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The Number of Undocumented Immigrants in the United States

Mohammad M. Fazel-Zarandi, Jonathan S. Feinstein, Edward H. Kaplan

Motivation

Research Question and Contribution

- Questions:
  1. How many undocumented immigrants are there in the United States?
  2. Are the current methods of estimating the number of undocumented immigrants adequate?

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- Contribution: Propose a new approach grounded on operational data and mathematical modeling that estimates annual population inflows and outflows from 1990 – 2016
- Why: Sets the scale of the issue

Outline

- Motivation
- Current estimates
- Snapshot of our results
- The model and the simulation
- Results, Receptions, and Policy Implications

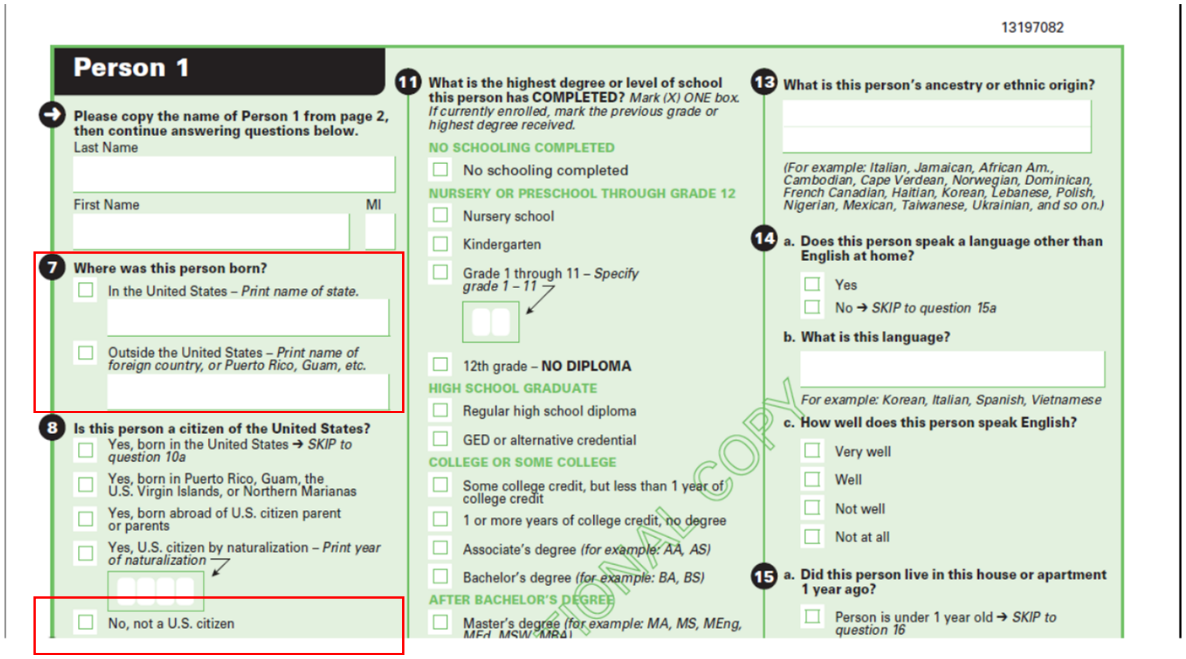
Current Estimates

- Residual Method
  - Passel (2016), Krogstad and Passel (2015), Baker and Rytina (2013), Warren and Warren (2013)

$$\begin{array}{c} Estimated\ Number\ of \\ UnauthorizedImmigrants \end{array} = \begin{array}{c} Estimated\ Total\ Foreign \\ Born\ Population \\ (Non-Citizen) \end{array} - \begin{array}{c} Estimated\ Lawful \\ Immigrant\ Population \end{array}$$

Current Estimates

- Total Foreign Born Population
  - Based on *surveys* (American Community Survey or Current Population Survey)



13197082

Person 1

➔ **Please copy the name of Person 1 from page 2, then continue answering questions below.**

Last Name

First Name MI

7 Where was this person born?

□ In the United States – *Print name of state.*

□ Outside the United States – *Print name of foreign country, or Puerto Rico, Guam, etc.*

8 Is this person a citizen of the United States?

□ Yes, born in the United States ➔ *SKIP to question 10a*

□ Yes, born in Puerto Rico, Guam, the U.S. Virgin Islands, or Northern Marianas

□ Yes, born abroad of U.S. citizen parent or parents

□ Yes, U.S. citizen by naturalization – *Print year of naturalization*

□ No, not a U.S. citizen

11 What is the highest degree or level of school this person has COMPLETED? *Mark (X) ONE box. If currently enrolled, mark the previous grade or highest degree received.*

NO SCHOOLING COMPLETED

□ No schooling completed

NURSERY OR PRESCHOOL THROUGH GRADE 12

□ Nursery school

□ Kindergarten

□ Grade 1 through 11 – *Specify grade 1 – 11*

□ 12th grade – **NO DIPLOMA**

HIGH SCHOOL GRADUATE

□ Regular high school diploma

□ GED or alternative credential

COLLEGE OR SOME COLLEGE

□ Some college credit, but less than 1 year of college credit

□ 1 or more years of college credit, no degree

□ Associate's degree *(for example: AA, AS)*

□ Bachelor's degree *(for example: BA, BS)*

AFTER BACHELOR'S DEGREE

□ Master's degree *(for example: MA, MS, MEng, MEd, MSW, MBA)*

13 What is this person's ancestry or ethnic origin?

(For example: Italian, Jamaican, African Am., Cambodian, Cape Verdean, Norwegian, Dominican, French Canadian, Haitian, Korean, Lebanese, Polish, Nigerian, Mexican, Taiwanese, Ukrainian, and so on.)

14 a. Does this person speak a language other than English at home?

□ Yes

□ No ➔ *SKIP to question 15a*

b. What is this language?

For example: Korean, Italian, Spanish, Vietnamese

c. How well does this person speak English?

□ Very well

□ Well

□ Not well

□ Not at all

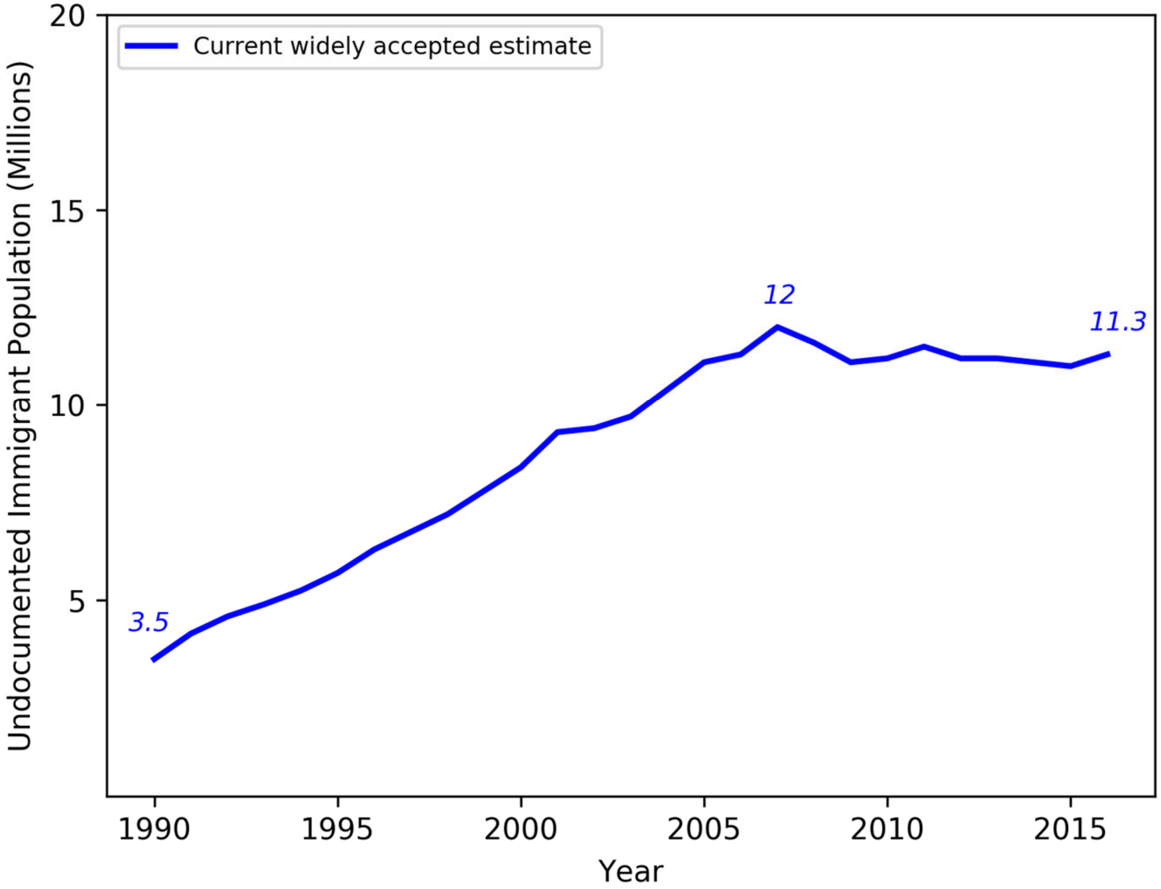
15 a. Did this person live in this house or apartment 1 year ago?

□ Person is under 1 year old ➔ *SKIP to question 16*

Current Estimates

- Total Foreign Born Population
  - Based on *surveys* (American Community Survey or Current Population Survey)
- Estimate of Lawful Immigrant Population
  - Use Department of Homeland Security data on lawful arrivals

Current Estimate



Source: Pew Research Center

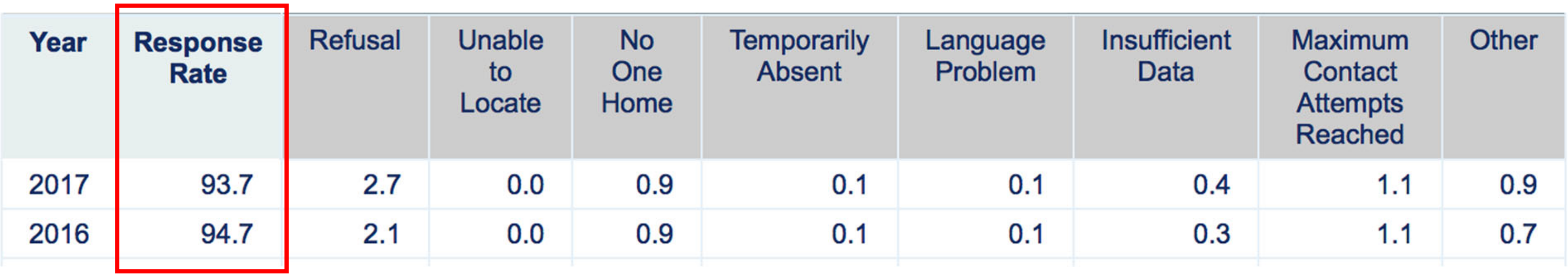
Current Estimates

Hidden Population

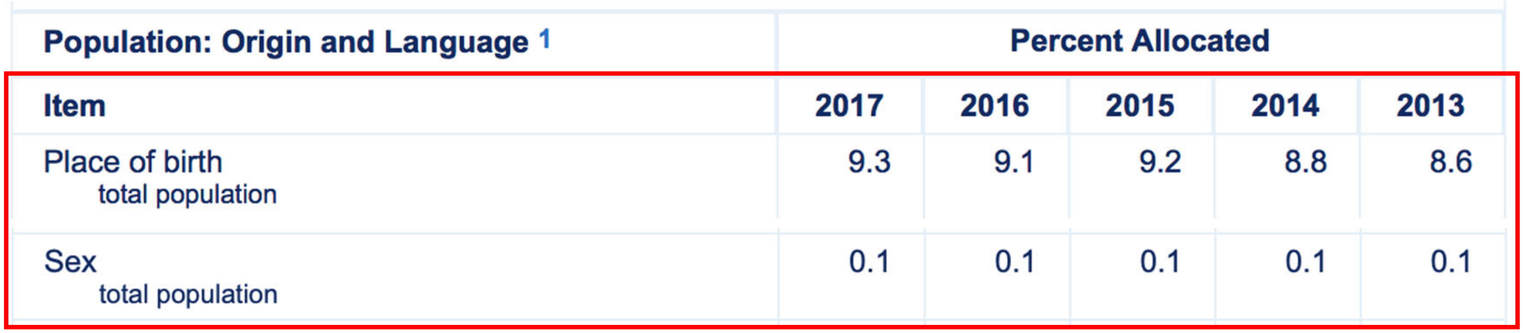
- Difficult to locate members of the target population (Goel and Salganik (2010), Crawford et al.(2018))
  - Reaching a representative sample of all those born outside of the U.S.
    - Undocumented immigrants are more difficult to locate and survey
  - Accurate responses from survey respondents
    - Undocumented immigrants may misreport their country of origin, citizenship, and number of household residents

Some Relevant Statistics

ACS response rates



Year	Response Rate	Refusal	Unable to Locate	No One Home	Temporarily Absent	Language Problem	Insufficient Data	Maximum Contact Attempts Reached	Other
2017	93.7	2.7	0.0	0.9	0.1	0.1	0.4	1.1	0.9
2016	94.7	2.1	0.0	0.9	0.1	0.1	0.3	1.1	0.7



Population: Origin and Language [1]	Percent Allocated				
Item	**2017**	**2016**	**2015**	**2014**	**2013**
Place of birth total population	9.3	9.1	9.2	8.8	8.6
Sex total population	0.1	0.1	0.1	0.1	0.1

ACS Question **non**-response rates among respondents

Source: U.S. Census Bureau

Some Relevant Statistics

5% non-response

+ 0.95 × 8% question skippers

12.6% no clear answer ≈ 40 million people

- Ignoring deliberate misreporting
  - Place birth
  - Number of household residents

