# Delinquency, Arrest and Early School Leaving

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# Introduction

- In the US the net annual burden of crime is $1 trillion.
  - 1.6 million adults in state and federal prisons, and 61,000 juveniles in residential placement
  - 2 out of 3 adult inmates have not graduated from high school
- Two strands of literature contribute significant insights:
  - studies demonstrating that education reduces crime and incarceration in adulthood (Lochner & Moretti, 2004; Oreoplolous and Salvanes, 2009; Merlo & Wolpin, 2009)
  - studies demonstrating the trajectory leading to adult crime and incarceration starts with juvenile delinquency (Moffitt, 2006; Sampson and Laub, 2005)

# Introduction

- Taken together, they suggest that the relationship between delinquency, education and crime is:
  - dynamic, and
  - choices made in youth regarding delinquency and school leaving are pivotal for adult outcomes.
- Yet the nature of the relationship between delinquency and school leaving remains unclear.

# Background

- Previous studies on the relationship between delinquency and schooling focus on either:
  - the impact of interactions with the justice system (arrest, incarceration) on school leaving, or
  - the impact of being in school on contemporaneous arrest, reported crime, and prosecutions
- They fail to recognize that interactions with the justice system arise as a result of the decision to engage in delinquency.
- This decision is likely to impact on school leaving whether or not arrest or incarceration eventuates.

# Our Contribution

1. We investigate whether and to what extent engaging in delinquency and being arrested in youth leads to early school leaving.
   - Our approach accounts for unobserved common confounders and reverse causality in the relationships between delinquency, arrest and school leaving.
2. We combine the estimated causal effect of delinquency and arrest on school leaving with the proportion of the population affected by each to obtain their overall impact on education.
3. We investigate differential impacts of
   - income and non-income generating delinquency
   - age of onset of each type of delinquency and arrests on school leaving

# The Outline

- Conceptual Framework
- Data
- Empirical Framework
- Results
- Sensitivity Analyses
- Summary and concluding remarks

# Conceptual Framework

- We draw on the life cycle model of human capital investment, work and crime developed by Lochner (2004)
  - individuals allocate time in each period so as to maximise expected lifetime earnings (from crime and work)
  - the decision to engage in crime depends on the determinants of the returns to crime: accumulated criminal stock (experience), and his endowment of criminal ability
  - engaging in crime builds criminal capital, which increases the expected future monetary returns to crime relative to education
  - early school leaving is then the consequence of falling expected relative returns to education.
- This model predicts:
  - effect of income generating crime on school leaving $>$ the effect of non-income generating crime
  - effect of early initiation into delinquency on school leaving $>$ effect of later onset

# Data

National Longitudinal Survey of Youth 1997 (NLSY97)

- Representative panel study of youths residing in the U.S.
- Round 1: 1997 $\rightarrow$ respondents aged 12 – 18
- Continue to interview annually
- Round 13: 2009 $\rightarrow$ respondents aged 24 – 30 (84% reinterviewed)
- 4,488 males in our sample

# Outcomes

- Age at which a respondent first leaves school
  - Defined as primary, secondary or tertiary education
- Age at first arrest
- Age at which a respondent first engages in delinquency
  - Income generating delinquency
    - stealing something worth $50 or more
    - other property crimes
    - selling drugs
  - Non-income generating delinquency:
    - attacking someone (e.g. being in a fight)
    - destroying property

Table: **Means of variables**

| Outcomes | |
|---|---|
| **School Leaving** | |
| % leave school (during observation period) | 94.4 |
| Age first left (conditional on leaving) | 19.5 |
| **Delinquency** | |
| % engaged in delinquency | 67.9 |
| Age of initiation (conditional on starting) | 12.9 |
| **Income Delinquency** | |
| % engaged in income delinquency | 43.3 |
| Age of initiation (conditional on starting) | 14.8 |
| **Non-income Delinquency** | |
| % engaged in non-income delinquency | 61.5 |
| Age of initiation (conditional on starting) | 12.9 |
| **Arrest** | |
| % arrested | 43.7 |
| Age of first arrest (conditional on having been arrested) | 17.4 |
| Observations | 4,488 |

Table: **Controls**

| | |
|---|---|
| **Siblings** | **Year of Birth** |
| Number of Younger Siblings | 1980 |
| Number of Older Siblings | 1981 |
| **Parents Present in the Household** | 1982 |
| Father Present | 1983 |
| Mother Present | 1984 |
| **Race** | **Geographic Variables** |
| Black | Suburbs |
| Hispanic | City |
| Non-Black/Non-Hispanic | Rural |
| **School Quality & Puberty** | Northeast |
| Private/Parochial School | North |
| Puberty $<$ 12 years old | South |
| **CAT-ASVAB (ability) score** | West |
| **Parent Characteristics** | |
| Parent education | |
| Teen mother at respondent's birth | |
| Parent very religious | |

