Market Size, Prices, and Purity

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Outline

• Estimating market size
• Fun with price & purity
• Other stuff on the supply side
• Concluding thought/comment on Belgium and supply side
Estimating Market Size

Supply side methods

- Seizures * 10
- Production – seizures – consumption elsewhere

Demand side methods

- # of users * consumption per user
- # of users * spending per user / price
Mr. Pareto’s Curse: You can only count the users that do not matter (as much)
Uncertainty comes from factors that have not been studied.

Recent estimate of US marijuana consumption.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>PM: # of Users</td>
<td>16,752,428</td>
<td>NSDUH 2009</td>
</tr>
<tr>
<td>R2</td>
<td>PM: Days used in past year</td>
<td>156.3</td>
<td>NSDUH 2009 (Mean)</td>
</tr>
<tr>
<td>R3</td>
<td>PM: Joints per use day</td>
<td>2.5</td>
<td>NHSDA 1994 (Mean)</td>
</tr>
<tr>
<td>R4</td>
<td>PY: Number of users</td>
<td>11,967,200</td>
<td>NSDUH 2009 (Mean)</td>
</tr>
<tr>
<td>R5</td>
<td>PY: Days used in past year</td>
<td>29.8</td>
<td>NSDUH 2009 (Mean)</td>
</tr>
<tr>
<td>R6</td>
<td>PY: Joints per use day</td>
<td>1.25</td>
<td>0.5 * R3 (assumed)</td>
</tr>
<tr>
<td>R7</td>
<td>Grams per joint</td>
<td>0.43</td>
<td>Kilmer et al., 2010</td>
</tr>
<tr>
<td>R8</td>
<td>PM: Total grams</td>
<td>2,815,145,011</td>
<td>=R1 * R2 * R3 * R7</td>
</tr>
<tr>
<td>R9</td>
<td>PY: Total grams</td>
<td>191,748,950</td>
<td>=R4 * R5 * R6 * R7</td>
</tr>
<tr>
<td>R10</td>
<td>% underreporting</td>
<td>20%</td>
<td>Various sources</td>
</tr>
<tr>
<td></td>
<td>Baseline Total</td>
<td>3,800 MT</td>
<td>=(R8+R9) / (1 - R10)</td>
</tr>
</tbody>
</table>
Supply (Price, Purity, and Availability) Matters

- People used to think “Addicts will do anything to get their fix” so elasticity of demand is 0.
- Once learned how to estimate price series, could show that is not true.
US Cocaine and Heroin ED Mentions Inversely Related to Prices
Price Raised to a Constant Elasticity Can Explain Most Variation in ED Mentions
HS Seniors Marijuana Use Inversely Correlated with Price

Trends in MJ Prices & MTF Annual Prevalence for HS Seniors

- **Prevalence (%)** & **Price ($/gram)**

- **Trends**
  - MJ Price/Gram
  - Annual Prevalence
  - Price Trend
  - Prevalence Trend

![Graph showing trends in MJ prices and annual prevalence for HS seniors](image-url)
Key May Be Affordability, Not Price Per Se

![Graph showing the relationship between GDP per capita and mean times cannabis used per student, ESPAD (2003) Data, Nordic Countries Excluded. The regression line is given by $y = 0.0002x - 0.4373$ with $R^2 = 0.5287$.](image)
Disequilibrium Models & Detective Work
Heroin Overdoses in Victoria

Definite heroin OD
Likely heroin involvement
Little Change in “Raw” Price

Heroin price per gram, without purity adjustment (gram level)

Price per Raw Gram (Interpolated from IDRS)
Big Change in Retail Heroin Purity

Average Heroin Purity (%) in VIC Seizures

- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004

Heroin purity has decreased significantly from 1998 to 2001, with a slight increase from 2001 to 2004.
So Purity-Adjusted Price Soared

Heroin Price/ Gram, with & without Purity Adjustment (gram level)

Price per Raw Gram (Interpolated from IDRS)

Price per Pure Gram

1998 1999 2000 2001 2002 2003 2004
Which Can Explain Variation in Ambulance Call-Outs

Compare Actual Total Monthly Ambulance Calls to What Would Be Predicted Based on Price Trends from Mid 1999 On with a Constant Elasticity Model (eta = -1.12)

- Actual Total Ambulance Calls
- Expected Total, from Price Trends
If Drought Was A Supply-Side Event, Question is: “What Level?”

- Sub-national?
- Importation level?
- Source zone?
  - SE Asia (Myanmar, etc.)
  - SW Asia (Afghanistan, etc.)
Market Decline & Shock Were National, not State Level Events

NSW Narcotics Arrests Correlate Extremely Well with VIC Heroin Purity

- Heroin Use/Possession Arrests in NSW
- VIC Heroin Purity (x4)
Similar Analysis for UK: Even Just Purity Can Be Useful
Monthly Cocaine & Crack Purity in London

Avg Monthly Cocaine and Crack Purity in London Area

- **COCAINEN**: Green diamonds
- **Crack**: Blue squares

Data points from 1997 to 2008.
Weekly Amphetamine Series Shows Abrupt Decline in Early 2000

Avg Amphetamine Purity, by Week (1997-Mid 2007)
Heroin Purity Series Also Suggestive of (Later) Market Shock
Other Stuff on the Supply Side

- The wisdom of suitcases
- Cycle times & transience of batches
- Distribution (not just mean) of seizure sizes in Australia
- Couriers’ wages
  - (and existence of sacrificial sheep)
- Etc.
Supply-Chain Modeling

