Disentangling the Contemporaneous and Life-Cycle Effects of Body Mass on Earnings

Donna B. Gilleskie\textsuperscript{1}, Euna Han\textsuperscript{2}, Edward C. Norton\textsuperscript{3}

\textsuperscript{1}Department of Economics  
University of North Carolina at Chapel Hill

\textsuperscript{2}Gachon Medical and Science University

\textsuperscript{3}Department of Health Management and Policy  
Department of Economics  
University of Michigan

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Body Mass as we Age
(same individuals followed over time)
Outline

1 Motivation
   - My research agenda and this paper
Outline

1. Motivation
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2. Individual Behavior
   - Decisionmaking under uncertainty
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3. Empirical Approach
   - Two possible routes
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4 Data
   - What do we observe, how can we explain it?
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   - What do we observe, how can we explain it?

5 Estimation
   - Features of the empirical model
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5. Estimation
   - Features of the empirical model

6. Results
   - Findings to date
Research Agenda

- How can we empirically capture/model the effect of life-cycle health on productivity?
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- What are the avenues through which health over the life cycle affects productivity? (and vice-versa)
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Given an empirical economic model, how can we best quantify/simulate the life-cycle effect of health on productivity?
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Health ⇝ Productivity

**What do we mean by health?**

- self-reported health
- chronic conditions (e.g., back pain, sleep apnea, obesity)
- disability
- mental health (e.g., depression, stress)
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What do we mean by productivity?

- employment (e.g., OLF, unemployed, FT/PT, hours worked)
Health $\leftrightarrow$ Productivity

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What do we mean by **productivity**?
- employment (e.g., OLF, unemployed, FT/PT, hours worked)
- wages
Health ⇐ Productivity

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- absenteeism and short-term disability
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- presenteeism
Our Discussion Today

- How can we empirically capture/model the effect of life-cycle health on productivity?
  - body mass wages

- What are the avenues through which health over the life cycle affects productivity?
  - body mass wages

- Given an estimated empirical model, how can we best quantify/simulate the life-cycle effect of health on productivity?
  - body mass wages
Pros and Cons of the Body Mass Index (BMI)

- A function of weight & height; independent of age & gender

\[ \text{BMI} = \frac{\text{weight (kg)}}{\text{height}^2 (\text{m}^2)} = \frac{\text{weight (lb)} \times 703}{\text{height}^2 (\text{in}^2)} \]

- A simple means for classifying (sedentary) individuals
  - BMI < 18.5: underweight
  - 18.5 ≤ BMI < 25.0: ideal weight
  - 25.0 ≤ BMI < 30.0: overweight
  - BMI ≥ 30.0: obese

- May over/under estimate in those with more/less lean body mass
- May only have self-reported weight & height (subjective measure, rounding issues)

Other measures:
- skinfold, underwater weighing, fat-free mass, body volume/location
Average Body Mass by Age
(using repeated cross sections from NHIS data)

Source: DiNardo, Garlick, Stange (2010)
Percent Overweight and Obese by Age
(using repeated cross sections from NHIS data)

Source: DiNardo, Garlick, Stange (2010)
Distribution of Body Mass over Time
(using repeated cross sections from NHIS data)

The distribution of BMI is changing over time.
- The mean and median have increased significantly.
- The right tail has thickened (larger percent obese).

Source: DiNardo, Garlick, Stange (2010)
What do we know about body mass and wages?

- Evidence in the economic literature that wages of white women are negatively correlated with BMI.
What do we know about body mass and wages?

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- Evidence that wages of white men, white women, and black women are negatively correlated with body fat (and positively correlated with fat-free mass).
What do we know about body mass and wages?

- Evidence in the economic literature that wages of white women are negatively correlated with BMI.

- Evidence that wages of white men, white women, and black women are negatively correlated with body fat (and positively correlated with fat-free mass).

- Evidence among males and females that BMI has a different effect depending on the wage level.
What might these “wage gap” findings represent?

- Unmeasured productivity that is correlated with health
- Unmeasured preferences for work/occupation that are correlated with health
- Unmeasured human capital investment that is correlated with health
- Unmeasured consumer distaste (expected productivity that is correlated with physical appearance)
- Unmeasured employer distaste (expected health insurance costs that are correlated with health; discrimination)

Note, however, that the work in the economics literature measures the contemporaneous relationship between body mass and wages.
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Note, however, that the work in the economics literature measures the *contemporaneous* relationship between body mass and wages.
The Big Picture

Body Mass_t → Wages_t

$t - 1$ → $t$ → $t + 1$
The Big Picture

Historyₜ of:

- Schooling
- Employment
- Marriage
- Children

Body Massₜ

Wagesₜ

<table>
<thead>
<tr>
<th>t − 1</th>
<th>t</th>
<th>t + 1</th>
</tr>
</thead>
</table>
The Big Picture

Info known entering period $t$

History$_t$ of:

- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

$Wages_t$

$t - 1$ $t$ $t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:

- Schooling
- Employment
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Body Mass$_t$

Employment

Wages$_t$

$t - 1$ $t$ $t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children
- Wages$_t$

$t - 1$  $t$  $t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Wages$_t$

$t - 1$ $t$ $t + 1$
The Big Picture

- Info known entering period $t$
- History$_t$ of:
  - Schooling
  - Employment
  - Marriage
  - Children
- Current Decisions$_t$:
  - Schooling
  - Employment
  - Marriage
  - Children
- Body Mass$_t$
- Wages$_t$
- Body Mass$_{t+1}$

$t - 1$ $t$ $t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:

- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:

- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Wages$_t$

Body Mass$_{t+1}$
The Big Picture

History of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions:
- Schooling
- Employment
- Marriage
- Children

Caloric Intake
Caloric Expenditure

$t - 1$ -> $t$ -> $t + 1$

Body Mass at time $t$ and $t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Wages$_t$

$t - 1$
$t$
$t + 1$

Caloric Intake$_t$
Caloric Expenditure$_t$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children

$Wages_t$

$Body\ Mass_t$

$t - 1$

$t$

$t + 1$

Caloric Intake$_t$ & Caloric Expenditure$_t$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Contemporaneous

Wages$_t$

Body Mass$_{t+1}$

Caloric Intake$_t$

Caloric Expenditure$_t$

$t - 1$
$t$
$t + 1$
The Big Picture

Info known entering period $t$

History$_t$ of:
- Schooling
- Employment
- Marriage
- Children

Current Decisions$_t$:
- Schooling
- Employment
- Marriage
- Children

Body Mass$_t$

Wages$_t$

$Caloric\ Intake_t$

$Caloric\ Expenditure_t$

$t - 1$  $t$  $t + 1$
Individual’s Optimization Problem — 1

Let $d_t^{semk}$ indicate the schooling ($s$), employment ($e$), marriage ($m$), and kids ($k$) alternative in period $t$.

