How US vapors choose among different e-cigarette (EC) models & cigarettes in response to prices

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Summary of this study

- Employ a volumetric choice experiment (VCE) for adult EC users in the US to study own and cross elasticities among six different e-cigarettes (EC) types & cigarettes

- Different EC types substitute each other

- Higher prices and taxes on ECs & cigarettes will reduce consumptions among adult EC users

- Cross-price elasticities between ECs & CIGs for vapors were largely nonsignificant
BACKGROUND & MOTIVATION
**Background**

- Growing popularity of e-cigarettes (ECs) → state & local EC excise taxes in the US


- Increasing EC taxes may increase smoking and cigarette sales, leading to unintended consequences. (i.e., ECs and cigarettes are likely economic substitutes)

- The current debate over EC taxes has also been focused on balancing the intended and unintended consequences of taxing ECs.
Motivation – What is not known in the EC tax literature?

- Almost all conclusions are based on sales or repeated cross-sectional data. Therefore, those studies did not control for tobacco users’ unobserved heterogeneity (e.g., beliefs in EC risks etc.) using individual fixed effects.

- Treat ECs as a homogeneous group while their characteristics and tax burdens significantly vary (Shang et al (2023)). E.g., most studies used past-30-day use as the sole outcome.

- The economic relationships (i.e., whether they are substitutes or not) among different types of ECs and between various EC types and cigarettes are unknown, despite their differential appeals and potentials to replace cigarettes.
Motivation – What is not known in the EC tax literature?

- Dual use of e-cigarettes and cigarettes are not well addressed in existing data
  - Survey data often measure whether to use cigarettes or ECs instead of measuring quantities. The allocations between ECs and cigarettes among dual users are unknown.
- Unlike cigarettes, ECs are platform goods (device + refills) in marketing and economics research, similar to Keurig coffee machine + pods. The purchasing patterns of ECs could be very different from cigarettes due to the nature of platform goods and need to be further investigated.
This study conducts a volumetric choice experiment (VCE) to fill in evidence gaps, which has the following advantages

- Use within variation that addresses confounding issues (controlling for individual fixed effects in assessing price impacts)
- Allow for the estimation of cross- and own- price elasticity for different EC types, which observational survey data are not able to estimate due to the lack of reporting, confounding, and multicollinearity issues.
- Causal interpretation of results ~ widely used in medical decision-making and marketing
- Flexibility in modeling dual use behaviors compared to discrete choice experiments
- Flexibility in modeling platform goods (Expensive device for one-time purchase + relatively cheaper refills)
Aims

- To study own & cross elasticities among six different EC types & cigarettes, we employed a volumetric choice experiment (VCE) for adult EC users in the US
- We chose these ECs based on market shares and differences in configurations and product characteristics

<table>
<thead>
<tr>
<th>Product type</th>
<th>Disposable</th>
<th>Tank device w/ e-liquid</th>
<th>E-liquid bottle</th>
<th>Pod device w/ pods</th>
<th>Pod starter kit</th>
<th>Pod refills</th>
<th>Cigarettes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotine (per ml)</td>
<td>30mg</td>
<td>6mg</td>
<td></td>
<td>50mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume size</td>
<td>1ml</td>
<td>60ml</td>
<td></td>
<td>0.8ml</td>
<td></td>
<td></td>
<td>Pack of 20</td>
</tr>
</tbody>
</table>
METHODS
Methods

Eligibility & Sample

- Online volumetric choice experiment (VCE) in May 2023
  - We pretested the survey and VCE design using 7 structured qualitative interviews and pretested the survey among 27 adult (18+) EC users

- A nationally-representative sample of 808 EC users (18+)
  - Recruited using the Knowledge Panel
  - Reported past-30-day EC
  - Lived in the US
  - Provided valid answers to VCE questions, total N = 700 persons
Methods (continued)

Online volumetric choice experiment (VCEs) design

- Participants answer 9 choice questions. In each question, they report # of units they will purchase for monthly use among the following products. Participants were advised to make purchases within their monthly budget and respond to changing taxes and prices across choice questions.

- Participants are allowed not to buy any product (opt-out)
### Attributes (levels)

<table>
<thead>
<tr>
<th>Attributes (levels)</th>
<th>Tank systems (tank &amp; e-liquid) (60 ml)</th>
<th>Pods (pack of 4 pods/starter kit/device) (0.7 ml)</th>
<th>Disposables (1 ml)</th>
<th>Cigarettes (pack of 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device prices</td>
<td>Low (25% percentile), median (50%), high (75%)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Device taxes</td>
<td>No taxes, low tax burden (10% of retail price), high tax burden (40% of retail price)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Refill prices</td>
<td>Low (25%), median (50%), high (75%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refill taxes</td>
<td>No taxes, low tax burden (20%), high tax burden (40%)</td>
<td></td>
<td>Current + 0%, 10%, 20%</td>
<td></td>
</tr>
</tbody>
</table>

The James
Mean prices per unit based on the VCE design

$ per unit in VCE design

- Disposables: $16
- Pod device: $23.25
- Pod kit: $34.28
- Pod refill pack: $23.46
- Tank device: $55.41
- E-liquid bottle: $22.49
- Cigarettes: $9.90
Please click on the product type of interest to navigate.

Please choose the quantity of the product you'd like to buy.

Not required to make a purchase, if not interested.

You can choose not to purchase any of the products in the store.