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  - Place birth
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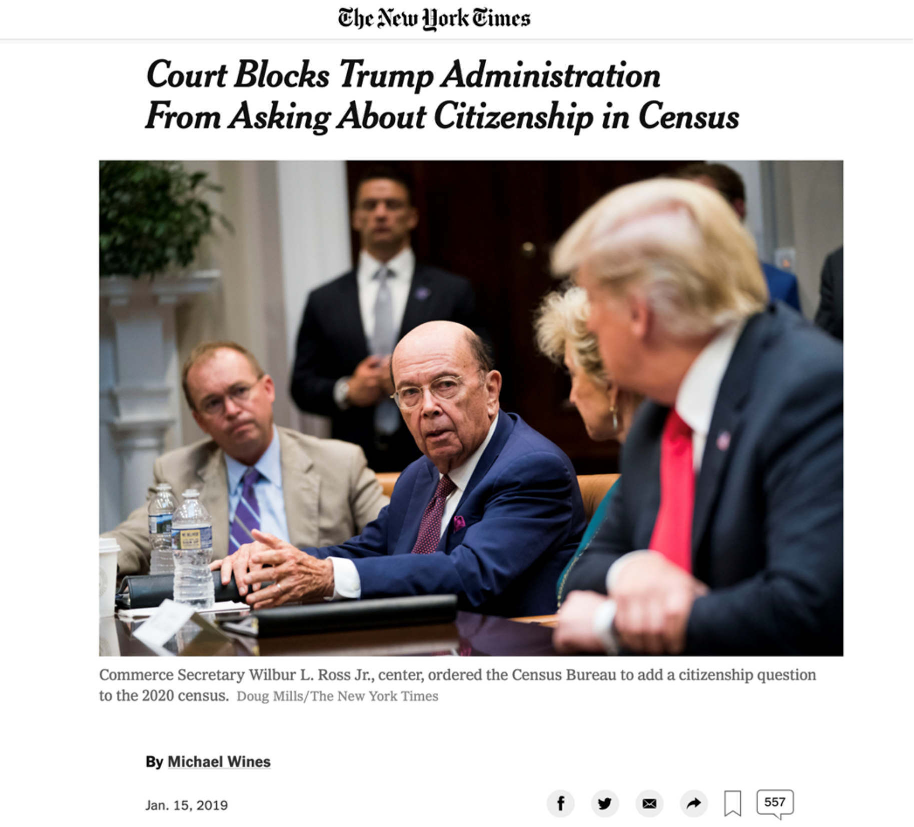
- Non-response bias
  - Missing at random vs ***missing on purpose***

Census may be too blunt an instrument to reach a relatively small population with an incentive to remain undetected

Census Citizenship Question Debate



The New York Times

Court Blocks Trump Administration From Asking About Citizenship in Census

Commerce Secretary Wilbur L. Ross Jr., center, ordered the Census Bureau to add a citizenship question to the 2020 census. Doug Mills/The New York Times

By Michael Wines

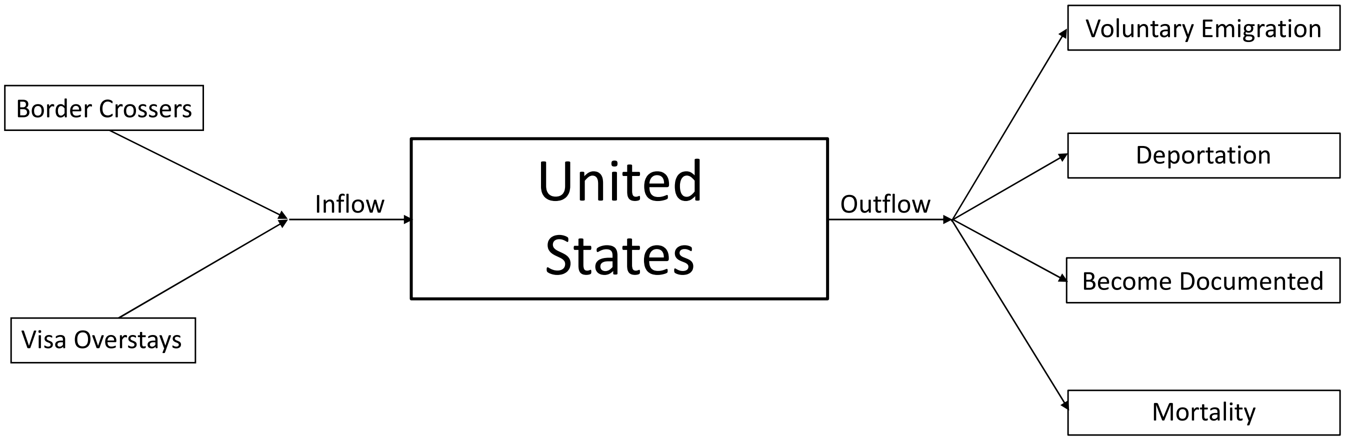
Jan. 15, 2019

"The result will not only be a decrease in the quality of census data — something Defendants concede — but likely also a net differential undercount (that is, an undercount of certain sectors of the population, including people who live in households containing noncitizens and Hispanics, relative to others)."

Judge Jesse M. Furman (United States District Court in Manhattan)

Our Estimate

- Combine mathematical modeling with data analysis
- Our model tracks and estimates annual inflows and outflows from 1990 - 2016

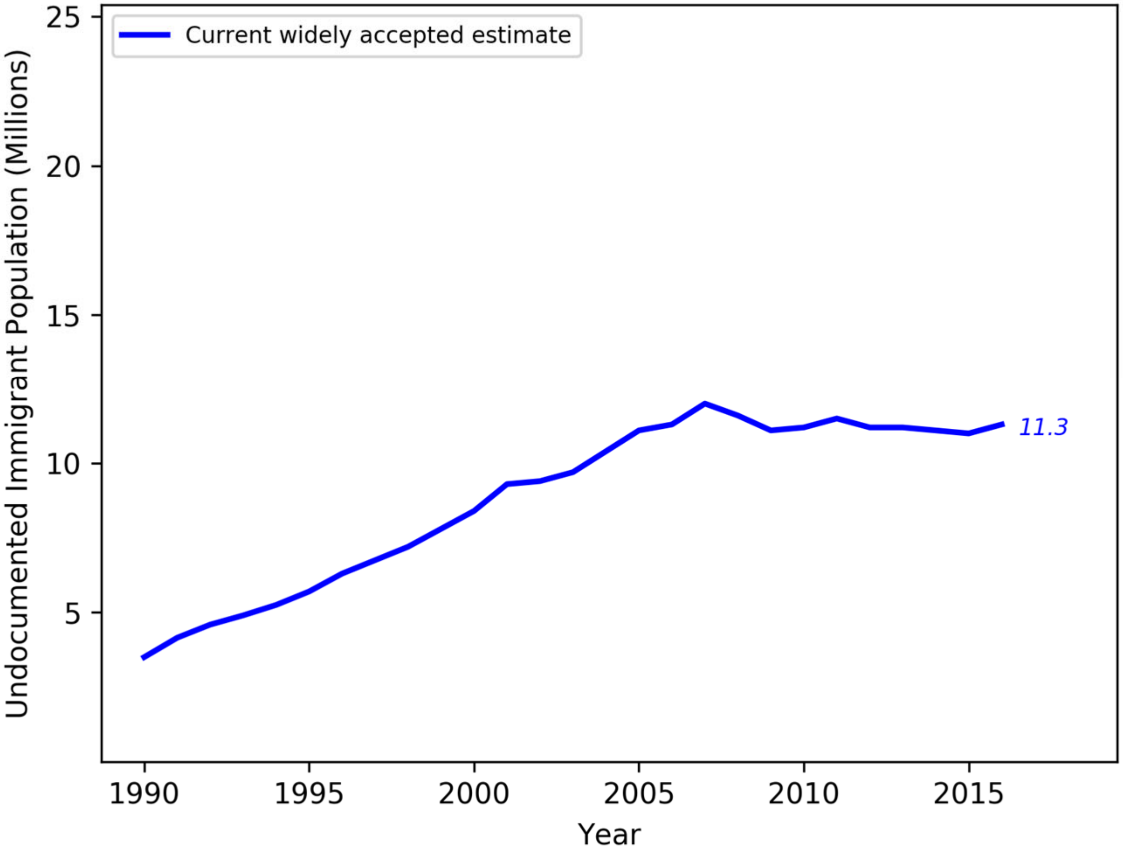


Our Estimation Result

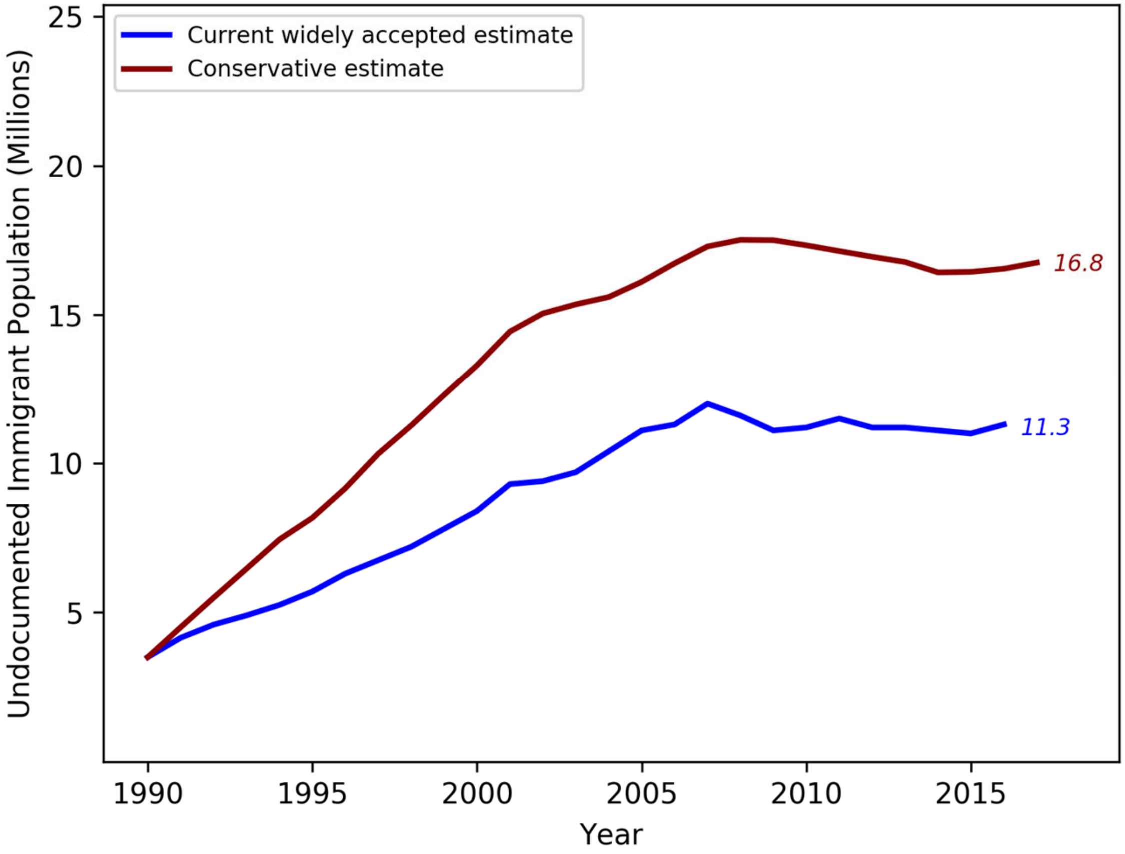
I. Generate a conservative estimate (low-end) of the number of undocumented immigrants

II. Generate probability distribution over the number of undocumented immigrants based on simulating our model over a wide range of assumptions

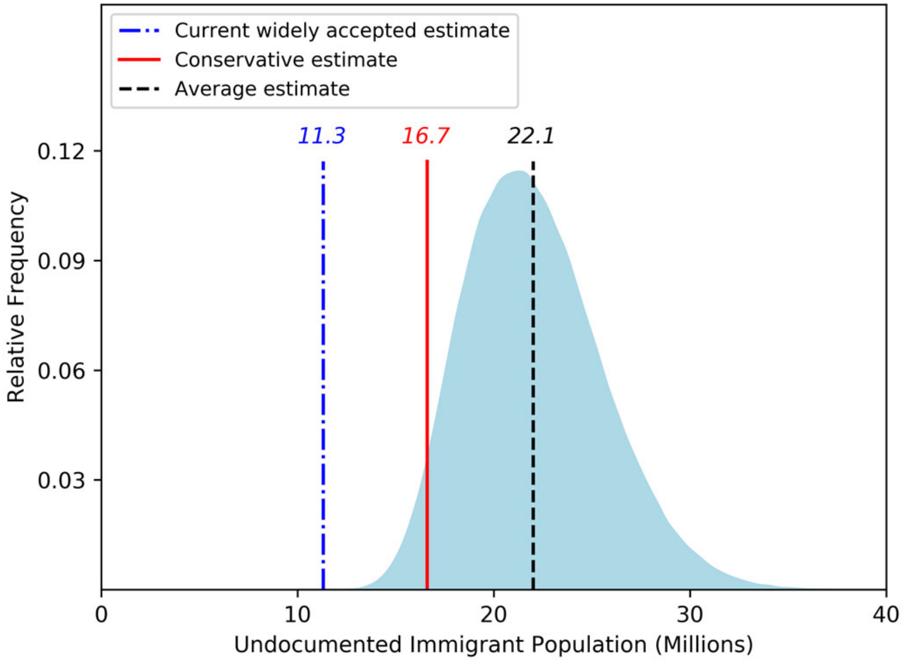
Results


Current widely accepted estimate
Undocumented Immigrant Population (Millions)
25
20
15
10
5
1990
1995
2000
2005
2010
2015
Year
11.3