$s = 0, 1$  
(not in school, in school)

$e = 0, 1, 2$  
(not employed, employed full time employed part time)

$m = 0, 1$  
(not married, married)

$k = 0, 1, 2$  
(no change in # of kids, increase hh size, decrease hh size)
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$$V_{semk}(\Omega_t, e_t \mid w_t)$$

info entering period
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$$V_{semk}(\Omega_t, \epsilon_t | w_t)$$

info entering period

$$\Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t)$$
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$$V_{semk}(\Omega_{t}, \epsilon_{t}|w_{t}) = U(C_{t}, C^{I*}_{t}, L_{t}, L^{E*}_{t}, K_{t}, d_{t}^{semk}; B_{t}, X_{t}, \epsilon_{t}^{semk})$$

where $\Omega_{t} = (B_{t}, S_{t}, E_{t}, M_{t}, K_{t}, X_{t}, P_{t})$
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$$+ \beta \int_B \int_W \int_\epsilon \left[ \max_{(semk)} V_{(semk)}' \left( \Omega_{t+1}, w_{t+1}, \epsilon_{t+1} \right) | d_t^{semk} = 1 \right] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon$$

$$\Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t)$$
Individual’s Optimization Problem — 2

\[ V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C_t^*, L_t, L_t^E, K_t, d_{tsemk}^t; B_t, X_t, \epsilon_t^{semk}) \]

\[ + \beta \int_B \int_W \int_{\epsilon} \left[ \max_{(semk)'} V_{(semk)}'(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d_{tsemk} = 1 \right] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon \]
Individual’s Optimization Problem — 2

\[ V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C^{l*}_t, L_t, L^{E*}_t, K_t, d^{semk}_t; B_t, X_t, \epsilon^{semk}_t) \]

\[ + \beta \int_B \int_W \int_\epsilon \left[ \max_{(semk)} V_{(semk)}' (\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d^{semk}_t = 1 \right] f_b(B) f_w(W) f(\epsilon) dB dW d\epsilon \]

\[ C_t + P^b_t \cdot C^{l*}_t \]

optimal caloric intake
Individual’s Optimization Problem — 2

\[ V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C^*_t, L_t, L^E_t, K_t, d_t^{semk}; B_t, X_t, \epsilon_t^{semk}) \]

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\[ C_t + P^b_t \cdot C^*_t = w_t \cdot 1000 \cdot e \cdot (1 - d_t^{s0mk}) + Y_t \cdot d_t^{se1k} + N_t \]

optimal caloric intake
Individual’s Optimization Problem — 2

\[ V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C^*_t, L_t, L^{E*}_t, K_t, d^{semk}_t; B_t, X_t, \epsilon^{semk}_t) \]

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\[ - P^s_t \cdot d^{1emk}_t \]

\[ - P^k_t \cdot (K_t + d^{sem1}_t - d^{sem2}_t + d^{se1k}_t) \]

earned income

non-earned income

optimal caloric intake
tuition

family consumption
Individual’s Optimization Problem — 2

\[ V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C_{t*}, L_t, L_{E*}, K_t, d_{semk}; B_t, X_t, \epsilon_{semk}) \]

\[ + \beta \int_B \int_W \int_\epsilon \left[ \max_{(semk)'} V_{(semk)'}(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d_{semk} = 1 \right] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon \]

\[
C_t + P^b_t \cdot C_{t*} = w_t \cdot 1000 \cdot e \cdot (1 - d^{s0mk}_t) + Y_t \cdot d^{se1k}_t + N_t
\]

optimal caloric intake

\[
- P^s_t \cdot d^{1emk}_t - P^k_t \cdot (K_t + d^{sem1}_t - d^{sem2}_t + d^{se1k}_t)
\]

tuition

family consumption

\[
L_t + L_{E*}
\]

optimal caloric expenditure

earned income

non-earned income
Individual’s Optimization Problem — 2

\[ V_{\text{semk}}(\Omega_t, \epsilon_t | w_t) = U(C_t, C_t^*, L_t, L_t^E^*, K_t, d_t^{\text{semk}}; B_t, X_t, \epsilon_t^{\text{semk}}) \]

\[ + \beta \int_B \int_W \int_\epsilon \left[ \max_{(\text{semk})'} V_{(\text{semk})'}(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) \right] d_t^{\text{semk}}=1] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon \]

\[ C_t + P_t^b \cdot C_t^* = w_t \cdot 1000 \cdot e \cdot (1 - d_t^{\text{s0mk}}) + Y_t \cdot d_t^{\text{se1k}} + N_t \]

optimal caloric intake

\[ - P_t^s \cdot d_t^{\text{1emk}} - P_t^k \cdot (K_t + d_t^{\text{sem1}} - d_t^{\text{sem2}} + d_t^{\text{se1k}}) \]

tuition

family consumption

\[ L_t + L_t^E^* = T_t - 1000 \cdot e \cdot (1 - d_t^{\text{s0mk}}) - P_t^s \cdot d_t^{\text{1emk}} \]

optimal caloric expenditure

time working

time in school

earned income

non-earned income

family consumption
Individual’s Optimization Problem — 2

\[
V_{semk}(\Omega_t, \epsilon_t|w_t) = U(C_t, C_t^*, L_t, L_t^{E*}, K_t, d_t^{semk}; B_t, X_t, \epsilon_t^{semk})
\]

