Prices versus Preferences: Taste Change and Tobacco Consumption

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- The relative efficacy of the different modes is important for designing health policies.
- Address a specific question: How much of the fall in tobacco consumption in the UK is due to a rise in the relative price of tobacco and how much can be attributed to taste changes?
- Aim to inform policy on the balance between information/health campaigns and tax reform.
- We also consider how tastes evolve across different education strata. Do tastes change differentially across education groups?

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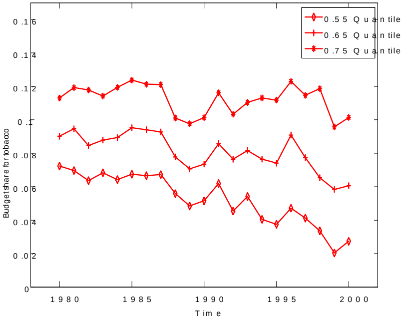
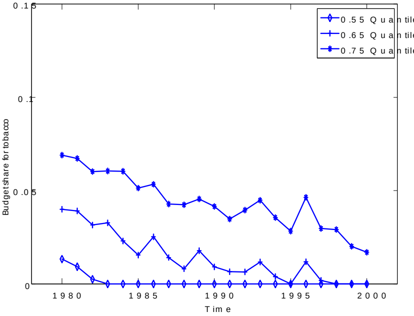
- Use conditional demands to allow for non-separability with alcohol consumption.

Taste changes and prices

UK Budget shares for Tobacco: Quantiles



(a) Low Education



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Taste changes and prices

UK relative price of tobacco, 1980-2000

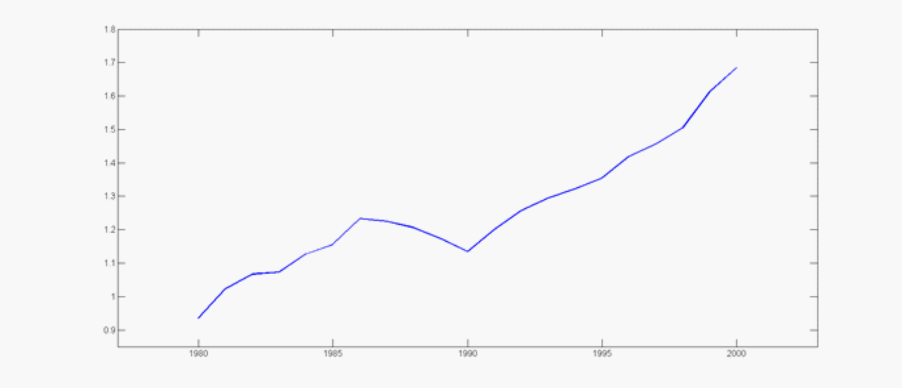

Figure: Relative price of tobacco (UK)

TASTE CHANGES AND PRICES

GALLUP POLL ON "DOES SMOKING CAUSE LUNG CANCER?"

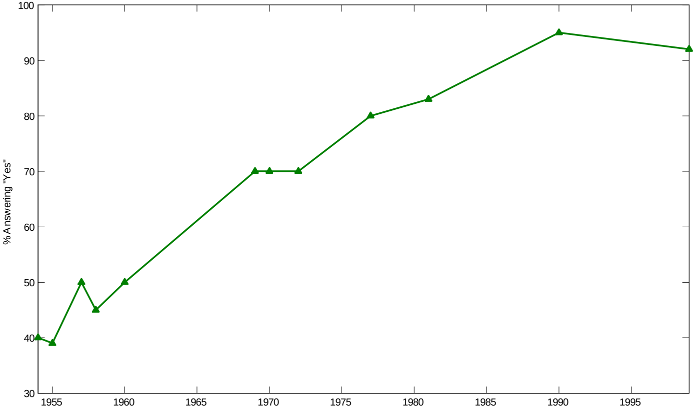

FIGURE: Beliefs on tobacco harm

Welcome to Afriat land

- To disentangle the effects of price and preference change, we use an Afriat (revealed preference) approach that explicitly allows for the fact that we only observe a finite set of data points.
- The usual features:
  - Nonparametric setting.
  - Reject/accept answers for rationalisation.
  - Tests for rationalisation involve algorithms that yield an answer in a finite number of steps.
  - If no rejection, set identification of objects of interest.
  - If no rejection, rationalisation is possible with smooth, monotone stable preferences.
- If rejection, derive a measure of the change in the distribution of tastes.

Taste Change

- Consumer i's maximisation problem can be expressed as:

$$\max_{\mathbf{q}} u^i(\mathbf{q}, \boldsymbol{\alpha}_t^i) \text{ subject to } \mathbf{p}'\mathbf{q} = x$$

where $\mathbf{q} \in \mathbb{R}_+^K$ denotes the demanded quantity bundle, $\mathbf{p} \in \mathbb{R}_{++}^K$ denotes the (exogenous) price vector faced by consumer i and x gives total expenditure.

