High Achievers?
Cannabis Access and Student Achievement

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20th Anniversary Conference – 17th July 2016
Wind of Change in Drug Policies

Marijuana/cannabis is *most widely consumed illicit substance in the world* (3-5% world pop) and use relatively higher in US (11%) and especially among young adults (*35% senior high school students*)

Public policies regarding its *recreational use* have been fast changing across the world in recent years

- **Europe**: in long footsteps of the tolerance policy of Netherlands, decriminalisation in Portugal, Czech Republic, Norway…

- **US**: rapid and radical change in public opinion and policy
  - Colorado and Washington have legalized recreational use in 2014
  - Alaska and Arizona just followed suit midterms last November

- **Uruguay** now first country on way to fully legalize marijuana
Wind of Change in Drug Policies
Wind of Change in Drug Policies

- Public opinion has reached a tipping point

*Americans' Views on Legalizing Marijuana*

Do you think the use of marijuana should be made legal, or not?

![Graph showing public opinion on legalizing marijuana from 1969 to 2013. The graph shows a decrease in the percentage of people opposing legalization and an increase in favor of it.](image-url)
The Pros and Cons of Legalization

- Proponents winning legalization debate over opponents?
  + Pros: cut illegal market link & war on drugs a loosing battle
  - Cons: bad for you (Hall 2014), gateway drug, morally wrong…

... & legal access increases consumption?

- Evidence for or against last argument still surprisingly weak
The ‘Worse than Usual’ Causality Difficulties

- Main issue is difficulty of establishing causal nature of the relationship between drug ‘choices’ and outcomes:
  - Individual consumption decision driven by unobserved factors (popular method ≠ onset ages: van Ours & Williams 2014)
  - Policy direction chosen result of more general societal change (US MMJ intro not ceteris paribus: Pacula & Sevigny 2014)

- Ideally could test effect of drug policy on outcome with:
  i. exogenous change of access rules for some and not others
  ii. longitudinal measure of outcome affected by drug taking

- We have here perhaps first experiment combining i & ii
Our Unique Natural Experiment

- A unique (and very strange) policy implemented in Maastricht restricting legal cannabis access guarantees that we meet i:
  - some nationalities banned from ‘coffie-shops’ in some periods
  - policy change because of ‘drug’ tourism but all indiv affected

- City has a large international student population for which we have regular test results throughout period that gives us ii:
  - THC has strong impact on human learning capacity/productivity
  - observe course results for all individuals throughout period

- Enables us to estimate causal impact of a change in soft drug access policy on smoking behaviour (via productivity)
Our Reduced Form Approach

- We take *reduced form approach* as we no direct measure of smoking behavior of students but only their test scores… Bad?

- Arguably more reliable outcome measure since policy change:
  - could affect probability to admit consumption in questionnaire studies
  - often coupled with changes in police behavior (Adda et al. 2014)

- To work however, we must be sure that cannabis consumption is likely to have a detectable effect on this outcomes measure?

- Review of medical evidence of effects of THC on cognitive functioning by Ranganathan & da Souza (2006) concludes that:

  “THC...impairs immediate and delayed free recall of information presented after, but not before, drug administration”
THC Consumption and Cognitive Functioning?

Bossong et al. (2013) experiment with random THC admission in fMRI where subjects had to indicate whether they have seen an item before.

Conclude that: “THC impairs performance on high-level cognitive functions essential for goal-directed behavior”
<table>
<thead>
<tr>
<th>Executive Function Measured</th>
<th>Acute Effects</th>
<th>Residual Effects</th>
<th>Long-Term Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention/Concentration</td>
<td>Impaired (light users)</td>
<td>Mixed findings</td>
<td>Largely normal</td>
</tr>
<tr>
<td></td>
<td>Normal (heavy users)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision Making &amp; Risk Taking</td>
<td>Mixed findings</td>
<td>Impaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Inhibition/Impulsivity</td>
<td>Impaired</td>
<td>Mixed findings</td>
<td>Mixed findings</td>
</tr>
<tr>
<td>Working Memory</td>
<td>Impaired</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>Normal</td>
<td>Mixed findings</td>
<td>Mixed findings</td>
</tr>
</tbody>
</table>

Note: Acute Effects denotes 0–6 hours after last cannabis use; Residual Effects denotes 7 hours to 20 days after last cannabis use; Long-Term Effects denotes 3 weeks or longer after last cannabis use.
Drug Policy in the Netherlands

- 1976 Opium Law basis of Dutch ‘tolerance’ policy introduced to “minimize harm done to users and their environment”

- Possession and retail sales of small quantities (< 5g) of cannabis are legal but cultivation or wholesale remains illegal

- Can buy exclusively via licensed ‘coffeeshops’ which must follow number of strict rules: e.g. no < 18s, no disturbance etc.