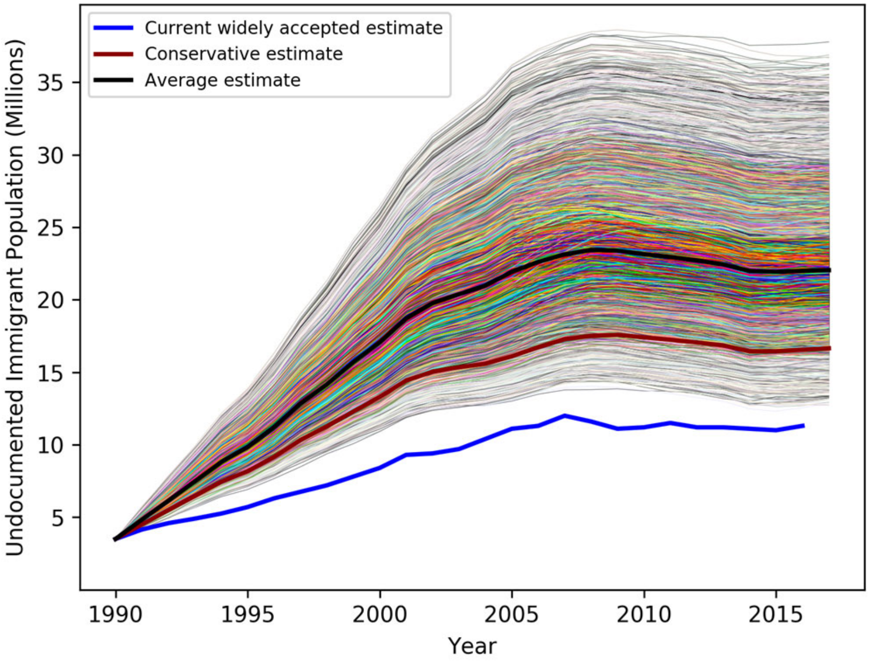
Results – Conservative Estimate



Results – 1,000,000 Simulation Runs



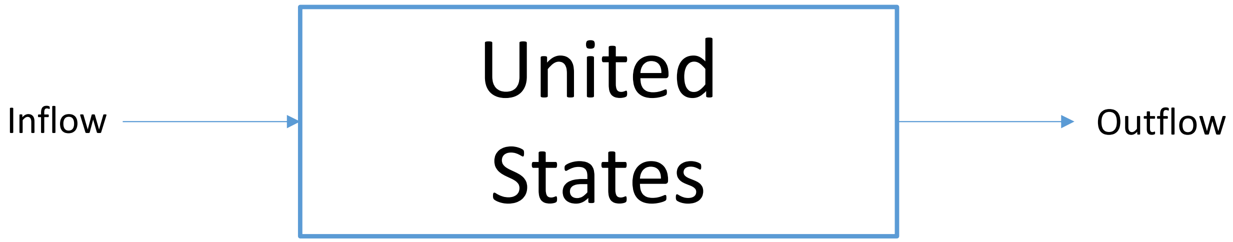
Probability Distribution (2016)



Trajectories

The Approach

The Model



Inflow

United States

Outflow

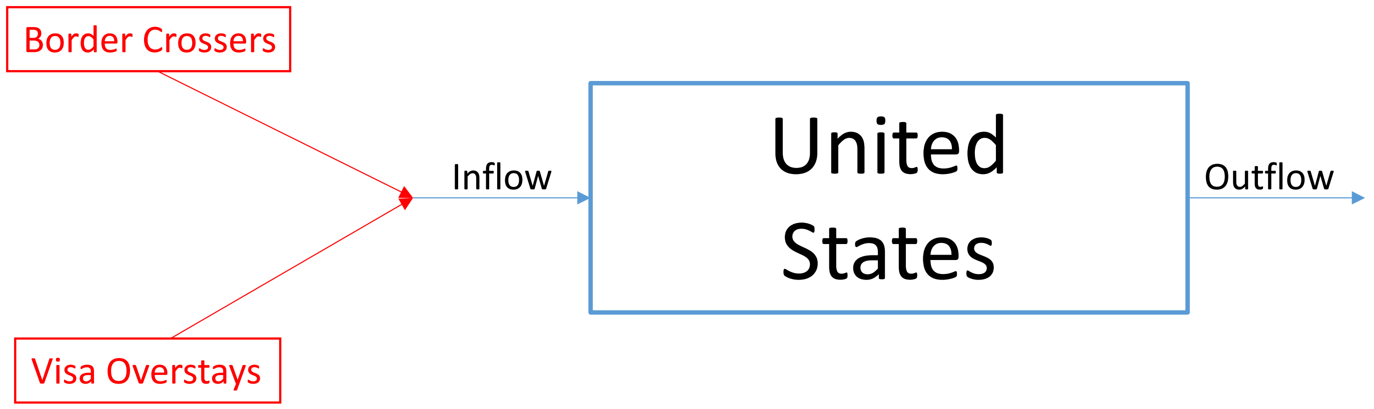
Number of undocumented immigrants in year *t*

Outflow in year *t*

$$N_t = N_{t-1} + I_t - O_t$$

Inflow in year *t*

The Model



Border Crossers

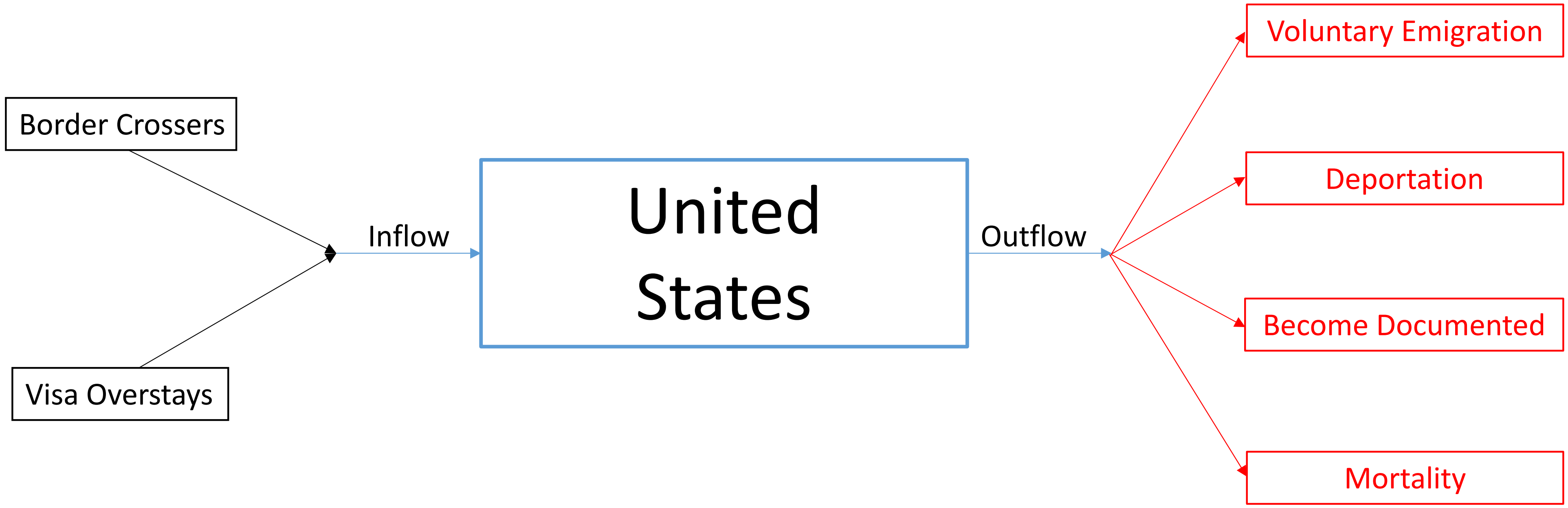
Visa Overstays

Inflow

United States

Outflow

The Model

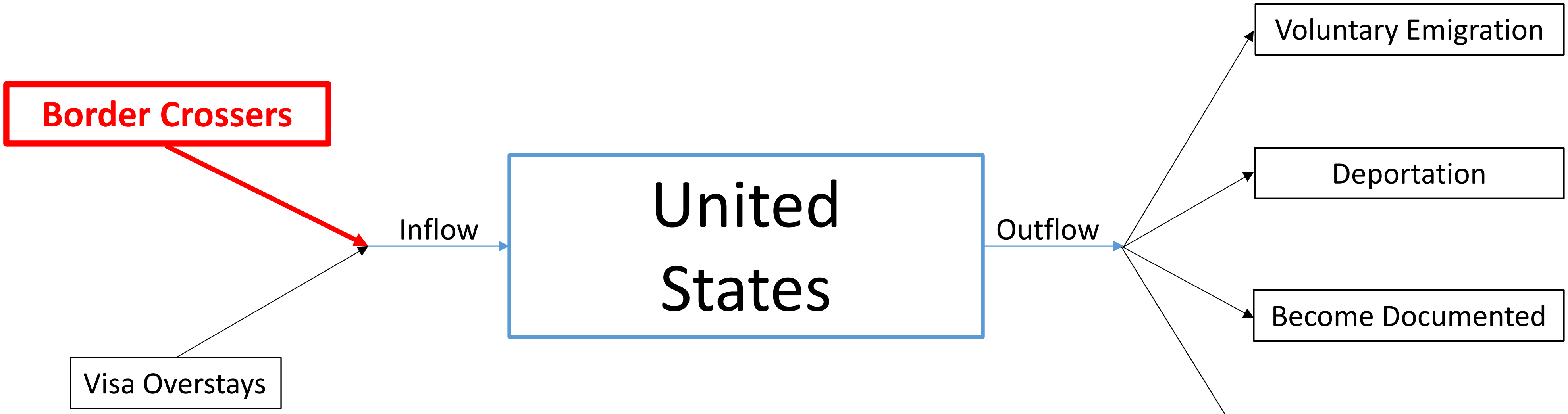

Border Crossers
Visa Overstays
Inflow
United States
Outflow
Voluntary Emigration
Deportation
Become Documented
Mortality

Estimation Strategy

- Generate a *conservative estimate* (low-end estimate)
  - Underestimate Inflows
  - Overestimate Outflows

Inflows

The Model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Illegal Border Crossers

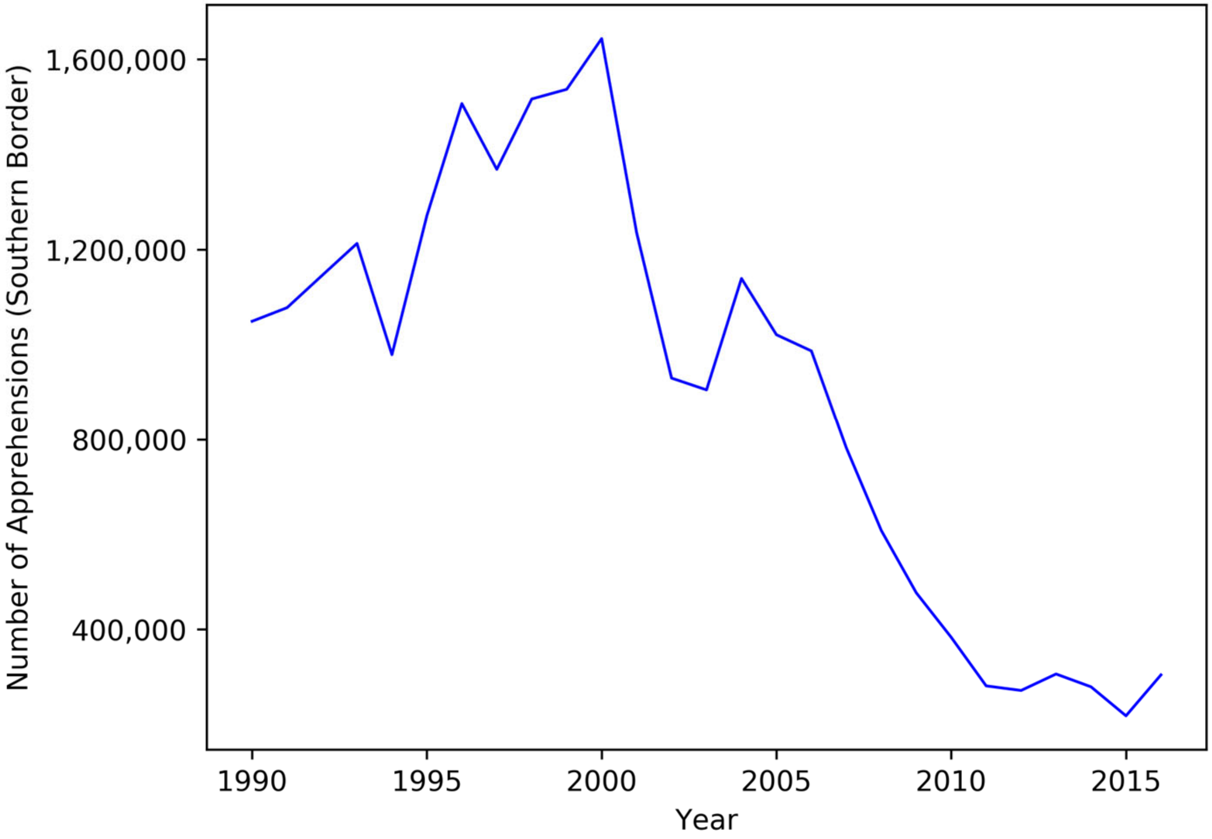
- Really hard component of the model

- To estimate this we use apprehension data on the Mexico - U.S. border

- Our model of the border crossers is based on standard repeated trials (Espenshade (1995)), i.e. a *Bernoulli process model*

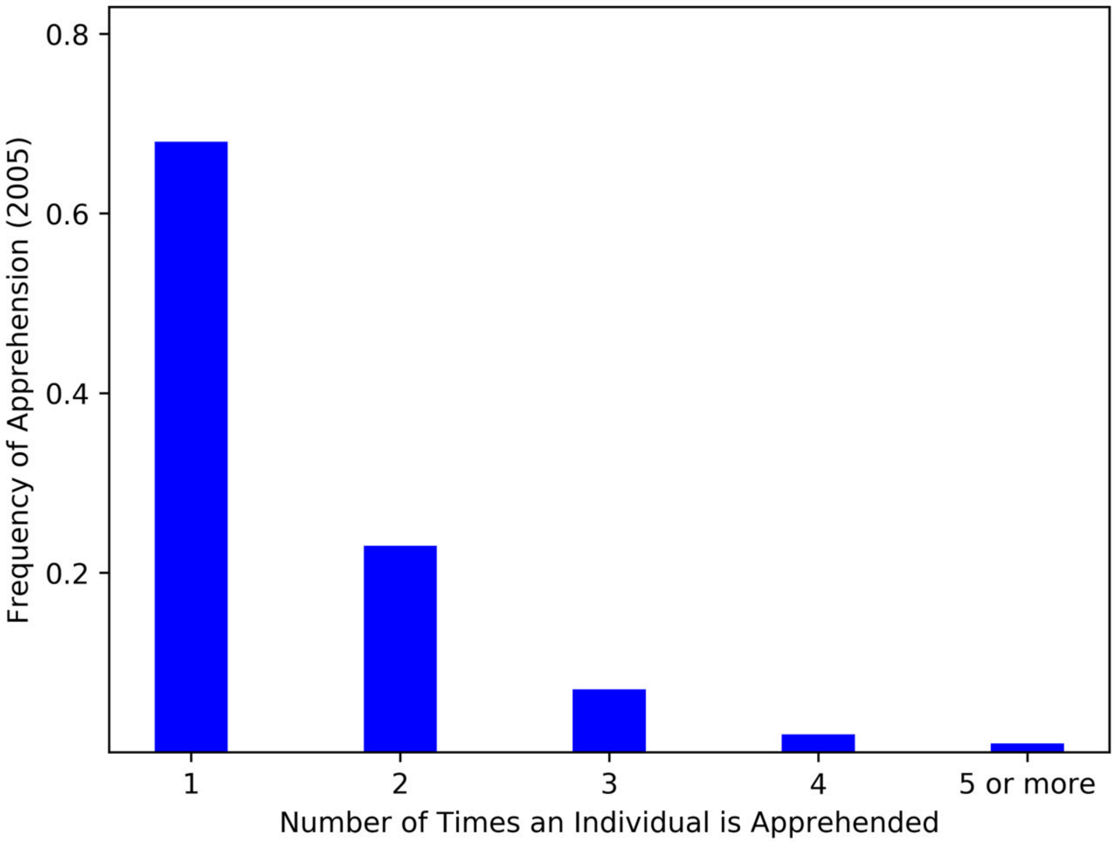
- The model estimates the number of border crossings consistent with observed apprehensions that are happening in the data