Figure: Transition rates for first delinquency, arrest and school leaving by age

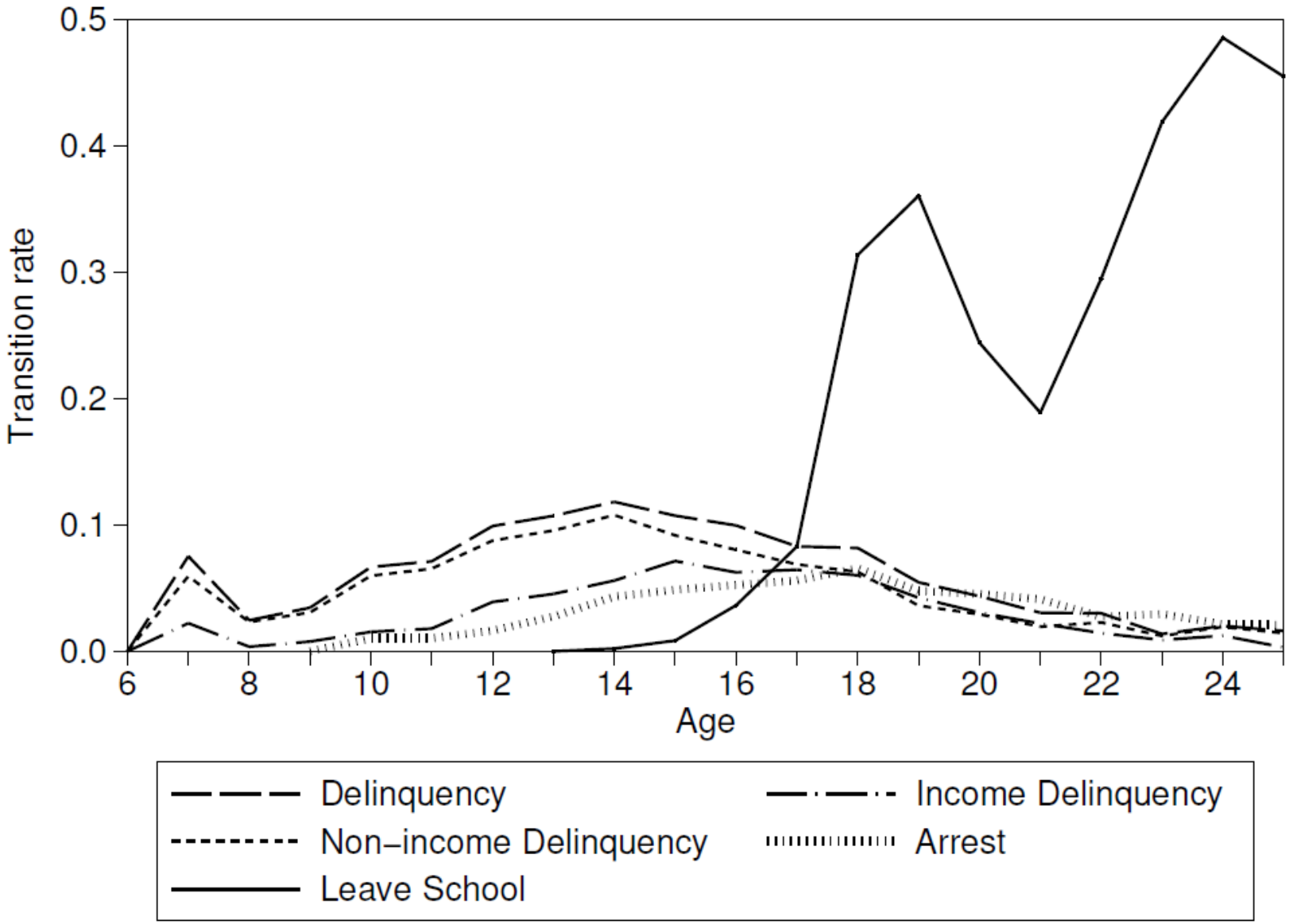


Figure: Cumulative starting probabilities for first delinquency, arrest and school leaving by age

