The Race Between Education, Technology, and Institutions

Jonathan Vogel

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What explains the evolution of U.S. wage inequality?

- Neoclassical perspective highlights roles of supply and demand
- Alternative perspective emphasizes changes in labor-market institutions

Literatures distinct in part because no simple framework synthesizes the two

Theoretically: develop a synthesis, augmenting the **canonical model**

- central organizing framework for neoclassical literature
  - with **monopsony power**, **minimum wages**, and **unemployment**

Empirically: show that **supply**, **demand**, and **minimum wages** are each central drivers of the **college premium**
1. Estimate canonical model, but incorporate the real minimum wage
   ▶ Improved out of sample fit  
   ▶ Jointly quantify impact of supply, demand, minimum wages on the college premium
      ★ e.g., decline in the real minimum wage btw 1979-89  ⇒ 4.5% ↑
      ★ e.g., slowdown in growth rate of college supply btw 1979-89 (vs. 1969-79)  ⇒ 6.9% ↑

2. Extend the theoretical canonical model (monopsony, minimum wages, unemployment)
   ▶ Extended estimating equation and structural interpretations of its parameters

3. Using theory, estimate a state-level extended canonical model
   ▶ Differential changes in state minimum wages (interacted with their initial *bite*) and college supplies drive the differential evolution of college premia across U.S. states
   ▶ State and national estimates are quantitatively consistent, lending credibility to each
Road Map

1. Estimate canonical model, but incorporate the real minimum wage
   - Improved out of sample fit
     (no strong slowdown in the rate of SBTC)
   - Jointly quantify impact of supply, demand, minimum wages on the college premium
     - e.g., decline in the real minimum wage btw 1979-89 ⇒ 4.5% ↑
     - e.g., slowdown in growth rate of college supply btw 1979-89 (vs. 1969-79) ⇒ 6.9% ↑

2. Extend the theoretical canonical model (monopsony, minimum wages, unemployment)
   - Extended estimating equation and structural interpretations of its parameters
   - Without unemployment effect of minimum wage: robust to arbitrary # of groups

3. Using theory, estimate a state-level extended canonical model
   - Differential changes in state minimum wages (interacted with their initial bite) and college supplies drive the differential evolution of college premia across U.S. states
   - State and national estimates are quantitatively consistent, lending credibility to each

4. Quantify impact of minimum wage on real wages and more disaggregated inequality
Canonical model (Tinbergen 74, Katz and Murphy 92, ...) or, more broadly, an aggregate production function (Krusell et al., 00, ...) including minimum wage (Autor, Katz, Kearney 08)

- While supply and demand remain crucial, so too is the minimum wage
- Minimum wage resolves the (apparent) rapid slowing SBTC in the 1990s

Neoclassical approach extended to study labor (and potentially capital) allocations
Caselli, Coleman, 01; Autor ea., 03; Autor, Dorn, 13; Buera ea., 2015; Burstein ea., 19; Acemoglu, Restrepo, 20; Oberfield, Raval, 21; ...

Roles of labor-market institutions, especially minimum wages, for shaping inequality
Meyer, Wise, 83; DiNardo et al., 96; Lee, 99; Card, DiNardo, 02; Autor ea., 16; Cengiz ea. 19; Dube, 19; Fortin ea. 21; Chen, Teulings 22; ...

Growing macro-labor literature of monopsony using quantitative models
Haanwinckel, 20; Engbom, Moser, 21; Ahlfeldt et al., 22; Berger et al., 22; Hurst et al., 22; Trottner, 22; ...

- Theoretically and empirically synthesize the neoclassical and institutional approaches
- Provide a unified analysis of evolution of inequality at national and regional levels

Synthesis is far from exhaustive; e.g., I abstract from unions (Farber et al., 21)
Literature

Did I know this? Or do I know it cannot be true?

- **Canonical model** (Tinbergen 74, Katz and Murphy 92, ...) or, more broadly, an aggregate production function (Krusell et al., 00, ...) including minimum wage (Autor, Katz, Kearney 08)
  - While supply and demand remain crucial, so too is the minimum wage
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  - Theoretically and empirically synthesize the neoclassical and institutional approaches
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Canonical Model Implementation
Incorporating the Real Minimum Wage
I consider (for now atheoretical) regressions of the form

$$\log \left( \frac{w_{ht}}{w_{lt}} \right) = \alpha + \beta_m \log m_t + \beta_L \log \left( \frac{Supply_{ht}}{Supply_{lt}} \right) + \gamma_1 t + [\gamma_2 t^2 + \gamma_3 t^3 + ...] + \iota_t$$

using national time-series, $t$, variation across two groups of workers, $h$ and $l$.

