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

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Outline

1. Motivation
   - HCEO-related questions and the question this paper tackles

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   - Features of the dynamic empirical model
4. Results
   - Impacts on wage distribution and over life cycle

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- self-reported health
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- absenteeism, short-term disability, and presenteeism

The Questions We Answer

- 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
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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

$$\begin{aligned} \text{BMI} &< 18.5\text{: underweight} \\ 18.5 \leq \text{BMI} &< 25.0\text{: ideal weight} \\ 25.0 \leq \text{BMI} &< 30.0\text{: overweight} \\ \text{BMI} &\geq 30.0\text{: obese} \end{aligned}$$

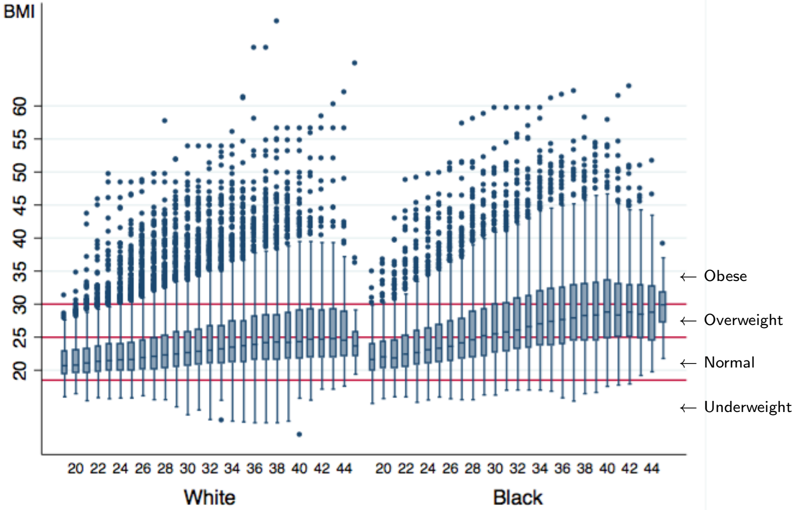
- May over/under estimate in those with more/less lean body mass
- May only have self-reported weight & height (subjective measure, rounding issues)

Other measures:

- skinfold, underwater weighing, fat-free mass, body volume/location

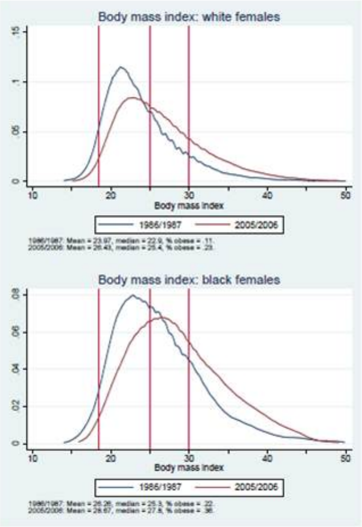
Body Mass as Females Age

(using same individuals followed over time from authors' NLSY79 data)



Distribution of Body Mass over Time

(using repeated cross sections from NHIS data)



Source: DiNardo, Garlick, Stange (2010)

Density in black: 1986/1987

Density in red: 2005/2006

Vertical lines: BMI thresholds

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

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Thus, there is some evidence of wage disparity by body mass...

contemporaneously.

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- Unmeasured productivity

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- Unmeasured employer preferences

  expected health insurance costs that are correlated with employee's health;
  expected product demand correlated with employee's physical appearance;

  or perhaps taste discrimination by employer or consumers

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So, what is the life cycle effect of an evolving variable on wages, which depend on these accumulated stocks?

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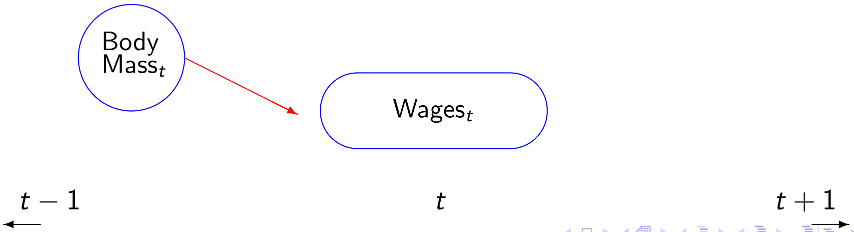

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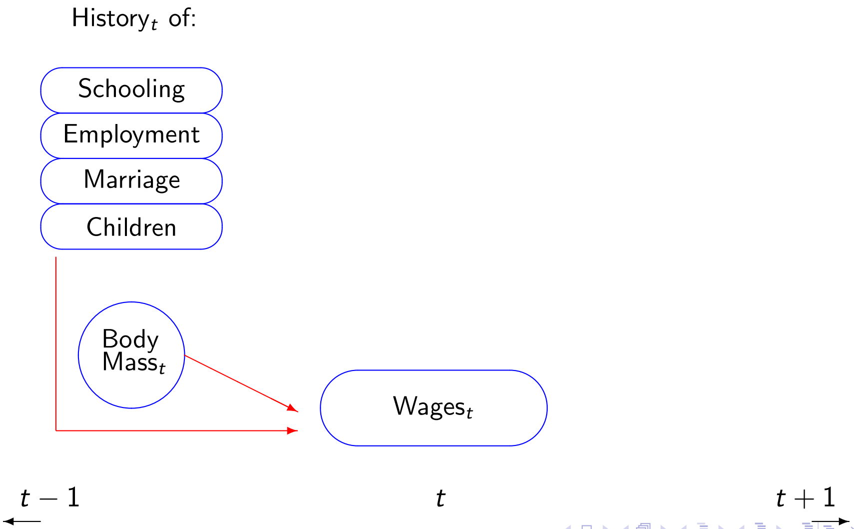