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\]

\[
C_t + P^b_t \cdot C_t^* = w_t \cdot 1000 \cdot e \cdot (1 - d_t^{s0mk}) + Y_t \cdot d_t^{se1k} + N_t
\]

Optimal caloric intake

\[
- P^s_t \cdot d_t^{1emk} - P^k_t \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})
\]

Tuition

\[
L_t + L_t^{E*} = T_t - 1000 \cdot e \cdot (1 - d_t^{s0mk}) - P^s_t \cdot d_t^{1emk}
\]

Optimal caloric expenditure

Time working

\[
- P^k_t \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})
\]

Time in school

\[
- P^k_t \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})
\]

Time with family
Individual’s Optimization Problem — 3

lifetime value of alternative \(semk\) at period \(t\)

\[
V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C_t^{l*}, L_t, L_t^{E*}, K_t, d_t^{semk}; B_t, X_t, \epsilon_t^{semk})\\ + \beta \int_B \int_W \int_{\epsilon} \left[ \max_{(semk)} V_{(semk)'}(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d_t^{semk} = 1 \right] f_b(B) f_w(W) f(\epsilon) \, d_B \, d_W \, d_\epsilon
\]

budget constraint

\[
C_t + P_t^b \cdot C_t^{l*} = w_t \cdot 1000 \cdot e \cdot (1 - d_t^{s0mk}) + Y_t \cdot d_t^{se1k} + N_t - P_t^s \cdot d_t^{1emk} - P_t^k \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})
\]

time constraint

\[
L_t + L_t^{E*} = T_t - 1000 \cdot e \cdot (1 - d_t^{s0mk}) - P_t^s \cdot d_t^{1emk} - P_t^k \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})
\]
Individual’s Optimization Problem — 3

lifetime value of alternative semk at period $t$

$$V_{semk}(\Omega_t, \epsilon_t|w_t) = U(C_t, C_t^I, L_t, L_t^E, K_t, d_t^{semk}; B_t, X_t, \epsilon_t^{semk})$$

$$+ \beta \int_B \int_W \int_\epsilon \max_{(semk)} V_{(semk)}(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d_t^{semk} = 1] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon$$

budget constraint

$$C_t + P_t^b \cdot C_t^I = w_t \cdot 1000 \cdot e \cdot (1 - d_t^{s0mk}) + Y_t \cdot d_t^{se1k} + N_t - P_t^s \cdot d_t^{1emk} - P_t^k \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})$$

time constraint

$$L_t + L_t^E = T_t - 1000 \cdot e \cdot (1 - d_t^{s0mk}) - P_t^s \cdot d_t^{1emk} - P_t^k \cdot (K_t + d_t^{sem1} - d_t^{sem2} + d_t^{se1k})$$

body mass distribution

$$B_{t+1} \sim F_b(B_t, C_t^I, L_t^E; X_t, \epsilon_t^b)$$
Individual’s Optimization Problem — 3

Lifetime value of alternative \(semk\) at period \(t\)

\[
V_{semk}(\Omega_t, \epsilon_t | w_t) = U(C_t, C^{l*}_t, L_t, L^{E*}_t, K_t, d^{semk}_t; B_t, X_t, \epsilon^{semk}_t)
\]

\[+ \beta \int_B \int_W \int_\epsilon \max_{(semk)'} V_{(semk)'}(\Omega_{t+1}, w_{t+1}, \epsilon_{t+1}) | d^{semk}_{t+1} = 1] f_b(B) f_w(W) f(\epsilon) d_B d_W d_\epsilon \]

Budget constraint

\[C_t + P_t^b \cdot C^{l*}_t = w_t \cdot 1000 \cdot e \cdot (1 - d^{s0mk}_t) + Y_t \cdot d^{s1k}_t + N_t - P_t^s \cdot d^{1emk}_t - P_t^k \cdot (K_t + d^{s1m1}_t - d^{s2m2}_t + d^{s1k}_t)\]

Time constraint

\[L_t + L^{E*}_t = T_t - 1000 \cdot e \cdot (1 - d^{s0mk}_t) - P_t^s \cdot d^{1emk}_t - P_t^k \cdot (K_t + d^{s1m1}_t - d^{s2m2}_t + d^{s1k}_t)\]

Body mass distribution

\[B_{t+1} \sim F_b(B_t, C^{l*}_t, L^{E*}_t; X_t, \epsilon^b_t)\]

Wage distribution

\[w_{t+1} \sim F_w(S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, B_{t+1}, X_{t+1}, P^e_{t+1}, \epsilon^w_{t+1})\]
Empirical Strategies

- Parametrize utility function and body mass and wage distributions.
- Assume additive Extreme Value distribution of preference errors.
- Solve the individual’s optimization problem.
- Calculate multinomial logit probabilities of the decision alternatives:

\[
p(d_{t}^{semk} = 1|\Omega_{t}) = \frac{e^{V_{semk}(\Omega_{t}|w_{t})}}{\sum (semk)' e^{V_{(semk)'}(\Omega_{t}|w_{t})}}
\]

- Use probabilities and densities to form likelihood function.
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\]

- Use probabilities and densities to form likelihood function.
- Estimate policy-invariant parameters (i.e., primitive or structural parameters) of the discrete choice, forward-looking decisionmaking problem.
Empirical Strategies

OR

Approximate the alternative-specific value functions with an $n^{th}$ order Taylor series expansion:

$$\bar{V}_{(semk)'}(\Omega_t|w_t) \approx \beta'_{semk} \Omega_t$$

- Estimate the probabilities of observed outcomes over time and densities of body mass and wages jointly.
- Allow for correlation in the error terms across equations.
- Estimate the effects of endogenous variables, as well as policy-relevant variables, on outcomes of interest.
Empirical Strategies

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\]

- Estimate the probabilities of observed outcomes over time and densities of body mass and wages jointly.

- Allow for correlation in the error terms across equations.

- Estimate the effects of endogenous variables, as well as policy-relevant variables, on outcomes of interest.

