Item #18

Draft seminar slides on sugar taxes

Draft seminar slides prepared by Professor John Gibson for his Motu Public Policy Seminar, 30 November 2016

Motu PPS
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Quality, Quantity, and Price:
Implications for Taxing Unhealthy Items
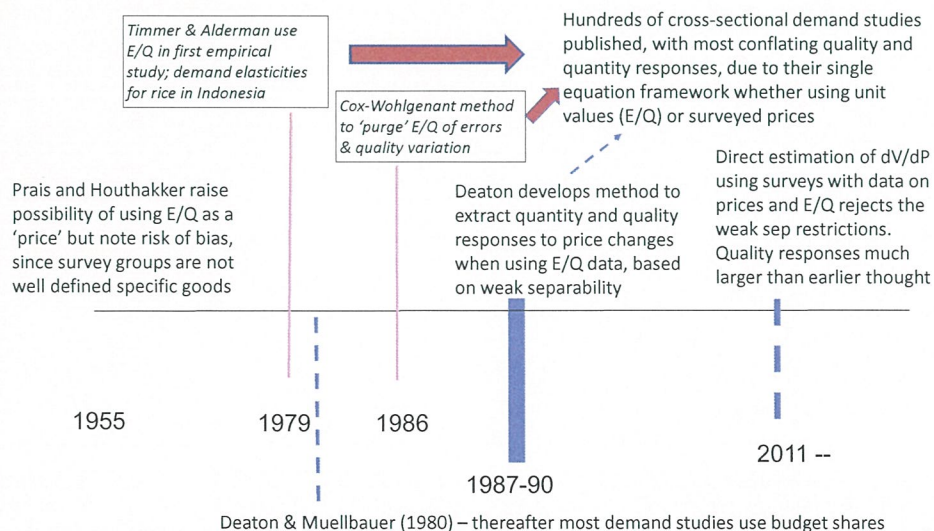
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Introduction

- Taxes on unhealthy items like sugar-sweetened beverages (SSBs) are increasingly advocated
    - Recently imposed in Mexico, France, UK, Romania, Barbados and 30 US states and some cities (SFO, Oakland, Boulder...)
- New Zealand Medical Association (2014)
    - "taxation on unhealthy foods is the single most cost-effective approach to tackling obesity"
- Several economic-epidemiological studies appear to support this development
    - Household-survey based demand estimates to get disaggregated price elasticities are at the heart of these studies

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elasticity estimates from HH survey data have a big (and largely ignored) problem

- Most demand modelling on household survey data uses budget share data
  - Budget shares vary with quality, quantity and price
- to derive quantity responses from observed budget shares as prices change, we also need to model quality choice
- Most studies in the literature ignore this and implicitly assume that there is zero scope for quality response
  - in countries studied thus far, much of the response to price changes is quality adjustment rather than quantity response

→ Efficacy of taxing unhealthy items will be greatly overstated by the elasticities in the existing literature

Timeline for understanding demand elasticities from household surveys

Timmer & Alderman use E/Q in first empirical study; demand elasticities for rice in Indonesia

Cox-Wohlgenant method to 'purge' E/Q of errors & quality variation

Hundreds of cross-sectional demand studies published, with most conflating quality and quantity responses, due to their single equation framework whether using unit values (E/Q) or surveyed prices

Prais and Houthakker raise possibility of using E/Q as a 'price' but note risk of bias, since survey groups are not well defined specific goods

Deaton develops method to extract quantity and quality responses to price changes when using E/Q data, based on weak separability

Direct estimation of dV/dP using surveys with data on prices and E/Q rejects the weak sep restrictions. Quality responses much larger than earlier thought

1955   1979   1986

1987-90

2011 --

Deaton & Muellbauer (1980) – thereafter most demand studies use budget shares

The Prais-Houthakker Insight

- Household surveys do not provide data on the expenditures on, and quantity consumed of, specific goods -- contrary to the textbook demand model

  "An item of expenditure in a family-budget schedule is to be regarded as the sum of a number of varieties of the commodity <u>each of different quality</u> and sold at a different price." (P&H, 1955, p.110)

