



Officer Features and Shooting Risk

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G. Ridgeway (2020). “The Role of Individual Officer Characteristics in Police Shootings,” *ANNALS of the American Academy of Political and Social Science* 687(1):58-66

Confounding Chronically Hindered Connecting Officer Features and Risk

“black officers are not prominent in the units of the Police Department which see the most shooting action”

Geller & Karales (1981)

Confounding Chronically Hindered Connecting Officer Features and Risk

the age/shooting risk relationship is “an artifact of age-related variations in assignment and in exposure to potential shooting situations”

Fyfe (1988)

Confounding Chronically Hindered Connecting Officer Features and Risk

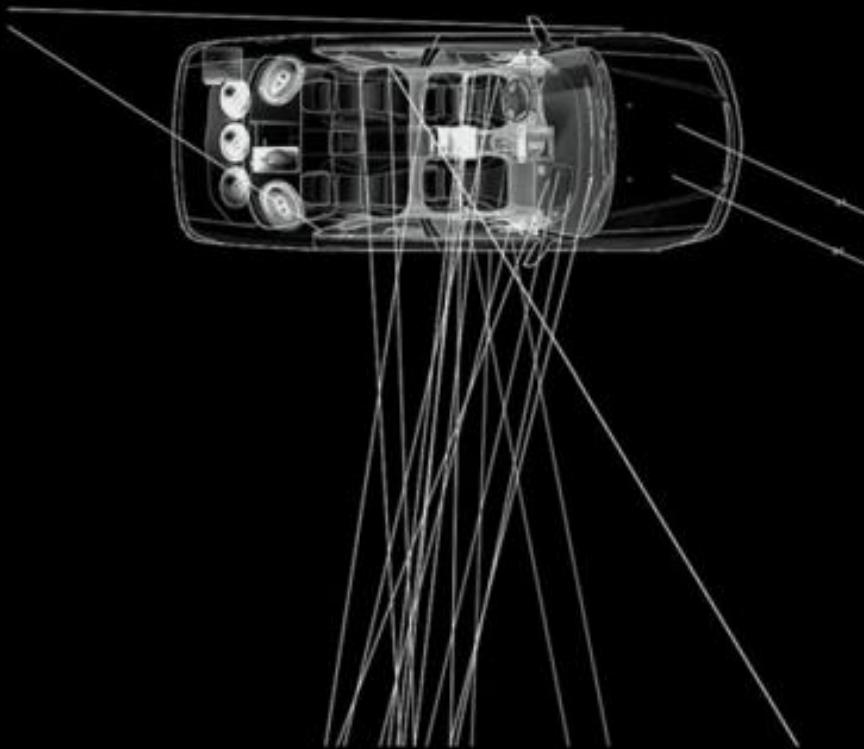
“based on an officer’s rank, time on the job, age, and gender, he or she may have been less active, assigned to areas with lower crime rates, or working in a position that did not have frequent contact with citizens”

McElvain and Kposowa (2008)

Officer Van Dyke Fired 16 Rounds
Officer Walsh Holstered His Firearm



Five Officers Discharged 50 Rounds, Killing Sean Bell in 2006



- Detective Oliver, age 35, white, 31 rounds
- Detective Isnora, age 28, black, 11 rounds
- Detective Cooper, age 39, black, 4 rounds
- Officer Carey, age 26, white, 3 rounds
- Detective Headley, age 35, black, 1 round

Matching Officers on the Same Shooting Scene Eliminates Sources of Confounding

- Laquan McDonald shooting
 - No confounding by assignment or opportunity
 - On the same scene, facing the same subject, operating in the same organization and environment
 - Differ in their own features and chance variation in space and positioning
- Sean Bell shooting
 - Surrounding the same vehicle, in the same neighborhood, at the same time

Link Shooting, Environment, Officers

- Probability of shooting, R , for an officer with features \mathbf{x} in an environment with features \mathbf{z}

$$\log \frac{P(R = 1|\mathbf{x}, \mathbf{z})}{P(R = 0|\mathbf{x}, \mathbf{z})} = h(\mathbf{z}) + \beta' \mathbf{x}$$

- \mathbf{z} includes suspect features, time, place, ...
- $h(\mathbf{z})$ is a large negative number for almost all environments
- \mathbf{x} includes officer age, race, sex, prior involvement in shootings, complaints, awards, assignment, ...
- $\exp(\beta_j)$ indicates how much a unit change in x_j increases the odds of the officer shooting