- Licensing decision at municipality level and under 1/4 th out of 443 actually have such one with concentration in liberal cities.
Cannabis Access in Maastricht

- All members of association that defends coffeeshop rights: VOCM
The Maastricht Policy Change

- Proximity to borders, especially being closest city to France, attracted a lot of ‘drug tourists’ to Maastricht.

- Problem was many came to buy larger quantities than what is legally available and this exacerbated ‘street dealer’ nuisance.

- To respond to city concerns, VOCM proposed to only allow coffie-shops access to Dutch, German, and Belgian (DGB).

- October 1\textsuperscript{st}, 2011 the ‘neighborhood country criterion’ was introduced in all establishments selling cannabis in Maastricht.
Vanaf 1 oktober 2011 gaan de Maastrichtse coffeeshops het buurlandcriterium toepassen.
À partir du 1er octobre 2011 les coffeeshops maastrichtois (VOCM) appliqueront le critère dit des pays limitrophes.
Ab 1 Oktober 2011 werden die Maastrichter Coffeeshops (VOCM) das Nachbarlandkriterium umsetzen.
Starting from 1 October 2011 the 'neighbouring country criterion' will be applied in the Maastricht coffeeshops (VOCM).

**Ja / Oui / Yes**

Nederland
Dit betekent dat alleen nog inwoners van 18 jaar en ouder uit Nederland en onze buurlanden België en Duitsland in de Maastrichtse coffeeshops worden toegelaten.

Belgique
En clair, cela signifie que seuls seront admis dans les coffeeshops maastrichtois les personnes âgées d'au moins 18 ans et résidant soit aux Pays-Bas, soit dans l'un de nos pays limitrophes, à savoir la Belgique et l'Allemagne.

Belgique
Das heißt, dass nur noch Einwohner von 18 Jahren und älter aus den Niederlanden und aus unseren Nachbarländern Belgien und Deutschland zu den Maastrichter Coffeeshops Zutritt haben.

Deutschland
This means that admission will be restricted to residents of the Netherlands, Belgium and Germany, aged 18 years and over. Coffeeshop visitors must be in possession of valid Dutch, German or Belgian proof of identity.

**Non / Nein / No**

France
À partir du 1er octobre 2011, seuls les habitants des pays voisins, à savoir l'Allemagne et la Belgique, disposant d'un justificatif d'identité valide seront encore admis. À partir de cette date, les visiteurs venus de France, du Luxembourg et d'autres pays n'auront plus accès aux coffeeshops maastrichtois.

Luxembourg
Les 1er octobre 2011, seuls les résidents du Luxembourg seront admis dans les coffeeshops maastrichtois. Les visiteurs venus d'autres pays seront exclus.

And All Other Countries

From 1 October 2011, only visitors from the Netherlands, Germany and Belgium, with valid proof of identity, will be admitted to the Maastricht coffeeshops. From that date, visitors from France, Luxembourg and other countries will not be admitted.
Potential Effects of the Policy?

- **Direct effect**: stop drug tourism and reduce nuisance from street dealing (municipality conducted questionnaire study and published very selective results, raw data unavailable)

- **Indirect effect**: ↑ access costs for non-DGB residents ↓ cannabis use of marginal consumer (i.e. one who hesitates)

- Although *not targeted* by the policy many of the 16,000 young individuals who study at Maastricht were thus affected!

- We do not observe smoking behavior of students but we have very good data on affected educational outcomes:

  *grades, course passing, course dropout*
Evidence of Actual Policy Effect on Legal Sales?

- We do not have ‘first stage’ but obtained data from survey on Maastricht cannabis shop visitors conducted before/after policy:

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Visitors before the restriction of legal cannabis access (September 2011)</th>
<th>Visitors after the restriction of legal cannabis access (October 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-treated nationalities:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dutch</td>
<td>16.56 %</td>
<td>20.94 %</td>
</tr>
<tr>
<td>Belgian</td>
<td>58.22 %</td>
<td>70.19 %</td>
</tr>
<tr>
<td>German</td>
<td>6.82 %</td>
<td>7.44 %</td>
</tr>
<tr>
<td>Treated nationalities:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French</td>
<td>9.90 %</td>
<td>0.29 %</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>2.12 %</td>
<td>0.04 %</td>
</tr>
<tr>
<td>Other nationality</td>
<td>6.39 %</td>
<td>1.10 %</td>
</tr>
<tr>
<td>Sample Size</td>
<td>4,955</td>
<td>4,145</td>
</tr>
</tbody>
</table>
Data: Course Grades and Student Evaluations