- Since there are many different varieties, brands, package sizes etc within a commodity group the consumer faces two choices:
  - What quantity to buy and consume
  - What quality (as shown by the price per unit) to buy and consume
- Demand estimates that do not allow for both of these choices will conflate quality responses to price changes with quantity responses

Quality Responses to Price Probably Outweigh Quantity Responses

- Quality is income elastic
  - We are far richer than our ancestors yet food quantity consumed is little changed (a bit higher relative to the lower activity-based requirements)
  - Adjustment has mostly been on the quality margin
  - Debate in development economics in 1980s on income effects on nutrition was due to this within-group quality upgrading as people got richer
- within-group quality variation gives easier substitutions in response to income or price differences than the more difficult between group substitutions
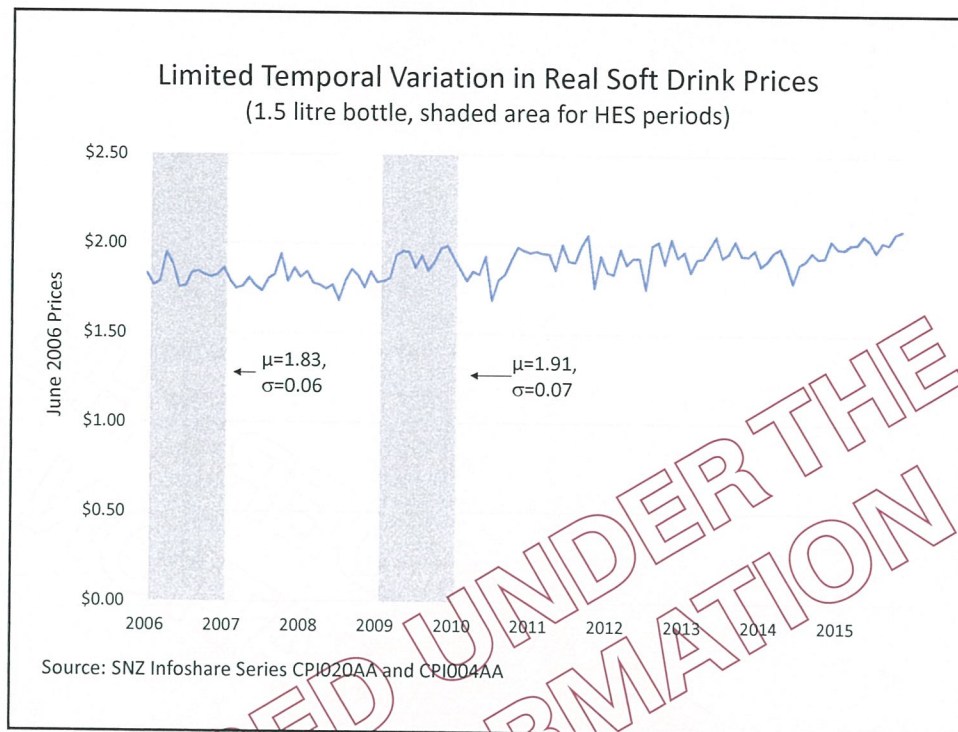 - Yet almost entirely ignored in empirical studies

A Local SSB Example

- Much recent publicity in NZ about advocacy for a SSB tax and claims about predicted effects on health
- Carbonated soft drinks are one of the 24 food and beverage groups used in the PLoS study by researchers at WSM, NZIER and Otago economics
  - Yet there is a big quality variation within this seemingly narrow group that is not controlled for in their analyses
  - This oversight is typical of the literature
  - Estimates of likely bias are from poorer countries, but both quality and demand for variety are income elastic, so ignoring quality is likely to be even bigger sources of bias in rich countries

The easiest, and probably largest, response is not controlled for

- sugar-sweetened beverages (SSBs) have limited price variation over time and space
  - Within-year variation during Household Economic Survey (HES) periods of $\sigma=0.06$ to 0.07 (20 cents up and down would cover 99.7% of the price range)
  - Between HES periods (3 years apart) average real prices changed by about 4%
  - Across regions and within year $\sigma=0.12$ so 36 cents up or down would cover 99.7% of range; high/low ratio of $\approx1.4:1$
- But huge price variation within group (and within the same store) of $\approx8:1$ magnitude is not controlled for