- $\log w_{ht}$ and $\log w_{lt}$ are measures of average log wages.
- $\log Supply_{ht}$ and $\log Supply_{lt}$ are measures of labor supply.
- $m_t$ is a measure of the real minimum wage at the national level.

Data spans the years 1963 - 2017.
I consider regressions of the form

$$\log \left( \frac{w_{ht}}{w_{\ell t}} \right) = \alpha + \beta_m \log m_t + \beta_L \log \left( \frac{Supply_{ht}}{Supply_{\ell t}} \right) + \gamma_1 t + [\gamma_2 t^2 + \gamma_3 t^3 + ...] + \nu_t$$

using national time-series, $t$, variation across two groups of workers, $h$ and $\ell$

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Measuring variables that enter the traditional canonical model (March CPS)

- Composition-adjusted college premium
  - avg. log hourly wage w/in 180 groups (9 age bins $\times$ 2 genders $\times$ 2 races $\times$ 5 educations) in year $t$
  - avg. across groups w/ and w/out college education using time-invariant weights
- Composition-adjusted supply: $h, \ell$ wages consistent w/ observed incomes
  - ... as in any price and quantity indices
I consider regressions of the form

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\log \left( \frac{w_{ht}}{w_{\ell t}} \right) = \alpha + \beta_m \log m_t + \beta_L \log \left( \frac{Supply_{ht}}{Supply_{\ell t}} \right) + \gamma_1 t + [\gamma_2 t^2 + \gamma_3 t^3 + ...] + \iota_t
\]

using national time-series, \( t \), variation across two groups of workers, \( h \) and \( \ell \)

- \( \log w_{ht} \) and \( \log w_{\ell t} \) are measures of average log wages
- \( \log Supply_{ht} \) and \( \log Supply_{\ell t} \) are measures of labor supply
- \( m_t \) is a measure of the real minimum wage at the national level

Measuring the national real minimum wage

- Two approaches (both nominal series deflated by GDP deflator)
  1. BL: For each state use the max of the state and national statutory minima then average across states using time-invariant weights
  2. ALT: Use the national FLSA minimum wage
Variation in the raw data

Figure: Relative Wages, Relative Supplies, and Real Minimum Wage Series

Notes: The left and middle panels display the composition-adjusted college premium and relative college supply. The right panel displays the baseline and alternative measures of the real minimum wage. All series are normalized to zero in 1963.

- Steep rise in college premium starting in early 1980s coincides w/decline in growth rate of relative supply, as first emphasized in Katz and Murphy (1992)
- Minimum wage series move in lockstep until the late 1980s; diverge thereafter
  - Minimum wages feature substantial time variation, dramatic declines in 1980s
Residualized Variation

Residualized College Premium and Relative Supply

Residualized College Premium and Real Minimum Wage

Notes: The left panel displays the composition-adjusted college premium and relative college supply residualized of the real minimum wage and a linear time trend. The right panel displays the composition-adjusted college premium and real minimum wage residualized of relative supply and a linear time trend.

- Clear negative relationships that identify $\beta_L$ and $\beta_m$ using OLS (with linear trend)
  - Robust to residualizing on high-dimensional polynomials of time (esp. for minimum wage)
## Results

### Regression Models for the College Wage Premium

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Notes: Real m.w. refers to the baseline measure whereas real FLSA m.w. refers to the alternative one. Time Polynom. refers to the polynomial of time included in the regression; the linear time effect is omitted whenever this polynomial is greater than one. Robust standard errors are reported.

- **Previous interpretation:** Poor out-of-sample fit (w/ rapid decline in rate of SBTC)
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- Real minimum wage helps resolve the “puzzle” of slowing SBTC
Results

Predicted College Premium (Estimated on 1963-87)

Omitting Real Minimum Wage
Results

Predicted College Premium (Estimated on 1963-87)

Omitting Real Minimum Wage

Including Real Minimum Wage
Results

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- Relative supply fluctuations, trend demand are crucial drivers of college premium...
  - e.g., slowdown in growth rate of relative supply 1979 – 89, relative to 1969 – 79
    \[ \Rightarrow 6.4 - 7.3\% \uparrow \text{ in college premium (compare to observed 13.4\% \uparrow)} \]
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... but changes in the real minimum wage are also crucial drivers of premium

- e.g., $27\% \downarrow$ in real minimum wage 1979 – 89 $\implies 3.7 – 5.3\% \uparrow$ in college premium
Summary (contrary to previous results):

1. Relative supply growth fluctuations + trend demand growth remain crucial drivers of college premium, but so too are changes in the real minimum wage.
2. Improved out-of-sample fit of the canonical model (no slowing of SBTC).

Robustness:

- Using an alternative measure of relative supply.
- Instrumenting for relative supply.
- Defining high-education workers differently.

Consistent with Previously Estimated Distributional Effects?