Number of Apprehensions



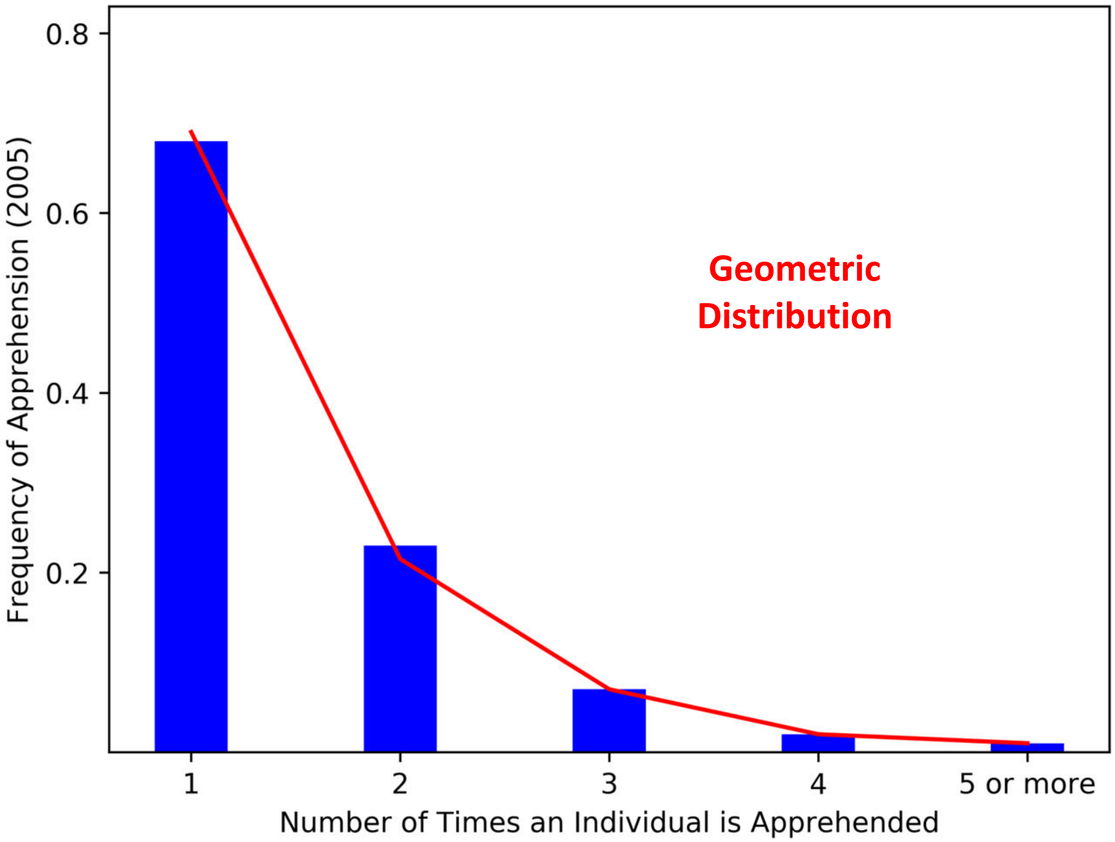
Data Source: U.S. Border Patrol

Frequency of Apprehension (2005)



Data Source: U.S. Department of Homeland Security

Frequency of Apprehension (2005)



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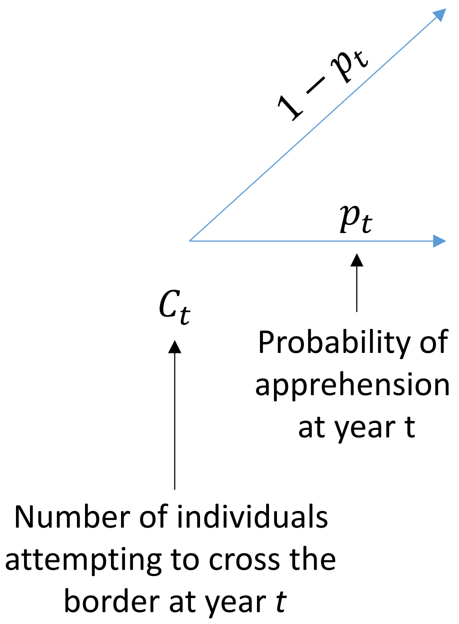
The Border Crossing Model



$1 - p_t$

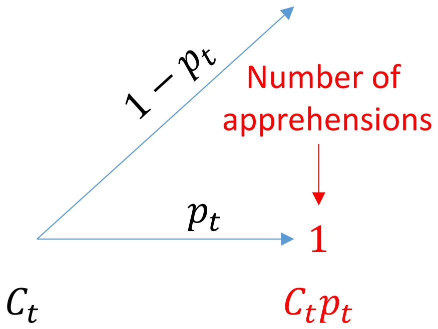
p_t

C_t

Probability of apprehension at year t

Number of individuals attempting to cross the border at year *t*

The Border Crossing Model



$1 - p_t$

Number of apprehensions

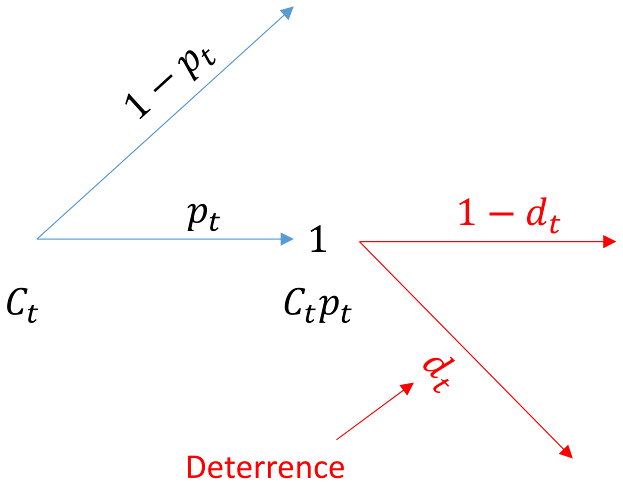
p_t

1

C_t

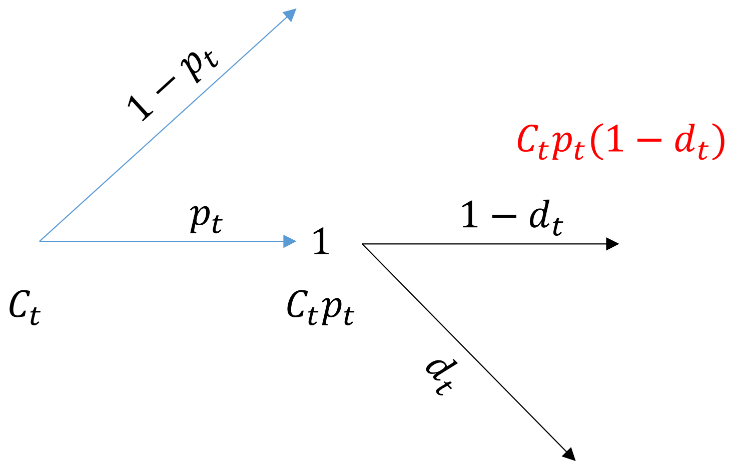
$C_t p_t$

The Border Crossing Model



Deterrence
due to apprehension
(estimated from
Encuesta sobre
Migración en la
Frontera Norte y Sur
de México (EMIF))

The Border Crossing Model



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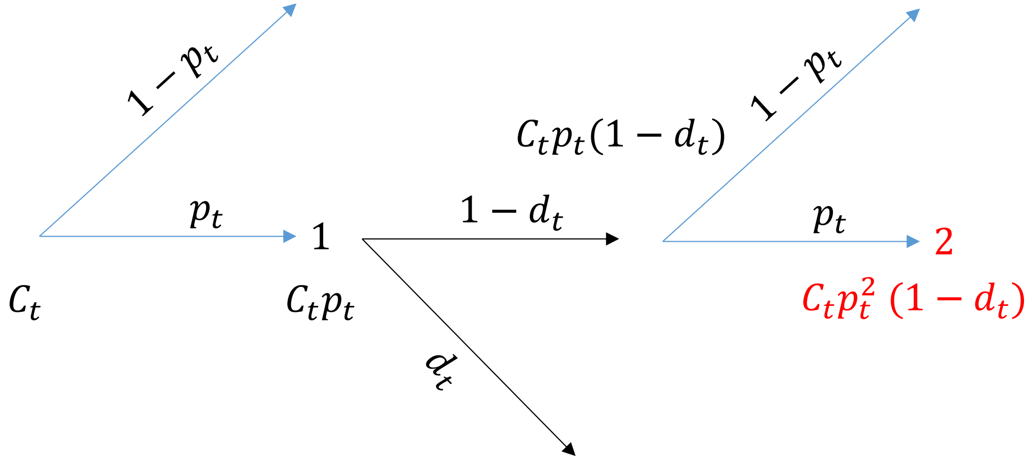

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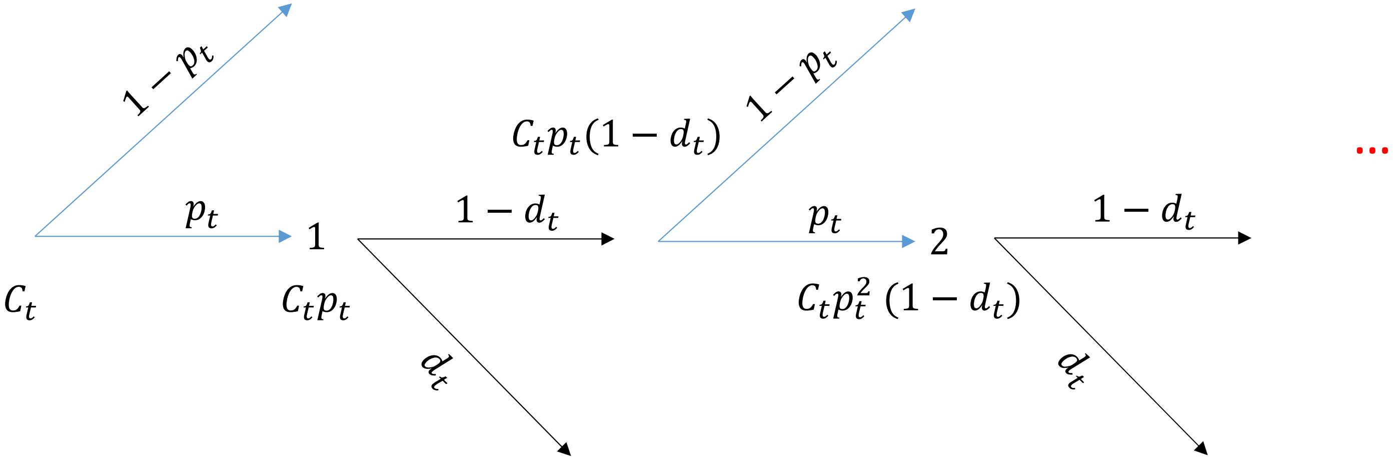
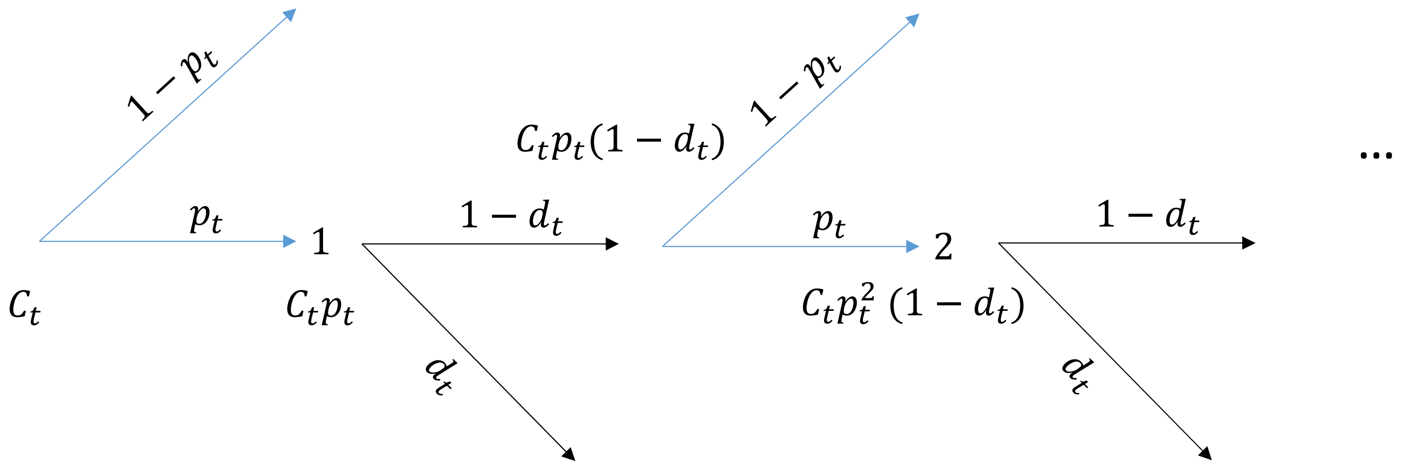
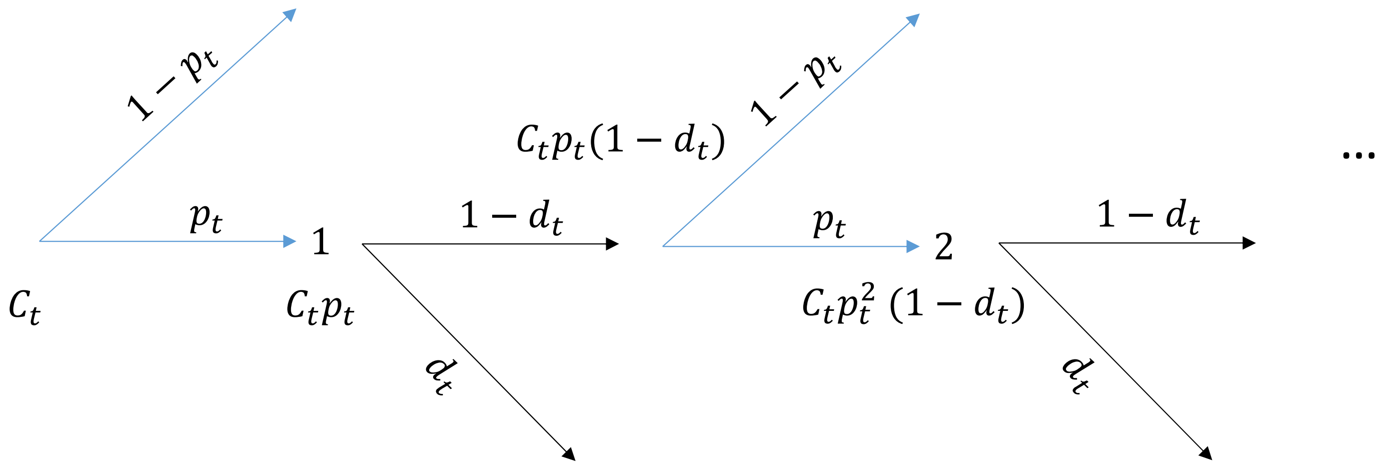