Limited Temporal Variation in Real Soft Drink Prices
(1.5 litre bottle, shaded area for HES periods)

$\mu=1.83, \sigma=0.06$

$\mu=1.91, \sigma=0.07$

Source: SNZ Infoshare Series CPI020AA and CPI004AA

Within-group variation

- Inside any store in NZ a far wider range of prices <u>within</u> the fizzy drink group than over time or between regions → offering great scope for quality substitution
- e.g New World Hillcrest (Hamilton) in mid-June, 2016
- Highest price: $5.83 per litre
  - (4 pack, *Coke* zero 330ml)
- Lowest price: $0.77/ per litre
  - (1.5 litre *Pams*)
- Standard dev of $1.10 across the 40 varieties in store

→ almost 10x as much within group-variability as cross-area variability ($\sigma=0.12$ at the time of the HES) yet most analyses ignore the within-group variability (and quality choice)

Huge within-group (quality) variation in prices, even within the same store

$ per litre

$5.83
$4.33
$2.81
$1.81
$0.77

← Higher Quality   Lower Quality →

Not much better for studies where spatial price variation is greater

- Middle income countries like Mexico have SSB prices in dearest cities that are at most 60% above the cheapest
  - Based on price surveys in 30 cities (www.profeco.gob.mx)
  - The peso/litre tax from 1/14 added some temporal variation but also altered relative prices

- Low income countries like Vietnam, PNG and Solomon Islands, dearest-to-cheapest areas for SSBs of ≈2:1
  - Thus even in these more favourable settings for spatial price variation, up to 5x as much within-group variation ignored
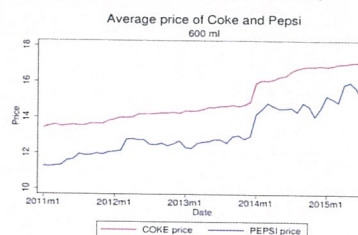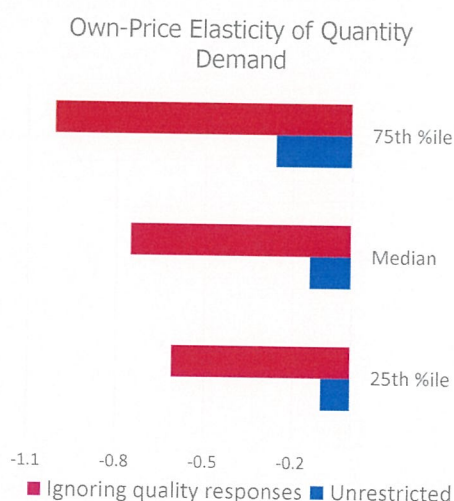
Ideal approach to get unbiased quantity responses to price changes

- Since within-group quality substitution and between group quantity substitution are both valid consumer responses, we need an equation for each choice
- A valid proxy for consumer quality choice is the unit value (group expenditure over group price)
  - Shows where on the within-group quality gradient the consumer locates (and the price level they face)
- Quantity responses to price changes can then be derived from the budget share equation
  → Need budget shares, unit values, and market prices

Results for 45 food and drink items from Vietnam surveys with the required data

Own-Price Elasticity of Quantity Demand

75th %ile

Median

25th %ile

-1.1   -0.8   -0.5   -0.2

■ Ignoring quality responses ■ Unrestricted

Quantity demand seems much more price elastic if within-group quality response wrongly treated as a quantity response

If no restriction placed on within-group quality response, own-price elasticity of quantity demand for median item is just -0.14 (c.f. -0.75)

Few estimates use the correct 2-equation approach to quantity and quality

- Most household surveys lack matched price surveys that are spatially and commodity-wise disaggregated
- Even if survey data are matched to an external price survey (e.g. for CPI) most analyses wrongly use a single-equation framework that ignores quality responses
  - Bias from single equation framework is irrespective of whether prices are measured using price surveys or using unit values
- Published evidence for correct 2-equation models is just from Indonesia (McKelvey, 2011) and Vietnam (Gibson/Kim, 2013)
  - Both studies show that the "standard price method" that ignores within-group quality substitution leads to greatly exaggerated estimates of how quantity demand responds to own-price