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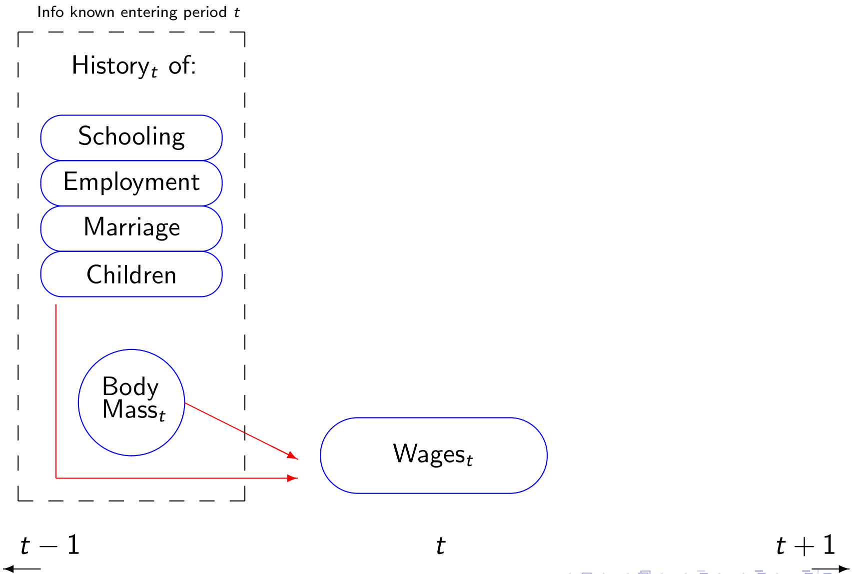

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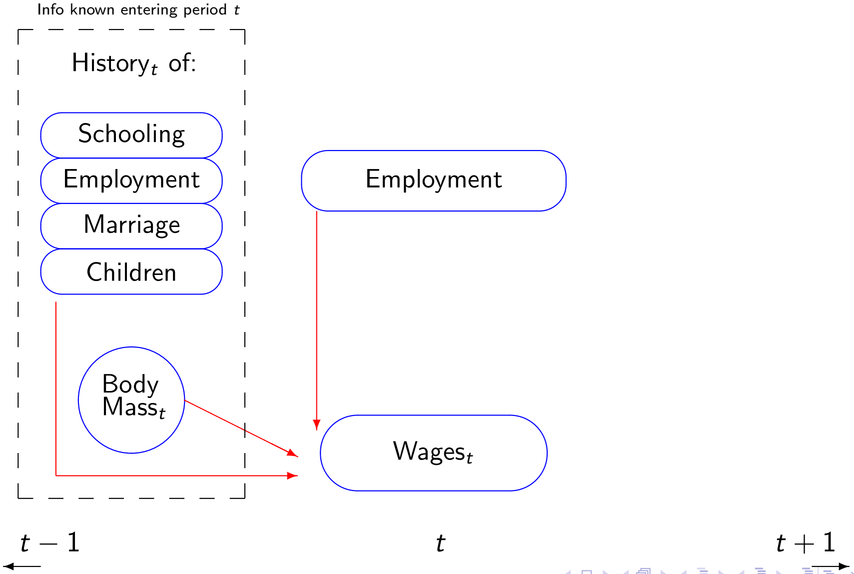

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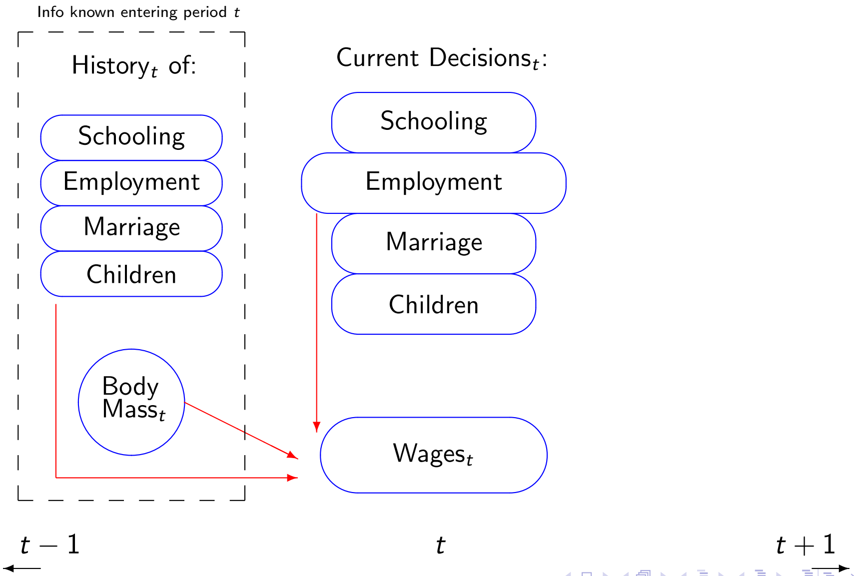