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- We also allow for unobserved (taste) heterogeneity *across* consumers.

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- Using this framework we derive RP inequality conditions that incorporate minimal perturbations to preferences to account for taste change.

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Definition 1: Consumer i's choice behaviour, $\{\mathbf{p}_t, \mathbf{q}_t^i\}_{t=1,...,T}$, can be "taste rationalised" by a utility function $u^i(\mathbf{q}, \boldsymbol{\alpha}_t^i)$ and the temporal series of taste parameters $\{\boldsymbol{\alpha}_t^i\}_{t=1,...,T}$ if the following set of inequalities is satisfied:

$$u^i(\mathbf{q}, \boldsymbol{\alpha}_t^i) \leq u^i(\mathbf{q}_t^i, \boldsymbol{\alpha}_t^i)$$

for all $\mathbf{q}$ such that $\mathbf{p}_t'\mathbf{q} \leq \mathbf{p}_t'\mathbf{q}_t^i$.

- In words, observed behaviour can be rationalised if an individual's choice at t yields weakly higher utility than all other feasible choices at t when evaluated with respect to their time t tastes.

Marginal utility (MU) perturbations

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- Characterising taste change in this way yields the temporal series of utility functions:

$$u^i(\mathbf{q}, \boldsymbol{\alpha}_t^i) = v^i(\mathbf{q}) + \boldsymbol{\alpha}_t^{i\prime}\mathbf{q}, \text{ where } \boldsymbol{\alpha}_t^i \in \mathbb{R}^K.$$

- Under this specification, $\alpha_t^{i,k}$ can be interpreted as the taste shift in the marginal utility of good k at time t for individual i.
- The theorems below imply this specification is not at all restrictive.

Taste changes for one good

- Begin with intertemporal separability (*no habits*), individual preferences in period t (individual subscript i is suppressed) are represented by:

$$u^t (q_1, q_2, ...q_K) = v (q_1, q_2, ...q_K) + \alpha_t q_1$$

- The function $v (q_1, q_2, ...q_K)$ is a time invariant base utility function which is strictly increasing and concave in quantities.
- The term $\alpha_t q_1$ is a taste shifter for good 1 in period t.
- Normalisation: $\alpha_1 = 0$ so that the baseline preferences $v (\mathbf{q})$ are for period 1.
- Show these individual utility function satisfies single crossing in $(\mathbf{q}, \alpha)$ space.

AFRIAT CONDITIONS

- For individual i we seek the Afriat inequalities that would allow us to rationalise observed prices $\left\{\mathbf{p}^1, ...\mathbf{p}^T\right\}$ and quantities $\left\{\mathbf{q}^1, ...\mathbf{q}^T\right\}$.
- We can '*good* 1 *taste rationalise*' the observed prices and quantities if there is a function $v\left(\mathbf{q}\right)$ and scalars $\{\alpha_1, \alpha_2, ...\alpha_T\}$ such that:

$$v\left(\mathbf{q}^t\right) + \alpha_t q_1^t \geq \psi\left(\mathbf{q}\right) + \alpha_t q_1$$

for all $\mathbf{q}$ such that $\mathbf{p}^t\mathbf{q} \leq \mathbf{p}^t\mathbf{q}^t$.

AFRIAT CONDITIONS

Theorem 1: The following statements are equivalent:

1. Individual observed choice behaviour, $\{\mathbf{p}_t, \mathbf{q}_t\}_{t=1,...,T}$, can be good-1 rationalised by the set of taste shifters $\{\alpha_t\}_{t=1,...,T}$.

2. One can find sets $\{v_t\}_{t=1,...,T}$, $\{\alpha_t\}_{t=1,...,T}$ and $\{\lambda_t\}_{t=1,...,T}$ with $\lambda_t > 0$ for all $t = 1, ..., T$, such that there exists a non-empty solution set to the following inequalities:

$$\begin{aligned} \left(v\left(\mathbf{q}^t\right) - v\left(\mathbf{q}^s\right)\right) + \alpha_t\left(q_1^t - q_1^s\right) &\leq \lambda_t\left(\mathbf{p}^t\right)'\left(\mathbf{q}^t - \mathbf{q}^s\right) \\ \alpha_t &\leq \lambda_t p_t \end{aligned}$$

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- These inequalities are a simple extension of Afriat (1967).
- When they hold there exists a well-behaved base utility function and a series of taste shifters on good-1 that perfectly rationalise observed behaviour.

