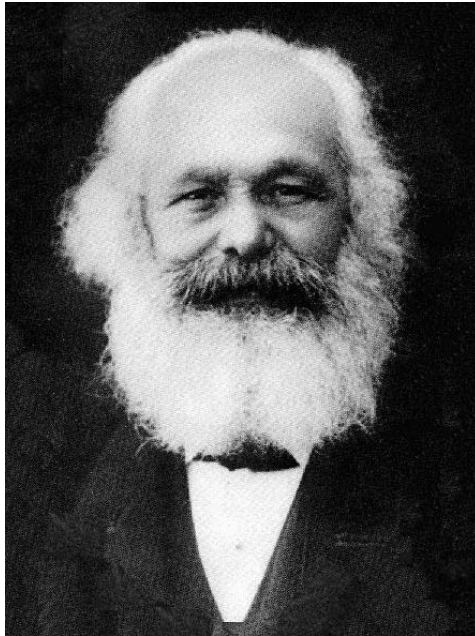
- What exactly is “quality”?
- Fillet versus rump steak
- Business class versus economy
- Restaurant meals vs medical services
- Whole consumption basket – how to measure quality?
- Subjectivity

Quality is difficult in principle and practice

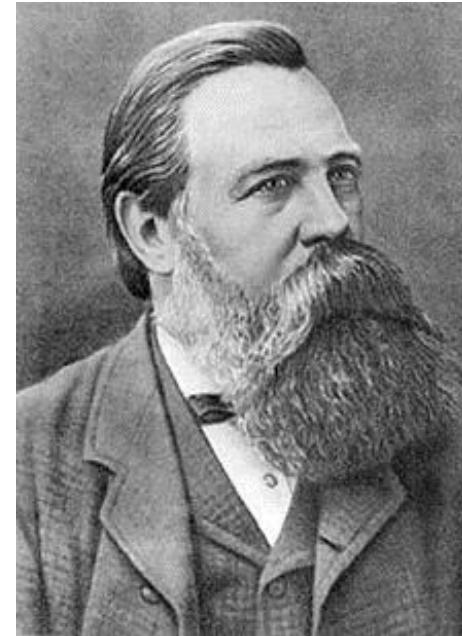
WHO SAID THIS?

- “[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...

...THEY HAVE HIGH STANDARDS

...It's a necessity.

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
 - Processed
 - Packaged
 - Colourful
 - Tasty?
 - Healthy?

TWO MORE COUNTRIES

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

Country	Quantities	Relative consumption	Budget shares
c	q_1^c, \dots, q_n^c	$\log \frac{q_1^c}{q_1^d}, \dots, \log \frac{q_n^c}{q_n^d}$	w_1^c, \dots, w_n^c
d	q_1^d, \dots, q_n^d		w_1^d, \dots, w_n^d

- 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

$$\boxed{\eta_i^{cd} > 1}, \text{ where } \eta_i^{cd} = \frac{w_i^c}{w_i^c + w_i^d} \cdot \eta_i^c + \frac{w_i^d}{w_i^c + w_i^d} \cdot \eta_i^d$$

and

- ii. Relative consumption of i exceeds relative income,

$$\boxed{\log \left(\frac{q_i^c}{q_i^d} \right) > \log Q^{cd}},$$

where $\log Q^{cd}$ 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

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

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

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

- 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 $\beta_i > 0 (< 0)$ means i is a luxury (necessity)

ADVANTAGES

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

1. 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 η_i
2. Some “high-quality” goods might come with some downside.
3. ???