- Small-medium effects on wages > m.w. (Autor et al., 16 and Cengiz et al., 19).
- Using AMS estimation, I construct counterfactual change in national college premium 1979 – 89. Results vary by order of magnitude with estimation sample (related Fortin et al. 20 critique).
- Can be quite close to (or far from) my estimates above.
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Robustness:

- ... higher-dimensional polynomials of time
- ... using an alternative measure of relative supply
- ... instrumenting for relative supply
- ... using data from Autor, Katz, and Kearney (2008)
- ... defining high-education workers differently
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Extending the Canonical Model
Framework

- Two labor “skills” indexed by $s$ ($h$ and $\ell$) hired by two types of firm
  - Continuum of $s$ labor, $\omega \in \Omega_s$, with measure $L_s \equiv |\Omega_s|$ \hfill (\text{$L_s$ shapes supply})
  - $N_s \geq 2$ skill $s$ firms, indexed by $n \in \mathcal{N}_s$

- If worker $\omega$ works for firm $n$ at wage $w_{\omega n}$, then
  - worker’s utility is $w_{\omega n}/\varepsilon_{\omega n}$
  - output is $A_s \phi_\omega$ \hfill (\text{$A_s$ shapes demand})

- CRS aggregate production function $Y = Y(Y_\ell, Y_h)$

- Firm $n$ can employ $\omega$ only at wage above minimum wage: $w_{\omega n} \geq m$
Framework

- Two labor “skills” indexed by $s$ ($h$ and $\ell$) hired by two types of firm
  - Continuum of $s$ labor, $\omega \in \Omega_s$, with measure $L_s \equiv |\Omega_s|$ \hspace{1cm} ($L_s$ shapes supply)
  - $N_s \geq 2$ skill $s$ firms, indexed by $n \in \mathcal{N}_s$
- If worker $\omega$ works for firm $n$ at wage $w_{\omega n}$, then
  - worker’s utility is $w_{\omega n}/\varepsilon_{\omega n}$
  - output is $A_s \phi_\omega$ \hspace{1cm} ($A_s$ shapes demand)
- CRS aggregate production function $Y = Y(Y_\ell, Y_h)$
- Firm $n$ can employ $\omega$ only at wage above minimum wage: $w_{\omega n} \geq m$

1. Firms observe worker characteristics, simultaneously make wage offers
2. Then, each worker chooses the firm that maximizes her utility
   - If $\max_n \{w_{\omega n}\} < m$, she is unemployed
- Look for SPNE in weakly undominated strategies
Cross-Sectional Results

- Worker chooses lowest $\varepsilon_{\omega n}$ (let $\varepsilon_{\omega} \leq 1$ be ratio of lowest to second lowest $\varepsilon_{\omega n}$)

- In the absence of a minimum wage, $m = 0$
  - Full employment and $w_\omega = A_s P_s \phi_\omega \varepsilon_\omega$ ($A_s P_s \phi_\omega =$ VMPL)
  - Wage markdown (VMPL divided by wage), is given by $1/\varepsilon_\omega \geq 1$

- Equilibrium differs in two respects with $m > 0$
  1. The least productive workers may be unemployed: $\phi_\omega < m_s \equiv m/(A_s P_s)$
  2. Wages for some may ↑, $w_\omega = \max\{A_s P_s \phi_\omega \varepsilon_\omega, m\}$, and wage markdowns ↓

Example with uniform value of $\varepsilon < 1$ across all workers (and $A_s P_s = 1$)
What Is the Goal?

- Elasticity of relative average real wages w.r.t.
  - canonical model: labor supplies \((L_h, L_\ell)\) and labor demands \((A_h, A_\ell)\)
  - extended canonical model: the minimum wage \((m)\)
- Average real wage paid to employed skill \(s\) workers

\[
\bar{w}_s = \mu_s m + (1 - \mu_s) P_s A_s E \left[ \phi \mid \phi > m_s \right]
\]

- \(P_s A_s E \left[ \phi \mid \phi > m_s \right]\): average wage of those earning above minimum wage
- \(\mu_s \equiv Pr \left[ \phi \leq m_s \mid \phi \geq m_s \right]\): share of skill \(s\) workers w/ wage equated to the real minimum wage \((\phi \leq m_s)\) conditional on being employed \((\phi \geq m_s)\)

- As in the canonical model: \(\log A_{st} = \alpha_s + \gamma_s t + \nu_{st}\)

- Note: I am not varying monopsony power (number of firms or distribution of \(\epsilon_\omega\))
Proposition 1. The log derivative of the skill premium can be expressed as

\[ d \log \left( \frac{W_{ht}}{W_{\ell t}} \right) = \beta_m d \log m_t + \beta_L d \log \left( \frac{L_{ht}}{L_{\ell t}} \right) + \beta_A dt + \iota_t \]