Link Shooting, Environment, Officers

- Probability of shooting – logistic regression

$$\log \frac{P(R = 1 | \mathbf{x}, \mathbf{z})}{P(R = 0 | \mathbf{x}, \mathbf{z})} = h(\mathbf{z}) + \beta' \mathbf{x}$$

- Probability of shooting R rounds – Poisson

$$\log P(R = r | \mathbf{x}, \mathbf{z}) =$$

$$r(h(\mathbf{z}) + \beta' \mathbf{x}) - \exp(h(\mathbf{z}) + \beta' \mathbf{x}) - \log r!$$

Conditional Likelihood Provides Consistent Estimates from Shooting Data Alone

- A randomly selected time and place contributes to the likelihood
$$\log L_i(h, \beta) = \log P(R_1 = r_1, \dots, R_n = r_n | \mathbf{x}_1, \dots, \mathbf{x}_n, \mathbf{z}, h, \beta)$$
- $S(R_1, \dots, R_n) = R_1 + \dots + R_n$ is sufficient for $h(\mathbf{z}_i)$
 - Number of shooters
 - Total rounds fired

$$\begin{aligned}\log L_i(h, \beta) &= \log P(S(R_1, \dots, R_n) | \mathbf{x}_1, \dots, \mathbf{x}_n, \mathbf{z}, h, \beta) + \\ &\quad \log P(R_1 = r_1, \dots, R_n = r_n | S(R_1, \dots, R_n), \mathbf{x}_1, \dots, \mathbf{x}_n, \beta) \\ &= \text{collective group contribution} + \\ &\quad \text{individual officer contribution}\end{aligned}$$

- Use the conditional likelihood, only the individual officer contribution to the likelihood

Conditional Likelihood Does Not Use, Need, Involve $h(z)$

- For the decision to shoot, the contribution of a shooting to the conditional likelihood is

$$\frac{e^{r_1\beta' \mathbf{x}_1 + \dots + r_n\beta' \mathbf{x}_n}}{\sum_{\rho_i \in \{0,1\}, \sum \rho_i = \sum r_i} e^{\rho_1\beta' \mathbf{x}_1 + \dots + \rho_n\beta' \mathbf{x}_n}}$$

The only moments that provide information through the conditional likelihood are those moments in which some officers shoot and some do not

Conditional Likelihood Does Not Use, Need, Involve $h(z)$

- For the decision to shoot, the contribution of a shooting to the conditional likelihood is

$$\frac{e^{r_1\beta' \mathbf{x}_1 + \dots + r_n\beta' \mathbf{x}_n}}{\sum_{\rho_i \in \{0,1\}, \sum \rho_i = \sum r_i} e^{\rho_1\beta' \mathbf{x}_1 + \dots + \rho_n\beta' \mathbf{x}_n}}$$

- For the number of rounds, the contribution of a shooting to the conditional likelihood is

$$\frac{e^{r_1\beta' \mathbf{x}_1 + \dots + r_n\beta' \mathbf{x}_n}}{\sum_{\sum \rho_i = \sum r_i} \frac{1}{\rho_1! \dots \rho_n!} e^{\rho_1\beta' \mathbf{x}_1 + \dots + \rho_n\beta' \mathbf{x}_n}}$$