- All students taking Bachelor courses in the School of Business and Economics over 3 academic years: 2009/10 to 2011/12

- Observe over 58,000 course grades for 4,800 students with 53% German, 33% Dutch, 4% Belgian and 10% Non-DGB

- Teaching structure in all years is composed of 6 blocks:
  4 regular blocks (2 months) + 2 skills blocks (2 weeks)

- Additionally we make use of student course evaluation surveys (1/3 response rate) to look at the underlying mechanisms
# Policy Timing and Student Course Grades

Timing of Changes to Cannabis Access in Maastricht and Mapping to Academic Year/Period with Student Course Grades (2 on average per teaching period)

<table>
<thead>
<tr>
<th>Cannabis Access</th>
<th>All Access</th>
<th>DGB only</th>
<th>All Restricted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Periods</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Periods</td>
<td>1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calendar Year</td>
<td>2009</td>
<td>2010</td>
<td>2011</td>
</tr>
</tbody>
</table>
## Descriptives: DGB and Non-DGB Students

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>DGB</th>
<th>Non-DGB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>35.3%</td>
<td>34.8%</td>
<td>40.8%</td>
</tr>
<tr>
<td>Age</td>
<td>20.3</td>
<td>20.3</td>
<td>20.2</td>
</tr>
<tr>
<td>Number of Students</td>
<td>4,419</td>
<td>4,083</td>
<td>336</td>
</tr>
<tr>
<td><strong>Course Outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average grade</td>
<td>6.54</td>
<td>6.57</td>
<td>6.09</td>
</tr>
<tr>
<td>Passed course</td>
<td>78.9%</td>
<td>79.6%</td>
<td>70.1</td>
</tr>
<tr>
<td>Course dropout</td>
<td>9.4%</td>
<td>9.1%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Observations</td>
<td>57,903</td>
<td>53,622</td>
<td>4,281</td>
</tr>
</tbody>
</table>
Empirical Strategy: Basic Diff-in-Diff

- Adopt simple *difference in differences* approach to identify the causal effect on exam results of restricting cannabis access

\[ T = 0 \quad T = 1 \]

- Start by looking at this graphically: Common trends hold?

Other Nationalities: Non-DGB
Average Grade of DGB and Non-DGB Students

Academic Period

DGB (Left Axis)  All Other (Right Axis)

No access

Have access

DGB (Left Axis)  All Other (Right Axis)
Empirical Strategy: Enhanced Diff-in-Diff

- Econometrically, the basic diff-in-diff coefficient is $\beta$:

$$Y_{it} = \alpha + \beta(NonDGB_i \ast Restriction_t) + \gamma NonDGB_i + \delta Restriction_t + \varepsilon_{it}$$

- Add observable individual characteristics: age, gender

- For heterogeneity in course choice: # courses and course FE

- Major problem of individual heterogeneity: individual FE (!)

- Finally for temporal specificities: period FE & time trends
Main Results: Student Grades and Pass Probability

Change in Test Score for Non-DGB

Change in Pass Probability for Non-DGB
# Main Results: Student Grades and Pass Probability

<table>
<thead>
<tr>
<th>Education Outcomes</th>
<th>Grade</th>
<th>Passed</th>
<th>Dropout</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-access nationality *</td>
<td>0.092***</td>
<td>0.040***</td>
<td>-0.011</td>
</tr>
<tr>
<td>Restriction time periods</td>
<td>(0.016)</td>
<td>(0.008)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>No Access Nationality</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Restriction time periods</td>
<td>0.016</td>
<td>0.013***</td>
<td>-0.012***</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.003)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Mean of Outcome</td>
<td>NA</td>
<td>0.746</td>
<td>0.142</td>
</tr>
<tr>
<td>Effect size at Mean</td>
<td>NA</td>
<td>0.054</td>
<td>-0.077</td>
</tr>
<tr>
<td>All Controls and FEs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>52,424</td>
<td>52,424</td>
<td>57,816</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Further Results to Explore/Test Policy Effect?

1. **Subgroups:** effect different by age, gender and student ability?

2. **Spillovers:** Does the change in consumption behavior of others (e.g. teachers or classmates) affect my own performance?

3. **Placebos:** Would our results in the end just a fluke of luck and would be found in other time period or other groups?

4. **Mechanisms** through which cannabis use affects performance:
   - Evidence of THC having more impact on **numerical tasks**
   - Student evaluations: **time use** or **understanding** is affected?
Results by Sub-Groups: Gender, Age, and Ability

Change in Test Score for Non-DGB Students by Subgroup

Change in Pass Probability for Non-DGB Students by Subgroup
Externalities: Non-DGB Peers and Teacher Effects?
Robustness: Placebos in Time and Nationality

1. **Placebo in time:** Is there a similar effect one year before the actual policy?