- This is the equation taken to the data in canonical model (in changes) but incorporating the minimum wage
- Simple intuition:
  - First-order approximation: change is a linear function of underlying shocks
  - CRS Y: changes in average wages depend only on the ratio of supplies

What about the values of the \( \beta \) parameters in general?
Corollary 1

**Corollary 1.** Suppose \( m_t = 0 \) and \( Y \) is CES w/ elasticity \( \eta \). Then

\[
\log \left( \frac{W_{ht}}{W_{lt}} \right) = \alpha - \frac{1}{\eta} \log \left( \frac{L_{ht}}{L_{lt}} \right) + \frac{\eta - 1}{\eta} (\alpha_h - \alpha_\ell) t + \nu_t
\]

- Eqn. identical to canonical model (although there are wage markdowns)
Corollary 2

**Corollary 2**

**Corollary 2** Suppose \( \phi_\omega \neq m_{st} \) for all \( \omega \in \Omega_s \) and each \( s \). Then

\[
\beta_m = \sigma_h - \sigma_\ell
\]

where \( \sigma_s = \text{share of } s \text{ wage income earned by minimum wage workers} \)

- Result holds given any number of skills and any CRS aggregator \( Y \)

- Simple intuition:
  - Direct effect:
    - \( \text{elasticity of wage of m.w. earners w.r.t. } m \) is one
    - \( \text{elasticity of } \bar{w}_s \text{ w.r.t. } m \) is then \( \sigma_s \)
  - Indirect effects:
    - \( m \) affects who earns m.w. cond. on employment: no first-order effect generically
    - \( m \) affects who is employed: assumed away in Corollary 2
Empirics leveraging state variation
Estimation using state-level variation: Approach

- Estimate a regional version of extended canonical model using Corollary 2

\[
\Delta \log \left( \frac{w_{hr}}{w_{\ell r}} \right) = \alpha_t + \beta_m b_{rt} \Delta \log m_{rt} + \beta_L \Delta \log \left( \frac{Supply_{hr}}{Supply_{\ell r}} \right) + [\gamma_{r0} + \ldots] + \epsilon_{rt}
\]

- \( r \) indexes region (fifty states) and \( t \) time (years 1979 – 2017)
- Define \( \Delta x_t \equiv x_{t+T} - x_t \) as the \( T \)-period difference for any \( x_t \)
- \( m_{rt} \) is real minimum wage in state \( r \) in year \( t \)
- \( b_{rt} \equiv \sigma_{hr} - \sigma_{\ell r} \) is the relevant bite of the minimum wage (15% above)

- Report two-way cluster-robust standard errors by state and year
- Weigh each state by avg across years of its share of national population
- Assuming region-specific labor markets
Estimation using state-level variation: Approach

- Estimate a regional version of extended canonical model using Corollary 2

\[
\Delta \log \left( \frac{w_{hrt}}{w_{\ell rt}} \right) = \alpha_t + \beta_m b_{rt} \Delta \log m_{rt} + \beta_L \Delta \log \left( \frac{Supply_{hrt}}{Supply_{\ell rt}} \right) + [\gamma_{r0} + \ldots] + \iota_{rt}
\]

- \( r \) indexes region (fifty states) and \( t \) time (years 1979 – 2017)
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- \( m_{rt} \) is real minimum wage in state \( r \) in year \( t \)
- \( b_{rt} \equiv \sigma_{hrt} - \sigma_{\ell rt} \) is the relevant bite of the minimum wage (15% above)
- \( \alpha_t \) absorbs national SBTC between \( t \) and \( t + T \)
- \( \gamma_{r0} \) absorbs linear deviation in region \( r \)'s trend SBTC growth from national
  - additionally include \( \gamma_{r1} t \) and \( \gamma_{r2} t^2 \), absorbing higher-order \( r \)-specific deviations

- Report two-way cluster-robust standard errors by state and year
- Weigh each state by avg across years of its share of national population
- Assuming region-specific labor markets
Estimation using state-level variation: Measurement

- Estimate a regional version of extended canonical model using Corollary 2

\[
\Delta \log \left( \frac{w_{hrt}}{w_{\ell rt}} \right) = \alpha_t + \beta'_m b_{rt} \Delta \log m_{rt} + \beta_L \Delta \log \left( \frac{Supply_{hrt}}{Supply_{\ell rt}} \right) + [\gamma_{r0} + ...] + \iota_{rt}
\]

- Measurement
  - \( w_{srt}, \) \( Supply_{srt} \) measured as before, but using state-specific data
  - \( b_{rt} \) using MORG CPS btw 1979 – 2017
    - assume minimum wage worker if earns \( \leq 1.15 \times \) minimum wage
    - do not measure \( b_{rt} \) in 1994 given missing imputation flags
    - leaving 38 years of data across fifty states
Estimation using state-level variation: Instrument