- Recover unbiased, \textit{reduced-form parameters of the structural equations} (i.e., demand and production functions).
Features of our Empirical Model

- **Panel data:**
  - Estimated using 20 years of data on the same individuals
Features of our Empirical Model

- **Panel data:**
  - Estimated using 20 years of data on the same individuals

- **Jointly-estimated, multiple-equation, dynamic model:**
  - Allows BMI to affect wages contemporaneously, but also incorporates the dynamic effects of BMI through other endogenous pathways (e.g., educ, exp, marriage, and kids)
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- **Conditional Density Estimation:**
  - Estimates a distribution-free density (of wages and BMI) conditional on endogenous variables that may have different effects at different levels of the dependent variable
### Data: National Longitudinal Survey of Youth (NLSY)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Attritors</th>
<th>Attrition Rate</th>
<th>Sample Size</th>
<th>Attritors</th>
<th>Attrition Rate</th>
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<td>1983</td>
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<td>1,893</td>
<td>101</td>
<td>5.34</td>
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<tr>
<td>2002</td>
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<td>-</td>
<td>-</td>
<td>1,792</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Number of person-year observations: 51,884 49,782
Body Mass Index Distribution
(of same females in 1984 and 1999 — our research sample from NLSY)

White females (n=1341)
% obese: 3.9 (1984); 21.2 (1999)

Black females (n=873)
% obese: 11.2 (1984); 43.4 (1999)
Wages by Age and BMI
(our research sample from NLSY)
Wages by Age and BMI
(our research sample from NLSY)
The Big Picture

Info known entering period $t$

**History$_t$ of:**
- Schooling
- Employment
- Marriage
- Children

**Current Decisions$_t$:**
- Schooling
- Employment
- Marriage
- Children

**Body Mass$_t$**

**Wages$_t$**

**Body Mass$_{t+1}$**

- Caloric Intake$_t$
- Caloric Expenditure$_t$

$t - 1$  \[ t \]  $t + 1$
Information entering period $t$

\[ \Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t) \]

Endogenous variables

- **Body Mass** $B_t$
  - BMI in $t$
  - Ever overweight prior to $t$
  - Ever obese prior to $t$

- **Education History** $S_t$
  - Enrolled in $t - 1$
  - Years enrolled in school entering $t$
  - Years enrolled $< 12$ entering $t$
  - Years enrolled $\geq 12$ entering $t$
  - Years enrolled $\geq 16$ entering $t$
  - First year of college in $t$
Information entering period $t$

$$\Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t)$$

Endogenous variables

- **Employment History** $E_t$
  - Employed in $t - 1$
  - Employed part time in $t - 1$
  - Years employed entering $t$
  - Years part time employed entering $t$

- **Marital History** $M_t$
  - Married in $t - 1$
  - Years married entering $t$ if married in $t - 1$
  - Years newly single entering $t$ is single in $t - 1$

- **Child History** $K_t$
  - Number of children in the household entering $t$
  - Increase in number of children in household from $t - 1$ to $t$
  - Decrease in number of children in household from $t - 1$ to $t$
Information entering period $t$

$$\Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t)$$

- Exogenous Demographics $X_t$
  - Age
  - Race: white, black
  - AFQT score
  - Non-earned income
  - Urbanicity: urban, rural
  - Region of country: northeast, northcentral, west, south
  - Time trend
Information entering period $t$

$$\Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t)$$

\[ \uparrow \text{ Price and Supply Side Variables } P_t \]

- **Schooling-related** $P_t^s$
  - Two-year college semester tuition (000s)
  - Four-year college semester tuition (000s)
  - Graduate school semester tuition (000s)

- **Employment-related** $P_t^e$
  - Unemployment rate
  - Total employment per capita
  - Ratio of manufacturing employment to total employment
  - Ratio of service employment to total employment
  - Total earnings per employee
  - Ratio of manufacturing earnings to total earnings
  - Ratio of service earnings to total earnings
Information entering period $t$

\[ \Omega_t = (B_t, S_t, E_t, M_t, K_t, X_t, P_t) \]

- **Marriage and Children-related** $P^m_t, P^k_t$
  - Total population (000,000s)
  - Mean Household income (000s)
  - AFDC per month for family of four (00s)

- **Body Mass-related** $P^b_t$
  - Mean price of food
  - Mean price of junk food
  - Mean price of carton of cigarettes
  - Mean price of 6-pack of beer
  - Mean price of bottle of wine
  - Mean price of liter of liquor
  - Ratio of food sales to total retail sales
  - Ratio of restaurant sales to total retail sales
Employment and Education Statistics by Age for Females (NLSY research subsample observed for 15 years)

- Probability of being employed at age $t$ (by race and body mass)
- Probability of working full time at age $t$ (by race and body mass)
- Probability of being enrolled at age $t$ (by race and body mass)
- Years of schooling at age $t$ (by race and body mass)
Marriage and Children Statistics by Age for Females
(NLSY research subsample observed for 15 years)
Jointly-Estimated Set of Equations ... so far...

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Estimator</th>
<th>Explanatory Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enrolled</strong></td>
<td>$s_t$</td>
<td>logit $B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td><strong>Employed</strong></td>
<td>$e_t$</td>
<td>mlogit $B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td><strong>Married</strong></td>
<td>$m_t$</td>
<td>logit $B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td><strong>△ Kids</strong></td>
<td>$k_t$</td>
<td>mlogit $B_t, S_t, E_t, M_t, K_t$</td>
</tr>
</tbody>
</table>

Wage if emp

Body Mass

Attrition

Initially observed

2 ols
Jointly-Estimated Set of Equations ... so far...

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<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
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<td>?</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>Body Mass</td>
<td>?</td>
<td>$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$</td>
</tr>
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</table>
Jointly-Estimated Set of Equations ... so far...