A surprising result

- We can then show, under mild assumptions on the characteristics of available choice data, that we can always find a pattern of taste shifters on a single good that are sufficient to rationalise any finite time series of prices and quantities:

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  Definition 2: There is 'perfect intertemporal variation' (PIV) in good 1 if $q_1^t \neq q_1^s$ for all $t \neq s = 1, ..., T$.

  Theorem 2: Given observed choice behaviour, $\{\mathbf{p}^t, \mathbf{q}^t\}$ for $t = 1, \ldots T$ where good-1 exhibits PIV, one can *always* find a set $\{v_t, \alpha_t, \lambda_t\}$ with $\lambda_t > 0$ for all $t = 1, ..., T$, that satisfy the Afriat inequalities.

- PIV is sufficient for rationalisation but not necessary.

Taste changes as price adjustments

- We can reinterpret the rationalisability question as a 'missing price problem'.
- We can find scalars $\{v_1, ...v_T\}$, positive scalars $\{\lambda_1, ...\lambda_T\}$, and a weakly positive taste-adjusted price vector, $\{\widetilde{\mathbf{p}}^t\}_{t=1,..,T}$, such that

$$v\left(\mathbf{q}^t\right) - v\left(\mathbf{q}^s\right) \geq \lambda_t \left(\widetilde{\mathbf{p}}^t\right)' \left(\mathbf{q}^t - \mathbf{q}^s\right)$$

  where

$$\widetilde{\mathbf{p}}^t = \left[p_1^t - \alpha_t/\lambda_t, \mathbf{p}_{\neg 1}^t\right].$$

- We refer to α_t/λ_t as the *taste wedge*.
- The change in demand due to a positive taste change for good 1 $(\alpha_t > 0)$ can be viewed as a price reduction in the price of good 1.
- This provides a link between two of the levers (*taxes and information*) available to governments.

Recovering taste change perturbations

- Given the no rejection result, we can always find a non-empty *set* of scalars that satisfy the Afriat conditions.
- Pick out values $\{v_t, \alpha_t, \lambda_t\}_{t=1,\dots T}$ that solve:

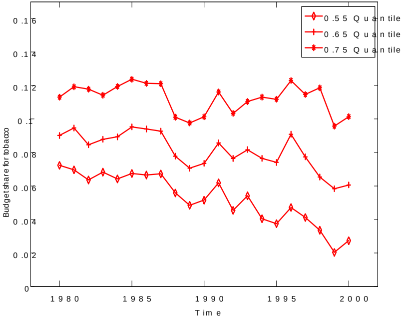
$$\min \sum_{t=2}^{T} \alpha_t^2 \text{ subject to the Afriat inequalities}$$

- This a quadratic-linear program.
- Minimizing the sum of squared α's subject to the set of RP inequalities ensures that the recovered pattern of taste perturbations are sufficient to rationalise observed choice behaviour.
- With $\alpha_1 = 0$, we interpret $\{\alpha_t\}_{t=2,\dots,T}$ as the minimal rationalising marginal utility perturbations to good-1 relative to preferences at $t = 1$.
- Can also impose more structure on the evolution of taste change over time. For example, monotonicity: $\alpha_{t+1} \leq \alpha_t$.

Empirical Strategy

- Our empirical analysis uses data drawn from the U.K. Family Expenditure Survey (FES) between 1980 and 2000.
- The FES records detailed expenditure and demographic information for 7,000 households each year.
- It is not panel data so we follow birth-cohorts of individuals stratified by education level.

Budget shares for Tobacco: Quantiles



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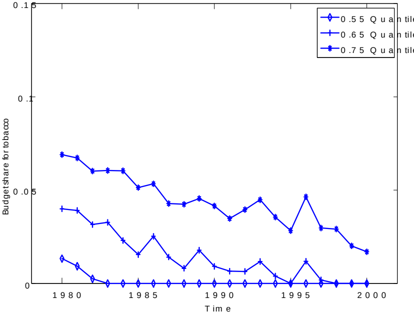

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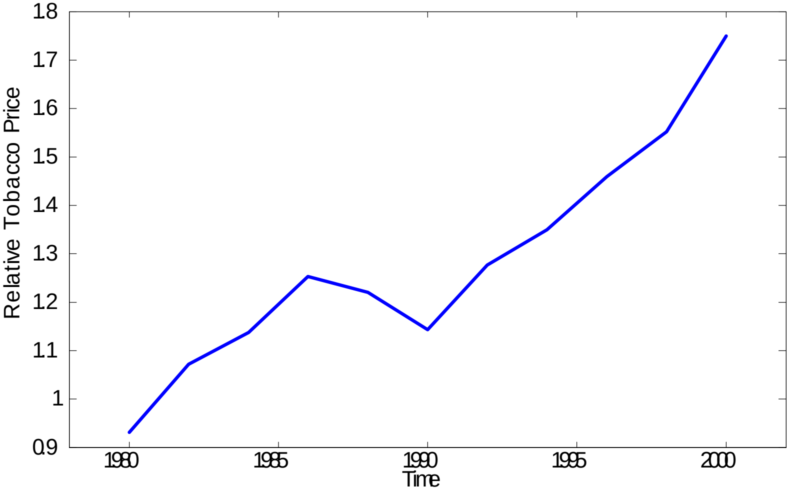
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Relative Tobacco Price
1980
1985
1990
1995
2000
Time

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- That is preferences are assumed take the form:

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- Note that RP consistent responses to price and income changes will also be represented by a shift in the distribution of demands.