Formal structure: Budget Share (w_{Gi}) and Unit Value (v_{Gi} to proxy quality) equations

$$w_{Gi} = \alpha_G^0 + \beta_G^0 \ln x_i + \sum_{H=1}^{N} \theta_{GH} \ln p_H + \gamma_G^0 z_i + u_{Gi}^0$$

$$\ln v_{Gi} = \alpha_G^1 + \beta_G^1 \ln x_i + \sum_{H=1}^{N} \psi_{GH} \ln p_H + \gamma_G^1 z_i + u_{Gi}^1$$

$i = household$, $G, H = goods$

If wrongly ignore quality effects, only 1st equation is used, with price elasticity formula: $\varepsilon_{GH} = (\theta_{GH} / w_G) - \delta_{GH}$,

$\delta_{GH} = 1 \, for \, own-price, \; 0 \, otherwise$

This implicitly assumes that all adjustment is on the quantity margin and none is on the quality margin

Correct, unrestricted, quantity elasticity
formula (2 equation system)

$$\partial \ln w_G / \partial \ln p_H = \theta_{GH}/w_G = \boxed{\varepsilon_{GH} + \psi_{GH}}$$

$$\varepsilon_{GH} = (\theta_{GH}/w_G) - \psi_{GH}.$$

combined effect of responses
to price change on the quality
and quantity margins is often
wrongly interpreted as the
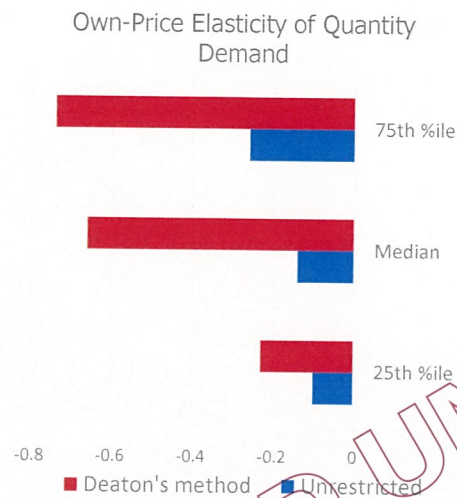elasticity of quantity w.r.t price

Need estimates of ψ_{GH} so as to isolate the quantity response

Less Ideal Methods

- Angus Deaton developed a way to estimate ψ_{GH} if one just had unit values (expenditures over quantities) from a household survey but not prices
  - the usual situation in poor countries, while opposite holds in rich countries where price surveys are available but indicators of quality are not available from the household surveys
  - Deaton's method relies on restricting the rate of quality response to price changes to what it would be if it operated like an income effect
  - Armed with this imputed rate of quality substitution, the quantity demand elasticity can be isolated
- Unfortunately, the restrictions do not seem to hold

Deaton's method thus leads to greatly exaggerated quantity demand elasticities

Own-Price Elasticity of Quantity Demand

75th %ile

Median

25th %ile

-0.8   -0.6   -0.4   -0.2   0

■ Deaton's method   ■ Unrestricted

Quantity demand seems much more price elastic if the quality separability restrictions of Deaton are used (median item has an elasticity of -0.66 rather than -0.14 if unrestricted)

Reason is that Deaton's restrictions cause the rate of quality response to price to be understated

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Four cuts at the literature to see how often quality responses are ignored

1. Own-price elasticity estimates for Mexico
   - Those used by Grogger (2016) to predict steady-state weight loss of 2-4 lb for Mexicans from the tax-induced price increase for soda
2. Systematic review of papers since 2012
3. Studies citing Cox and Wohlgenant (1986)
   - Not just restricted to SSBs but most users think that 'quality-adjusted prices' solve the issue
4. US SSB studies in Lisa Powell review

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Mexican SSB demand studies Grogger uses to go from prices to pounds