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<tr>
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<th>Exogenous</th>
<th>Unobs'd Het</th>
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<td>$s_t$</td>
<td>logit</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
<td>$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$</td>
</tr>
<tr>
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<td>$e_t$</td>
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<td>$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$</td>
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<td>$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$</td>
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</tr>
<tr>
<td>Wage if emp</td>
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<td>?</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
<td>$X_t, P^e_t$</td>
</tr>
<tr>
<td>Body Mass</td>
<td>$B_{t+1}$</td>
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<td>$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$</td>
<td>$X_t, P^b_t$</td>
</tr>
<tr>
<td>Attrition</td>
<td>$A_{t+1}$</td>
<td>logit</td>
<td>$B_{t+1}, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}$</td>
<td>$X_t$</td>
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<tr>
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<td>$B_t, S_t, E_t, M_t, K_t$</td>
<td>$X_t, P_t^e$</td>
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<tr>
<td>Body Mass</td>
<td>$B_{t+1}$</td>
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<td>$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$</td>
<td>$X_t, P_t^b$</td>
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<tr>
<td>Attrition</td>
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<td>$X_1, P_1, Z_1$</td>
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Unobserved Heterogeneity

(Discrete Factor Random Effects: Heckman and Singer, 1984; Guilkey and Mroz, 1992; Mroz, 1999)

- Permanent: rate of time preference, genetics
- Time-varying: unmodeled stressors, health shocks
Motivation

Individual Behavior

Empirical Approach

Data

Estimation

Results

Unobserved Heterogeneity

(Discrete Factor Random Effects: Heckman and Singer, 1984; Guilkey and Mroz, 1992; Mroz, 1999)

- Permanent: rate of time preference, genetics
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The unobserved part of equation $e$, $u^e_t$, is decomposed into three components:

$$u^e_t = \rho^e \mu + \omega^e \nu_t + \epsilon^e_t$$
Unobserved Heterogeneity

(Discrete Factor Random Effects: Heckman and Singer, 1984; Guilkey and Mroz, 1992; Mroz, 1999)

- **Permanent:** rate of time preference, genetics
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The unobserved part of equation $e$, $u^e_t$, is decomposed into three components:

$$u^e_t = \rho^e \mu + \omega^e \nu_t + \epsilon^e_t$$

where the first two unobservables are modeled as random effects:

- permanent heterogeneity factor $\mu$ with factor loading $\rho^e$
- time-varying heterogeneity factor $\nu_t$ with factor loading $\omega^e$
- iid component $\epsilon^e_t$

  distributed $N(0, \sigma^2_e)$ for continuous equations and Extreme Value for dichotomous/polychotomous outcomes
What do hourly wages (among the employed) look like?
... and ln(hourly wages)?
(An) Empirical Model of Wages

\[ \ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t \]

- schooling (entering \( t \))
(An) Empirical Model of Wages

\[ \ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t \quad \text{schooling (entering } t) \]

\[ + \alpha_2 E_t + \alpha_3 1[e_t = 1(pt)] \]

work experience and part time indicator
(An) Empirical Model of Wages

$$\ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t$$

- schooling (entering $t$)
- work experience and part time indicator $\rightarrow +\alpha_2 E_t + \alpha_3 1[e_t = 1(pt)]$
- productivity $\rightarrow +\alpha_4 B_t$
(An) Empirical Model of Wages

\[ \ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t \quad \text{schooling (entering } t) \]

- work experience and part time indicator \[ + \alpha_2 E_t + \alpha_3 1[e_t = 1(pt)] \]
- productivity \[ + \alpha_4 B_t + \alpha_5 M_t + \alpha_6 K_t \]
(An) Empirical Model of Wages

\[ \ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t \quad \text{schooling (entering } t \text{)} \]

- work experience and part time indicator: \( \alpha_2 E_t + \alpha_3 1[e_t = 1(pt)] \)
- productivity: \( \alpha_4 B_t + \alpha_5 M_t + \alpha_6 K_t \)
- exogenous determinants and skill prices: \( \alpha_7 X_t + \alpha_8 P_t^e + \alpha_9 t \)
(An) Empirical Model of Wages

\[
\ln(w_t) | e_t \neq 0 = \alpha_0 + \alpha_1 S_t \quad \text{schooling (entering } t) \\
+ \alpha_2 E_t + \alpha_3 1[e_t = 1(pt)] \\
+ \alpha_4 B_t + \alpha_5 M_t + \alpha_6 K_t \\
+ \alpha_7 X_t + \alpha_8 P_t^e + \alpha_9 t \\
+ \rho^w \mu + \omega^w \nu_t + \epsilon^w_t 
\]
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_t^*, L_t^{E*}; X_t, \epsilon_t^b) \]

\[ bi\text{ological production function} \]
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_t^*, L_t^{E*}; X_t, \epsilon^b_t) \]

\[ B_{t+1} = \delta_0 + \delta_1 B_t \]

biological production function
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_t^I, L_t^E, X_t, \epsilon_t^b) \]

\[ B_{t+1} = \delta_0 + \delta_1 B_t \]

biological production function

replace with the determinants of these demand functions
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_t^*, L_t^{E*}; X_t, \epsilon^b_t) \]

biological production function

replace with the determinants of these demand functions

\[ B_{t+1} = \delta_0 + \delta_1 B_t \]

\[ + \delta_2 S_{t+1} + \delta_3 E_{t+1} + \delta_4 M_{t+1} + \delta_5 K_{t+1} \]
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_t^{l*}, L_t^{E*}, X_t, \epsilon_t^b) \]

\[ B_{t+1} = \delta_0 + \delta_1 B_t \]

\[ + \delta_2 S_{t+1} + \delta_3 E_{t+1} + \delta_4 M_{t+1} + \delta_5 K_{t+1} \]

\[ + \delta_6 X_t + \delta_7 P_t^b \]
(An) Empirical Model of Body Mass Transition

\[ B_{t+1} = b(B_t, C_{t^*}, L_{t^*}^E; X_t, \epsilon_t^b) \]

\[ B_{t+1} = \delta_0 + \delta_1 B_t \]

\[ + \delta_2 S_{t+1} + \delta_3 E_{t+1} + \delta_4 M_{t+1} + \delta_5 K_{t+1} \]

\[ + \delta_6 X_t + \delta_7 P_t^b \]

\[ + \rho^b \mu + \omega^b \nu_t + \epsilon_t^b \]

biological production function

replace with the determinants of these demand functions
How should we estimate wages (and BMI)?