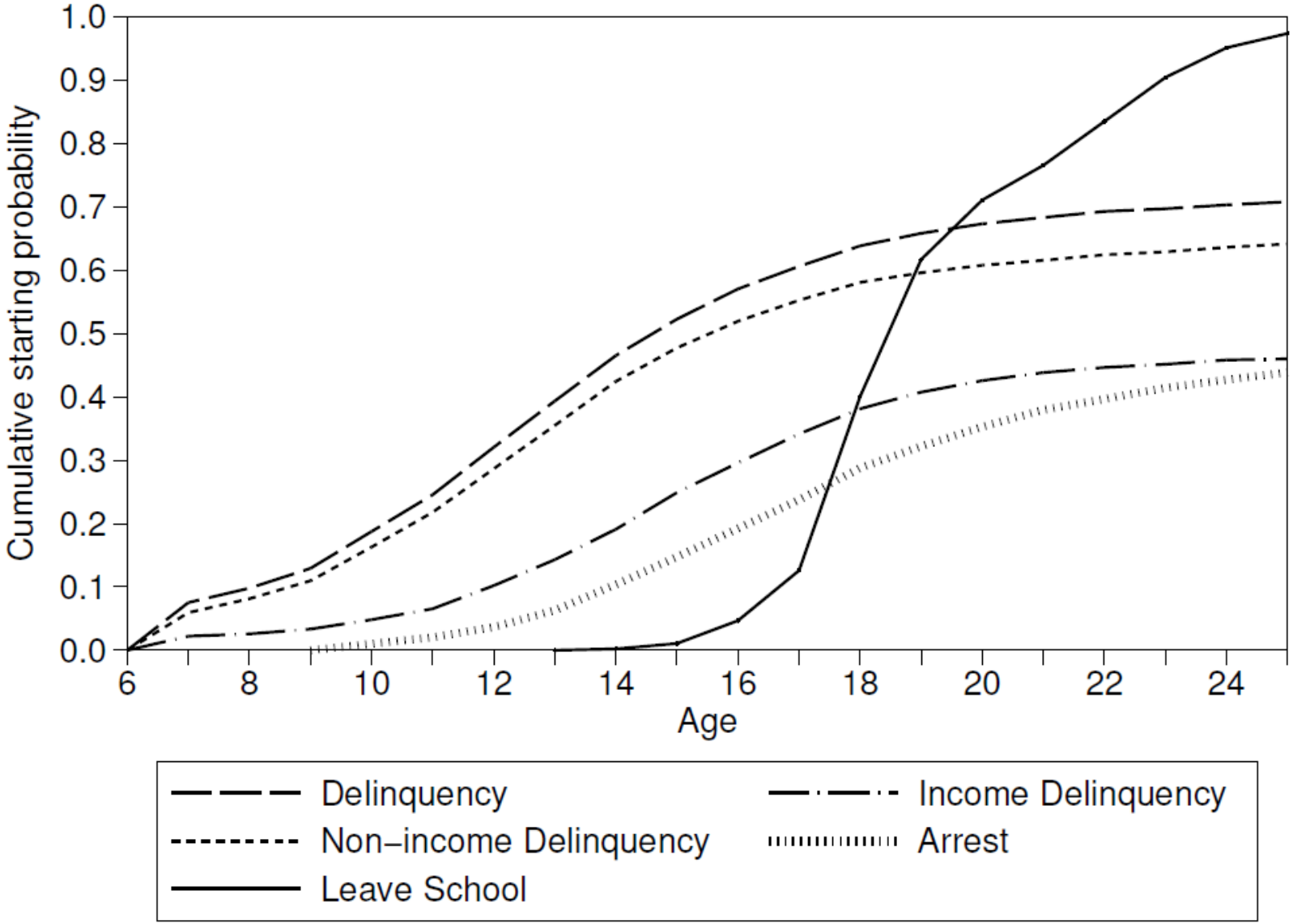


Table: **Timing of events (percentages)**

| | Delinquency | | | | | | Arrest | |
|---|---|---|---|---|---|---|---|---|
| Order of events | Any | | Income | | Non-income | | Any | |
| Delinquency/arrest, school leaving | 2811 | (62.7) | 1650 | (36.8) | 2548 | (56.8) | 1206 | (26.8) |
| School leaving, delinquency/arrest | 141 | (3.1) | 180 | (4.0) | 131 | (2.9) | 572 | (12.8) |
| Delinquency/arrest = school leaving | 94 | (2.1) | 114 | (2.5) | 81 | (1.8) | 182 | (4.1) |
| No delinquency/arrest | 1442 | (32.1) | 2544 | (56.7) | 1728 | (38.5) | 2528 | (56.3) |
| Total | 4488 | (100) | 4488 | (100) | 4488 | (100) | 4488 | (100) |

# Empirical Framework

- Primary objective
  - What is the impact of delinquency and arrest on school leaving
- Strategy
  - MMPH model in which we jointly model the transitions into delinquency, arrest and school leaving as a system.
- Baseline specification
  - both delinquency and arrest affect school leaving
  - unobserved heterogeneity terms in the three processes are correlated
- Sensitivity analysis
  - additionally permit school leaving to effect delinquency and arrest

# Identification

- Proof of the identification of the treatment effect in the MMPH model is provided by Abbring and Van den Berg (2003)
- Identification is achieved through the order in which events occur
  - eg. the timing of delinquency initiation relative to school leaving
- No need to rely on:
  - exclusion restrictions
  - conditional independence
  - parametric functional form assumptions for unobserved heterogeneity
  - multiple observations on the same individual

# Empirical Framework: School leaving & arrest

- The hazard rate for school leaving at time $t$ is assumed be the mixed proportional hazard:

$$\theta_s(t|x, t_a, v) \quad = \quad \lambda_s(t) \exp(x'\beta_s + \delta_a I(t_a < t)).exp(v) \tag{1}$$

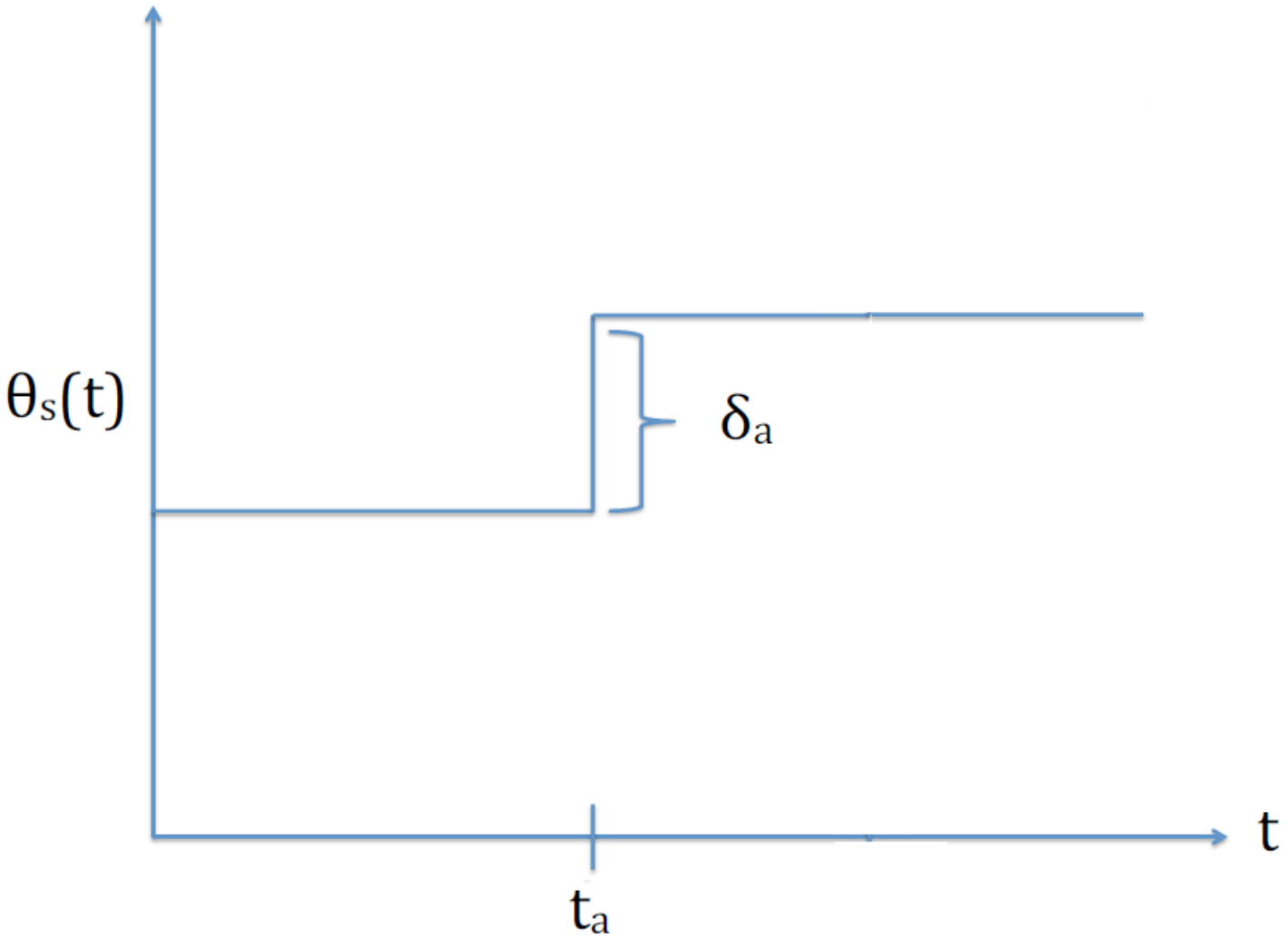
  - $\lambda_s(t)$ – duration dependence
  - $x$ – observable characteristics
  - $t_a$ – the time at which an individual is first arrested
  - $I(t_a < t)$=1 if the individual is first arrested before time $t$
  - $v$ – unobservable characteristics (allows for discrete types)