Two Nearly Identical Officers

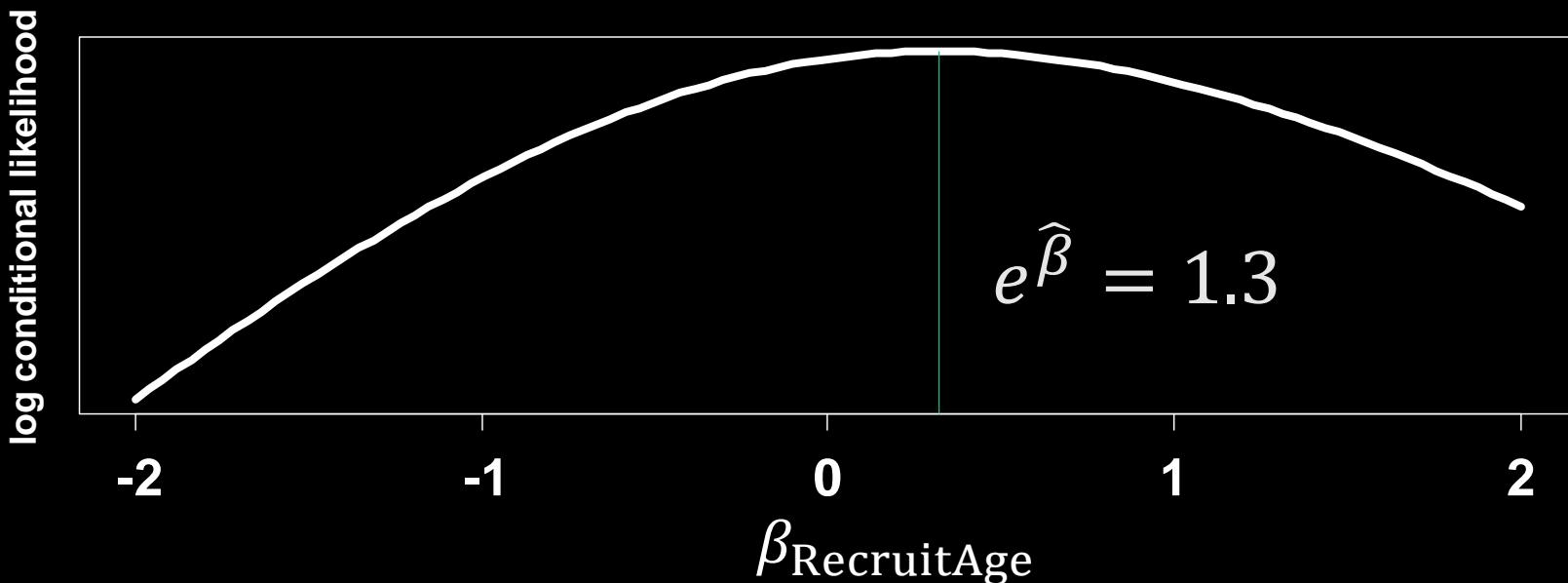
| OIS ID | Rounds | Recruit age | Years on job | Sex | Race | Prior OIS # | Force complaints | Rank | Assign | Gun type | Caliber |
|--------|--------|-------------|--------------|------|-------|-------------|------------------|------|---------|----------|---------|
| 2 | 3 | 24 | 4 | Male | White | 0 | 0 | Off | Special | Pistol | 9 mm |
| 2 | 4 | 25 | 4 | Male | White | 0 | 0 | Off | Special | Pistol | 9 mm |

- Identical on all features except recruit age
- Older officer shot one additional round, 1.3 times more than the younger officer

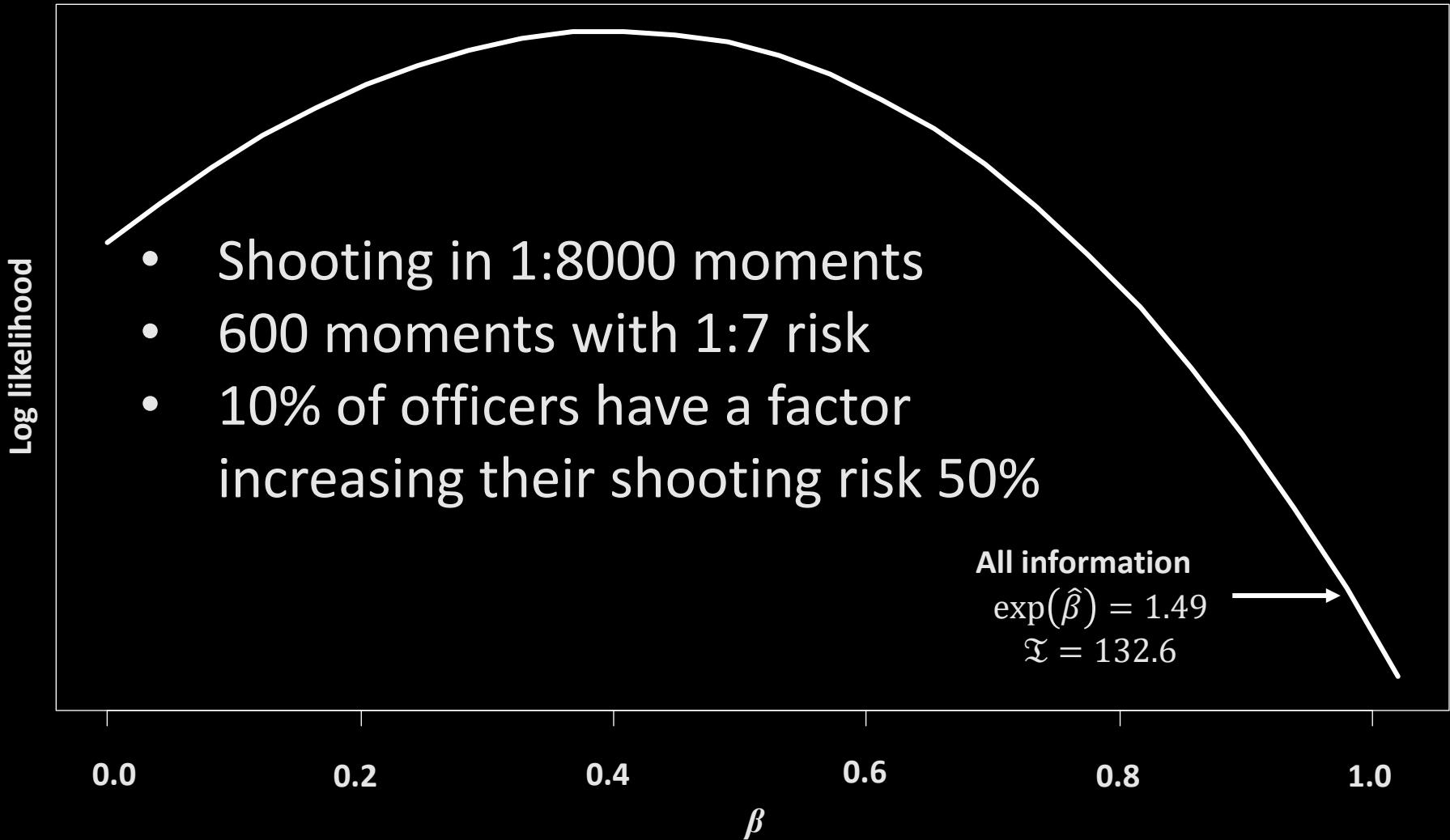
Example Shooting Only Has Information on Recruit Age