- Estimate a regional version of extended canonical model using Corollary 2

\[
\Delta \log \left( \frac{w_{hrt}}{w_{\ell rt}} \right) = \alpha_t + \beta_m b_{rt} \Delta \log m_{rt} + \beta_L \Delta \log \left( \frac{Supply_{hrt}}{Supply_{\ell rt}} \right) + [\gamma_{r0} + \ldots] + \epsilon_{rt}
\]

Instruments

- Measurement error in \( b_{rt} \) and it is likely correlated w/ dependent variable
- I consider two distinct instruments for \( b_{rt} \Delta \log m_{rt} \)

1. Baseline: \( \bar{b}_t^r \bar{b}_t^r \Delta \log m_{rt} \), where
   - \( \bar{b}_t^r \equiv \frac{1}{37} \sum_{j \neq t} b_{rj} \) average bite of minimum wage in state \( r \) (leave-out \( t \))
   - \( \bar{b}_t^r \equiv \frac{1}{49} \sum_{j \neq r} b_{jt} \) average bite of minimum wage in year \( t \) (leave-out \( r \))

2. Alternative: \( b_{rt-1} \Delta \log m_{rt} \)
## Results

### Regression Models for Changes in State-Level College Wage Premia

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Two-stage least squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Δ relative supply</td>
<td>-0.419</td>
<td>-0.424</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.041)</td>
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<tr>
<td>bite x Δ real mw.</td>
<td>3.549</td>
<td>3.493</td>
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<tr>
<td></td>
<td>(1.144)</td>
<td>(1.212)</td>
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<tr>
<td>State effect</td>
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<td>X</td>
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<td>Difference T</td>
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<td>Instrument</td>
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<tr>
<td>First-stage F</td>
<td>433</td>
<td>394</td>
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</table>

**Notes:** Dependent variable and "Δ relative supply": log changes in composition-adjusted college premium and relative supply at state level. "bite x Δ real mw." is state m.w. bite in t times log change in state real m.w. t is each year in 1979-2017 excluding 1994. Instrument is baseline (BL) in columns (c) and (d) and alternative (Alt) in columns (e) and (f). Using Alt instrument drops t = 1979 and t = 1995, since $bite_{rt-1}$ is not defined for these years. "First stage F" reports the KP F statistic. Robust standard errors are two-way clustered on state and year.

- Relative supply coefficient similar to national time-series estimates (a bit lower)
# Results

## Regression Models for Changes in State-Level College Wage Premia

<table>
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<tr>
<th></th>
<th>OLS</th>
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<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
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<tr>
<td><strong>Δ relative supply</strong></td>
<td><strong>-0.419</strong></td>
<td><strong>-0.424</strong></td>
</tr>
<tr>
<td></td>
<td><strong>(0.041)</strong></td>
<td><strong>(0.041)</strong></td>
</tr>
<tr>
<td><strong>bite x Δ real mw.</strong></td>
<td><strong>3.549</strong></td>
<td><strong>3.493</strong></td>
</tr>
</tbody>
</table>

- State effect: X
- Difference T: 4
- Observations: 1,700
- Instrument: BL
- First-stage F: 433

### Notes:

- Dependent variable and "Δ relative supply": log changes in composition-adjusted college premium and relative supply at state level. "bite x Δ real mw." is state m.w. bite in t times log change in state real m.w. t is each year in 1979-2017 excluding 1994. Instrument is baseline (BL) in columns (c) and (d) and alternative (Alt) in columns (e) and (f). Using Alt instrument drops t = 1979 and t = 1995, since \( \text{bite}_{t-1} \) is not defined for these years. "First stage F" reports the KP F statistic. Robust standard errors are two-way clustered on state and year.

- Dividing national estimates by average bite across years \((-0.045) \Rightarrow 3 - 4.3\)
- Minimum wage coefficients similar to the national time-series estimates
Summary + Robustness + Literature Comparison

Summary:

1. Minimum wage + relative supply play central roles shaping differential evolution of college premia across U.S. states
2. Parameter estimates leveraging state and national variation very similar, lending credibility to each

Robustness:

- ... higher-dimensional polynomials of time
- ... varying time difference $T$

Literature Comparison:

Consistent with Previously Estimated Distributional Effects?
- Small-medium effects on wages $w > m.w.$ (Autor et al., 16 and Cengiz et al., 19)
- Cengiz et al. find 40% of wage effect with in $4$ of m.w. caused by spillovers
- I find that 70% of wage effect on skill premium caused by spillovers

⋆ Not yet sure how to compare these

My empirical approach allows for arbitrary state-time-varying changes in composition of employed (theirs that entrants identical to exits)
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Summary:
2. Parameter estimates leveraging state and national variation very similar, lending credibility to each.