- Three existing studies with own-price elasticities for soda between -1 and -1.3
- None provide plausible estimates of quality response
  - Castro-Carrillo (2014) regress quantity on unit values for soda, water and juice (ignoring correlated error problem of quantity on LHS & RHS inducing spurious negative relationship) using ENIGH 2008, 2010, 2012
    - Pooling across bottle/can sizes, own-price elasticity ≈ -1.2; for 3 sub-samples based on size (330-600ml, 600ml-1.5l, >1.5l) much less elastic ≈ -0.2
  - Barquera et al (2008) regress quantity on unit values for soda, sweet drinks, milk, juice, bottled water using ENIGH 1989, 1998, 2006
    - own-price elasticity for soda of -0.6 in 1989, -0.8 in 1998, -1.1 in 2006
  - Valero (2006) - Deaton approach with 1992 and 2002 ENIGH budget shares and unit values, where one group has soda, natural juice, flavoured water
   - Approach understates quality substitution, and results had perverse response

Systemic Review of 2012-16 papers

- 2 sets of keywords in EconLit and MEDLINE
  - Soda, soft drinks, sugar sweetened beverages, beverage, beverages, fast food
  - Price elasticity, demand elasticity, tax, taxation, price, prices
- After filtering get 62 papers in English with "SSB tax" and "price elasticity"
- 18/62 are review studies
  - High rate of reviewing/re-reviewing studies
- Of the 44 original empirical papers, 31 are based on household survey data and only 5 of these have plausible ways to deal with quality substitution

Review of studies citing Cox and Wohlgenant (*AJAE,* 1986)

- Increasingly popular method that misses the point

Citations to Cox and Wohlgenant (1986)
(3 year moving average)
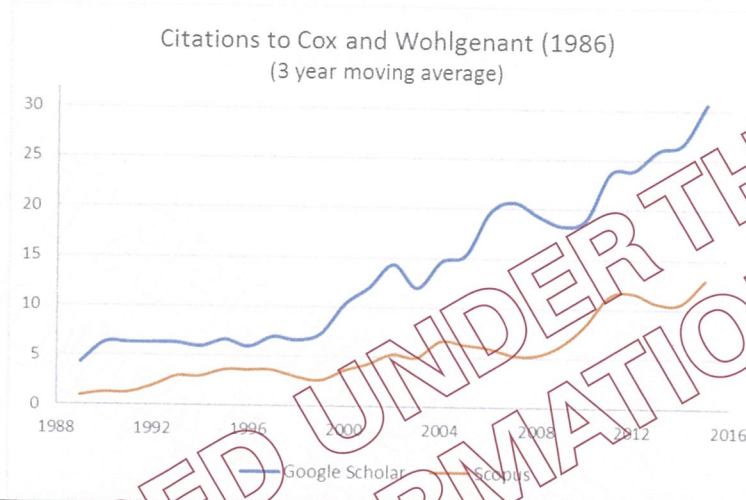
Cox and Wohlgenant Approach (1)

- Based on unit values (group expenditures over group quantity)
- Recognizes that these are not prices, so regress the unit values on household characteristics and temporal/regional dummies
  - Adjusted unit values should be purged of household level variation (so-called 'quality-adjusted prices') and are argued to reflect time/space price variation
- But there are two problems...
  - Even if had actual prices, there is bias if ignore quality response
  - Identifying assumption that quality is pre-chosen is strange

Cox and Wohlgenant Approach (2)

Identifying assumption

- consumers choose quantity (if any) of a commodity aggregate (such as a survey food group) whose quality is already set by prior decisions about the component foods within the group
  - E.g. prior decision to only buy dear *Coke* in small bottles and if get surprised by the price level, cut back quantity but don't slide down the quality scale
  - Far more plausible that quantity is predetermined and quality is adjusted in response to income/price shocks
- Amongst ≈150 articles (in SCOPUS) citing Cox/Wohlgenant, almost none have plausible treatment for quality responses

Cox and Wohlgenant Approach (3)

exaggerates quantity responses to price

- Benchmark against the unrestricted estimates from Vietnam that allow consumers to respond on both the quality and quantity margins
- so-called own-price elasticities of quantity demand from the Cox and Wohlgenant approach are at least twice as large, for major food groups like rice, pork, and beef
  - Unrestricted responses on the quality margin exceed those on the quantity margin ➔ wrong to use an approach that treats the quality substitution as a nuisance to deal with prior to the main analysis

Powell et al (2013) *Obesity Reviews*

- Survey 14 US studies of SSB demand, 10 with own-price elasticity estimates
  - mean own-price elasticity for SSBs of -1.21
    - This estimate used by UConn Rudd Center for Food Policy and Obesity for SSB tax revenue calculator
  - the studies surveyed mostly use HomeScan barcoded data
    - With this level of product specificity within-group quality adjustment should not matter
- But there is another bias...