This shows your monthly budget based on your response.
Questions?
RESULTS
### Distribution of units reported (N=33,473)*

<table>
<thead>
<tr>
<th>Units</th>
<th>Frequency</th>
<th>[%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26,926</td>
<td>[80.44%]</td>
</tr>
<tr>
<td>1-10</td>
<td>6,013</td>
<td>[17.96%]</td>
</tr>
<tr>
<td>11-20</td>
<td>311</td>
<td>[0.99%]</td>
</tr>
<tr>
<td>21-30</td>
<td>119</td>
<td>[0.36%]</td>
</tr>
<tr>
<td>31-100</td>
<td>53</td>
<td>[0.16%]</td>
</tr>
<tr>
<td>101 or above</td>
<td>31</td>
<td>[0.09%]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.47</td>
</tr>
</tbody>
</table>

**Standard Deviation**

|        | 20.5      |

* 700 individuals × 7 products × an average of 6.8 answered questions
E-cigarettes (EC) and cigarettes (CIG) dual use status: 36% of total EC users

26% of daily EC users and 64% of some days EC users smoke CIG too
E-cigarette product of use and demographics (%, N = 33,473)

- **Product type**
  - Multiple products: 23%
  - Pods only: 18%
  - E-liquid only: 31%
  - Disposables only: 29%

- **Age**
  - 18-29: 17%
  - 30-44: 38%
  - 45-49: 27%
  - 60+: 18%

- **Gender**
  - Male: 40%
  - Female: 60%

- **Household Income**
  - <$10k: 8%
  - $10k - $25k: 12%
  - $25k - $50k: 13%
  - $50k - $75k: 19%
  - $75k - $100k: 13%
  - $100k - $150k: 15%
  - $150k+: 10%
Zero-inflated negative binomial regression

\[ U_{ijm} = \beta_0 \text{ASC}_{ijm} + \beta_1 \text{OwnPrice}_{ijm} + \beta_2 \text{CrossPrice}_{ijm} + \beta_5 X_i + \epsilon_{ijm} \]

- **\( U \)**: person \( i \)'s consumption units of product \( j \) in choice set \( m \)
- **\( \text{ASC} \)**: alternative-specific constant to estimate how the consumption of product \( j \) significantly differs by product or alternatives of person \( i \) when they are in choice set \( m \)
- **\( \text{OwnPrice} \)**: a price of product \( j \) that person \( i \) faces in choice set \( m \)
- **\( \text{CrossPrice} \)**: a vector of prices of alternatives to product \( j \) that \( i \) faces in choice set \( m \)
- **\( X_i \)**: individual-level fixed effects
- **\( \beta_1 \) & \( \beta_2 \)** capture own-price elasticity & cross-price elasticity
- **Group difference by EC only vs. EC-CIG dual use**: interactions between group and elasticities are added. Individual fixed effects are replaced by tobacco use patterns & socio-demographics for convergence.

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Own price elasticities (N = 33,473; 700 unique individual persons using EC)

- Disposable: -1.4***
- Pod device: -1.6**
- Pod kit: -1.5***
- Pod pack: -0.9***
- Tank device: -0.5*
- E-liquid bottle: -0.8***
- Cigarette: -0.9*

* p<0.05, ** p<0.01, *** p<0.001

% change in consumption in response to 10% change in price
Cross price elasticities (N = 33,473; 700 unique persons using EC)

- Pod device to disposable price: 0.5*
- Pod device to e-liquid bottle price: 0.5***
- Pod kit to disposable price: 0.4*
- Pod kit to pod pack price: 0.8*
- Pod kit to e-liquid bottle price: 0.3*
- E-liquid bottle to tank price: -0.5***

* p<0.05, ** p<0.01, *** p<0.001

% change in consumption in response to 10% change in price
CONCLUSIONS
Conclusions

- Using VCE, we found that higher prices and taxes on ECs & cigarettes will reduce consumptions among adult EC users in the US.
  - A 10% increase in own prices will reduce the consumption of ECs by 0.5%-1.6% among vapors and the consumption of cigarettes by 0.9%.

- Cross-price elasticities between ECs & CIGs for vapors were largely nonsignificant
  - Cigarette taxes unlikely move dual users of CIGs & ECs to more EC use instead of cigarette smoking.
  - Similarly, higher EC prices or taxes may not lead to increased CIG use of adult EC users.
  - The conclusions did not vary by whether an EC user is a dual user or not
Conclusions (continued)

- Different EC types are substitutes
  - Pods are substitutes for disposables and tank systems (e-liquid).
  - Pod kit and pod refills are substitutes (device is relatively cheap and devices and pods may need to be matched in brands)
- Tank systems and e-liquid are complements
  - Reflect the complementarity between components in a platform combo with relatively high costs of devices+ cheaper refills.
- If there is consensus about which EC type has the greatest potential for helping quitting while not as preferred by young populations, tax policies can be designed to promote the use of a certain EC type (e.g., differential taxes by EC types).
Conclusions continued: why there is a difference in substitutability between ECs and CIG?

- All existing observational studies did not control for individual fixed effects (heterogeneity)
- Differences in samples: Nationally representative sample of adult vapors in our study vs. general adult populations in observational studies.
  - EC/cigarette use may be more impacted by taxes and prices than consumption.
- Differences in outcomes: Consumption units in VCE vs. Use or sales measures in observational studies.
- Possibility of hypothetical biases in choice experiments? (We did take procedures to reduce possible biases)
  - Participants were making choices based on their current budget in real life.
  - Mechanisms such as motivations to complete tasks and to report real-life behaviors.

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Sensitivity and additional analysis in progress

- VCE was not designed to conduct stratified analysis. Nonetheless, we did stratification analyses, and the conclusions did not change.

- Reconduct analyses by converting outcomes from purchasing units into nicotine consumption.

- Estimate the impacts of tax levels instead of prices on outcomes.

- Predict market share shifts under different tax scenarios.

- Assess possible hypothetical biases where we will estimate cross- and own-price elasticities using the Deaton method, which relies on real-world expenditure data that we collect in the same survey from the same population. We will then compare the results between Deaton Method and VCE.
Questions and comments

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