- Conditional likelihood contribution simplifies to

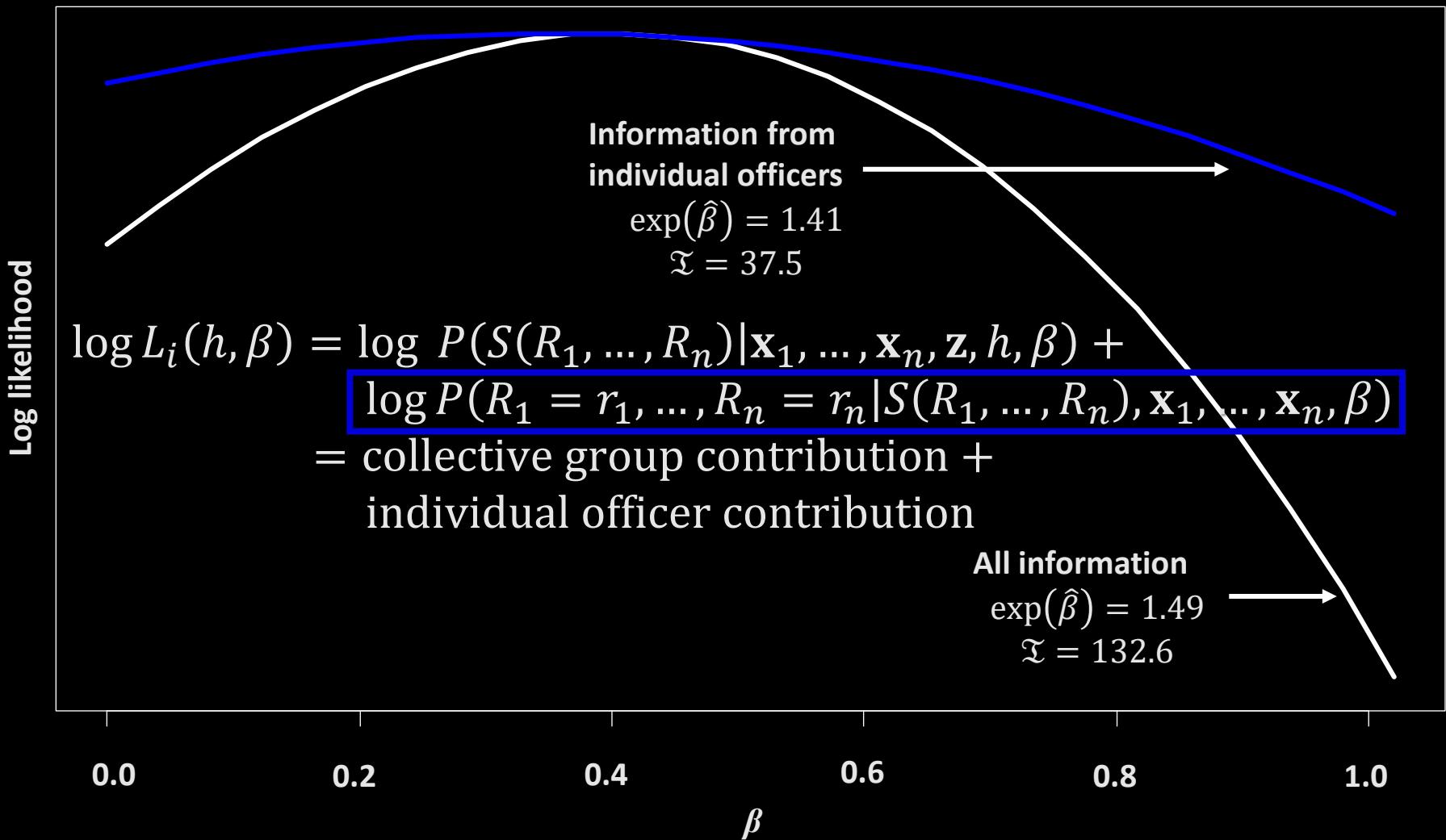
$$\frac{1}{\sum_{\rho_2=1}^6 \frac{1}{(7 - \rho_2)! \rho_2!} \exp((\rho_2 - 4)\beta_{\text{RecruitAge}})}$$