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- ... varying time difference $T$

Consistent with Previously Estimated Distributional Effects?
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- Cengiz et al. find 40% of wage effect w/ in $4$ of m.w. caused by spillovers.
- I find that 70% of wage effect on skill premium caused by spillovers:
  - Not yet sure how to compare these
  - My empirical approach allows for arbitrary state-time-varying changes in composition of employed (theirs that entrants identical to exits)
Connecting Theory and Data
+ Quantification (and Disaggregation)
Connecting Theory and Data

- **Theory**: If no unemployment effects of minimum wage, elasticity of college premium w.r.t. m.w. is \( \sigma_h - \sigma_\ell \)

- **Empirics**: Estimated effect is about 3 - 4 times larger

- **Simplest fix**: wage measurement error ⇒ spillovers up wage distribution
  - Assumption in Derenoncourt and Montialoux (2021); similar to Cengiz et al. (2019)
  - Empirical finding in Autor Manning and Smith (2016)

- Theory and empirics align if workers earning \( \leq 155\% \) of m.w. are m.w. workers

- If no unemployment effects of minimum wage, elasticity of real wage to factual or counterfactual changes in minimum wages for *any arbitrary group* \( g \) is \( \sigma_g \)
  - Use this 155% rule in measuring \( \sigma_g \) in what follows for any \( g \)
Quantification 1: ↓ in Real Wages for Least Educated

What was effect of 18.3% ↓ real m.w. on real wages between 1979 and 1993...

- ... among males who didn’t finish high school ($\sigma_{HSD} = 27.8\%$)? ↓5.1%
- ... among males who finished high school ($\sigma_{HSG} = 11.3\%$)? ↓2.1%
- ... and among males w/ some college ($\sigma_{SMC} = 8.1\%$) ↓1.5%
Quantification 2: Pervasive ↑ in Inequality vs. Polarization

- To what extent do changes in m.w.s btw 1979-1993 and 1996-2017 explain differences in evolution of inequality across male HSD relative to HSG?
  
  ▶ 1979-93: 18.3% ↓ real m.w. and 11.4% ↓ in relative HSD wage (pervasive ↑ inequality)
  
  ▶ 1996-17: 26.2% ↑ real m.w. and 5.9% ↑ in relative HSD wage (wage polarization)

- If the real m.w. had stayed flat in each period HSD relative wage would have
  
  ▶ fallen by 8.4% instead of 11.4% in the first period
  
  ▶ risen by 1.5% instead of 5.9% in the latter period

- > two-fifths \((2/5 \approx 1 - (8.4 + 1.5)/(11.4 + 5.9))\) of the differential evolution of inequality across these groups in earlier, latter periods explained by real m.w. changes

- Minimum wages play an important role in observed changes btw periods of pervasive increases in inequality and wage polarization
Conclusions

- Synthesis of neoclassical + institutional perspectives of wage inequality

- Theoretically, provided generalization of canonical model
  - maintains simplicity and tractability of the purely neoclassical model
  - generates a simple estimating equation incorporating the real minimum wage

- Empirically, real minimum wage improves canonical model out-of-sample fit

- Empirically, minimum wage, supply and demand each play substantial roles shaping U.S. and state college premia

- Quantitatively, shed light on role of minimum wages in explaining declining real wages and patterns of wage polarization
Empirical Appendix
### Regression Models for the College Wage Premium

<table>
<thead>
<tr>
<th></th>
<th>1963-2017</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
<td>(f)</td>
<td>(g)</td>
<td>(h)</td>
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<td>(0.052)</td>
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<td>(0.092)</td>
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<td></td>
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<td>(0.059)</td>
<td>(0.055)</td>
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<td>(0.041)</td>
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<td>(0.030)</td>
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<td>(0.029)</td>
<td>(0.028)</td>
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<td>(0.012)</td>
<td>(0.013)</td>
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<td>4</td>
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<td>55</td>
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<td>55</td>
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<tr>
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<td>0.969</td>
<td>0.971</td>
<td>0.981</td>
<td>0.990</td>
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Regression Models for the College Wage Premium
Instrument: log of Relative Population (vs. Efficiency-Unit Hours)

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<th>Reduced form</th>
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<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
<td>(f)</td>
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<tr>
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<td></td>
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<td>(0.064)</td>
<td>(0.060)</td>
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<td>(0.034)</td>
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<td>(0.026)</td>
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<td>2</td>
<td>3</td>
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Regression Models for the College Wage Premium
Using Data from AKK Replication Package (1963-2005)