OLS?

- It quantifies how variation in the rhs variables explain variation in the lhs variable, on average.
- It explains how the mean $W$ varies with $Z$.
- In estimation, we also recover the variance of $W$.
- The mean and variance of $W$ define the distribution of wages (and we could assume a normal density).

Using OLS, we obtain the marginal effect of $Z$ on $W$, on average.
How should we estimate wages (and BMI)?

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- It explains how the mean $W$ varies with $Z$.
- In estimation, we also recover the variance of $W$.
- The mean and variance of $W$ define the distribution of wages (and we could assume a normal density).

Using OLS, we obtain the marginal effect of $Z$ on $W$, on average.

But what if $Z$ has a different effect on $W$ at different values of $W$?
A flexible way to model the density

\[ p[w_{k-1} \leq W \leq w_k | Z] = \int_{w_{k-1}}^{w_k} f(w | Z) dw \]
A flexible way to model the density

$$p[w_{k-1} \leq W \leq w_k | Z] = \int_{w_{k-1}}^{w_k} f(w | Z) dw$$

$$\lambda(k, Z) = \frac{p[w_{k-1} \leq W \leq w_k | Z; W \geq w_{k-1}]}{1 - \int_{w_0}^{w_{k-1}} f(w | Z) dw}$$
A flexible way to model the density

\[ p[w_{k-1} \leq W \leq w_k | Z] = \int_{w_{k-1}}^{w_k} f(w | Z) dw \]

\[ \lambda(k, Z) = \frac{p[w_{k-1} \leq W \leq w_k | Z, W \geq w_{k-1}]}{1 - \int_{w_0}^{w_k-1} f(w | Z) dw} \]

\[ p[w_{k-1} \leq W \leq w_k | Z] = \lambda(k, Z) \prod_{j=1}^{k-1} [1 - \lambda(j, Z)] \]
A flexible way to model the density

\[ p[w_{k-1} \leq W \leq w_k | Z] = \int_{w_{k-1}}^{w_k} f(w | Z) \, dw \]

\[ \lambda(k, Z) = \frac{p[w_{k-1} \leq W \leq w_k | Z, W \geq w_{k-1}]}{1 - \int_{w_0}^{w_{k-1}} f(w | Z) \, dw} \]

\[ p[w_{k-1} \leq W \leq w_k | Z] = \lambda(k, Z) \prod_{j=1}^{k-1} [1 - \lambda(j, Z)] \]

\[ E[W | Z] = \sum_{k=1}^{K} \bar{w}(k | K) \lambda(k, Z) \prod_{j=1}^{k-1} [1 - \lambda(j, Z)] \]
Conditional Density Estimation
(Gilleskie and Mroz, 2004)

Determine cut points such that \( \frac{1}{K} \)th of individuals are in each cell.
Conditional Density Estimation
(Gilleskie and Mroz, 2004)

- Determine cut points such that $\frac{1}{K}$th of individuals are in each cell.
- Then, the probability of being in the kth cell, conditional on not being in a previous cell, is $\frac{1}{K-(k-1)}$. 
Conditional Density Estimation
(Gilleskie and Mroz, 2004)

- Determine cut points such that $\frac{1}{K}$th of individuals are in each cell.
- Then, the probability of being in the kth cell, conditional on not being in a previous cell, is $\frac{1}{K-(k-1)}$.
- Define a cell indicator:
  $\gamma_k = -\ln(K - k)$ for $k < K$, such that $\logit(\gamma_k) = \frac{e^{\gamma_k}}{1+e^{\gamma_k}}$. 

\[
E[W|Z] = \sum_{k=1}^{K} w(k|K) \lambda(k, Z) \prod_{j=1}^{k-1} [1 - \lambda(j, Z)]
\]
**Conditional Density Estimation**  
*(Gilleskie and Mroz, 2004)*

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- Then, the probability of being in the kth cell, conditional on not being in a previous cell, is $\frac{1}{K-(k-1)}$.

- Define a cell indicator:  
  \[ \gamma_k = -\ln(K - k) \text{ for } k < K, \]
  such that  
  \[ \text{logit}(\gamma_k) = \frac{e^{\gamma_k}}{1 + e^{\gamma_k}}. \]

- Replicate each observation $K$ times and create a 0/1 dependent variable indicating into which cell the individual's wage falls.
Conditional Density Estimation
(Gilleskie and Mroz, 2004)

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- Replicate each observation $K$ times and create a 0/1 dependent variable indicating into which cell the individual’s wage falls.
- Interact $Z$s with $\gamma$s fully. Estimate logit equation (or hazard) for $\lambda(k, Z)$. 
Conditional Density Estimation
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$$\gamma_k = -\ln(K-k) \text{ for } k < K,$$

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- Replicate each observation $K$ times and create a 0/1 dependent variable indicating into which cell the individual's wage falls.
- Interact $Z$s with $\gamma$s fully. Estimate logit equation (or hazard) for $\lambda(k, Z)$.

$$E[W|Z] = \sum_{k=1}^{K} \bar{w}(k|K)\lambda(k, Z) \prod_{j=1}^{k-1}[1 - \lambda(j, Z)]$$
## Jointly-Estimated Set of Equations