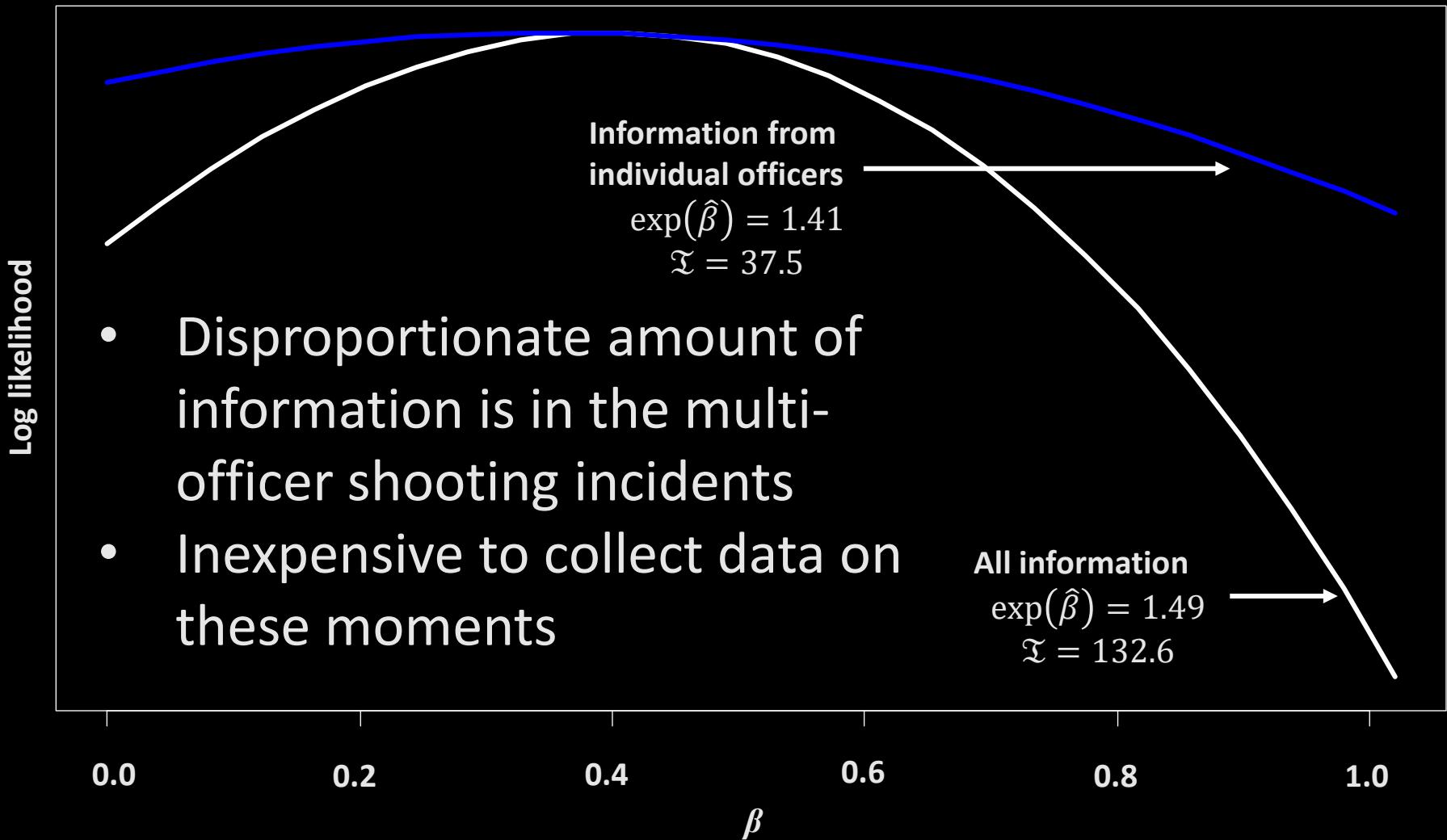
Simulated Data on 5 Million “Moments”