• Much like other distribution chains
  – Multi-layered network for heroin (and cocaine)
  – Log-linear price-quantity relationship
  – Price mark-ups may be slightly smaller
    • And curiously stable across drugs

• Other comments
  – High cycle frequency (low inventory holding?)
  – Importers are vertically integrated into domestic distribution
## Typical Heroin Distribution

<table>
<thead>
<tr>
<th>Transaction Level</th>
<th>Seller</th>
<th>Buyer</th>
<th>Amount</th>
<th>Price (per transaction)</th>
<th>Price/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th Level Wholesale</td>
<td>Importer</td>
<td>Respondent B</td>
<td>10-60 kg</td>
<td>£437,500</td>
<td>£12,500</td>
</tr>
<tr>
<td></td>
<td>Respondent B</td>
<td>Respondent A</td>
<td>1 kg</td>
<td>£15,000</td>
<td>£15,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5 kg</td>
<td>£8,000</td>
<td>£16,000</td>
</tr>
<tr>
<td>3rd Level Wholesale</td>
<td>Respondent A</td>
<td>A's Customers</td>
<td>9 oz.</td>
<td>£6,750</td>
<td>£27,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 oz.</td>
<td>£900</td>
<td>£32,400</td>
</tr>
<tr>
<td>2nd Level Wholesale</td>
<td>A's Customers</td>
<td>Retail Sellers</td>
<td>0.5 oz.</td>
<td>£625</td>
<td>£45,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.25 oz.</td>
<td>£350</td>
<td>£50,400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.125 oz.</td>
<td>£187.50</td>
<td>£54,000</td>
</tr>
<tr>
<td>Retail</td>
<td>Retail Sellers</td>
<td>Users</td>
<td>1 gram</td>
<td>£60</td>
<td>£60,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1 gram</td>
<td>£10</td>
<td>£100,000</td>
</tr>
</tbody>
</table>
Prices Follow Classic Log-Linear Model:

\[ P = \alpha Q^\beta \]
### Price-Quantity Exponent Fairly Stable Across Substances

<table>
<thead>
<tr>
<th>Substance</th>
<th># of Cycles</th>
<th>Average</th>
<th>Min</th>
<th>Max</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannabis</td>
<td>5</td>
<td>0.817</td>
<td>0.674</td>
<td>0.966</td>
<td>0.116</td>
</tr>
<tr>
<td>Cannabis Resin</td>
<td>4</td>
<td>0.851</td>
<td>0.775</td>
<td>0.932</td>
<td>0.076</td>
</tr>
<tr>
<td>Cocaine</td>
<td>7</td>
<td>0.869</td>
<td>0.792</td>
<td>0.920</td>
<td>0.040</td>
</tr>
<tr>
<td>Crack</td>
<td>5</td>
<td>0.827</td>
<td>0.731</td>
<td>0.886</td>
<td>0.058</td>
</tr>
<tr>
<td>Ecstasy</td>
<td>6</td>
<td>0.754</td>
<td>0.547</td>
<td>0.937</td>
<td>0.129</td>
</tr>
<tr>
<td>Heroin</td>
<td>28</td>
<td>0.834</td>
<td>0.253</td>
<td>0.975</td>
<td>0.142</td>
</tr>
<tr>
<td>Heroin (w/o outlier)</td>
<td>27</td>
<td>0.855</td>
<td>0.620</td>
<td>0.975</td>
<td>0.086</td>
</tr>
</tbody>
</table>
Price-Quantity Exponent Larger in the UK, Which Makes Sense

<table>
<thead>
<tr>
<th></th>
<th>UK</th>
<th></th>
<th>US</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UK</td>
<td></td>
<td>US</td>
<td>Retail</td>
<td>Level</td>
<td>Mid-Level</td>
</tr>
<tr>
<td>Cannabis</td>
<td>0.817</td>
<td>0.72 imported 0.76 domestic</td>
<td>0.573</td>
<td>0.802</td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>Sinsemilla</td>
<td>0.850</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannabis Resin</td>
<td>0.851</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hashish</td>
<td>0.770</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocaine</td>
<td>0.869</td>
<td>0.830</td>
<td>0.716</td>
<td>0.751</td>
<td>0.787</td>
<td>0.813</td>
</tr>
<tr>
<td>Crack</td>
<td>0.827</td>
<td>0.790</td>
<td>0.731</td>
<td>0.661</td>
<td>0.833</td>
<td></td>
</tr>
<tr>
<td>Heroin</td>
<td>0.834</td>
<td>0.83 brown 0.84 white</td>
<td>0.531</td>
<td>0.718</td>
<td>0.764</td>
<td></td>
</tr>
</tbody>
</table>
Modeling Suppliers as Businesses

- Project consequences of legalization
  - Production cost
  - Distribution cost
  - Price declines around the country
Legal production and supply far cheaper than illegal wholesale prices

Sources: *Altered State?* (RAND 2010), interview with medical marijuana cultivator, Kilmer (2012)
US MJ wholesale prices increase systematically with distance from source

\[ y = 0.4633x + 281.53 \]
\[ R^2 = 0.4728 \]

\[ y = 0.3428x + 561.22 \]
\[ R^2 = 0.454 \]
Trafficking legally produced MJ could lead to price collapse across U.S.
Concluding Comment

- Belgium is affected by supply but cannot affect (wholesale) supply
- Targeting retail supply
  - Possible in theory
  - Perilous in practice (at least for the US)