Powell et al (continued)

- Average over conditional and unconditional estimates of own-price elasticities
  - Conditional elasticities are from multi-stage budgeting
    - Allocate budget to food versus non-food
      - Allocate food to cereals, meats, veges, beverages etc
      - Then elasticities within each of these groups
  - Within group elasticity is much larger because it is for close substitutes and holds constant the spending on the group ≠ unconditional elasticity
  - E.g. Brown (2008) is for 12 types of non-alcoholic bev with own-price elasticities for SSBs from -1.5 to -2.0

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Other sources of overstatement

- Failure to account for storability
  - SSBs are storable for several months so purchase in the survey period need not be for consumption then
    - Wang et al find 65% stockpile SSBs during sales, *storers* are less price sensitive, and are more prevalent in obese areas
- Wrongful use of censored demand models
  - Focus is changes in population average sugar intake irrespective of whether on intensive or extensive margins → unconditional expected value we need
  - Censored demand (or Tobit) doesn't give this and has to be adjusted down by % of non-limit observations

Some sociological observations

- Important disciplinary differences between economics, agricultural/applied economics, and public health
  - Uneven standards of evidence within and between journals in these disciplines
  - Different approaches to summarizing the state of knowledge
  - Different approaches to the research/policy nexus
- may contribute to a misreading of the evidence and unwarranted expectations about what taxes on unhealthy items may achieve

Economists...

- ## Don't publish much
  - 60% of PhDs from the top 10 US departments had published less than the equivalent of one paper in a second-tier field journal, by six years after graduation (Conley and Önder, *JEconPersp*, 2014)
- ## Are surprisingly hierarchical
  - Focus on the 'top-5' in job market and (U.S.) publication strategies
- ## Use rejection after publication
  - Oxley et al report that an average of 26% of articles in 40 top econ journals are never cited
- ## Don't find demand elasticities very interesting
  - Demand elasticities are 'old hat' to economists, since undergrad and grad training use these as examples, so rare to find applied demand studies in top journals

Agricultural (applied) economists...

- ## Research returns are a counting exercise
  - Gibson et al compare salary structure and research output of matched Econ and Ag Econ departments in the U.S.
  - Ag Econ pay rises with article counts not with quality-weighted journal output while article counts have no effect for Econ
  - One-third of the Ag Econ people have Econ PhDs so this is institutional pay differences, not selection/human capital
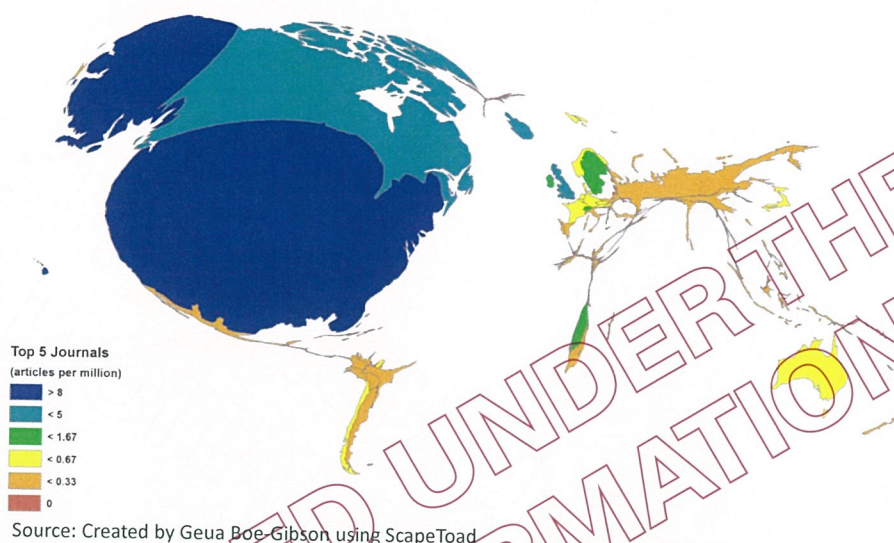- ## Incentivized into low impact publishing
  - Ag Econ also much lower payoff to total citations or h-index
- ## More likely to publish applied demand studies
  - Produce results for all sorts of minor countries with limited general interest that would be largely ignored by economists