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Estimator</th>
<th>Explanatory Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endogenous</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrolled</td>
<td>logit</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>Employed</td>
<td>mlogit</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>Married</td>
<td>logit</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>$\triangle$ Kids</td>
<td>mlogit</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>Wage if emp</td>
<td>CDE</td>
<td>$B_t, S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td>Body Mass</td>
<td>CDE</td>
<td>$B_{t+1}$, $S_{t+1}$, $E_{t+1}$, $M_{t+1}$, $K_{t+1}$, $w_t$</td>
</tr>
<tr>
<td>Attrition</td>
<td>logit</td>
<td>$B_{t+1}$, $S_{t+1}$, $E_{t+1}$, $M_{t+1}$, $K_{t+1}$</td>
</tr>
<tr>
<td>Initially observed state variables</td>
<td>2 logit, 7 ols</td>
<td>$X_1, P_1, Z_1$</td>
</tr>
</tbody>
</table>

| **Exogenous**    |           |                       |
| $X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$ | $\rho^s \mu, \omega^s \nu_t$ |
| $X_t, P_t^e$ | $\rho^e \mu, \omega^e \nu_t$ |
| $X_t, P_t^m, P_t^k, P_t^b$ | $\rho^m \mu, \omega^m \nu_t$ |
| $X_t, P_t^e$ | $\rho^k \mu, \omega^k \nu_t$ |
| $X_t$ | $\rho^w \mu, \omega^w \nu_t$ |
| $X_t, P_t^B$ | $\rho^B \mu, \omega^B \nu_t$ |
| $X_t$ | $\rho^A \mu, \omega^A \nu_t$ |
| $X_1, P_1, Z_1$ | $\rho^I \mu$ |
Replicated Results for Females:
Estimated Effects of Body Mass on Wages using OLS model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>-0.009</td>
<td>(0.002)</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>$BMI_t \times \text{Black}$</td>
<td>0.006</td>
<td>(0.002)</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

Estimation Method: OLS on lnW

Model Includes: $X_t, B_t$

Marginal Effect of Overweight to Normal:
White: 0.33
Black: 0.10
Replicated Results for Females:
Estimated Effects of Body Mass on Wages using OLS model

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</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>$-0.009^{***}$</td>
<td>$-0.007^{***}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$BMI_t \times$ Black</td>
<td>$0.006^{***}$</td>
<td>$0.004^{*}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimation Method:
- OLS on lnW
- OLS on lnW

Model Includes:
- $X_t, B_t$
- $S_t, E_t, M_t, K_t$

Marginal Effect of Overweight to Normal:
- White: 0.33
- Black: 0.10
## Replicated Results for Females:
**Estimated Effects of Body Mass on Wages using OLS model**

<table>
<thead>
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<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td><strong>-0.009</strong> $(0.002)$ <strong>∗ ∗ ∗</strong></td>
<td><strong>-0.007</strong> $(0.002)$ <strong>∗ ∗ ∗</strong></td>
<td><strong>-0.007</strong> $(0.002)$ <strong>∗ ∗ ∗</strong></td>
<td></td>
</tr>
<tr>
<td>$BMI_t \times$ Black</td>
<td><strong>0.006</strong> $(0.002)$ <strong>∗ ∗ ∗</strong></td>
<td><strong>0.004</strong> $(0.002)$ <strong>∗</strong></td>
<td><strong>0.003</strong> $(0.002)$ <strong>∗</strong></td>
<td></td>
</tr>
<tr>
<td>Estimation Method:</td>
<td>OLS on lnW clustered std err</td>
<td>OLS on lnW clustered std err</td>
<td>OLS on lnW clustered std err</td>
<td></td>
</tr>
<tr>
<td>Model Includes:</td>
<td>$X_t, B_t$</td>
<td>$X_t, B_t$</td>
<td>$X_t, B_t$</td>
<td>$X_t, B_t$</td>
</tr>
<tr>
<td></td>
<td>$S_t, E_t, M_t, K_t$</td>
<td>$S_t, E_t, M_t, K_t$</td>
<td>$S_t, E_t, M_t, K_t$</td>
<td>$S_t, E_t, M_t, K_t$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$P_t^e$</td>
</tr>
<tr>
<td>Marginal Effect of Overweight to Normal</td>
<td>White: 0.33</td>
<td>0.29</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black: 0.10</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>
## Replicated Results for Females:
### Estimated Effects of Body Mass on Wages using OLS model

<table>
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<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>$-0.009$ (0.002) $^* * *$</td>
<td>$-0.007$ (0.002) $^* * *$</td>
<td>$-0.007$ (0.002) $^* * *$</td>
<td>$-0.004$ (0.002) $^*$</td>
</tr>
<tr>
<td>$BMI_t \times $ Black</td>
<td>$0.006$ (0.002) $^* * *$</td>
<td>$0.004$ (0.002) $^*$</td>
<td>$0.003$ (0.002) $^*$</td>
<td>$0.003$ (0.002)</td>
</tr>
</tbody>
</table>

**Estimation**
- Method: OLS on $\ln W$
- Method: clustered std err
- Method: clustered std err
- Method: clustered std err
- Method: fixed effects

**Model**
- Includes: $X_t, B_t$
- Includes: $X_t, B_t$
- Includes: $X_t, B_t$, $S_t, E_t, M_t, K_t$
- Includes: $X_t, B_t$, $S_t, E_t, M_t, K_t$, $P_t^e$

**Marginal Effect**
- White: 0.33
- Black: 0.10
- White: 0.29
- Black: 0.13
- White: 0.27
- Black: 0.13
- White: 0.14
- Black: 0.03
Replicated Results for Males:
Estimated Effects of Body Mass on Wages using OLS model

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>0.002 (0.002)</td>
<td>-0.002 (0.002)</td>
<td>-0.002 (0.002)</td>
<td>0.004 (0.002)</td>
</tr>
<tr>
<td>$BMI_t \times$ Black</td>
<td>0.006 * (0.003)</td>
<td>0.007 ** (0.003)</td>
<td>0.007 ** (0.003)</td>
<td>-0.003 (0.00)</td>
</tr>
</tbody>
</table>

Estimation Method:
- OLS on lnW
  - clustered std err

Model Includes:
- $X_t, B_t$
- $S_t, E_t, M_t, K_t$
- $P_t^e$

Marginal Effect:
- White: -0.08
- Black: -0.29

Marginal Effect of Overweight to Normal:
- White: -0.08
- Black: -0.29
Single Equation QR and CDE Results for Females: The Role of Body Mass on Wages across the Support of Wages

<table>
<thead>
<tr>
<th>Variable</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>-0.056</td>
<td>-0.069</td>
<td>-0.080</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>$BMI_t \times$ Black</td>
<td>0.020</td>
<td>0.038</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.012)</td>
</tr>
</tbody>
</table>