- The conditional density function for the completed durations until the individual leaves school:

$$f_s(t|x, t_a, v) = \theta_s(t|x, t_a, v) \exp\left(-\int_0^t \theta_s(z|x, t_a, v)dz\right) \tag{2}$$

- Incomplete durations are treated as right censored.

Figure: Effect of arrest on the transition rate for school leaving



# Empirical Framework: School leaving & arrest

- The hazard rate for arrest at time $t$:

$$\theta_a(t|x,\varepsilon) \quad = \quad \lambda_a(t)\exp(x\,\beta_a).exp(\varepsilon) \tag{3}$$

  - $\lambda_a(t)$ – duration dependence
  - $x$ – observable characteristics
  - $\varepsilon$ – unobservable characteristics

- The conditional density function for the completed durations until an individual's first arrest:

$$f_a(t|x,t_s,u) = \theta_a(t|x,\varepsilon)\exp \quad - \int_0^t \theta_a(z|x,\varepsilon)dz \tag{4}$$

- Incomplete durations are treated as right censored.

# Empirical Framework: School leaving & arrest

- Correlation may exists between
  - $v$, unobserved heterogeneity entering the hazard rate for school leaving,
  - $\varepsilon$, unobserved heterogeneity entering the hazard rate for arrest.
- It is accounted for by specifying $(v, \varepsilon)$ as drawn from a discrete joint distribution function, $G(v, \varepsilon)$

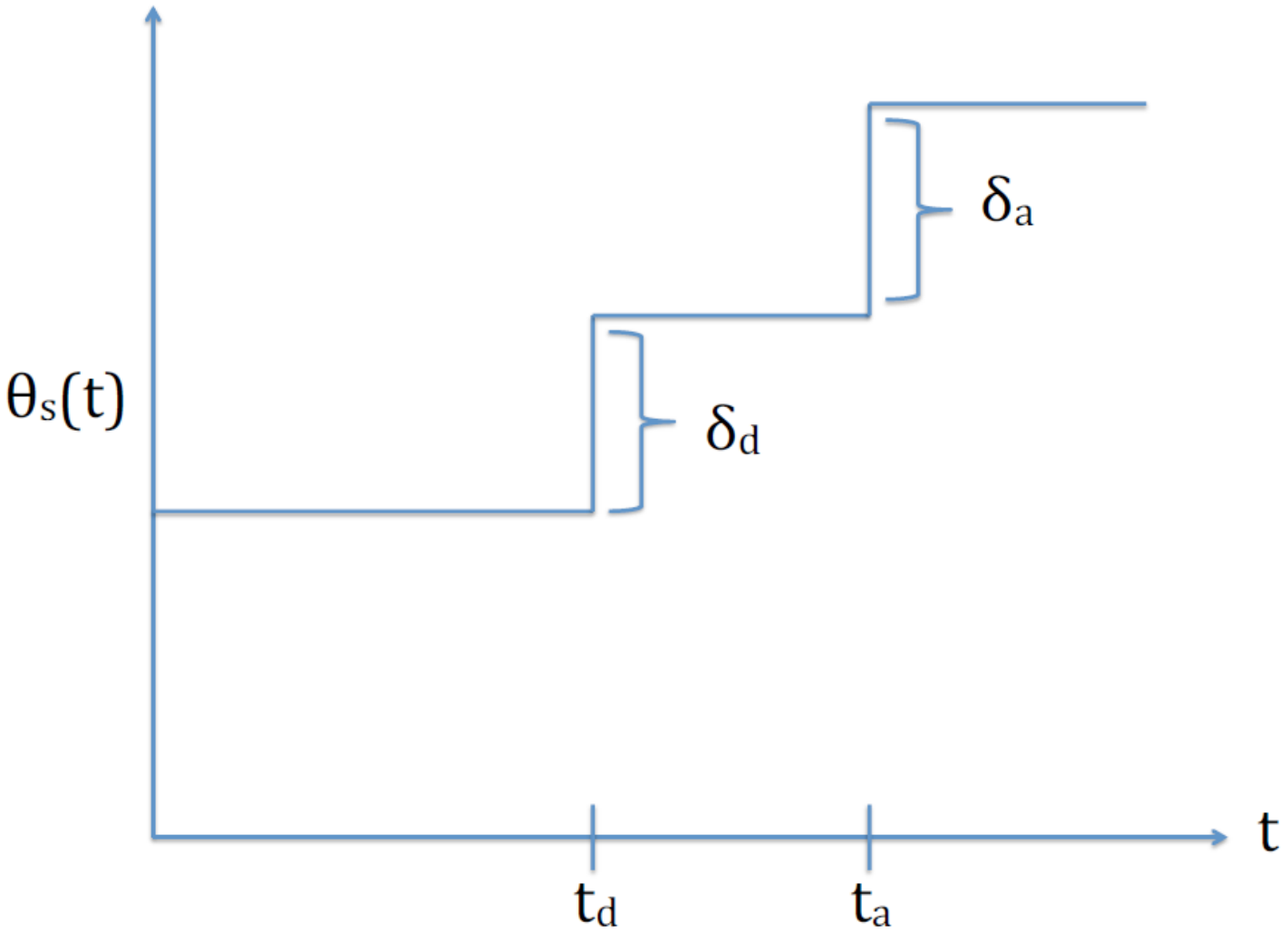
$$\Pr(v = v_1, \varepsilon = \varepsilon_1) = p_1 \qquad \Pr(v = v_1, \varepsilon = \varepsilon_2) = p_2$$
$$\Pr(v = v_2, \varepsilon = \varepsilon_1) = p_3 \qquad \Pr(v = v_2, \varepsilon = \varepsilon_2) = p_4$$