157 Shootings Have Information Through the Conditional Likelihood



157 Shootings Contain 28% of the Fisher Information in All Interactions



Utilized Data on a Review of Three Years of NYPD Records

- All New York City officer-involved shootings adjudicated in 2004, 2005, and 2006
- 106 incidents involving 150 shooting officers and 141 non-shooting officers
- Collected data on age, experience, education, training, and past performance

G. Ridgeway (2016). “Officer Risk Factors Associated with Police Shootings: A Matched Case-Control Study,” *Statistics and Public Policy* 3(1):1-6

| Officer characteristic | Odds ratio | 95% CI | Rate ratio | 95% CI |
|----------------------------------|------------|--------------|------------|--------------|
| Rank (reference: officer) | | | | |
| Detective | 1.30 | (0.34, 5.03) | 0.95 | (0.28, 3.25) |
| Sergeant | *0.29 | (0.10, 0.80) | *0.40 | (0.19, 0.86) |
| Lieutenant or above | *0.04 | (0.01, 0.30) | *0.11 | (0.03, 0.45) |
| Years at NYPD | 0.98 | (0.90, 1.07) | | |
| Age when recruited | *0.90 | (0.81, 0.99) | | |
| Race (reference: white) | | | | |
| Black | *2.96 | (1.17, 7.46) | | |
| Other | 1.09 | (0.45, 2.65) | | |
| Average annual | | | | |
| CPI points > 3.1 | *3.09 | (1.11, 8.56) | | |
| Misdemeanor arrests > 10.0 | *0.26 | (0.09, 0.74) | | |

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| Black | *2.96 | (1.17, 7.46) | | |
| Other | 1.09 | (0.45, 2.65) | | |
| Male | 2.19 | (0.50, 9.63) | | |
| Education (reference: HS) | | | | |
| High school+some college | 1.30 | (0.54, 3.16) | | |
| College | 1.98 | (0.61, 6.40) | | |
| College+some graduate | 2.06 | (0.08, 56.18) | | |
| Average annual | | | | |
| CPI points > 3.1 | *3.09 | (1.11, 8.56) | | |
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| College | 1.98 | (0.61, 6.40) | | |
| College+some graduate | 2.06 | (0.08, 56.18) | | |
| Average annual | | | | |
| CPI points > 3.1 | *3.09 | (1.11, 8.56) | | |
| Misdemeanor arrests > 10.0 | *0.26 | (0.09, 0.74) | | |
| Evaluation score < 3.5 | 0.60 | (0.25, 1.46) | | |
| Range score < 86 | 1.71 | (0.70, 4.19) | | |
| Complaints > 0.6 | 1.99 | (0.71, 5.57) | | |
| Medal count/year > 3.8 | 2.12 | (0.62, 7.20) | | |
| Gun arrests > 2.4 | 0.83 | (0.25, 2.79) | | |
| Felony arrests > 9.3 | 1.38 | (0.44, 4.38) | | |
| Days of leave | | | | |
| Not line of duty injury> 8.4 | 1.11 | (0.49, 2.52) | | |
| Line of duty injury > 5.6 | 1.13 | (0.45, 2.86) | | |