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<tbody>
<tr>
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<tr>
<td>Relative supply</td>
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<tr>
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<td>(0.051)</td>
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<tr>
<td>Minimum wage</td>
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<td>(0.083)</td>
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<tr>
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<tr>
<td>R-squared</td>
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Regression Models for the College Wage Premium

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<th>1963-2017</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
<td>(f)</td>
<td>(g)</td>
<td>(h)</td>
</tr>
<tr>
<td>Relative supply</td>
<td>-0.267</td>
<td>-0.495</td>
<td>-0.228</td>
<td>-0.134</td>
<td>0.005</td>
<td>0.043</td>
<td>0.065</td>
<td>0.100</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.111)</td>
<td>(0.117)</td>
<td>(0.114)</td>
<td>(0.075)</td>
<td>(0.049)</td>
<td>(0.060)</td>
<td>(0.050)</td>
</tr>
<tr>
<td>Real m.w.</td>
<td>-0.181</td>
<td>-0.113</td>
<td>-0.031</td>
<td>-0.092</td>
<td>-0.110</td>
<td>-0.088</td>
<td>-0.091</td>
<td>-0.057</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.062)</td>
<td>(0.047)</td>
<td>(0.056)</td>
<td>(0.035)</td>
<td>(0.027)</td>
<td>(0.028)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.002</td>
<td>-0.033</td>
<td>0.033</td>
<td>0.026</td>
<td>-0.014</td>
<td>-0.052</td>
<td>-0.059</td>
<td>-0.016</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.013)</td>
<td>(0.027)</td>
<td>(0.024)</td>
<td>(0.010)</td>
<td>(0.013)</td>
<td>(0.020)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Time Polynom.</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Observations</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.895</td>
<td>0.907</td>
<td>0.948</td>
<td>0.952</td>
<td>0.974</td>
<td>0.985</td>
<td>0.985</td>
<td>0.990</td>
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### Regression Models for the State-Level College Wage Premium Including Higher-Order State-Specific Time Trends

<table>
<thead>
<tr>
<th></th>
<th>Baseline instrument</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
<td>(f)</td>
<td>(g)</td>
<td>(h)</td>
</tr>
<tr>
<td>Δ relative supply</td>
<td>-0.419 (0.040)</td>
<td>-0.424 (0.041)</td>
<td>-0.422 (0.042)</td>
<td>-0.426 (0.044)</td>
<td>-0.407 (0.041)</td>
<td>-0.412 (0.041)</td>
<td>-0.409 (0.042)</td>
<td>-0.411 (0.044)</td>
</tr>
<tr>
<td>bite x Δ real mw.</td>
<td>3.484 (1.411)</td>
<td>3.665 (1.481)</td>
<td>3.806 (1.568)</td>
<td>4.036 (1.568)</td>
<td>4.119 (1.268)</td>
<td>4.182 (1.372)</td>
<td>4.553 (1.343)</td>
<td>5.240 (1.155)</td>
</tr>
<tr>
<td>State effect</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Time Poly.</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Difference T</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>Observations</td>
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<td>1,700</td>
<td>1,700</td>
<td>1,700</td>
<td>1,600</td>
<td>1,600</td>
<td>1,600</td>
<td>1,600</td>
</tr>
<tr>
<td>First-stage F</td>
<td>433</td>
<td>394</td>
<td>305</td>
<td>307</td>
<td>1692</td>
<td>1569</td>
<td>1516</td>
<td>801</td>
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</tbody>
</table>
## Robustness: Varying Time Difference $T$

### Regression Models for the State-Level College Wage Premium

Varying the Length of the Time Difference

<table>
<thead>
<tr>
<th>2SLS using the baseline instrument, state-specific time trends</th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
<th>(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$ relative supply</td>
<td>-0.550</td>
<td>-0.476</td>
<td>-0.448</td>
<td>-0.424</td>
<td>-0.417</td>
<td>-0.412</td>
<td>-0.409</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.040)</td>
<td>(0.044)</td>
<td>(0.041)</td>
<td>(0.041)</td>
<td>(0.043)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>bite x $\Delta$ real mw.</td>
<td>4.016</td>
<td>0.849</td>
<td>2.105</td>
<td>3.665</td>
<td>4.362</td>
<td>3.503</td>
<td>2.944</td>
</tr>
<tr>
<td></td>
<td>(2.225)</td>
<td>(1.789)</td>
<td>(1.659)</td>
<td>(1.481)</td>
<td>(1.410)</td>
<td>(1.376)</td>
<td>(1.656)</td>
</tr>
<tr>
<td>Difference $T$</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Observations</td>
<td>1,850</td>
<td>1,800</td>
<td>1,750</td>
<td>1,700</td>
<td>1,650</td>
<td>1,600</td>
<td>1,550</td>
</tr>
<tr>
<td>First-stage F</td>
<td>215</td>
<td>210</td>
<td>301</td>
<td>394</td>
<td>253</td>
<td>148</td>
<td>140</td>
</tr>
</tbody>
</table>

**Notes:** This table replicates column (d) of baseline state-specific regression—all specifications are estimated using 2SLS and the baseline instrument and include a state fixed effect and a state-specific linear time trend—varying the time length of the difference $T$ in $\Delta x_t = x_{t+T} - x_t$ from $T = 1$ to $T = 7$.