where $0 \leq p_j \leq 1$ for $j = 1, ..., 4$

- Intergrating out the unobserved heterogeneity leads to the following **joint density function** for $t_s$ and $t_a$ conditional on $x$:

$$h_{s,a}(t_s, t_a|x) = \int_v \int_\varepsilon f_s(t|x, t_a, v) f_a(t|x, \varepsilon) dG(v, \varepsilon) \tag{5}$$

Figure: Effect of arrest & delinquency on school leaving



# Outline of Results

- Preliminary results: Effect of Arrest on School leaving
  - bivariate MPH model
- Baseline analysis: Effect of Delinquency & Arrest on School leaving
  - trivariate MPH model
- Sensitivity analysis:
  - reverse causality
  - effect of delinquency on arrest
  - differential effects of income and non-income generating delinquency
  - differential effects of age of onset of income and non-income generating delinquency

Table: **Bivariate hazard model: arrest and school leaving**

| | Arrest | | School Leaving | |
|---|---|---|---|---|
| **(a) Correlated unobserved heterogeneity** | | | | |
| **Effect Arrest** | – | | 0.42 | (8.7)*** |
| **Distribution of unobserved heterogeneity** | | | | |
| Masspoints: $u_1, v_1$ | -3.34 | (11.7)*** | -5.39 | (16.1)*** |
| $u_2, v_2$ | -1.83 | (6.1)*** | -1.76 | (15.1)*** |
| Logit parameters: $\alpha_1$ | | 1.61 | (4.3)*** | |
| $\alpha_2$ | | -2.87 | (1.1) | |
| $\alpha_3$ | | 1.35 | (5.3)*** | |
| $-$Loglikelihood | | 16782.1 | | |
| **(b) Independent unobserved heterogeneity** | | | | |
| **Effect Arrest** | – | | 0.60 | (14.3)*** |
| $-$Loglikelihood | 8126.7 | | 8667.0 | |
| LR test statistic | | 23.2** | | |

Absolute t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

# Interpretation: Arrest and school leaving

- The unobserved heterogeneity terms are correlated
- We identify 3 out of 4 potential types:
  - high susceptibility for school leaving and arrest (51%)
  - high susceptibility for school leaving, low susceptibility for arrest (39%)
  - low susceptibility for school leaving and arrest (10%)
- After accounting for correlated unobserved heterogeneity:
  - arrest increases the school leaving rate by 52%
- Failing to account for correlation in unobserved heterogeneity:
  - arrest increases the school leaving rate by 82%
- This over-statement of the effect of arrest indicates a positive correlation in susceptibilities for school leaving and arrest.
- Our results are consistent with previous studies

Table: **Trivariate hazard model: delinquency, arrest and school leaving**

| | Delinquency | | Arrest | | School Leaving | |
|---|---|---|---|---|---|---|
| **(a) Correlated unobserved heterogeneity** | | | | | | |
| **Effect Delinquency** | – | | – | | 0.27 | (5.5)*** |
| **Effect Arrest** | – | | – | | 0.45 | (9.0)*** |
| **Unobserved heterogeneity** | | | | | | |
| Constant: $u_1, v_1, \varepsilon_1$ | -1.56 | (9.2)*** | -2.83 | (11.5)*** | -5.54 | (16.3)*** |
| $u_2, v_2, \varepsilon_2$ | -2.33 | (14.3)*** | -2.52 | (20.6)*** | -1.86 | (14.5)*** |
| $\alpha_1$ | | | 1.88 | (9.0)*** | | |
| $\alpha_2$ | | | 1.49 | (6.2)*** | | |
| $\alpha_3$ | | | -1.09 | (3.0)*** | | |
| $\alpha_4$ | | | -0.50 | (1.5) | | |
| $\alpha_5$ | | | $-\infty$ | | | |
| $\alpha_6$ | | | 2.19 | (10.3)*** | | |
| $\alpha_7$ | | | $-\infty$ | | | |
| $-$Loglikelihood | | | 27087.0 | | | |
| **(b) Independent unobserved heterogeneity** | | | | | | |
| **Effect Delinquency** | – | | – | | 0.28 | (7.1)*** |
| **Effect Arrest** | – | | – | | 0.52 | (12.0)*** |
| $-$Loglikelihood | 10589.6 | | 8126.7 | | 8642.0 | |
| LR test statistic | | | 542.6** | | | |