| Officer characteristic | Odds ratio | 95% CI | Rate ratio | 95% CI |
|----------------------------------|------------|---------------|------------|--------------|
| Rank (reference: officer) | | | | |
| Detective | 1.30 | (0.34, 5.03) | 0.95 | (0.28, 3.25) |
| Sergeant | *0.29 | (0.10, 0.80) | *0.40 | (0.19, 0.86) |
| Lieutenant or above | *0.04 | (0.01, 0.30) | *0.11 | (0.03, 0.45) |
| Years at NYPD | 0.98 | (0.90, 1.07) | 0.99 | (0.94, 1.05) |
| Age when recruited | *0.90 | (0.81, 0.99) | 0.94 | (0.88, 1.01) |
| Race (reference: white) | | | | |
| Black | *2.96 | (1.17, 7.46) | *2.30 | (1.09, 4.86) |
| Other | 1.09 | (0.45, 2.65) | 1.24 | (0.71, 2.16) |
| Male | 2.19 | (0.50, 9.63) | 1.64 | (0.43, 6.27) |
| Education (reference: HS) | | | | |
| High school+some college | 1.30 | (0.54, 3.16) | 0.75 | (0.35, 1.59) |
| College | 1.98 | (0.61, 6.40) | 0.69 | (0.33, 1.47) |
| College+some graduate | 2.06 | (0.08, 56.18) | 0.78 | (0.20, 3.05) |
| Average annual | | | | |
| CPI points > 3.1 | *3.09 | (1.11, 8.56) | 1.44 | (0.74, 2.81) |
| Misdemeanor arrests > 10.0 | *0.26 | (0.09, 0.74) | 0.89 | (0.41, 1.95) |
| Evaluation score < 3.5 | 0.60 | (0.25, 1.46) | 0.62 | (0.33, 1.16) |
| Range score < 86 | 1.71 | (0.70, 4.19) | 1.42 | (0.83, 2.43) |
| Complaints > 0.6 | 1.99 | (0.71, 5.57) | 1.40 | (0.77, 2.56) |
| Medal count/year > 3.8 | 2.12 | (0.62, 7.20) | 1.63 | (0.80, 3.33) |
| Gun arrests > 2.4 | 0.83 | (0.25, 2.79) | 0.94 | (0.45, 1.95) |
| Felony arrests > 9.3 | 1.38 | (0.44, 4.38) | 0.73 | (0.36, 1.48) |
| Days of leave | | | | |
| Not line of duty injury> 8.4 | 1.11 | (0.49, 2.52) | 1.23 | (0.70, 2.16) |
| Line of duty injury > 5.6 | 1.13 | (0.45, 2.86) | 1.38 | (0.64, 2.96) |

Major Cities Chiefs (MCCA) and Police Foundation Standardized Collection

- 56 agencies from MCCA in the U.S. and Canada contributed to this data collection effort
- Full dataset describes 2,574 officers involved in 1,600 shootings between 2010-2018
- Analysis used all 317 multi-officer shootings, 849 officers, 5,026 rounds

G. Ridgeway, B. Cave, J. Grieco, and C.E. Loeffler (2020). "A Conditional Likelihood Model of the Relationship Between Officer Features and Rounds Discharged in Police Shootings," *Journal of Quantitative Criminology*

No Effect of Age on Number of Rounds

| Officer features | Rate ratio | Permutation 95% CI | Permutation p-value |
|---------------------|------------|-----------------------|------------------------|
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 |
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No Effect of Sex or Race on Rounds Fired

| Officer features | Rate ratio | Permutation | Permutation |
|--------------------------|------------|--------------|-------------|
| | | 95% CI | p-value |
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 |
| Female | 0.86 | (0.63, 1.16) | 0.31 |
| Race (relative to white) | | | |
| Black | 1.05 | (0.86, 1.28) | 0.62 |
| Hispanic | 1.09 | (0.87, 1.36) | 0.46 |
| Other | 0.76 | (0.56, 1.03) | 0.07 |



No Effect of Prior OIS or Complaints

| Officer features | Rate ratio | Permutation | Permutation |
|----------------------------------|------------|--------------|-------------|
| | | 95% CI | p-value |
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 |
| Female | 0.86 | (0.63, 1.16) | 0.31 |
| Race (relative to white) | | | |
| Black | 1.05 | (0.86, 1.28) | 0.62 |
| Hispanic | 1.09 | (0.87, 1.36) | 0.46 |
| Other | 0.76 | (0.56, 1.03) | 0.07 |
| Prior OIS (relative to 0) | | | |
| 1 or more | 1.02 | (0.77, 1.35) | 0.90 |
| 2 or more | 1.23 | (0.88, 1.73) | 0.21 |
| Prior force complaint | 1.25 | (0.95, 1.64) | 0.10 |