The Border Crossing Model



Number of Apprehensions in Year *t* → $A_t = \underbrace{C_t p_t}_{First\ Attempt} + \underbrace{C_t p_t^2(1-d_t)}_{Second\ Attempt} + \cdots$

The Border Crossing Model

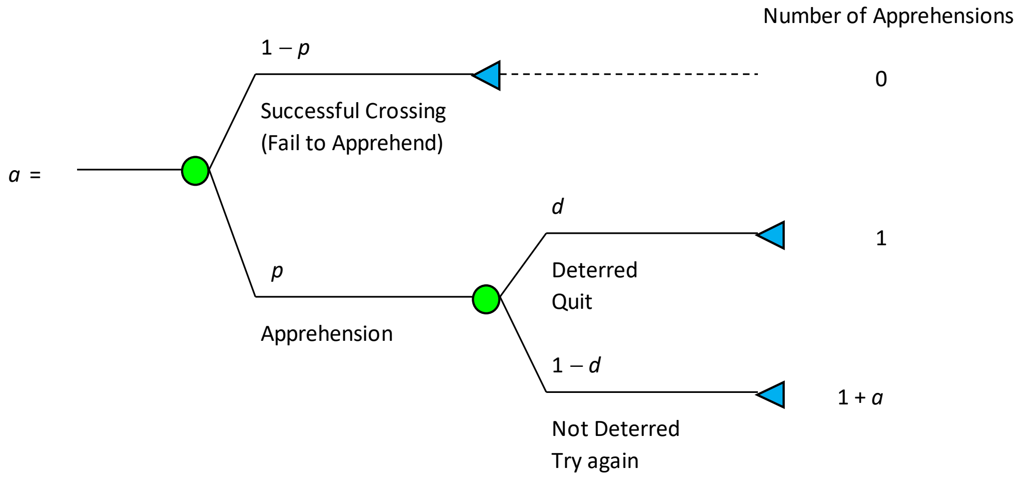


$$A_t = \underbrace{C_tp_t}_{\textit{First Attempt}} + \underbrace{C_tp_t^2(1-d_t)}_{\textit{Second Attempt}} + \cdots$$

Expected Number of Apprehensions in Year *t* → $A_t = \underbrace{C_t}_{\substack{\textit{Number}\\ \textit{of}\\ \textit{attempters}}} \times \frac{1}{\underbrace{1-p_t(1-d_t)}_{\substack{\textit{Expected}\\ \textit{number of}\\ \textit{attempts}}}} \times \underbrace{p_t}_{\substack{\textit{Probability of}\\ \textit{apprehension}\\ \textit{in each attempt}}}$

Mean Apprehensions Over All Attempted Border Crossers

- Let *p* = Pr{Apprehension per crossing attempt}
- Let *d* = Pr{Deterrence | Apprehension}
- Let *a* = mean number of apprehensions over all attempted border crossers



a = (1 – *p*) x 0 + *pd* x 1 + *p*(1 – *d*) x (1 + *a*)

$$a = \frac{p}{1 - p(1 - d)}$$

If *C* persons are attempting to cross, then

$$E(Apprehensions) = Ca = C\frac{p}{1 - p(1 - d)}$$

What Does the Model Imply So Far?

- Number of apprehensions at year *t*: $A_t = C_t \frac{p_t}{1-p_t(1-d_t)}$
- Number of attempters at year *t*: $C_t = A_t \frac{1-p_t(1-d_t)}{p_t}$
- Number of undocumented border crossers at year *t*: $B_t = C_t - Q_t$ ← Individuals who give up
- Number of individuals deterred at year *t*: $Q_t = A_t d_t$
- Number of undocumented border crossers at year *t*: $\boldsymbol{B_t = A_t \frac{1-p_t}{p_t}}$

We Need The Apprehension Probability *p*

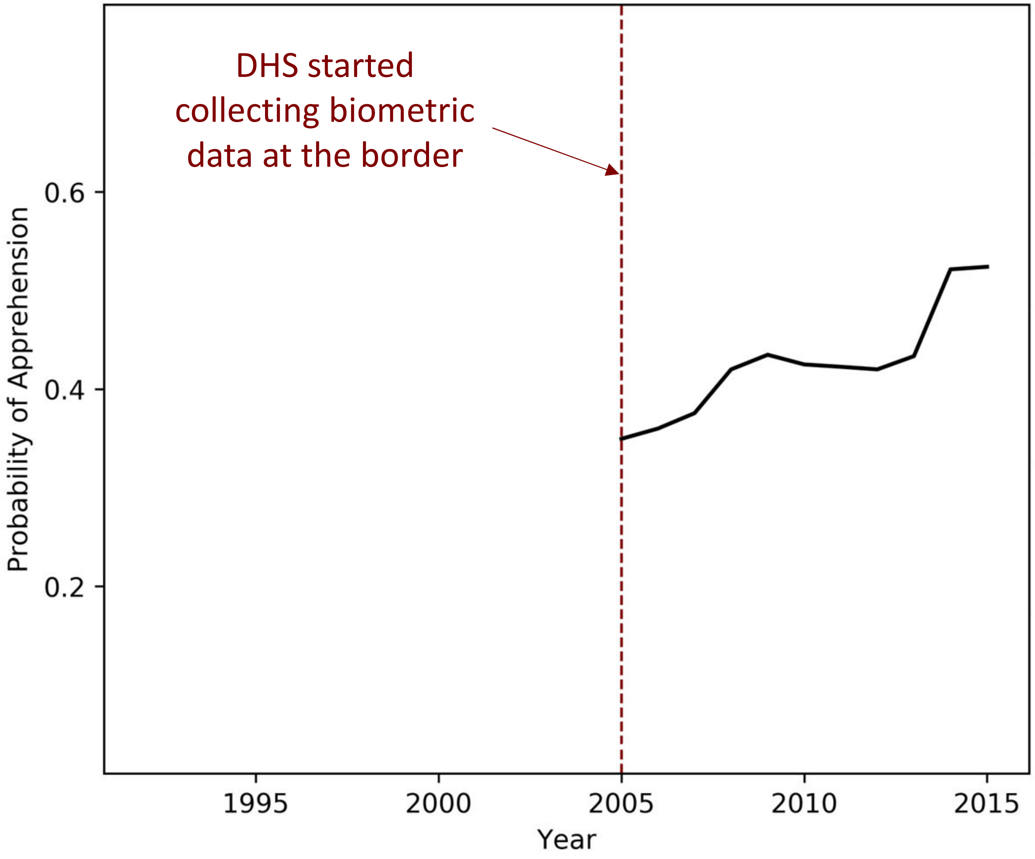
- Define $\bar{A}$ = *recidivist* apprehensions (that is, # 2nd or higher apprehension)
- Recall *A* = total apprehensions
- All apprehensions = First time apprehensions + recidivist apprehensions
- $A = Cp + \bar{A}$
- Recall $C = A\frac{1-p(1-d)}{p}$
- ==> $\bar{A} = A - Cp = A - A(1 - p(1 - d)) = Ap\,(1 - d)$
- Solve for *p*: $p = \frac{\bar{A}}{A(1-d)}$
- Note: $A(1 - d)$ is total undeterred apprehensions, which equals the number of crossing opportunities for *recidivist* apprehensions

What Does the Model Imply So Far?

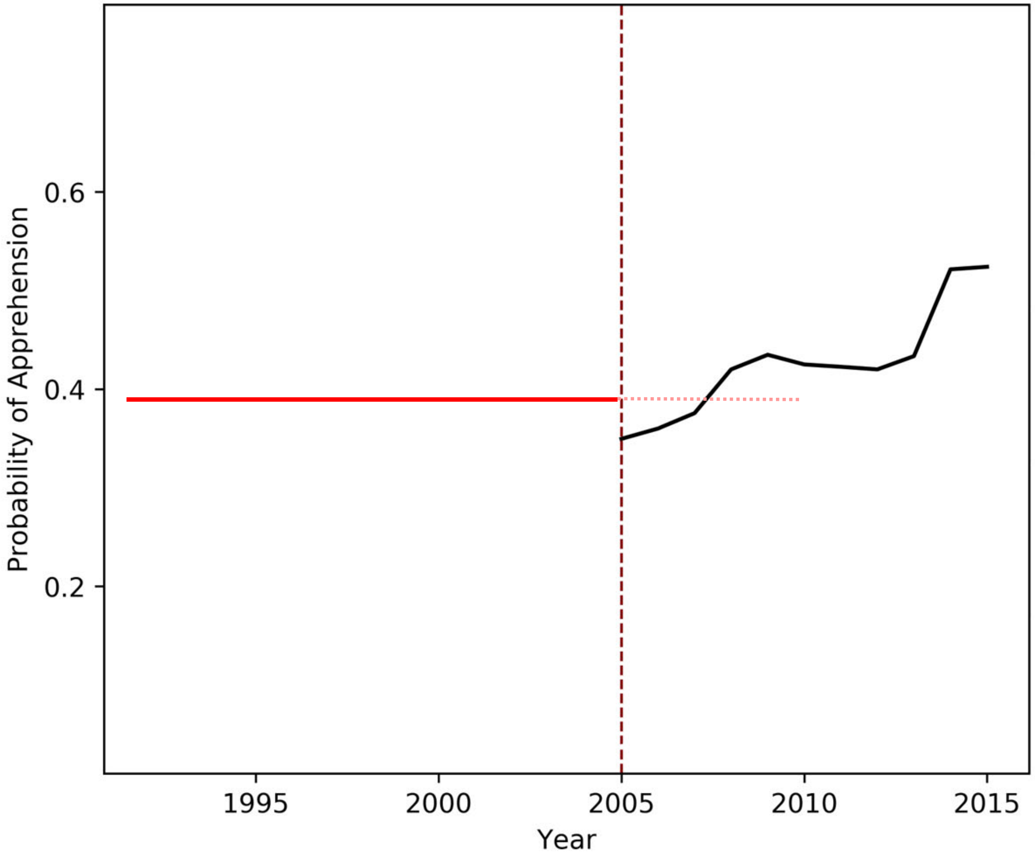
- Number of apprehensions at year *t*: $A_t = C_t \frac{p_t}{1-p_t(1-d_t)}$
- Number of attempters at year *t*: $C_t = A_t \frac{1-p_t(1-d_t)}{p_t}$
- Number of individuals deterred at year *t:* $Q_t = A_t d_t$
- Number of undocumented border crossers at year *t*: $B_t = A_t \frac{1-p_t}{p_t}$
- The probability of apprehension at year *t*: $p_t = \frac{\bar{A}_t}{A_t(1-d_t)}$