Absolute t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

# Interpretation: Delinquency, arrest and school leaving

- The unobserved heterogeneity terms are correlated
- We identify 6 out of 8 potential types:
  - high susceptibility for school leaving, low susceptibility for arrest & delinquency (41%)
  - high susceptibility for school leaving, arrest & delinquency (30%)
  - high susceptibility for school leaving and delinquency, low susceptibility for arrest (20%)
- After accounting for correlated unobserved heterogeneity:
  - delinquency increases the school leaving rate by 31%
  - arrest increases the school leaving rate by 57%
  - The effect of arrest on school leaving is twice the size of the effect of delinquency.
- Failing to account for correlation in unobserved heterogeneity:
  - delinquency increases the school leaving rate by 32%
  - arrest increases the school leaving rate by 68%
  - This over-statement of the effects indicates a positive correlation in unobserved heterogeneities.

# Outline of Results

- Preliminary results: Effect of Arrest on School leaving
  - bivariate MPH model
- Baseline analysis: Effect of Delinquency & Arrest on School leaving
  - trivariate MPH model
- Sensitivity analysis:
  - reverse causality
  - effect of delinquency on arrest
  - differential effects of income and non-income generating delinquency
  - differential effects of age of onset of income and non-income generating delinquency

## Table: **Sensitivity**

| | Delinquency | | Arrest | | School Leaving | |
|---|---|---|---|---|---|---|
| **(a) Accounting for Reverse Causality** | | | | | | |
| Effect Delinquency | – | | – | | 0.27 | (5.6)*** |
| Effect Arrest | – | | – | | 0.48 | (9.5)*** |
| Effect School Leaving $\leq$ age 17 | 0.14 | (0.6) | 0.97 | (7.6)*** | | – |
| Effect School Leaving at age 18 or 19 | 0.18 | (1.0) | 0.36 | (3.1)*** | | – |
| Effect School Leaving $\geq$ age 20 | -0.17 | (0.4) | 0.14 | (0.9) | | – |
| $-$Loglikelihood | | | 27058.8 | | | |
| **(b) Accounting for Effect of Delinquency on arrest** | | | | | | |
| Effect Delinquency | – | | – | | 0.23 | (4.5)*** |
| Effect Arrest | – | | – | | 0.41 | (8.0)*** |
| Initiate delinquency $\leq$ age 15 | – | | 0.94 | (5.6)*** | | – |
| Initiate delinquency at age 16 or 17 | – | | 0.41 | (2.1)** | | – |
| No delinquency | – | | -1.92 | (10.9)*** | | – |
| $-$Loglikelihood | | | 27030.1 | | | |

# Interpretation: Reverse causality

- We distinguish between early (by age 17), mid (aged 18 or 19) and late (after age 19) school leaving, finding
  - neither early, mid nor late school leaving effects the onset of delinquency
  - late school leaving has no effect on the onset of arrest
  - early school leaving increases the transition rate into first arrest by 164%
  - mid school leaving increases the transition rate into first arrest by 43%
- The effect of early school leaving on arrest appears to work via the intensive margin of delinquency, rather than the extensive margin.
- Accounting for reverse causality has
  - no impact on the estimated effect of delinquency on school leaving,and
  - little effect on the estimated effect of arrest on school leaving.

# Interpretation: The Effect of Delinquency on Arrest

- We distinguish between the effect of early (by age 15), mid (16 or 17) and late (age 18 or older), and no onset of delinquency on arrest, finding
  - early the onset of delinquency increases the transition rate into arrest by 156% compared to late onset
  - mid onset of delinquency increases the transition rate into arrest by 51% compared to late onset
  - those who are not observed to initiate delinquency are 85% less likely to be arrested compared to those who initiate at age 18 or later.
- Accounting for the effect of delinquency on arrest leads to a small reduction in the magnitude of the estimated effects of delinquency and arrest on school leaving, but the main findings are unaltered.

# Income versus non-income generating delinquency

- The human capital model predicts:
  - income generating crime has a larger effect on school leaving than non-income generating crime
  - early onset income generating crime has a larger effect on school leaving than later onset income generating crime

Table: **Multivariate hazard model: school leaving, arrest, income and non-income delinquency**

| | Income Delinquency | Non-Income Delinquency | Arrest | School Leaving | |
|---|---|---|---|---|---|
| **(a) Correlated unobserved heterogeneity** | | | | | |
| **Effect Income Delinquency** | – | – | | 0.34 | (6.7)*** |
| **Effect Non-income Delinquency** | – | – | | 0.09 | (1.8)* |
| **Effect Arrest** | – | – | – | 0.40 | (7.7)*** |
| −Loglikelihood | | 33913.7 | | | |
| **(b) Differential Effects by Age** | | | | | |
| **Effect Income Delinquency** | | | | | |
| Initiate Income Delinquency $\leq 15$ | – | – | – | 0.37 | (6.4)*** |
| Initiate Income Delinquency aged 16 or 17 | – | – | – | 0.29 | (3.6)*** |
| Initiate Income Delinquency $\geq 18$ | – | – | – | 0.32 | (3.0)*** |
| **Effect Non-income Delinquency** | | | | | |
| Initiate Non-income Delinquency $\leq 15$ | – | – | – | 0.08 | (1.4) |
| Initiate Non-income Delinquency aged 16 or 17 | – | – | – | 0.01 | (0.1) |
| Initiate Non-income Delinquency $\geq 18$ | – | – | – | 0.27 | (2.0)*** |
| **Effect Arrest** | | | | | |
| First Arrest $\leq 15$ | – | – | – | 0.54 | (8.8)*** |
| First Arrest aged 16 or 17 | – | – | – | 0.32 | (4.3)*** |
| First Arrest $\geq 18$ | – | – | – | 0.14 | (1.4) |
| −Loglikelihood | | 33903.2 | | | |

Absolute t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

# Interpretation: The Effect of Income and Non-income generating Delinquency on School Leaving

- We distinguish between the effect of income and non-income generating delinquency on school leaving, finding
  - income generating delinquency increases the transition rate out of school by 41%
  - non-income generating delinquency increases the transition rate out of school by 10%
  - arrest increases the transition rate out of school by 49%
- The effect of delinquency on school leaving is driven by income generating delinquency, and the magnitude of its impact is similar to that of arrest.