INCOME ELASTICITIES

(Selected food items)

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

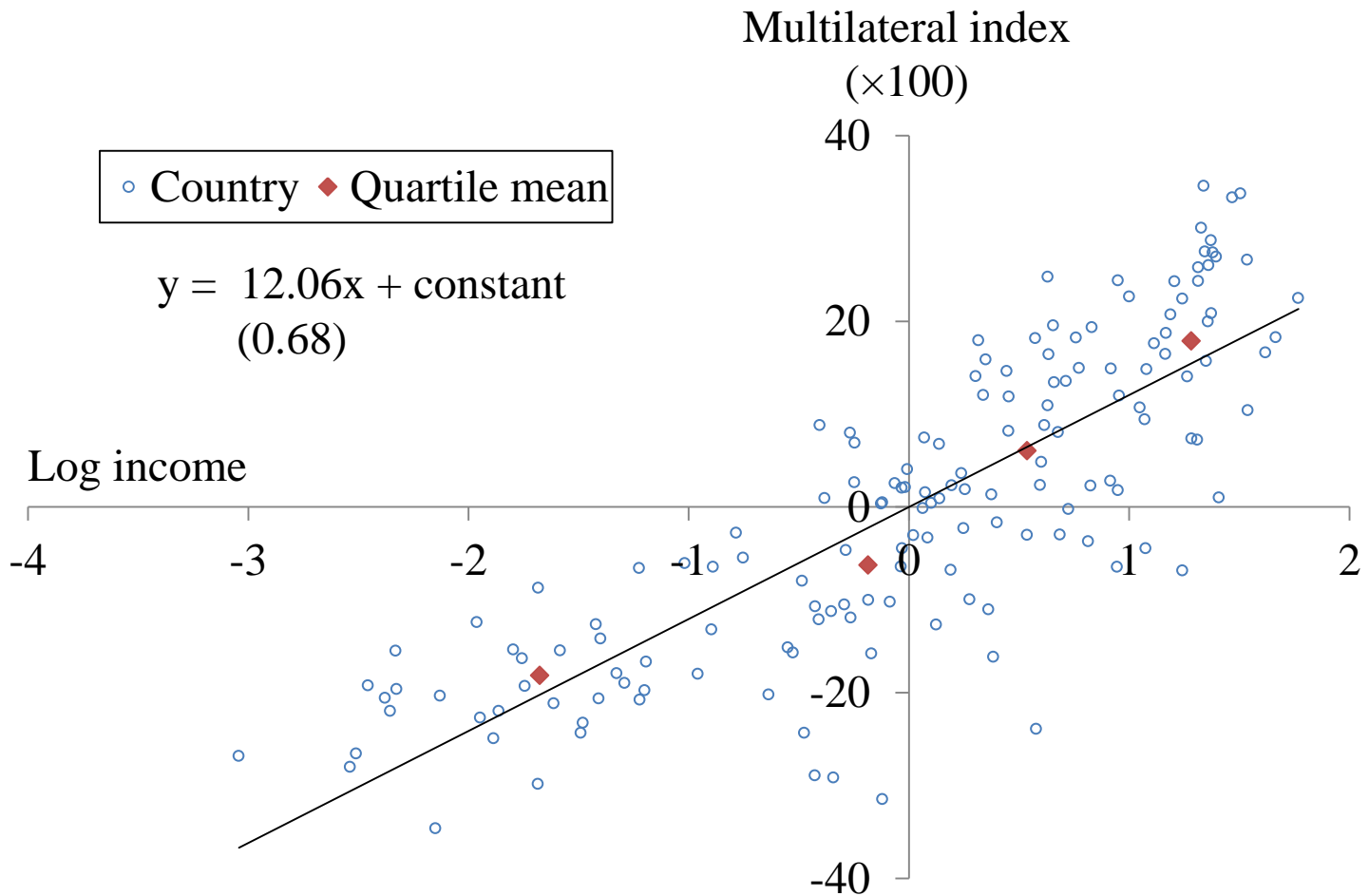
Rich = countries in first income quartile; poor = countries in fourth quartile (averages)

MULTILATERAL QUALITY INDEX

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

$$\text{Multilateral quality index for } c = \frac{1}{C} \sum_{d=1}^C y_q^{cd}$$

FOOD QUALITY AND INCOME



THE DUAL PRICE OF QUALITY

- Quality of spending

y_{pq}^{cd} = weighted covariance of income elasticities and spending

- Deflate spending to get back quality index: $y_p^{cd} = y_q^{cd}$, 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