Number of recidivist apprehensions

Probability of Apprehension

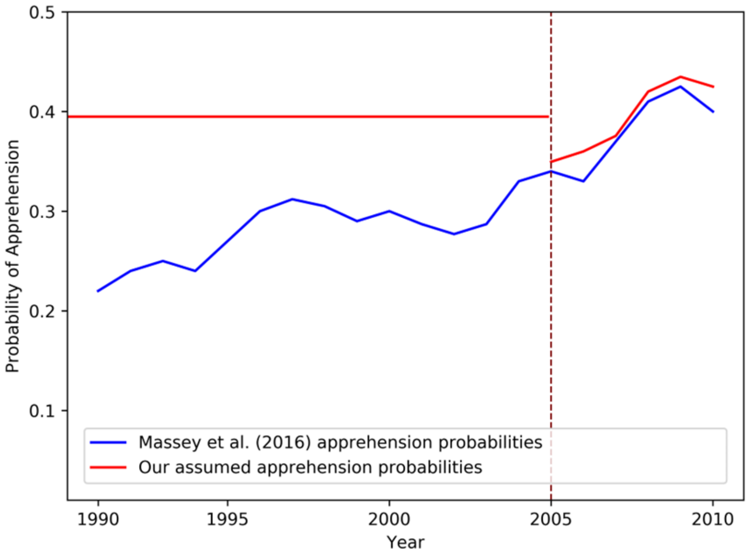


Probability of Apprehension

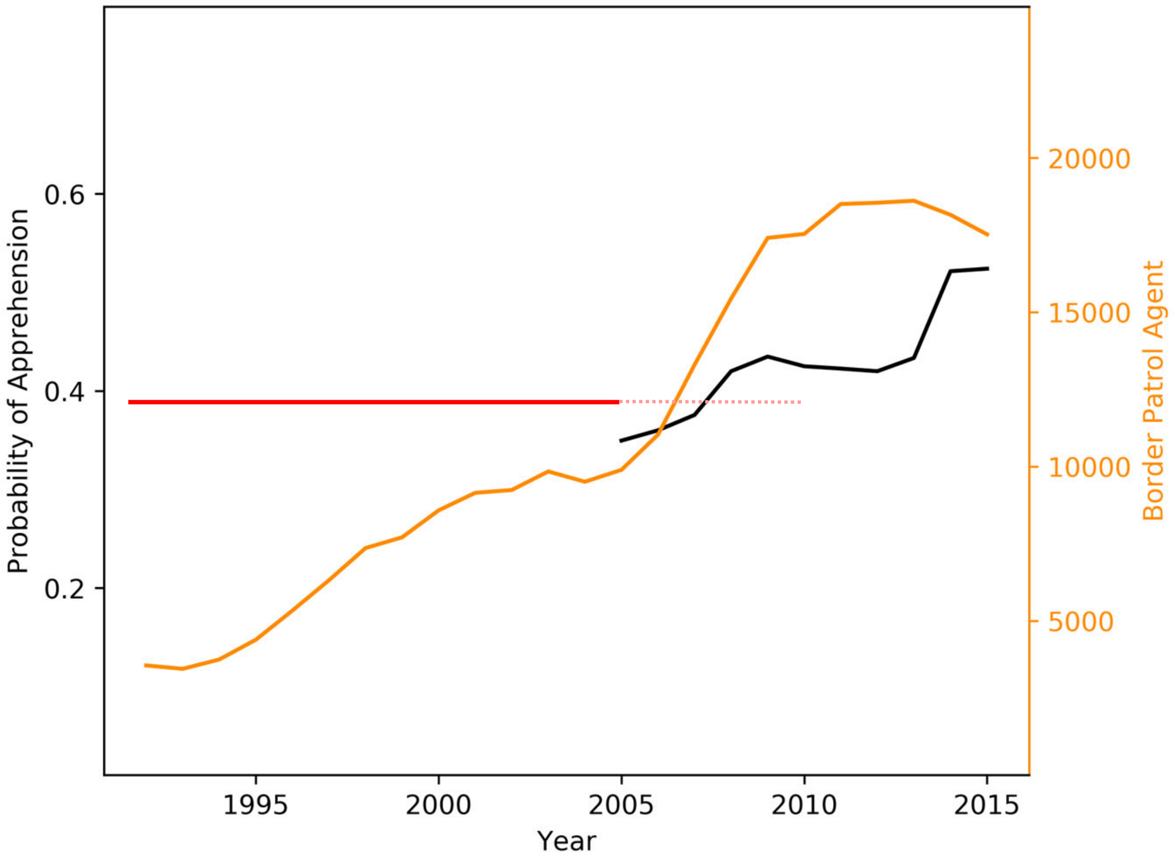


Probability of Apprehension

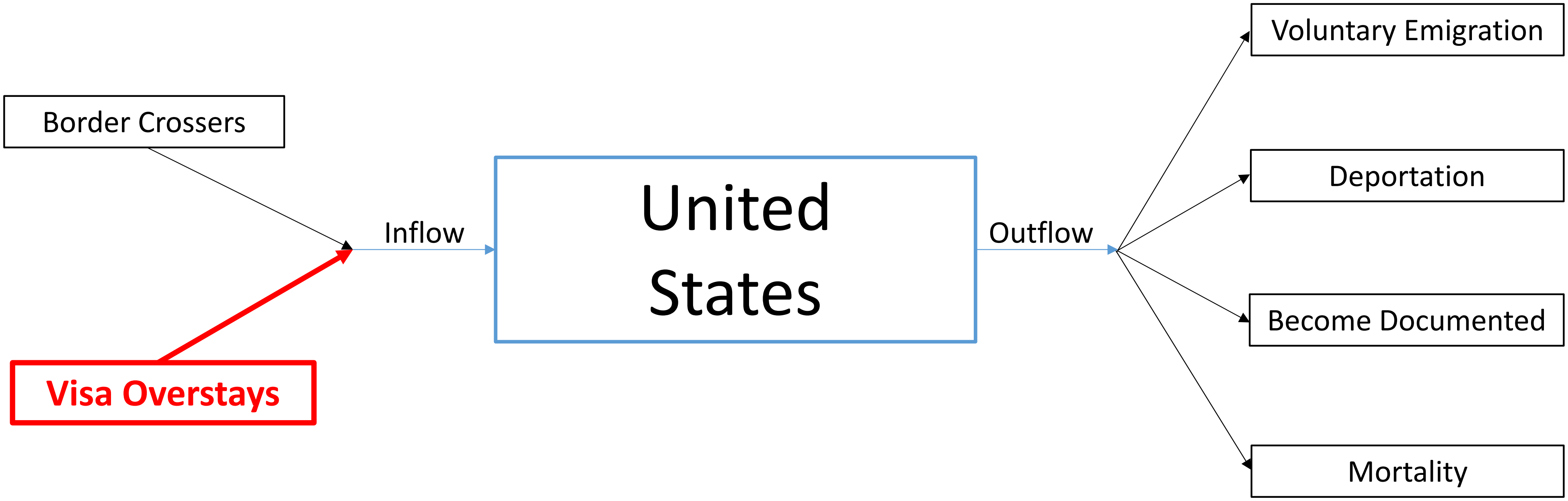
- What does the literature says?
  - Massey et al. (2016):
    - Start from the low 20% range in the 1990s ranging upward to approximately 30% in the earlier 2000s
  - Wein and Motskin (2009):
    - Estimate the 2003 rate at around 20%



Probability of Apprehension



The Model


Border Crossers
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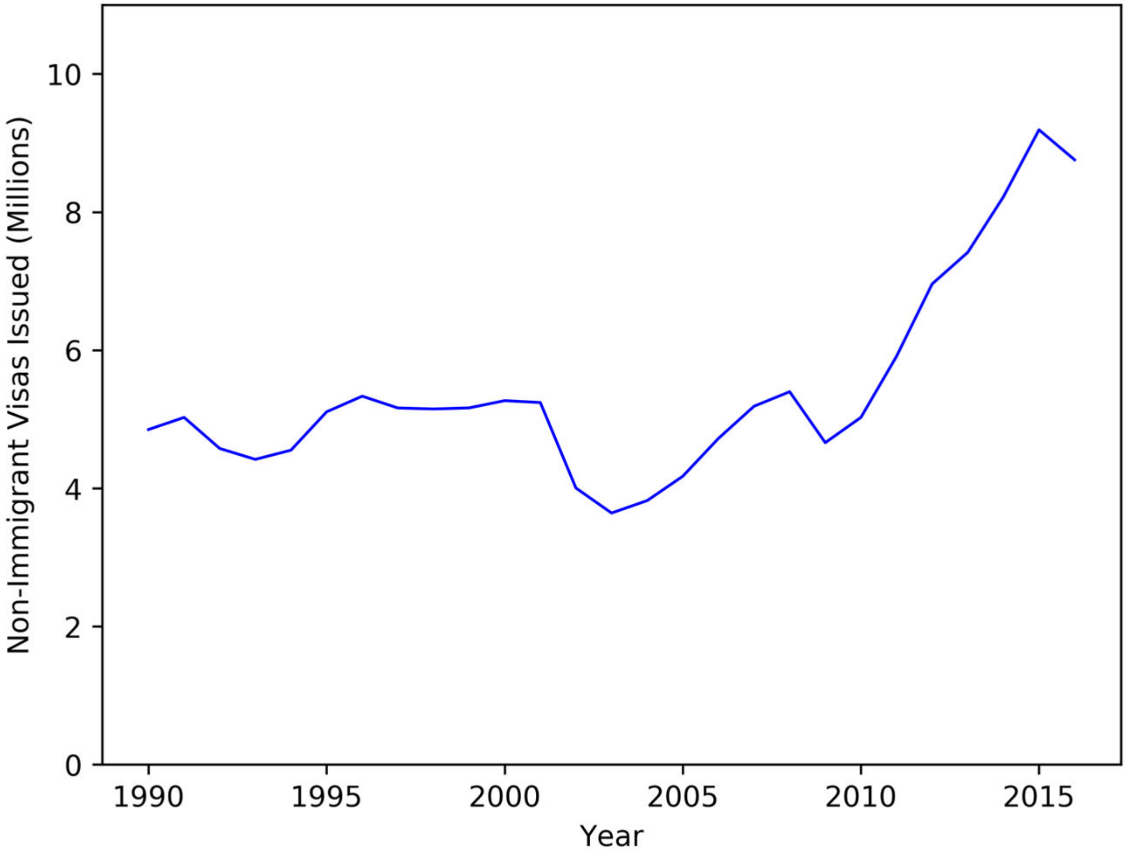
Mortality

Visa Overstays

- Non-immigrants who are admitted to the U.S. lawfully, but do not leave after the period during which they have been allowed to remain in the U.S. legally ends

- Comprehensively measured by Department of Homeland Security starting in 2016

Number of Non-Immigrant Visas Issued



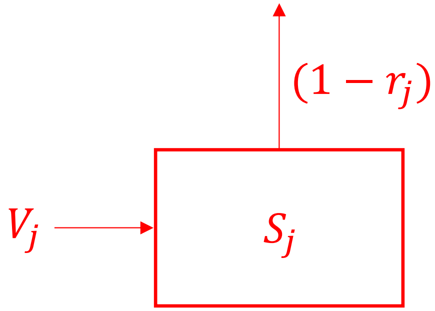
Data Source: U.S. Department of State

Visa Overstays

V_j : Number of visas issued in year j

S_j : Number of visa overstays in year j

r_j: Visa overstay rate in year j



$$S_j = r_j \times V_j$$

Visa Overstays

V_j : Number of visas issued in year j

S_j : Number of visa overstays in year j

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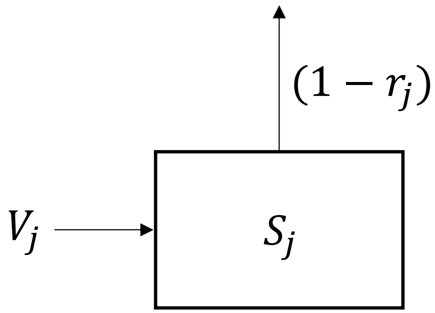


2016 visa overstay rate

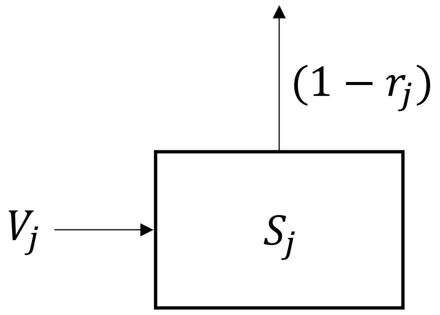
$$S_j = r_j \times V_j \qquad\qquad r_j = \frac{S_{2016}}{V_{2016}}, \qquad \forall j$$

Visa Overstays

V_j : Number of visas issued in year j

S_j : Number of visa overstays in year j

r_j: Visa overstay rate in year j



$$S_j = r_j \times V_j$$

2016 visa overstay rate

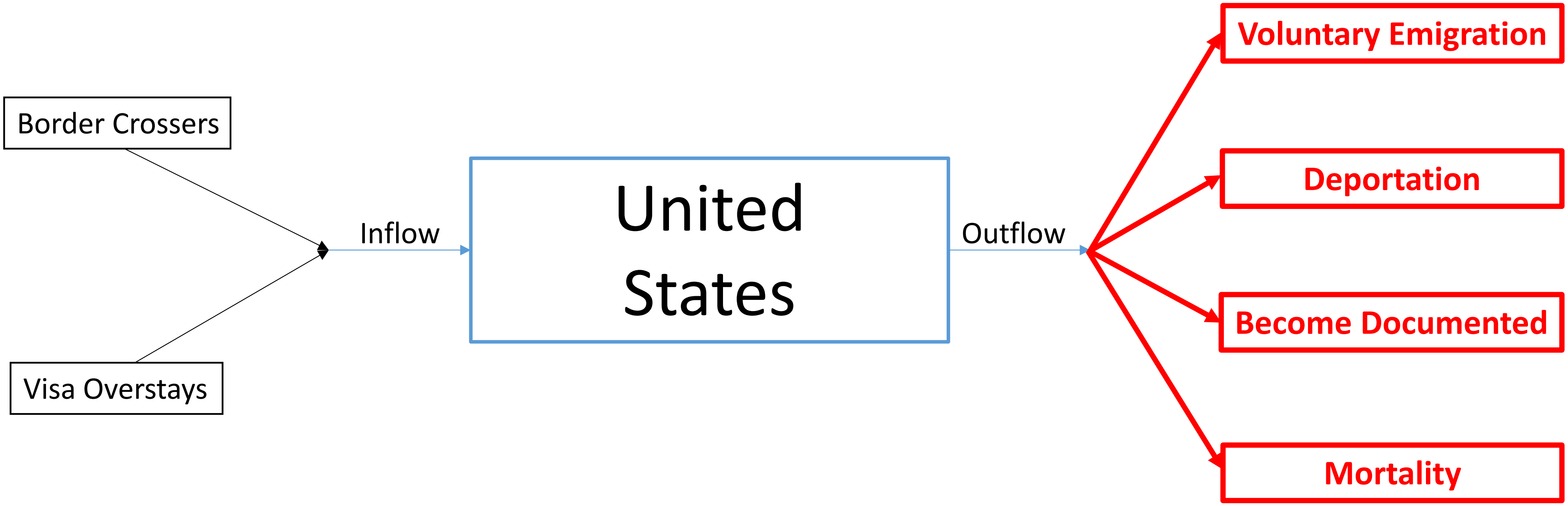
$$r_j = \frac{S_{2016}}{V_{2016}}, \qquad \forall j$$

Calibration:

$$\underbrace{\sum_{j=1}^{t=26} S_j \times \overbrace{Pr\{\tau_j \geq t-j\}}^{\text{Fraction of undocumented immigrants arriving in year } j \text{ still in the US in 2015}}}_{\text{Model estimate of the population of overstayers in 2015}} < \text{Number of overstayers in the current widely accepted estimate for 2015}$$

Outflows

The Model


Border Crossers
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Outflows

- Voluntary Emigration
- Deportations
- Become Documented
    - Including DACA in the outflows
- Mortality

Outflows

- Voluntary Emigration
- Deportations
- Become Documented
    - Including DACA in the outflows
- Mortality