# Interpretation: The Effect of Income and Non-income generating Delinquency on School Leaving

- We distinguish between the effect of early (by age 15), mid (16 or 17) and late (age 18 or older) onset of income and non-income generating delinquency and arrest, finding
  - Income generating delinquency:
    - early onset has a larger effect on the rate of leaving school (45% increase) than mid (33% increase) or late (38% increase) onset
  - Non-income generating delinquency:
    - only late onset has a significant effect, increasing school leaving by 30%.
  - Arrest:
    - early onset has a larger effect on the rate of leaving school (72% increase) than mid (38% increase) or late (no significant increase) onset
- The evidence for income generating delinquency is consistent with a human capital accumulation story.
- The evidence for non-income generating delinquency suggests salience or critical life-cycle stages.

# Simulations

Table: **Effect on cumulative probability of school leaving for a reference individual who is susceptible to early school leaving; simulations (%)**

| Age | No delinquency | Delinquent at 16 | | Delinquent at 14 | |
|---|---|---|---|---|---|
| | No arrest | No arrest | Arrest at 17 | No arrest | Arrest at 15 |
| 14 | 0 | 0 | 0 | 0 | 0 |
| 15 | 1 | 1 | 1 | 1 | 1 |
| 16 | 4 | 4 | 4 | 5 | 7 |
| 17 | 10 | 12 | 12 | 13 | 19 |
| 18 | 35 | 42 | 55 | 43 | 58 |
| 19 | 60 | 69 | 83 | 69 | 84 |
| 20 | 73 | 81 | 92 | 82 | 93 |
| 21 | 81 | 88 | 96 | 89 | 97 |
| 25 | 100 | 100 | 100 | 100 | 100 |

# Magnitude of the of delinquency and arrest on school leaving

- Comparing columns 2 and 3 with column 1
  - The probability of leaving school at age 18 is:
    - 35% if not delinquent or arrested,
    - 42% if delinquent at age 16 but not arrested
    - 55% if delinquent at age 16 and arrested at age 17
  - Arrest has roughly twice the effect of delinquency
  - The percentage of the sample that are still in school at age 17 and
    - ever been delinquent but not arrested is 36.3%
    - ever arrested is 17.2%
  - The sample proportion in school, delinquent but never arrested is twice the proportion in school and arrested
- So the population impact of delinquency in terms of school leaving is similar to that of arrest

# Discussion

- Theory suggests that engaging in delinquent behaviour will lead to early school leaving via the accumulation of criminal capital stock even in the absence of arrest or incarceration.
- We empirically investigate this prediction using longitudinal data on males from the NLSY97 and a MMPH approach.
- Our key findings are:
  - after accounting for common unobserved confounders and reverse causality, both arrest and delinquency increase the school leaving rate;
  - on the basis of these estimates, we calculate that the societal impact of delinquency and arrest are similar.
- More detailed analyses reveals
  - the effect of delinquency on school leaving is driven by offences that are income generating, and
  - early initiation into income generating delinquency has a larger effect on school leaving than later initiation into delinquency

  as predicted by the human capital model of crime.

# Discussion

Policy implications:

- We have found that there are a large group of delinquents who avoid arrest whose reduction in schooling is equally as important as for those who are arrested
- To focus on individuals who interact with the criminal justice system is, therefore, to miss half the problem
- Although undetected by the law, delinquents who avoid arrest are likely to come to the attention of teachers and principals
    - School-based prevention programs:
        - eg. Becoming a Man (Heller et al, 2013)

Thank you

# Table: **Age Pattern**

| | Left School | | Committed Delinquency | | Arrested | |
|---|---|---|---|---|---|---|
| Age | No | Yes | No | Yes | No | Yes |
| 7 | 0 | 0 | 0 | 338 | 0 | 0 |
| 8 | 0 | 0 | 0 | 102 | 0 | 0 |
| 9 | 0 | 0 | 0 | 140 | 0 | 0 |
| 10 | 0 | 0 | 0 | 261 | 0 | 46 |
| 11 | 0 | 0 | 0 | 260 | 0 | 46 |
| 12 | 0 | 0 | 3 | 336 | 2 | 72 |
| 13 | 0 | 0 | 8 | 327 | 4 | 119 |
| 14 | 26 | 10 | 27 | 321 | 15 | 182 |
| 15 | 21 | 38 | 25 | 254 | 20 | 195 |
| 16 | 26 | 160 | 24 | 208 | 23 | 199 |
| 17 | 38 | 349 | 38 | 154 | 31 | 200 |
| 18 | 26 | 1,199 | 44 | 136 | 28 | 219 |
| 19 | 18 | 936 | 210 | 81 | 32 | 148 |
| 20 | 12 | 401 | 223 | 52 | 37 | 132 |
| 21 | 13 | 232 | 191 | 28 | 33 | 113 |
| 22 | 13 | 290 | 167 | 21 | 55 | 71 |
| 23 | 8 | 285 | 155 | 7 | 57 | 73 |
| 24 | 10 | 188 | 30 | 7 | 110 | 50 |
| 25 | 19 | 86 | 63 | 5 | 467 | 45 |
| 26 | 13 | 39 | 78 | 4 | 459 | 26 |
| 27 | 6 | 14 | 54 | 0 | 439 | 15 |
| 28 | 3 | 5 | 52 | 1 | 404 | 6 |
| 29 | 1 | 3 | 49 | 3 | 309 | 3 |
| 30 | 0 | 0 | 1 | 0 | 3 | 0 |
| Total | 253 | 4,235 | 1,442 | 3,046 | 2,528 | 1,960 |
| | 4,488 | | 4,488 | | 4,488 | |