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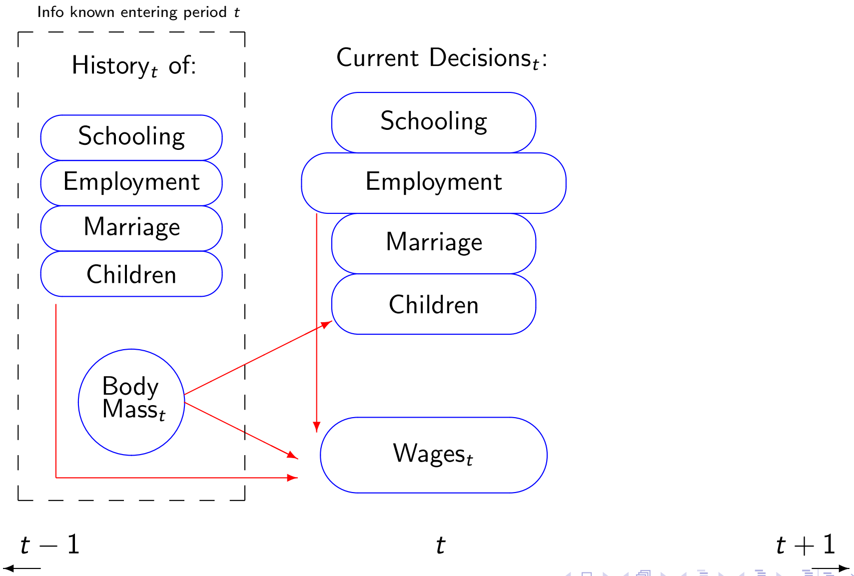

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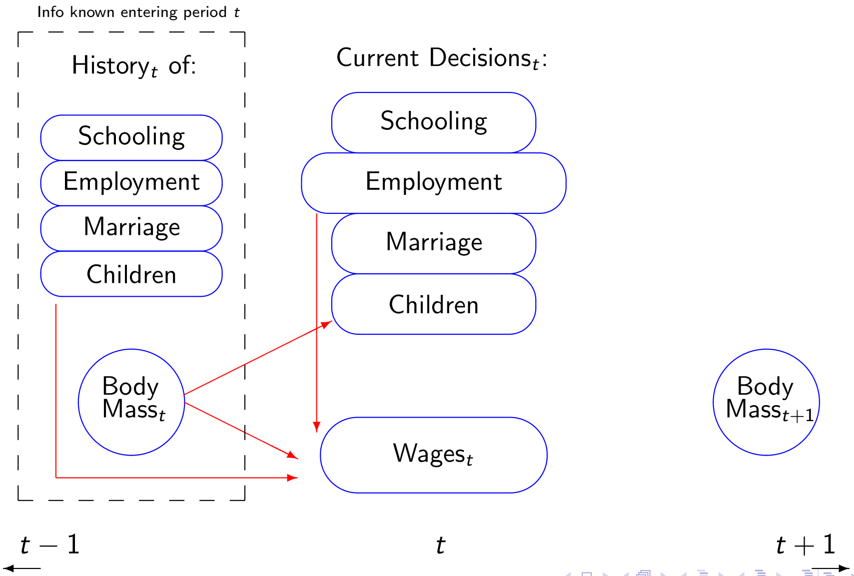

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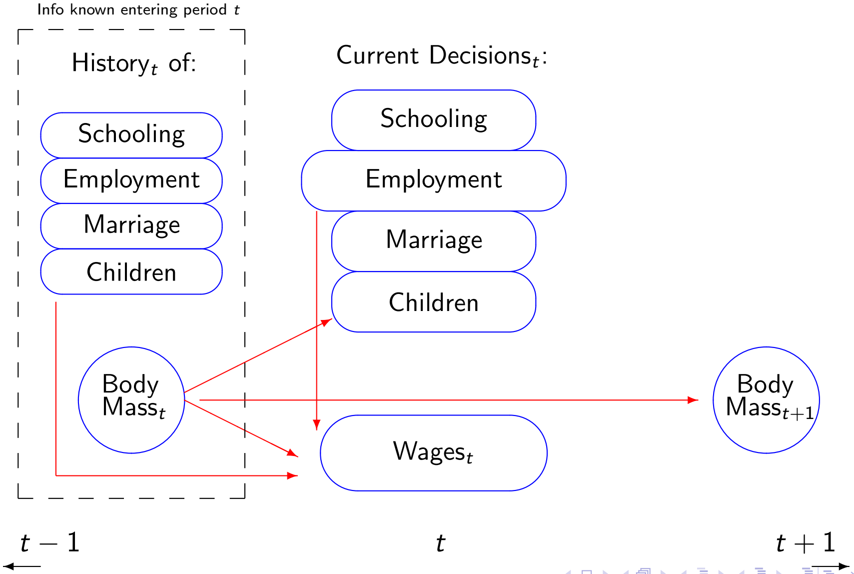