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- This SMP framework requires us to estimate the expansion paths (Engel curves) $\mathbf{q}^E(\mathbf{p}_t, x_t)$ for each education cohort E at each price regime $\mathbf{p}_t$.

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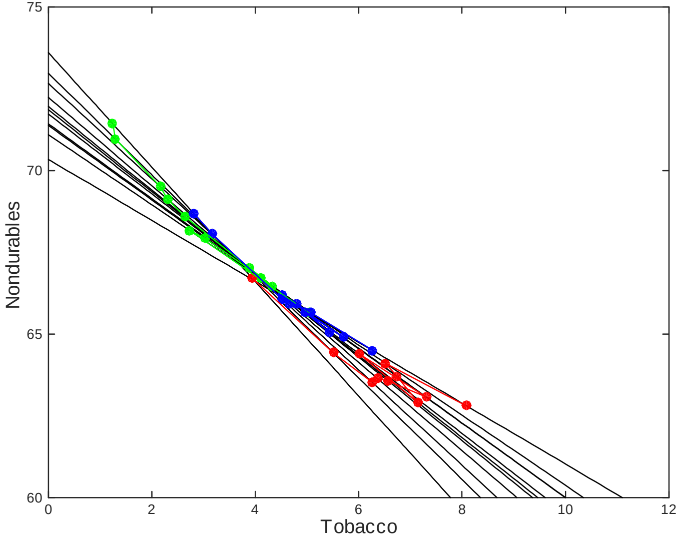
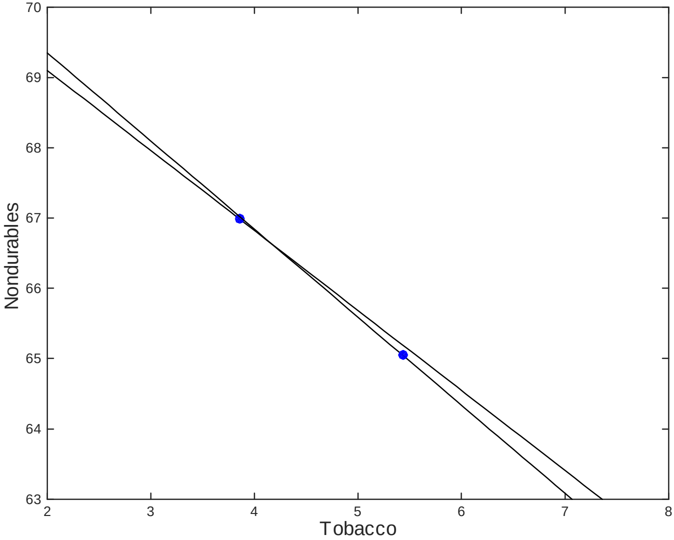
- We recover shifts in the distribution of demands and ask what are the minimal perturbations to tastes that maintain the RP inequalities at each particular quantile.

THE PATH OF QUANTILE DEMANDS - LOW ED



Violation - Low Ed moderate smoker.



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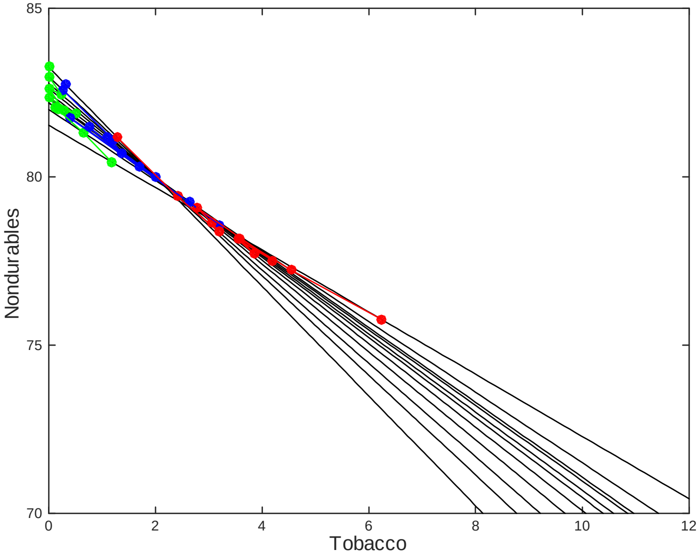

RESULTS

- Minimal virtual prices along each birth cohort's SMP path τth quantile and education group E are recovered as:

$$\widehat{\pi}_t^{E,\tau} = p_t^1 - \frac{\widehat{\alpha}_t^{E,\tau}}{\widehat{\lambda}_t^{E,\tau}}$$

The "taste wedge", $\widehat{\alpha}_t^{E,\tau}/\widehat{\lambda}_t^{E,\tau}$ represents the change in the marginal willingness to pay for tobacco relative to base tastes.