The World as Seen From the Top 5 Economics Journals

Top 5 Journals
(articles per million)
- > 8
- < 5
- < 1.67
- < 0.67
- < 0.33
- 0

Source: Created by Geua Boe-Gibson using ScapeToad

Public health researchers seem to...

- **Treat published results as equally valid**
  - Attitude seems to be that if a study is in a peer-reviewed journal it is worthy of being covered by a systematic review
  - Many of these estimates are in journals (perhaps even in economics journals) that many economists would ignore
- **Are interested in evidence from everywhere**
  - the geographic bias in economics does not seem to be matched by public health researchers, who seem interested in results from all sorts of minor/obscure places that would fail the 'external validity' standard in economics
- **Continuously/systematically review the evidence**
  - Papers with unreliable results that would sink without trace in economics may have an on-going life in influencing policy because public health researchers hoover up estimates from everywhere

One example

- Paraje (2016 *PLoS one*) reports price elasticities for SSBs in Ecuador, using the 2011/12 HIES
  - Promisingly, starts out with Deaton's 2-equation system with cluster dummy variables in place of unavailable prices
    - Even though results from VN, Indonesia and PNG show that the Deaton restrictions to derive Ψ_{GH} don't hold, it at least it shows an awareness of the within-group quality substitution issue
  - Yet elasticity formula used ignores the Ψ_{GH} and is correct only for a homogenous good with no quality variation
  $$\varepsilon_{GH} = \left(\theta_{GH} / w_G \right) - \delta_{GH},$$
    - As if cut and paste from incompatible frameworks→ incoherent
  - Yet headline result, own-price elasticity of quantity demand for SSBs of -1.2 has been captured in a systematic review of SSB taxes to reduce obesity in middle-income countries

Some possible solutions

- Neglect of within-group quality substitution in demand analyses has two sources
  - Incorrect estimation framework
    - Point out why this error matters, how widespread it is and hope people listen
  - Lack of data on prices and quality
    - In poor countries typically due to a lack of spatially disaggregated price surveys that can link to a household survey, since E/Q from the survey is a proxy for quality
      - Use alternative ways to gather the needed prices
      - Opinions about prices from key informants in Vietnam (based on triangular distribution questions on low, high, typical local prices)
      - Crowd-sourcing prices using smart phone technology in Indonesia

Alternative approaches

- Brand level effects
  - If quality is only due to brand, rather than to package size, and survey data include brand details, can use brand fixed effects as a proxy for quality
    - We have a cigarette demand study for Indonesia using this approach (for 17 brands of cigarette)
    - Simulated effect of 10% increase in the excise tax
    - Predicted fall in quantity consumed overstated by 56% when the quality information ignored
  - Scanner data also allow this sort of quality control
    - e.g. study with such data, using diff-in-diff from two episodes of SSB tax increases in US finds no decrease in volume of soft drinks consumption in treated areas

Conclusions

- Many price elasticity of demand estimates conflate quality responses and quantity responses
- Method to untangle these proposed by Deaton in 1980s
  - separability assumptions needed by Deaton's method do not seem to hold in practice and understate the quality responses
- <u>Both</u> prices and unit values are needed to get unbiased quantity elasticities from budget share equations
  - Part of the budget share response to a price change involves consumers changing their quality choice, so an index of quality like a unit value is needed to account for this response
- food and drink quantity demand is likely to be much less price-responsive than is suggested by many studies relied upon by advocates for SSB and other health-related taxes

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