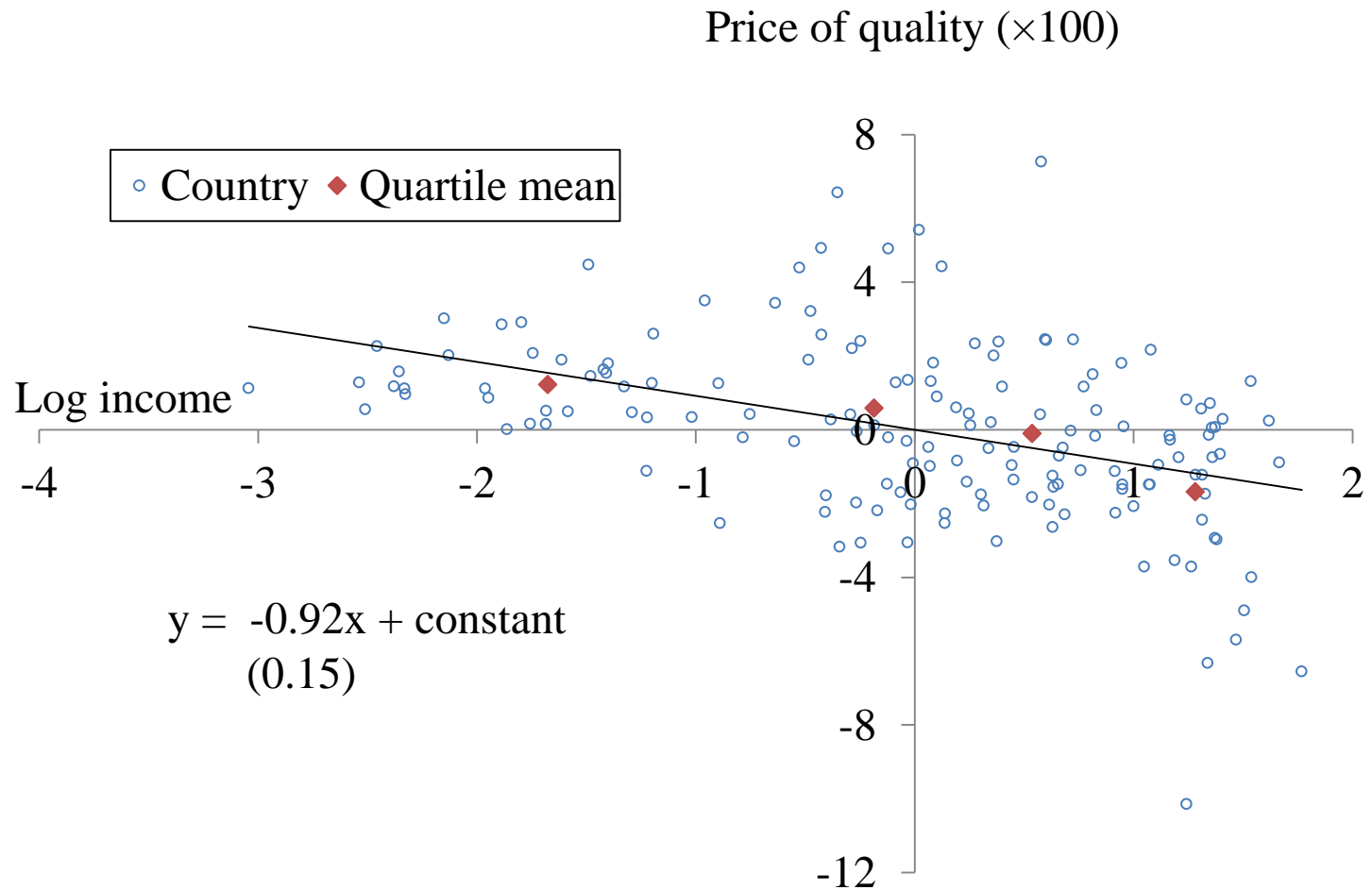
QUALITY AND INEQUALITY

- 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



FOOD PRICES REGRESSIVE

- More luxurious foods cheaper in richer countries; necessities more expensive
- Structure of food prices has regressive impact on income distribution
- 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 quite small

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