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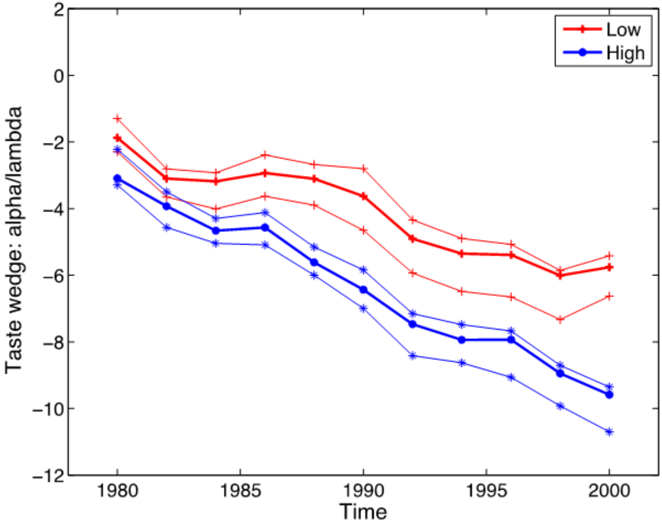
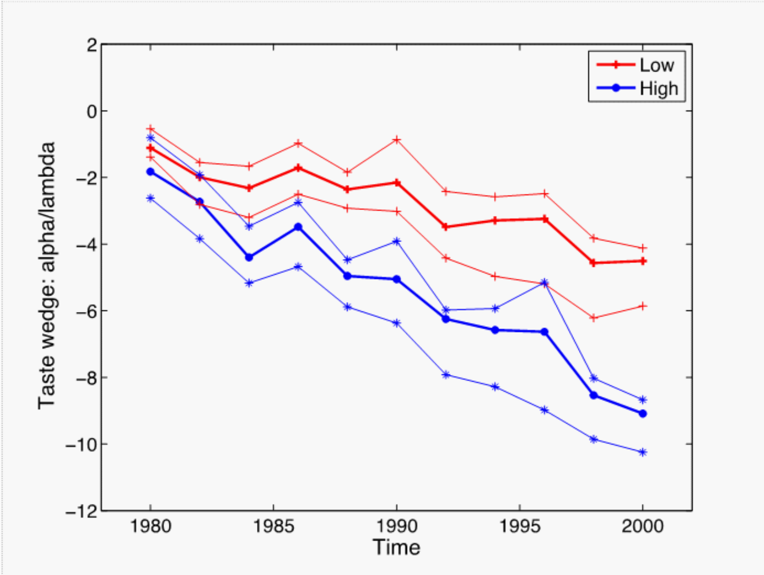
2. There are significant differences in the path of *systematic taste change* between education cohorts for light and moderate smokers.
3. The taste change trajectories for light and moderate smokers in the high education cohort are similar.
4. Education is irrelevant for explaining the evolution of virtual prices amongst heavy smokers.

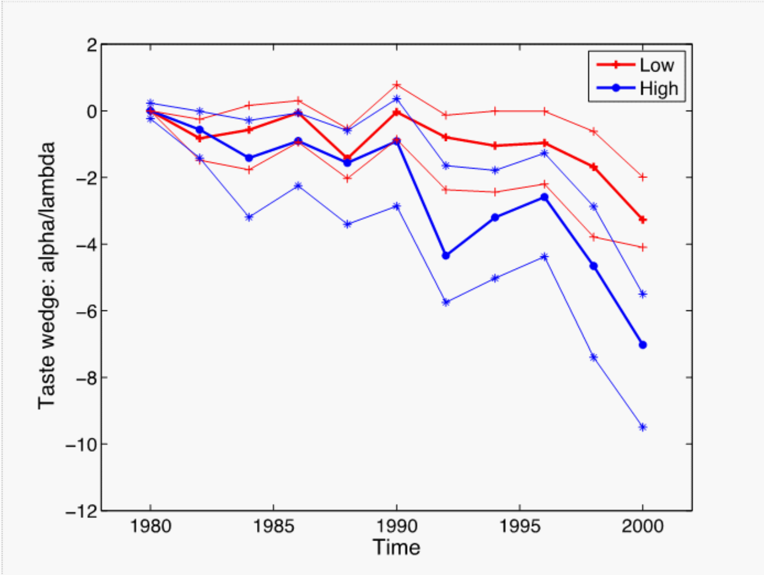
Taste wedges for light smokers



Taste wedges for medium smokers



TASTE WEDGES FOR HEAVY SMOKERS



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- To relax this weak separability assumption we re-run our quadratic programming procedure on quantile demands that are estimated *conditional on alcohol consumption*.
- We partition the set of observations into "light" and "heavy" drinkers depending on whether an individual is below or above the median budget share for alcohol.