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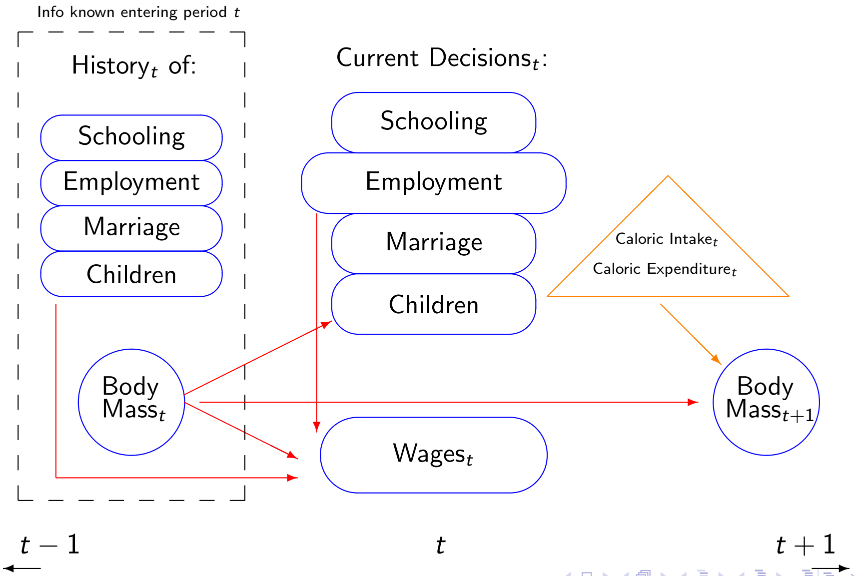

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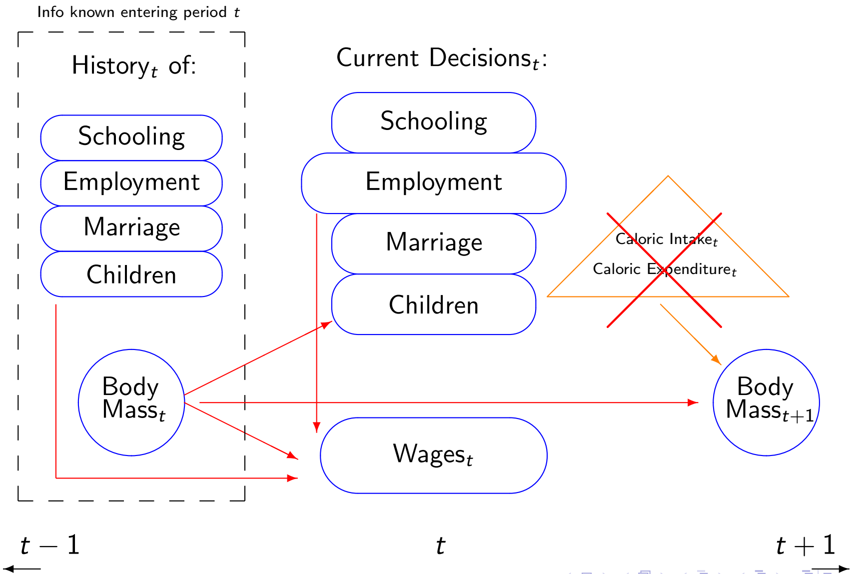

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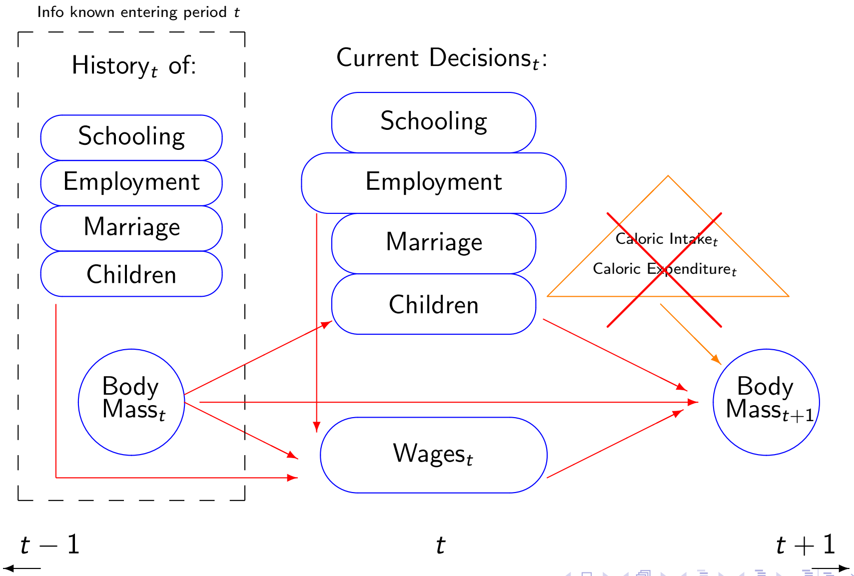