No Effect of Rank or Assignment

| Officer features | Rate ratio | Permutation | Permutation |
|----------------------------------|------------|--------------|-------------|
| | | 95% CI | p-value |
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 |
| Female | 0.86 | (0.63, 1.16) | 0.31 |
| Race (relative to white) | | | |
| Black | 1.05 | (0.86, 1.28) | 0.62 |
| Hispanic | 1.09 | (0.87, 1.36) | 0.46 |
| Other | 0.76 | (0.56, 1.03) | 0.07 |
| Prior OIS (relative to 0) | | | |
| 1 or more | 1.02 | (0.77, 1.35) | 0.90 |
| 2 or more | 1.23 | (0.88, 1.73) | 0.21 |
| Prior force complaint | 1.25 | (0.95, 1.64) | 0.10 |
| Role | | | |
| Detective | 1.09 | (0.72, 1.64) | 0.68 |
| Sergeant or more senior | 1.03 | (0.82, 1.30) | 0.81 |
| Other | 0.66 | (0.34, 1.31) | 0.23 |
| Special assignment | 1.28 | (0.95, 1.72) | 0.10 |

No Effect of Firearm Type

| Officer features | Rate ratio | Permutation | Permutation |
|--------------------------------------|------------|--------------|-------------|
| | | 95% CI | p-value |
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 |
| Female | 0.86 | (0.63, 1.16) | 0.31 |
| Race (relative to white) | | | |
| Black | 1.05 | (0.86, 1.28) | 0.62 |
| Hispanic | 1.09 | (0.87, 1.36) | 0.46 |
| Other | 0.76 | (0.56, 1.03) | 0.07 |
| Prior OIS (relative to 0) | | | |
| 1 or more | 1.02 | (0.77, 1.35) | 0.90 |
| 2 or more | 1.23 | (0.88, 1.73) | 0.21 |
| Prior force complaint | 1.25 | (0.95, 1.64) | 0.10 |
| Role | | | |
| Detective | 1.09 | (0.72, 1.64) | 0.68 |
| Sergeant or more senior | 1.03 | (0.82, 1.30) | 0.81 |
| Other | 0.66 | (0.34, 1.31) | 0.23 |
| Special assignment | 1.28 | (0.95, 1.72) | 0.10 |
| Long gun (relative to pistol) | 1.01 | (0.78, 1.30) | 0.97 |

Few Incidents Provide Information

| Officer features | Rate ratio | Permutation 95% CI | Permutation p-value | Shootings with info |
|--------------------------------------|------------|--------------------|---------------------|---------------------|
| Age at recruitment | 1.01 | (0.99, 1.02) | 0.25 | 272 |
| Years of experience | 1.00 | (0.98, 1.01) | 0.62 | 277 |
| Female | 0.86 | (0.63, 1.16) | 0.31 | 36 |
| Race (relative to white) | | | | |
| Black | 1.05 | (0.86, 1.28) | 0.62 | 49 |
| Hispanic | 1.09 | (0.87, 1.36) | 0.46 | 73 |
| Other | 0.76 | (0.56, 1.03) | 0.07 | 35 |
| Prior OIS (relative to 0) | | | | |
| 1 or more | 1.02 | (0.77, 1.35) | 0.90 | 86 |
| 2 or more | 1.23 | (0.88, 1.73) | 0.21 | 30 |
| Prior force complaint | 1.25 | (0.95, 1.64) | 0.10 | 40 |
| Role | | | | |
| Detective | 1.09 | (0.72, 1.64) | 0.68 | 21 |
| Sergeant or more senior | 1.03 | (0.82, 1.30) | 0.81 | 67 |
| Other | 0.66 | (0.34, 1.31) | 0.23 | 9 |
| Special assignment | 1.28 | (0.95, 1.72) | 0.10 | 40 |
| Long gun (relative to pistol) | 1.01 | (0.78, 1.30) | 0.97 | 54 |

Effective Use of Conditional Likelihood Depends on Data Collection

1. Amass sufficient data
 - A third of shootings involve multiple officers
 - 4% of shootings had information for the relationship between prior force complaints and shooting risk
2. Standardize reporting
3. Document the presence of non-shooting officers
 - New Chicago PD consent decree requires documenting all “CPD units identified in the incident report as being on the scene of the use of force incident”



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G. Ridgeway (2020). “The Role of Individual Officer Characteristics in Police Shootings,” *ANNALS of the American Academy of Political and Social Science* 687(1):58-66