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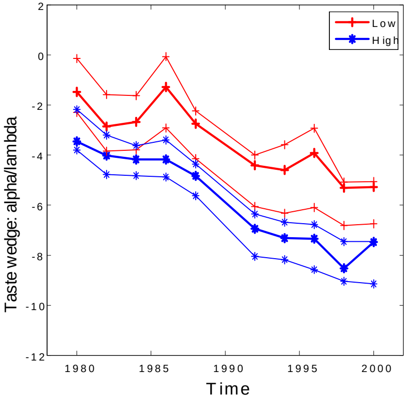
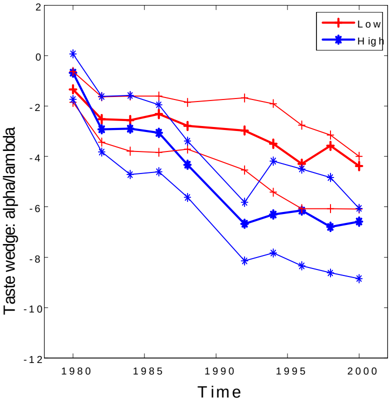
- *Weak separability with alcohol consumption* is a strong assumption. Alcohol is often thought to be complementary with tobacco consumption.
- To relax this weak separability assumption we re-run our quadratic programming procedure on quantile demands that are estimated *conditional on alcohol consumption*.
- We partition the set of observations into "light" and "heavy" drinkers depending on whether an individual is below or above the median budget share for alcohol.
- The significant difference by education group in the evolution taste change for light and moderate smokers is robust to non-separability.
- 95% confidence intervals on virtual prices and the taste wedge are disjoint across education groups for all cohorts except for the "heavy smoking"-"heavy drinking" group. Effective tastes for this group evolved very little for both education groups.

Taste Wedge Results: Conditional Quantiles (Moderate Smoker)

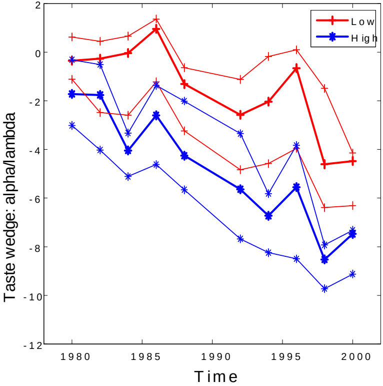


Light Drinker

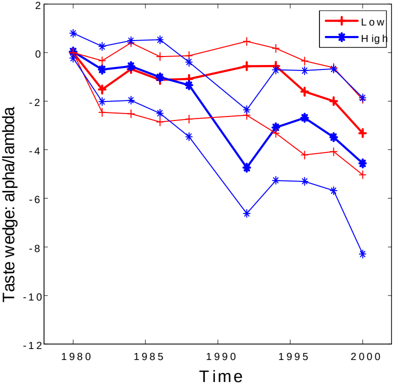


Heavy Drinker

Taste Wedge Results: Conditional Quantiles (Heavy Smoker)



Light Drinker



Heavy Drinker

Summary and Conclusions I

- This paper has provided a theoretical and empirical framework for characterising taste change.
- We have uncovered a surprising non-identification result: observational data sets on a K-dimensional demand system can always be rationalised by taste change on a single good in a nonparametric setting.
- Our theoretical results were used to develop a quadratic programming procedure to recover the minimal intertemporal (and interpersonal) taste heterogeneity required to rationalise observed choices.
- A censored quantile approach was used to allow for unobserved heterogeneity and censoring of consumption.
- Non-separability between tobacco and alcohol consumption was incorporated using a conditional (quantile) demand analysis.
- Future work will use intertemporal RP conditions to recover the path of λ_t.

Summary and Conclusions II

- *Systematic* taste change was required to rationalise the distribution of demands in our expenditure survey data.
- A series of strictly negative perturbations to the marginal utility of tobacco were found to be sufficient to rationalise the trends in tobacco consumption.
- Statistically significant educational differences in the marginal willingness to pay for tobacco were recovered; more highly educated cohorts experienced a greater shift in their effective tastes away from tobacco.
- We find virtual prices and the taste wedge are disjoint across education groups for all cohorts except for the "heavy smoking"-"heavy drinking" group.
- Education is irrelevant for explaining the evolution of virtual prices amongst heavy smokers.
- Line up taste change estimates with information/health campaigns/awareness.