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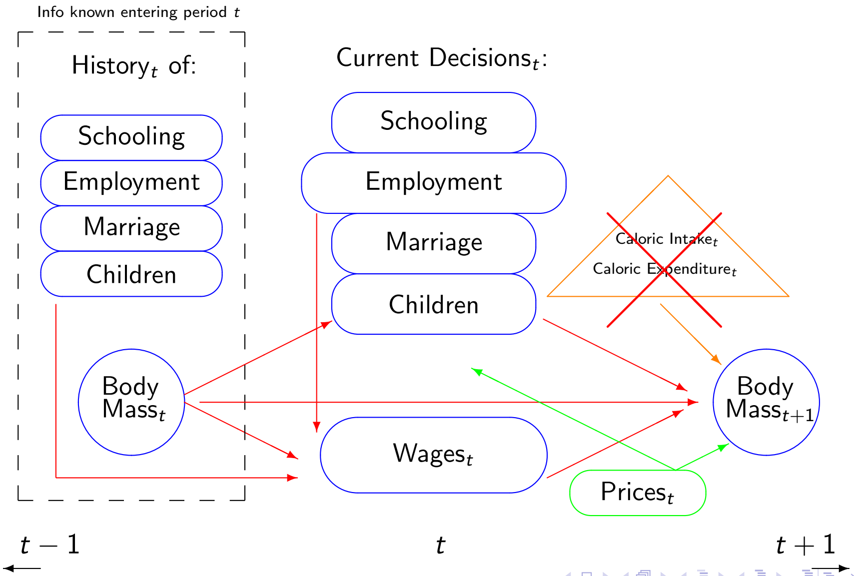

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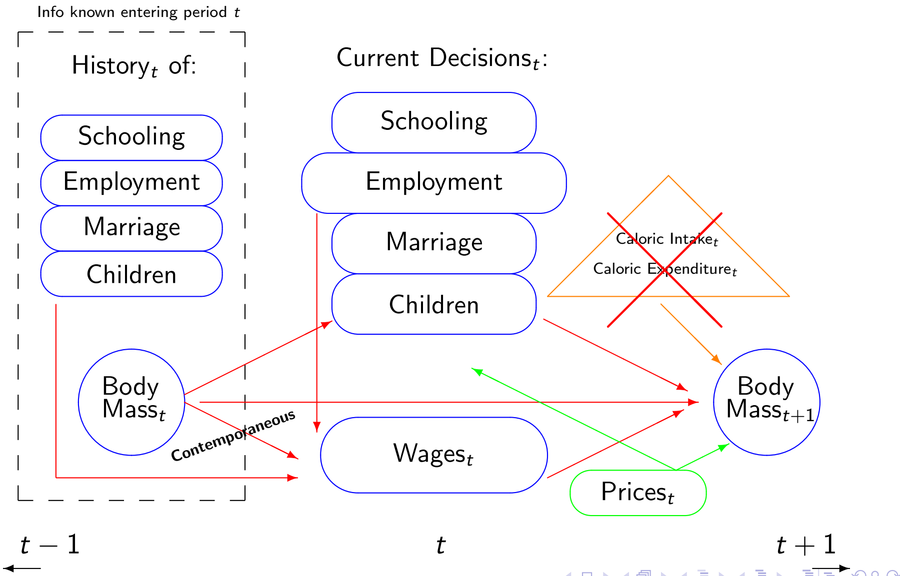

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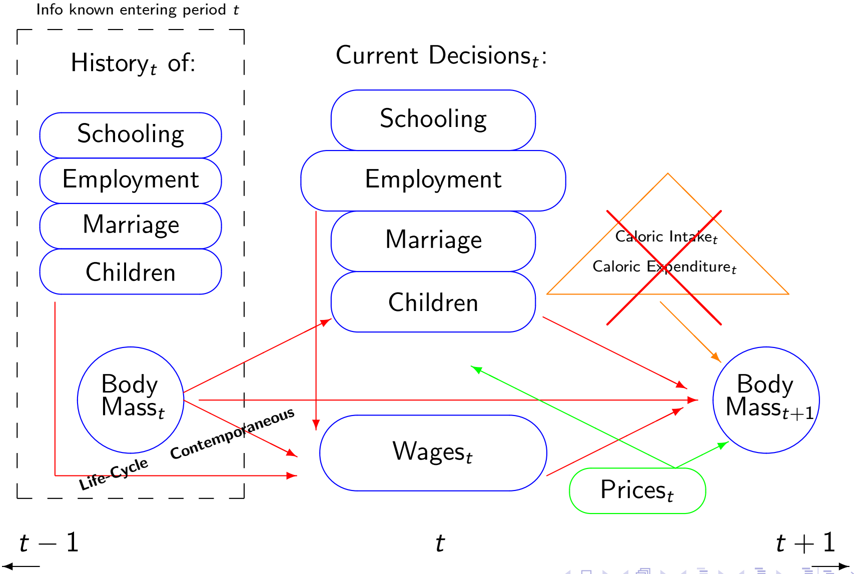

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- Conditional Density Estimation:
  - Estimates a distribution-free density (of wages and BMI) conditional on endogenous variables that may have different effects at different levels of the dependent variable

Data: National Longitudinal Survey of Youth (NLSY79)

Year	Sample Size	Attriters	Attrition Rate
1983	3,213	-	-
1984	3,213	67	2.09
1985	3,146	81	2.57
1986	2,065	101	3.30
1987	2,964	97	3.27
1988	2,867	52	1.81
1989	2,815	57	2.02
1990	2,758	46	1.67
1991	2,712	60	2.21
1992	2,652	35	1.32
1993	2,617	39	1.49
1994	2,578	134	5.20
1995	2,444	78	3.19
1996	2,366	102	4.31
1997	2,264	70	3.09
1998	2,194	58	2.64
1999	2,136	114	5.34
2000	2,022	42	2.08
2001	1,980	102	5.15
2002	1,878	-	-