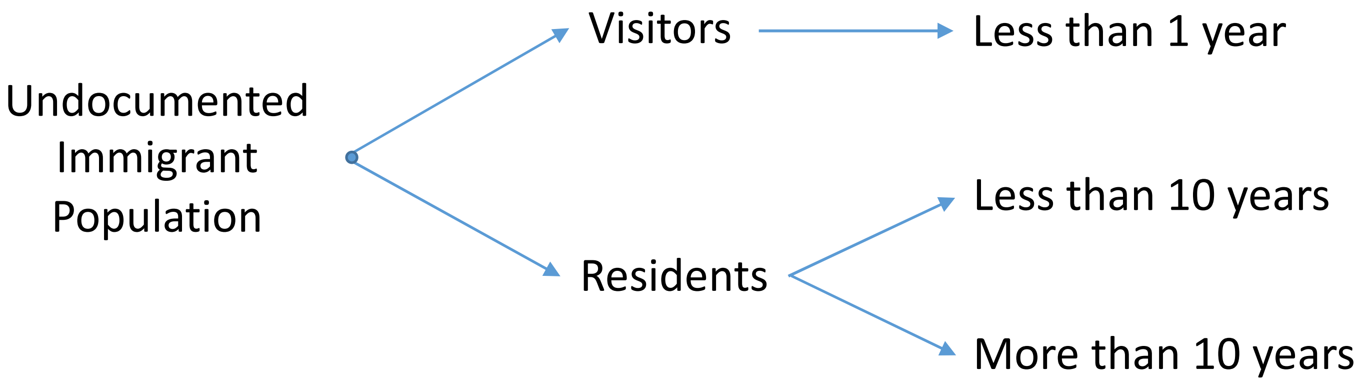
Voluntary Emigration

- Emigration decreases with time spent in the country
  - Van Hook and Zhang (2011), Bhaskar et al. (2013), Warren and Warren (2013)

- For each undocumented immigrant we must keep track of duration in the country

  - Duration-dependent emigration rate

Voluntary Emigration



Undocumented Immigrant Population

Visitors

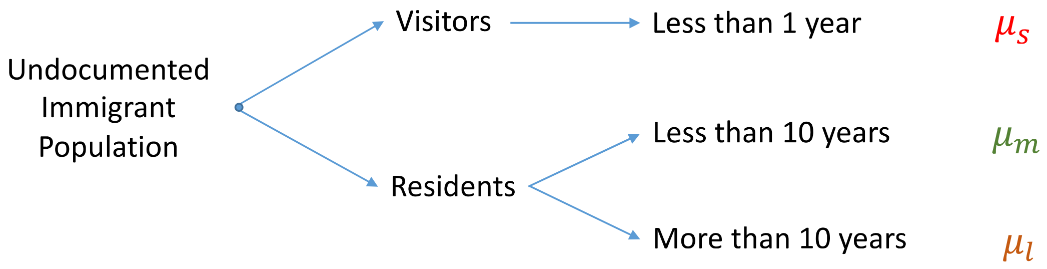
Residents

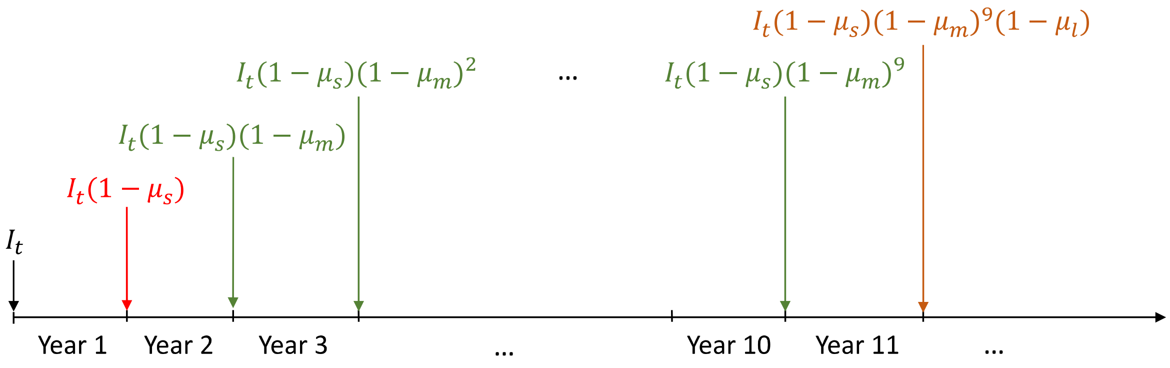
Less than 1 year

Less than 10 years

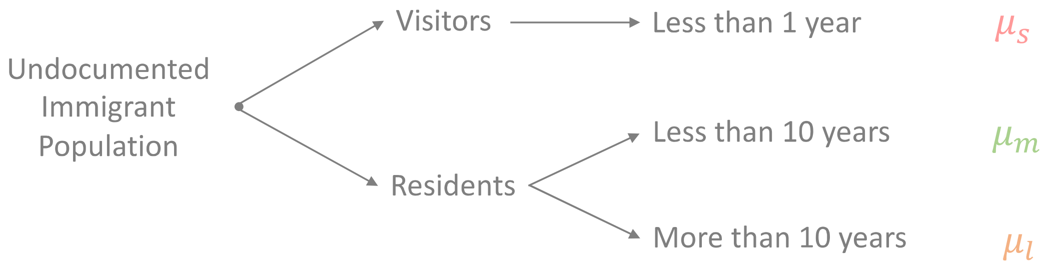
More than 10 years

Voluntary Emigration – **Simplified Example**




$I_t(1-\mu_s)(1-\mu_m)^9(1-\mu_l)$
$I_t(1-\mu_s)(1-\mu_m)^2$
...
$I_t(1-\mu_s)(1-\mu_m)^9$
$I_t(1-\mu_s)(1-\mu_m)$
$I_t(1-\mu_s)$
I_t
Year 1
Year 2
Year 3
...
Year 10
Year 11
...

Voluntary Emigration – **Simplified Example**



Undocumented Immigrant Population

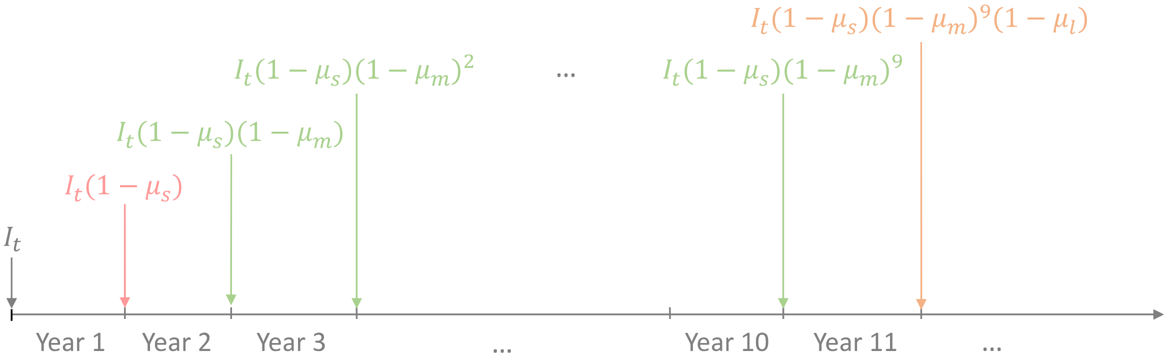
Visitors

Less than 1 year μ_s

Residents

Less than 10 years μ_m

More than 10 years μ_l



I_t

$I_t(1-\mu_s)$

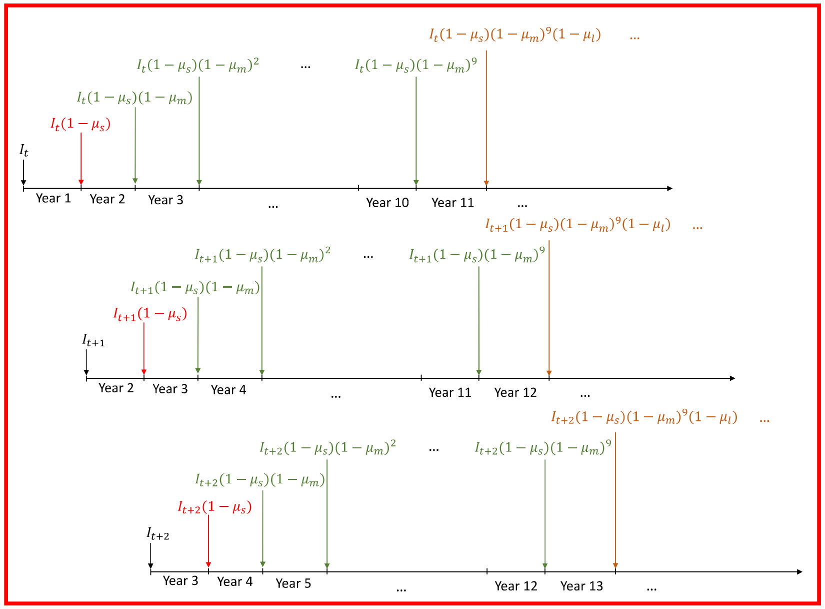
$I_t(1-\mu_s)(1-\mu_m)$

$I_t(1-\mu_s)(1-\mu_m)^2$ …

$I_t(1-\mu_s)(1-\mu_m)^9$

$I_t(1-\mu_s)(1-\mu_m)^9(1-\mu_l)$

Year 1 Year 2 Year 3 … Year 10 Year 11 …



$I_t(1-\mu_s)(1-\mu_m)^9(1-\mu_l)$ …

$I_t(1-\mu_s)(1-\mu_m)^2$ … $I_t(1-\mu_s)(1-\mu_m)^9$

$I_t(1-\mu_s)(1-\mu_m)$

$I_t(1-\mu_s)$

I_t

Year 1 Year 2 Year 3 … Year 10 Year 11 …

$I_{t+1}(1-\mu_s)(1-\mu_m)^9(1-\mu_l)$ …

$I_{t+1}(1-\mu_s)(1-\mu_m)^2$ … $I_{t+1}(1-\mu_s)(1-\mu_m)^9$

$I_{t+1}(1-\mu_s)(1-\mu_m)$

$I_{t+1}(1-\mu_s)$

I_{t+1}

Year 2 Year 3 Year 4 … Year 11 Year 12 …

$I_{t+2}(1-\mu_s)(1-\mu_m)^9(1-\mu_l)$ …

$I_{t+2}(1-\mu_s)(1-\mu_m)^2$ … $I_{t+2}(1-\mu_s)(1-\mu_m)^9$

$I_{t+2}(1-\mu_s)(1-\mu_m)$

$I_{t+2}(1-\mu_s)$

I_{t+2}

Year 3 Year 4 Year 5 … Year 12 Year 13 …

Voluntary Emigration - Data

- Residents: use ***largest*** values in published academic and government sources
  - Ahmed and Robinson (1994), Mulder (2003), Van Hook and Zhang (2011), Baker and Rytina (2013), Warren and Warren (2013), Bhaskar et al. (2013)

- Visitors: use data on first-year exit rate for visa overstayers
  - The assumed emigration rates are an upper bound for border crossers (Massey et al (2002), Massey et al. (2016))

- The emigration rates used significantly overestimate outflows

The Final Formula

$$N_t = N_{t-1} + I_t - O_t$$

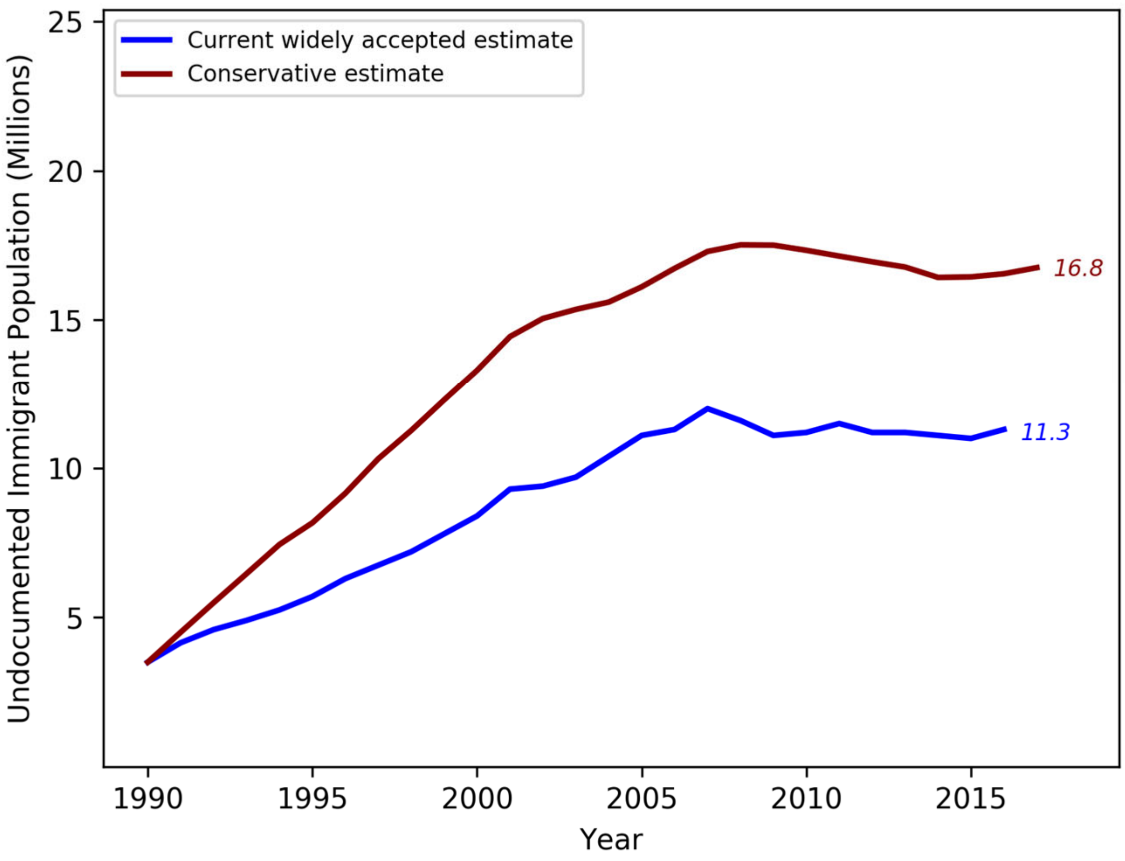
$$\Downarrow$$

$$N_t = N_0 \times Pr\{\tau_0 > t\} + \sum_{j=1}^{t} \Big(\big(I_j (1 - \mu_s) - D_j \big) \times Pr\{\tau_j > t\} \Big)$$

$$I_t = S_t + B_t = r \times V_t + A_t \frac{1 - p_t}{p_t} \qquad , \qquad p_t = \frac{\bar{A}_t / A_t}{(1 - d_t)}$$

$$Pr\{\tau_j > t\} = \begin{cases} (1 - \mu_m - \delta)^{10} (1 - \mu_l - \delta)^{t-10}, & j = 0 \\ (1 - \mu_m - \delta)^{9} (1 - \mu_l - \delta)^{t-j-9}, & 0 < j \leq t - 10 \\ (1 - \mu_m - \delta)^{t-j}, & j > t - 10 \end{cases}$$