Taste changes and prices

US Gallup poll on "Does Smoking Cause Lung Cancer?"

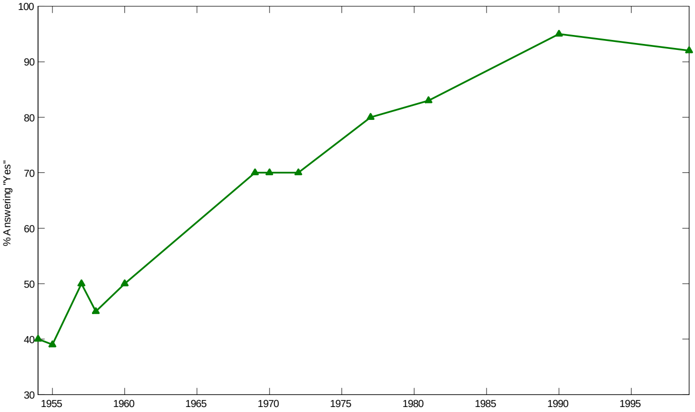
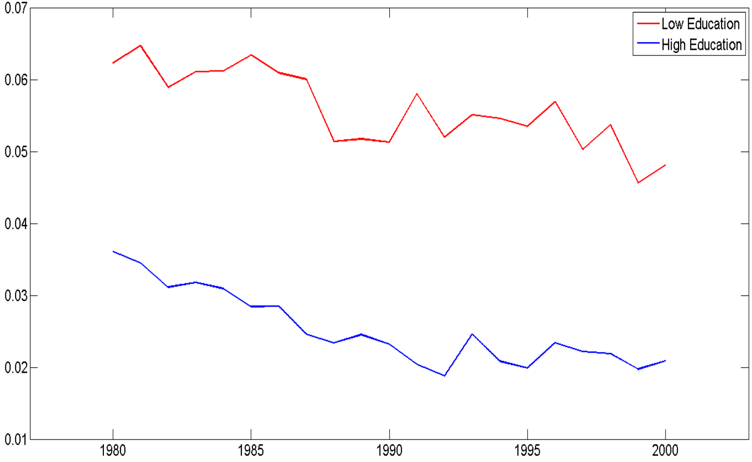


Figure: Beliefs on tobacco harm (US)

Extra Slides

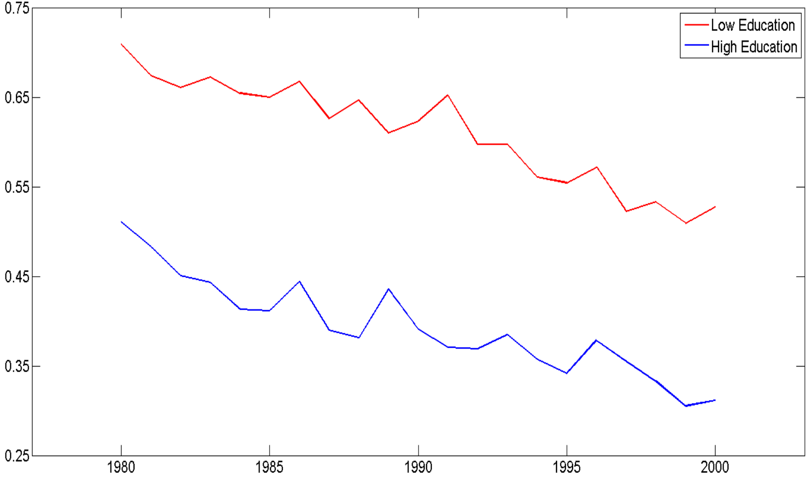
RESULTS

BUDGET SHARE TOBACCO

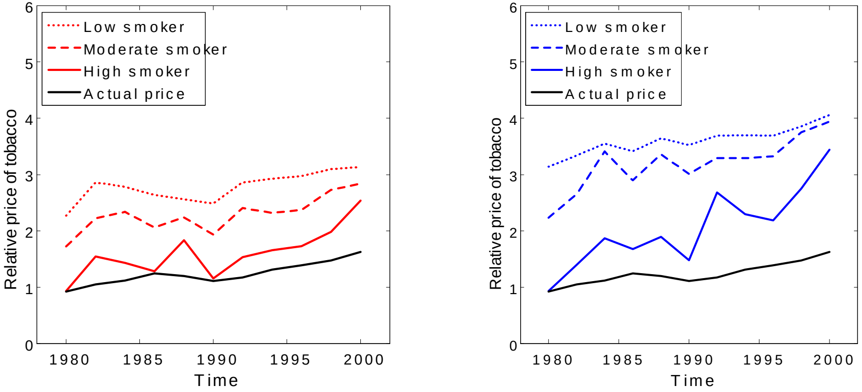


Results

Proportion Smoking



Virtual price for tobacco



(a) Low Education (b) High Education

In other words....