- Column (d) replicates the baseline state-level regression
- Results are robust for $T \in \{1, 4, 5, 6, 7\}$ while noisy for $T \in \{2, 3\}$
Theoretical Appendix
Proposition 2: Partial Equilibrium

**Proposition 2.** For given changes in $P_s, A_s$, and $m$,

\[
d \log \bar{w}_s = \sigma_s d \log m + (1 - \sigma_s) d \log (P_s A_s)
\]

\[
+ \frac{\chi_s (\mu_s - \sigma_s)}{e_s \mu_s} m_s \left[ d \log m - d \log (P_s A_s) \right]
\]

where $\mu_s, \sigma_s$ are shares of employment, income earned by m.w. workers, $e_s$ is share of workers who are employed, and $\chi_s$ is probability an agent is marginally employed.
General Equilibrium

For given changes in supplies, \( L_h, L_\ell, \) productivities, \( A_h, A_\ell, \) and the minimum wage, \( m, \)

\[
\beta_m \equiv \rho_\ell - \rho_h - \left( \frac{\zeta_\ell m_\ell - \zeta_h m_h}{\eta + \zeta_h m_h} \right) \left( \rho_h \frac{P_\ell Y_\ell}{Y} + \rho_\ell \frac{P_h Y_h}{Y} \right)
\]

\[
\beta_L \equiv -\frac{1}{\eta + \zeta_h m_h} \left( \rho_h \frac{P_\ell Y_\ell}{Y} + \rho_\ell \frac{P_h Y_h}{Y} \right)
\]

where I have defined

- \( \rho_s \equiv (1 - \sigma_s) - \frac{\chi_s (\mu_s - \sigma_s)}{\ell_s \mu_s} m_s \) as the elasticity of \( \bar{w}_s \) w.r.t. \( P_s A_s \) (from Prop 2)
- \( \zeta_s \) is the share of \( Y_s \) lost when the cutoff \( m_s \) marginally increases
Corollary 2: Value of $\beta_L$

**Corollary 2.** Suppose $\phi_\omega \neq m_{st}$ for all $\omega \in \Omega_s$ and each $s$. Then

$$\beta_L = -\frac{1}{\eta} \left( 1 - \sigma_h \frac{P_\ell Y_\ell}{Y} - \sigma_\ell \frac{P_h Y_h}{Y} \right)$$

where $\eta = \text{local elasticity of substitution in the aggregate production function}$

- Elasticity of $P_h/P_\ell$ with respect to $Y_h/Y_\ell$ is $-1/\eta$, as in canonical model
- Unlike canonical model, not all workers receive VMPL
- Hence, without unemployment effects we have $\frac{d \log \bar{w}_s}{d \log P_s} = 1 - \sigma_s$
Counterfactual Change in Skill Premium Using AMS 16

- Counterfactual change in US college premium 1979 – 89 caused by $\Delta$ m.w.
  1. Use AMS replication package to estimate parameters required to...
  2. ... construct CF $\Delta$ college premia by state implied by $\Delta$ m.w. ...
  3. ... and average across states to obtain national $\Delta$ college premium

- Results highly unstable to years used in estimation (see Fortin et al. 20 for instability of parameters)
  - Estimated using 1979 – 91: national $\Delta$ college premium $\uparrow$ 2.4%
  - Estimated using 1979 – 00: national $\Delta$ college premium $\uparrow$ 0.2%
  - Estimated using 1979 – 12: national $\Delta$ college premium $\uparrow$ 0.4%
Let $w^p_{rt}$ be the wage of percentile $p$ in region $r$ and $\lambda^p_{srt}$ be share of employment of skill $s$ in $r$ that is in percentile $p$:

$$w_{srt} = \sum_p \lambda^p_{srt} w^p_{rt} \implies d \log w_{srt} = \sum_p \frac{\lambda^p_{srt} w^p_{rt}}{w_{srt}} (d \log \lambda^p_{srt} + d \log w^p_{rt})$$

AMS estimates impact of m.w. on $\tilde{w}^p_{rt} \equiv w^p_{rt} - w^{50}_{rt}$ btw $t$ and $t + 1$.

I measure $d \log (w_{Hrt}/w_{Lrt})$ using the above equation assuming m.w. has no effect on wages at the median.