Model Includes: $X_t, B_t, S_t, E_t, M_t, K_t, P^e_t$

Marginal Effect
- White: 0.19 0.24 0.28
- Black: 0.12 0.11 0.18

QR Average: White: 0.24 Black: 0.14

CDE Average: White: 0.29 Black: 0.12
Single Equation QR and CDE Results for Males: The Role of Body Mass on Wages across the Support of Wages

<table>
<thead>
<tr>
<th>Variable</th>
<th>25&lt;sup&gt;th&lt;/sup&gt;</th>
<th>50&lt;sup&gt;th&lt;/sup&gt;</th>
<th>75&lt;sup&gt;th&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BMI_t$</td>
<td>-0.013 (0.009)</td>
<td>-0.023 (0.011)**</td>
<td>-0.060 (0.014)**</td>
</tr>
<tr>
<td>$BMI_t \times$ Black</td>
<td>0.030 (0.011)**</td>
<td>0.048 (0.016)**</td>
<td>0.128 (0.023)**</td>
</tr>
</tbody>
</table>

Model X<sub>t</sub>, B<sub>t</sub>
Includes: $S_t$, $E_t$, $M_t$, $K_t$, $P_t^e$

Marginal Effect of Overweight to Normal
White: 0.05 0.08 0.21
Black: -0.06 -0.09 -0.24

QR Average: White: 0.11 Black: -0.13
CDE Average: White: 0.21 Black: -0.27
Comparison of Observed Data to Model Predictions - Females

- Probability of being enrolled at age $t$
- Probability of being employed at age $t$
- Probability of being married at age $t$
- Probability of no change in kids at age $t$

**Observed Data**
- Simulated - no het, no upd
- Simulated - het, no upd
- Simulated - het, upd
Comparison of Observed Data to Model Predictions - Females

Body Mass Index at age t

Hourly wage rate at age t

: Observed Data

: Simulated - no het, no upd

: Simulated - het, no upd

: Simulated - het, upd
Contemporaneous Effect of Body Mass on Wages - Females (without and with unobserved heterogeneity)
Simulations to determine life-cycle effect

- Calculate (simple) marginal effect of an x% increase in BMI on wages (i.e., contemporaneous effect)
Simulations to determine life-cycle effect

- Calculate (simple) marginal effect of an x% increase in BMI on wages (i.e., contemporaneous effect)

- Impose normal weight over life cycle and compare that to imposed overweight (and obesity) throughout the life cycle; compare average wages and age 40 wage.

- Compare age 40 wages of someone who becomes overweight (or obese) early with someone who gains weight later in career.

- Compare also to someone who gains weight steadily over the life cycle.
Contemporaneous and Life-Cycle Effect of Body Mass on Wages - Females
Preliminary Explanations...

An improvement in health over the life cycle suggests a lower level of improved wages than the positive contemporaneous effect. Why?
An improvement in health over the life cycle suggests a lower level of improved wages than the positive contemporaneous effect. Why?

- Given that an additional year of education and work experience increase hourly wages (by $0.90 and $0.68 and by $0.34 and $0.27, for white and black females respectively), the life-cycle weight improvement must reduce investment in human capital.
Preliminary Explanations...

An improvement in health over the life cycle suggests a lower level of improved wages than the positive contemporaneous effect. Why?

- Given that an additional year of education and work experience increase hourly wages (by $0.90 and $0.68 and by $0.34 and $0.27, for white and black females respectively), the life-cycle weight improvement must reduce investment in human capital.
  
  - But the probability of enrollment actually increases slightly,
  - And the probability of full time employment increases (by 1.6 and 4 percentage points).
  - White females substitute full time employment for part time employment; Black females substitute this way also, but are less likely to be non-employed.
Preliminary Explanations...

An improvement in health over the life cycle suggests a lower level of improved wages than the positive contemporaneous effect. Why?

- So what happens to productivity measures (other than health) that may be impacted by body mass over time? Marital status and Number of children?
Preliminary Explanations...

An improvement in health over the life cycle suggests a lower level of improved wages than the positive contemporaneous effect. Why?

- So what happens to productivity measures (other than health) that may be impacted by body mass over time? Marital status and Number of children?
  - Females are more likely to be married, and to be married longer.
  - White females have more children in the household.
Concluding Remarks...

- The contemporaneous wage penalty attributed to body mass is smaller when unobserved permanent and time-varying heterogeneity is modeled.

For white females, a one unit decrease in BMI is equivalent to $\frac{1}{20}$ th of a year of schooling and $\frac{1}{8}$ th of a year of work experience.
Concluding Remarks...

- The contemporaneous wage penalty attributed to body mass is smaller when unobserved permanent and time-varying heterogeneity is modeled.
  
  *For white females, a one unit decrease in BMI is equivalent to $\frac{1}{20}$th of a year of schooling and $\frac{1}{8}$th of a year of work experience.*

- The effect of a body mass reduction is different over the support of wages.
  
  *For white females, the contemporaneous positive effect is smaller in percentage terms as wages increase. For black females, the percentage increase is constant.*
The contemporaneous wage penalty attributed to body mass is smaller when unobserved permanent and time-varying heterogeneity is modeled. For white females, a one unit decrease in BMI is equivalent to $\frac{1}{20}$th of a year of schooling and $\frac{1}{8}$th of a year of work experience.

The effect of a body mass reduction is different over the support of wages. For white females, the contemporaneous positive effect is smaller in percentage terms as wages increase. For black females, the percentage increase is constant.

There are sizable effects of body mass on life-cycle behaviors that also impact wages. The life-cycle effect a weight improvement puts downward pressure on wages through productivity not human capital accumulation.
Concluding Remarks...

- The contemporaneous wage penalty attributed to body mass is smaller when unobserved permanent and time-varying heterogeneity is modeled.
  
  For white females, a one unit decrease in BMI is equivalent to \( \frac{1}{20} \) th of a year of schooling and \( \frac{1}{8} \) th of a year of work experience.

- The effect of a body mass reduction is different over the support of wages.
  
  For white females, the contemporaneous positive effect is smaller in percentage terms as wages increase. For black females, the percentage increase is constant.

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The life-cycle effect a weight improvement puts downward pressure on wages through productivity not human capital accumulation.