- Using the FOC for optimisation subject to the linear budget constraint yields:

$$\begin{aligned}\left(v\left(\mathbf{q}^{t}\right)-v\left(\mathbf{q}^{s}\right)\right)+\alpha_{t}\left(q_{1}^{t}-q_{1}^{s}\right) &\geq \lambda_{t}\left(\mathbf{p}^{t}\right)^{\prime}\left(\mathbf{q}^{t}-\mathbf{q}^{s}\right)\\ \alpha_{t} &\leq \lambda_{t} p_{1}^{t}\end{aligned}$$

- *Afriat*: replace functions with T values of the function.
- Find scalars $\{v_1, ...v_T\}$, $\{\alpha_1, ...\alpha_T\}$ and positive scalars $\{\lambda_1, ...\lambda_T\}$ which satisfy these (linear) constraints.

The SMP Path

- The SMP path starts at an education group's median demand in 1980 and continues sequentially over time to select the demand that is just weakly preferred to the SMP demand in the previous period.

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- Specifically, we recover taste changes for cohort demands at the SMP expenditure levels $\{\tilde{x}_t\}_{t=1,..,T}$, which are determined as:

$$x_1^E = Q_x(0.5|E) \tag{1}$$

and

$$\widetilde{x}_t^E = \mathbf{p}_t'\mathbf{q}_{t-1}^E \tag{2}$$

for $t = 2, ..., T$ and $E = \{L, H\}$, where $\mathbf{q}_t^E = \mathbf{q}^E(\mathbf{p}_t, \widetilde{x}_t)$.

- Note that we can abstract from the complicating issues caused by transitivity in the construction of the SMP path that are examined in Blundell *et al.* (AEJ: Micro 2014) because ours is a two-good demand system. Transitivity has no empirical content for a 2-good demand system.

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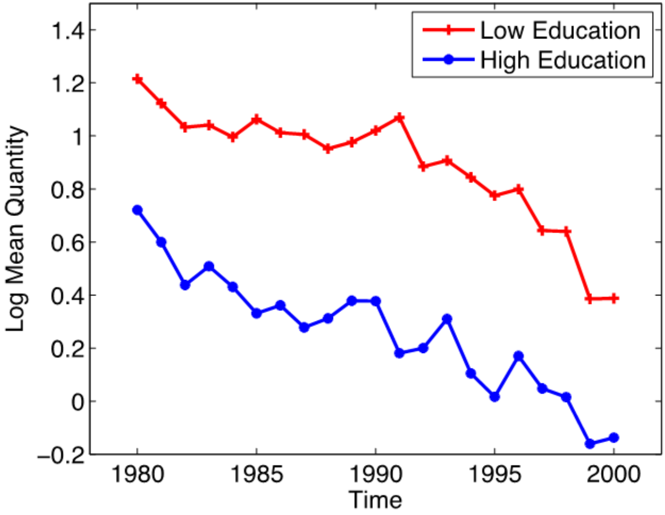
- To operationalise the SMP methodology, we require the sequence of quantities $\{\mathbf{q}^E(\mathbf{p}_t, \widetilde{x}_t)\}_{t=1,...,T}$.

Taste changes and prices

UK log demand, 1980-2000



Estimation

- Use censored quantile regression for a triangular system of equations for the budget share of tobacco, w^i, at each price regime:

$$\begin{aligned} w^i &= max(0, w^{i,\star}) \\ w^{i\star} &= Q_{w^{i,\star}}(\epsilon^i | x^i, \mathbf{z}^i, v^i, E^i) \\ x^i &= Q_{x^i}(v^i | z^i, m^i, E^i) \end{aligned} \quad (3)$$

  where

$$\begin{aligned} \epsilon^i &\sim U(0,1) | x^i, \mathbf{z}^i, v^i, m^i, v^i, E^i \\ v^i &\sim U(0,1) | \mathbf{z}^i, m^i, E^i \end{aligned} \quad (4)$$

  and x^i is total expenditure, $\mathbf{z}^i$ is a vector of household characteristics, v^i is an unobserved latent variable that is included to account for the possible endogeneity of x^i , and $E^i \in \{L, H\}$ denotes individual i's education cohort membership. m^i , the log of disposable income, is our excluded instrument that allows us to recover v^i.
- For each education level and each year, we estimate 55th, 65th and 75th quantiles.