2. **Placebo in nationality:** Effects if we pretend Belgians instead of Non-DGB treated?
Cannabis Effect? Numerical vs. Non-numerical Skills

Cannabis consumption has been shown to be worse for numerical skills!

→ Split courses by reported need for numerical skills (40%) or not (60%)
# Cannabis Effect? Student Course Evaluations

<table>
<thead>
<tr>
<th>Mechanism Category</th>
<th>Non-DGB *Restriction</th>
<th>Survey Question(s) in Course Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours Worked</td>
<td>-0.244 (0.376)</td>
<td>How many hours per week on average did you spend on self-study?</td>
</tr>
<tr>
<td>Feel</td>
<td>0.087 (0.059)</td>
<td>‘The learning materials <em>stimulated</em> me to start and keep on studying’ &amp; ‘…<em>stimulated</em> discussion with my fellow students.’</td>
</tr>
<tr>
<td>Functions Well</td>
<td>0.032 (0.064)</td>
<td>‘overall <em>functioning</em> of your tutor…’ &amp; ‘My tutorial group has <em>functioned</em> well.’</td>
</tr>
<tr>
<td>Understand Better</td>
<td>0.122* (0.064)</td>
<td>‘The lectures contributed to a better understanding…’ &amp; ‘Working in tutorial groups helped me to better <em>understand</em> the subject matters of this course’</td>
</tr>
<tr>
<td>Quality Improved</td>
<td>0.017 (0.061)</td>
<td>‘The tutor sufficiently <em>mastered</em> the course content of this course’ &amp; ‘give overall grade for the <em>quality</em> of this course’</td>
</tr>
</tbody>
</table>
Main Results - Interpretation

- The cannabis ban raised grades by 0.093 standard deviations and increased pass rate by 5.4 percent.

- These are large effects! But are they unrealistically large?
  - Same impact on college performance: good teacher, roommate, sleep…
  - Legal alcohol access estimated at -0.092 of a std in reduced form!

- Treatment effect depends on proportion of potential consumers in the underlying population.

- To get an idea on baseline consumption rates we ran a survey among UM students (N = 192) on cannabis smoking behaviour.
Main Results - Interpretation

<table>
<thead>
<tr>
<th>Cannabis Consumption</th>
<th>DGB</th>
<th>Non-DGB</th>
<th>Potentially Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never tried</td>
<td>22.32%</td>
<td>27.27%</td>
<td>No</td>
</tr>
<tr>
<td>Ever (&gt; 12 months)</td>
<td>17.86%</td>
<td>15.15%</td>
<td></td>
</tr>
<tr>
<td>Past 12 months</td>
<td>23.21%</td>
<td>24.24%</td>
<td></td>
</tr>
<tr>
<td>Past 30 days</td>
<td>11.61%</td>
<td>15.15%</td>
<td>57.6%</td>
</tr>
<tr>
<td>Past 7 days</td>
<td>25.00%</td>
<td>18.18%</td>
<td></td>
</tr>
</tbody>
</table>

- Define potentially treated as Non-DGBs who have smoked marijuana in at least past year = 58%

- Treatment effect on potential smokers (ATT):
  - Total compliance: \( \frac{0.093}{0.58} = 0.16 \text{ std.} \) & \( \frac{0.054}{0.58} = 9.3\% \) pass
  - 50% partial compliance estimated by Jacoby and Sovinsky (2013):
    \( \frac{0.093}{0.58}/0.5 = 0.32 \text{ std.} \) & \( \frac{0.054}{0.58}/0.50 = 18.6\% \) pass
Price Effect is Driving our Results?

- One final concern: restriction policy $\rightarrow$ lower demand $\rightarrow$ reduction in prices $\rightarrow$ increase smoking of Non-DGB
  - *Problem*: estimates are bias upwards as do not account for phenomenon decreasing performance of control group
  - *Solution*: check legal cannabis prices around policy. How?

- Extensive search of historical entries in online smoker forums for reports of prices in Maastricht coffee-shops

- Generate average price for 10 most popular strands and find:
  - before policy: €9.6/g
  - after policy: €9.7/g
Conclusions

- This is the first causal evidence that a change in drug access policy can have strong immediate impact on performance.

- As understanding and numerical skills are affected the most indicates that change in cannabis consumption drive results.

- Caveats: different for prohibition Vs legalization; depend on drug strength (THC NL ≈ 2xUSA); not everyone eco student!

- Still robust results lead us to conclude that cannabis access affects the probability of consumption in the short run.

- Only a small part of in societal cost-benefit analysis of drug policy decision but must be seriously taken into account.