Number of person-year observations: 51,884

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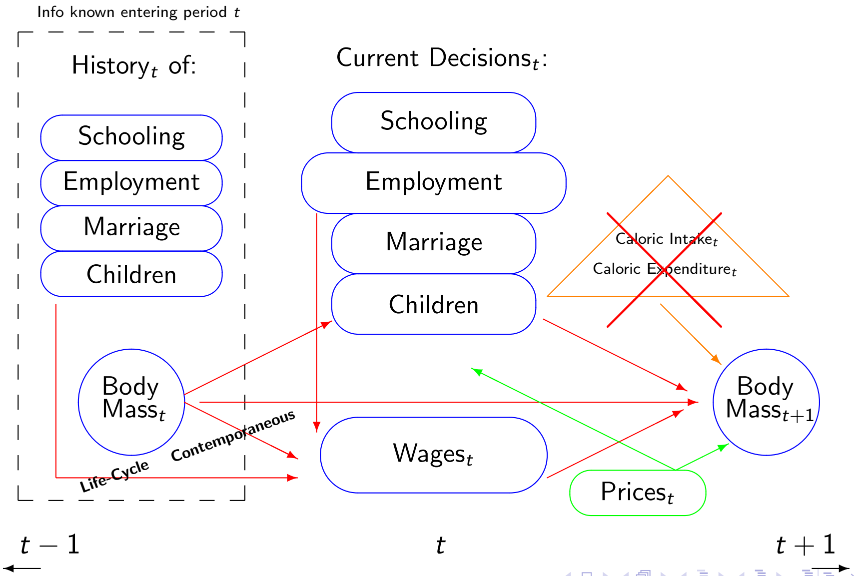

Information entering period t

$$\Omega_t = (\underbrace{B_t, S_t, E_t, M_t, K_t,}_{\text{Endogenous variables}} X_t, P_t)$$

- Body Mass History B_t
  - BMI in t
  - Ever overweight ($25 \leq \text{BMI} < 30$) prior to t
  - Ever obese ($\text{BMI} \geq 30$) prior to t
  - Standardized deviations from mean BMI at t by race
- Schooling History S_t
  - Enrolled in $t-1$
  - Years enrolled in school entering t
  - Years enrolled ≥ 12 entering t
  - Years enrolled ≥ 16 entering t
  - First year of college in t

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- 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 single entering t is single in $t-1$ and ever married
- 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

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$$\Uparrow$$

- 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

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$\Uparrow$ Price and Supply Side Variables P_t that vary at the state and local level

- 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

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

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- Marriage and Children-related P_t^m, P_t^k
  - Total population (000,000s)
  - Gender ratio by race (males, aged 20-60/ females, aged 15-50)
  - Mean Household income (000s)
  - AFDC per month for family of four (00s)
- Body Mass-related P_t^b
  - 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

Optimization Problem

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

Outcome		Estimator	Explanatory Variables		
			Endogenous	Exogenous	Unobs'd Het
Enrolled	s_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
Employed	e_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
Married	m_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
$\triangle$ Kids	k_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	

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Wage if emp	w_t	?	B_t, S_t, E_t, M_t, K_t	X_t, P^e_t	

▸ Wage Equation

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Wage if emp	w_t	?	B_t, S_t, E_t, M_t, K_t	X_t, P^e_t	
Body Mass	B_{t+1}	?	$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$	X_t, P^b_t	

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Enrolled	s_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$	
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Married	m_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$	
$\triangle$ Kids	k_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P^s_t, P^e_t, P^m_t, P^k_t, P^b_t$	
Wage if emp	w_t	?	B_t, S_t, E_t, M_t, K_t	X_t, P^e_t	
Body Mass	B_{t+1}	?	$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$	X_t, P^b_t	
Attrition	A_{t+1}	logit	$B_{t+1}, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}$	X_t	

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

Outcome		Estimator	Explanatory Variables		
			Endogenous	Exogenous	Unobs'd Het
Enrolled	s_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
Employed	e_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
Married	m_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	
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Wage if emp	w_t	?	B_t, S_t, E_t, M_t, K_t	X_t, P_t^e	
Body Mass	B_{t+1}	?	$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$	X_t, P_t^b	
Attrition	A_{t+1}	logit	$B_{t+1}, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}$	X_t	
Initially observed state variables		2 logit 7 ols		X_1, P_1, Z_1	

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

Outcome		Estimator	Explanatory Variables: Endogenous	Explanatory Variables: Exogenous	Unobs'd Het
Enrolled	s_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	?
Employed	e_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	?
Married	m_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	?
△ Kids	k_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	?
Wage if emp	w_t	?	B_t, S_t, E_t, M_t, K_t	X_t, P_t^e	?
Body Mass	B_{t+1}	?	$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$	X_t, P_t^b	?
Attrition	A_{t+1}	logit	$B_{t+1}, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}$	X_t	?
Initially observed state variables		2 logit 7 ols		X_1, P_1, Z_1	? ?