Results – Conservative Estimate



Incorporate Uncertainty Into The Model

- Build uncertainty into the model to take into account variability
  - Produce probability distribution over the number of undocumented immigrants

- Main source of uncertainty
  - Parameter uncertainty

Incorporate Uncertainty Into The Model

- Parameter Uncertainty:

$$\left\{ \underbrace{\begin{matrix} \mathit{Overstay} \\ \mathit{Rate} \end{matrix}, \begin{matrix} \mathit{Apprehension} \\ \mathit{Probabilities} \end{matrix}}_{\text{Inflow Parameters}}, \underbrace{\begin{matrix} \mathit{Emigration} \\ \mathit{Rates} \end{matrix}, \begin{matrix} \mathit{Mortality} \\ \mathit{Rate} \end{matrix}}_{\text{Outflow Parameters}} \right\}$$

- Taking into account:
  - Circular flows which link apprehension probability with emigration rates (Massey (2004, 2013), Massey and Pren (2012))
  - Cohort dependent emigration rates

Incorporate Uncertainty Into The Model

- Parameter Uncertainty:

$$\left\{\underbrace{\begin{matrix}Overstay\\ Rate\end{matrix}, \begin{matrix}Apprehension\\ Probabilities\end{matrix}}_{\text{Inflow Parameters}}, \underbrace{\begin{matrix}Emigration\\ Rates\end{matrix}, \begin{matrix}Mortality\\ Rate\end{matrix}}_{\text{Outflow Parameters}}\right\}$$

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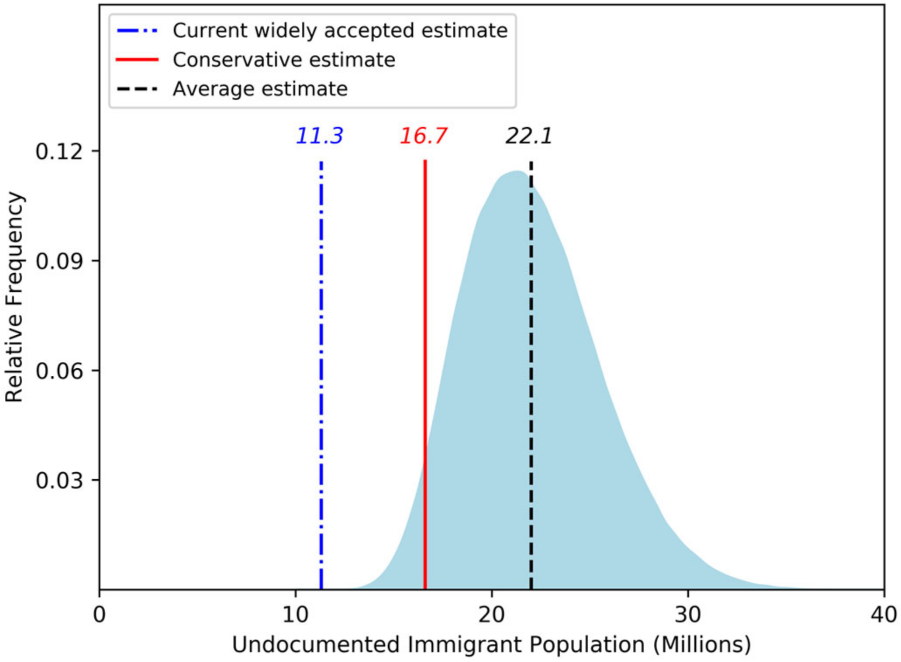
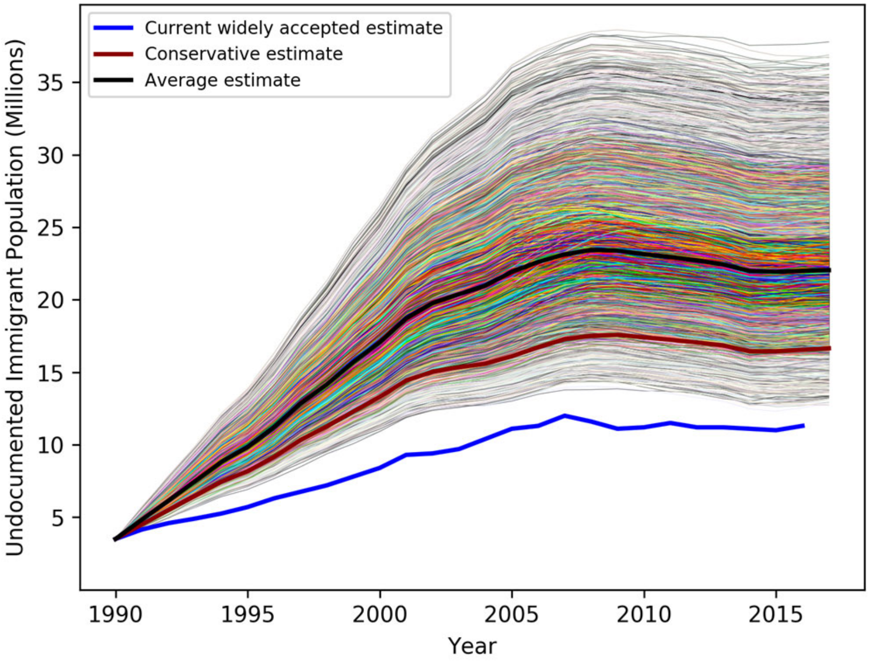
- **Poisson structure with mean dependent upon the underlying parameter**

Results – 1,000,000 Simulation Runs



Probability Distribution (2016)



Trajectories

Reception

The New York Times

LA Times

The Boston Globe

The Washington Post

THE HILL

Bloomberg

POLITICO

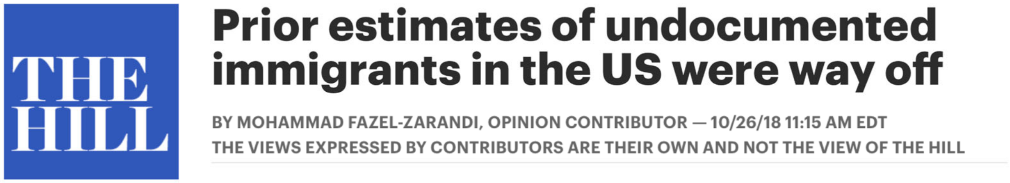
MotherJones

Daily Mail

DAILY NEWS NEW YORK

NATIONAL REVIEW

n p r

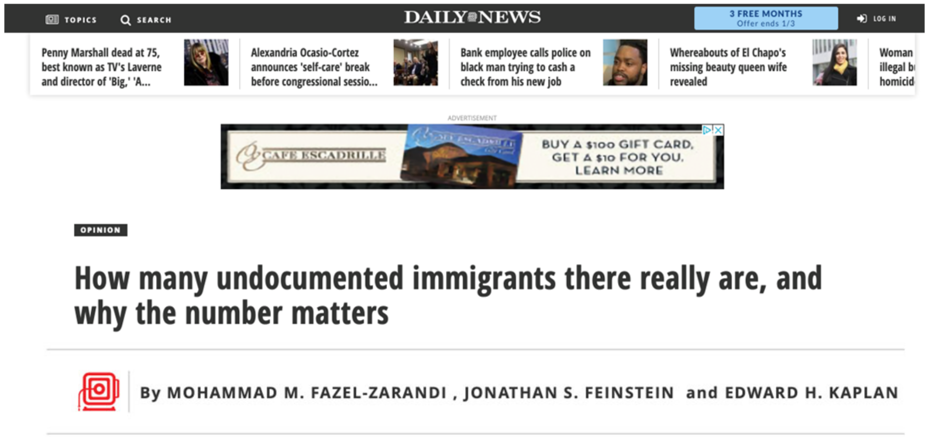


THE HILL

Prior estimates of undocumented immigrants in the US were way off

BY MOHAMMAD FAZEL-ZARANDI, OPINION CONTRIBUTOR — 10/26/18 11:15 AM EDT

THE VIEWS EXPRESSED BY CONTRIBUTORS ARE THEIR OWN AND NOT THE VIEW OF THE HILL



Penny Marshall dead at 75, best known as TV's Laverne and director of 'Big,' 'A...

Alexandria Ocasio-Cortez announces 'self-care' break before congressional sessio...

Bank employee calls police on black man trying to cash a check from his new job

Whereabouts of El Chapo's missing beauty queen wife revealed

Woman illegal b homicid

OPINION

How many undocumented immigrants there really are, and why the number matters

By MOHAMMAD M. FAZEL-ZARANDI , JONATHAN S. FEINSTEIN and EDWARD H. KAPLAN

https://video.foxnews.com/v/5839718007001#sp=show-clips

Reception

Some of the issues in dispute:

1. The undercount implied by the new model is too high.

2. The range of model-estimated populations is too large to be useful for policy purposes, while the residual method gives a much smaller range of uncertainty.

3. The voluntary emigration rates of undocumented immigrants employed in the model are too low.

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Census/American Community Survey Undercount

- For around 40 million there is no clear answer to place of birth (ignored deliberate misreporting)

- Fill in the blanks using “hot deck” allocation

  - Missing at random vs *missing on purpose*

  - Due to *missing on purpose*, the number of “donors” to the hot deck will be disproportionately US born

  - Imputed value for the place of birth variable will disproportionately point to “born in the USA”

  - Undercounting number foreign born ⇒ undercount in number of undocumented immigrants

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- Precise estimate of wrong quantity: undocumented immigrants who are located and answering truthfully
- Small variability stems from the sampling variation that accompanies large samples

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- After accounting for the sampling bias, we find that the resulting emigration rates are consistent with our presumed rates

Snapshot Models of Undocumented Immigration

Scott Rodilitz[1,*] and Edward H. Kaplan[2]

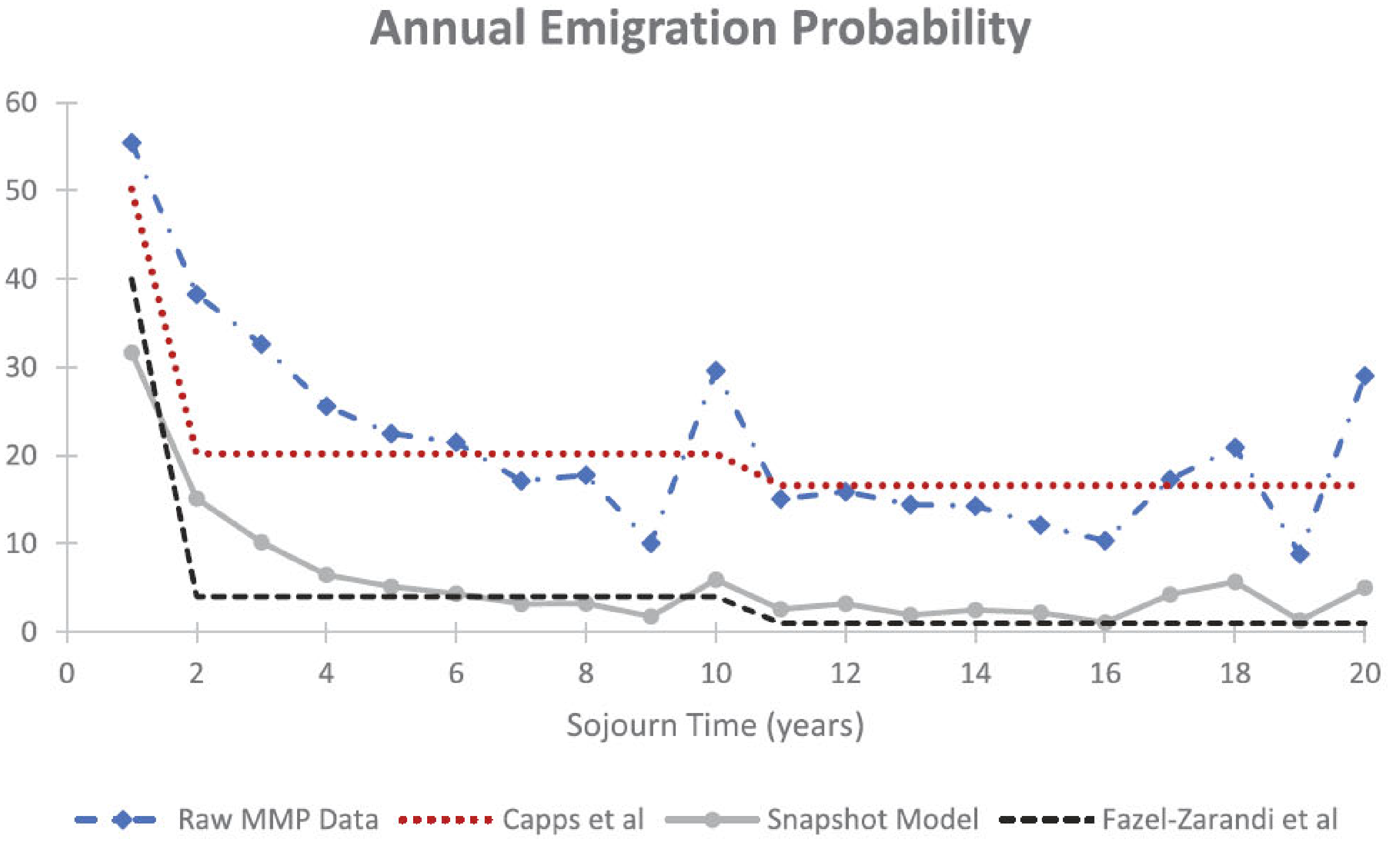

Fig 8. Annual emigration probabilities from the United States.

Policy Implications

- **Social services**:
  - agencies that have been working off of the previous estimate should recognize that the resources they have allocated for this population may be too low
- **Border control**:
  - In the last few years, the majority of new undocumented entrants are visa overstays
  - The number of illegal border crossers has substantially decreased
- **Crime:**
  - Further calls into question the claim of elevated risks of criminality surrounding undocumented immigrants.
  - The crime rate is much smaller