Table: **Means of variables**

| Explanators | |
|---|---|
| **Siblings** | |
| Number of Younger Siblings | 1.19 |
| Number of Older Siblings | 0.97 |
| **Parents Present in the Household** | |
| Father Present | 0.69 |
| Mother Present | 0.92 |
| **Parent Education**[a] | |
| Father: $<$ high school graduate | 0.24 |
| Father: high school graduate | 0.39 |
| Father: $>$HS & $<$college grad | 0.17 |
| Father: $\geq$college graduate | 0.20 |
| Mother: $<$ high school graduate | 0.23 |
| Mother: high school graduate | 0.37 |
| Mother: $>$HS & $<$college grad | 0.22 |
| Mother: $\geq$college graduate | 0.18 |
| **Parent Characteristics**[a] | |
| Mother's Age at Respondent's Birth: $\leq$19 | 0.13 |
| Parent very religious | 0.36 |
| Observations | 4,488 |

[a] $N < 4,488$

## Table: **Means of variables**

| Explanators | |
|---|---|
| **Ability**[a] | |
| Standardised CAT-ASVAB score | 0.00 |
| **Race** | |
| Black | 0.25 |
| Hispanic | 0.21 |
| Non-Black/Non-Hispanic | 0.54 |
| **School Quality and Puberty** | |
| Private/Parochial School | 0.06 |
| Puberty $<$ age 12 | 0.26 |
| **Year of Birth** | |
| Year of Birth: 1980 | 0.19 |
| Year of Birth: 1981 | 0.21 |
| Year of Birth: 1982 | 0.21 |
| Year of Birth: 1983 | 0.20 |
| Year of Birth: 1984 | 0.20 |
| **Geographic Variables** | |
| Suburbs | 0.36 |
| City | 0.31 |
| Rural | 0.33 |
| Northeast | 0.18 |
| North | 0.23 |
| South | 0.37 |
| West | 0.22 |
| Observations | 4,488 |

[a] $N < 4,488$

# Identification Assumptions

$$\theta(t|x, v) = \phi(x).\lambda(t).v \tag{6}$$

- The MMPH is non-parametrically identified if:
  - $\lambda(t)$ is continuous and positive on $[0; \infty)$
  - $g(v)$ is non-degenerate and $E(v) < \infty$
  - $\phi(x) > 0$ for all $x$
  - $v$ is time-invariant and independently distributed of $x$
  - Observed explanatory variables $x$ are linearly independent and have sufficient variation

# Empirical Framework: School leaving, delinquency & arrest

- The hazard rate for delinquency at time $t$:

$$\theta_d(t|x,u) \quad = \quad \lambda_d(t)\exp(x\,\beta_d + u) \tag{7}$$

- The conditional density function for the completed durations until the onset of delinquent behaviour:

$$f_d(t|x,u) = \theta_d(t|x,u)\exp \quad - \int_0^t \theta_d(z|x,u)dz \tag{8}$$

- Potential correlation in unobserved heterogeneity terms affecting school leaving, delinquency and arrest is accounted for by specifying $(v,u,\varepsilon)$ as drawn from a discrete joint distribution function, $G(v,u,\varepsilon)$
- Intergrating out the unobserved heterogeneity leads to the following **joint density function** for $t_d$, $t_s$, and $t_a$ conditional on $x$:

$$h_{d,s,a}(t_d,t_s,t_a|x) = \sum_u \sum_v \sum_\varepsilon f_s(t|x,t_d,t_a,v)f_d(t|x,t_s,u)f_a(t|x,t_s,\varepsilon)dG(u,v,\varepsilon) \tag{9}$$

# Empirical Framework: School leaving, delinquency & arrest

- Suppose there exist 2 types of individuals (high susceptibility, low susceptibility) for school leaving, delinquency and arrest
- This implies up to eight point so support (types of individuals) in the joint distribution fo unobserved heterogeneity with the following probabilities:

$$\Pr(u = u_1, v = v_1, \varepsilon = \varepsilon_1) = p_1 \qquad \Pr(u = u_1, v = v_1, \varepsilon = \varepsilon_2) = p_2$$
$$\Pr(u = u_1, v = v_2, \varepsilon = \varepsilon_1) = p_3 \qquad \Pr(u = u_1, v = v_2, \varepsilon = \varepsilon_2) = p_4$$
$$\Pr(u = u_2, v = v_1, \varepsilon = \varepsilon_1) = p_5 \qquad \Pr(u = u_2, v = v_1, \varepsilon = \varepsilon_2) = p_6$$
$$\Pr(u = u_2, v = v_2, \varepsilon = \varepsilon_1) = p_7 \qquad \Pr(u = u_2, v = v_2, \varepsilon = \varepsilon_2) = p_8$$

where $0 \leq p_j \leq 1$ for $j = 1, ..., 8$

- We model these probabilities using a multinomial logit specification:

$$p_j = \frac{\exp(\alpha_j)}{\sum_j \exp(\alpha_j)} \qquad \text{for } j = 1, ..., 8$$