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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$$u_t^e = \rho^e \mu + \omega^e \nu_t + \epsilon_t^e$$

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$$u_t^e = \rho^e \mu + \omega^e \nu_t + \epsilon_t^e$$

where the first two unobservables are modeled as random effects:

- permanent heterogeneity factor μ with factor loading ρ^e
- time-varying heterogeneity factor ν_t with factor loading ω^e
- iid component ϵ_t^e
  distributed $N(0, \sigma_e^2)$ for continuous equations
  and Extreme Value for dichotomous/polychotomous outcomes

How should we estimate wages (and body mass index)?

OLS?

- It quantifies how variation in the rhs variables (Z) explain variation in the lhs variable (W), on average.
- It explains how the mean of W varies with Z.
- In estimation, we also recover the variance of W.
- The mean and variance of W, and a distributional assumption, describe the distribution of (log) offered wages.

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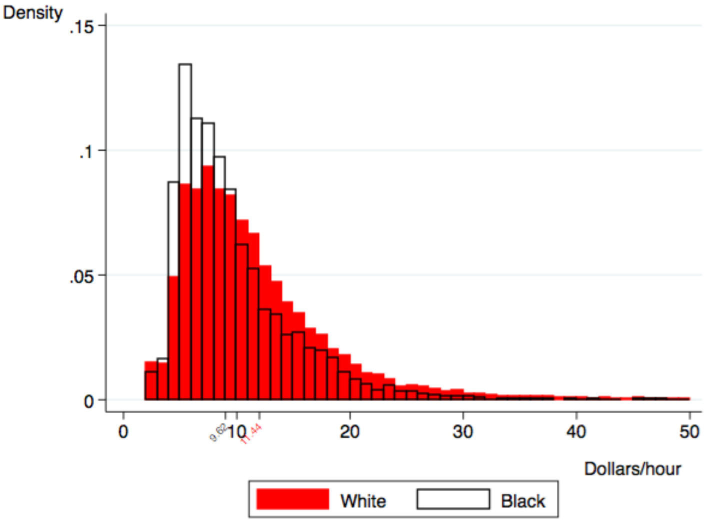
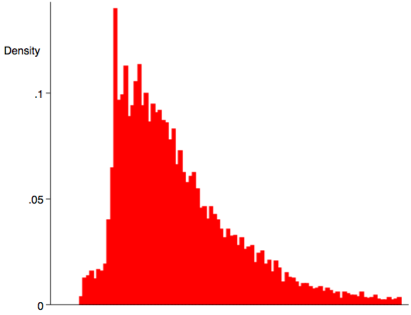
But what if Z has a different effect on W at different values of W?

What do hourly wages (among the employed) look like?



A flexible way to model the density



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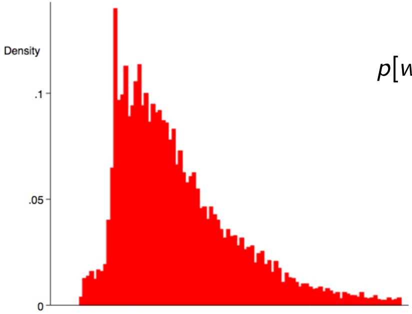

$$p[w_{k-1} \leq W \leq w_k | Z] = \int_{w_{k-1}}^{w_k} f(w|Z)dw$$

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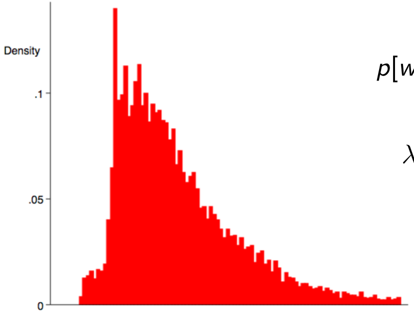

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$$\lambda(k, Z) = p[w_{k-1} \leq W \leq w_k | Z, W \geq w_{k-1}] = \frac{\int_{w_{k-1}}^{w_k} f(w|Z)dw}{1 - \int_{w_0}^{w_{k-1}} f(w|Z)dw}$$

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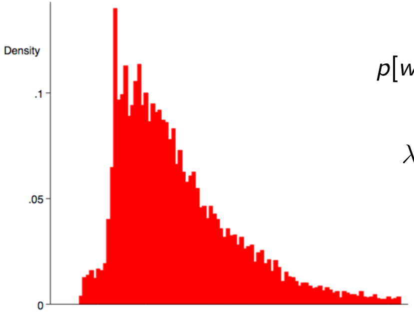

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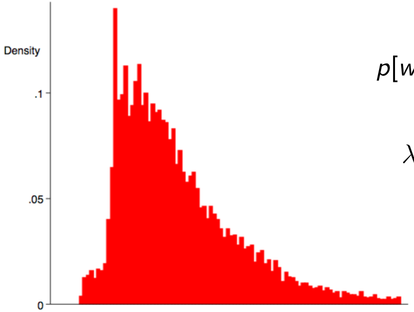

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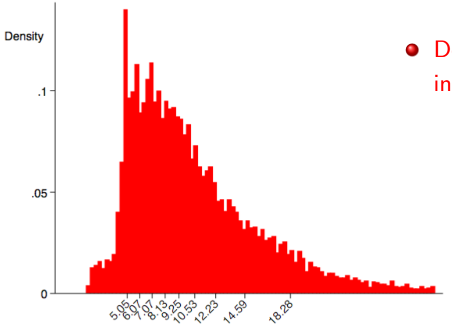
Conditional Density Estimation

(Gilleskie and Mroz, 2004)



- Determine cut points such that $\frac{1}{K}^{th}$ of individuals are in each cell.

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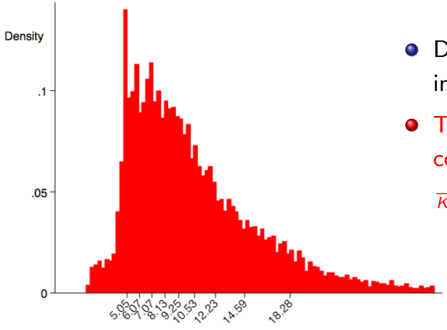

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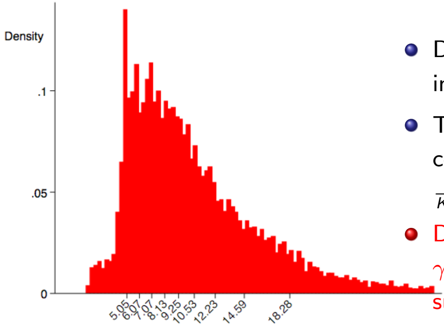

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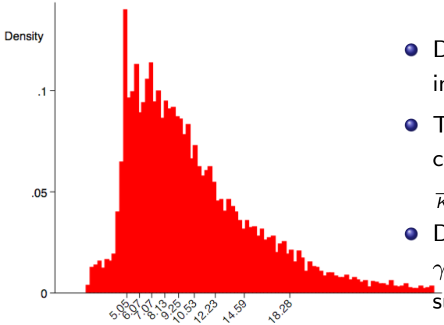

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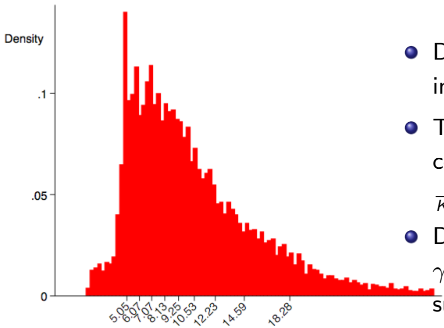

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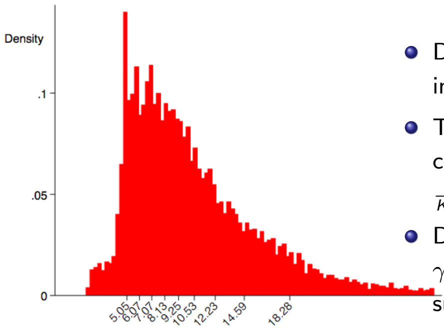

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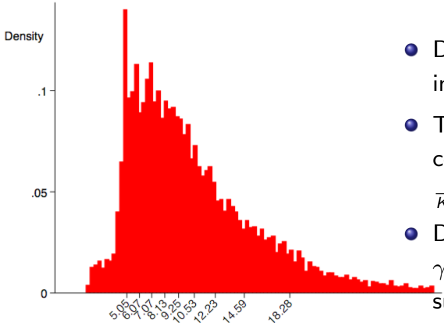

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Jointly-Estimated Set of Equations

Outcome		Estimator	Explanatory Variables		
			Endogenous	Exogenous	Unobs'd Het
Enrolled	s_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	$\rho^s \mu, \omega^s \nu_t$
Employed	e_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	$\rho^e \mu, \omega^e \nu_t$
Married	m_t	logit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	$\rho^m \mu, \omega^m \nu_t$
$\triangle$ Kids	k_t	mlogit	B_t, S_t, E_t, M_t, K_t	$X_t, P_t^s, P_t^e, P_t^m, P_t^k, P_t^b$	$\rho^k \mu, \omega^k \nu_t$
Wage if emp	w_t	CDE	B_t, S_t, E_t, M_t, K_t	X_t, P_t^e	$\rho^w \mu, \omega^w \nu_t$
Body Mass	B_{t+1}	CDE	$B_t, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, w_t$	X_t, P_t^B	$\rho^B \mu, \omega^B \nu_t$
Attrition	A_{t+1}	logit	$B_{t+1}, S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}$	X_t	$\rho^A \mu, \omega^A \nu_t$
Initially observed state variables		2 logit 7 ols		X_1, P_1, Z_1	$\rho^I \mu$

Replicated Results (from literature):

Estimated Effects of Body Mass on Wages using OLS model

Variable	Model 1	Model 2	Model 3	Model 4
BMI_t	**-0.008** (0.002) $***$			
$BMI_t \times$ Black	**0.006** (0.002) $***$			
Method	OLS on lnW clustered std err			
Model Spec	X_t, B_t			
R-squared	0.28			
Marginal Effect of Overweight to Normal (in cents)	White: 0.31 Black: 0.08			

Replicated Results (from literature):

Estimated Effects of Body Mass on Wages using OLS on lnW model

Variable	Model 1	Model 2	Model 3	Model 4
BMI_t	**-0.008** (0.002) ***	**-0.007** (0.002) ***		
$BMI_t \times$ Black	**0.006** (0.002) ***	**0.003** (0.002) *		
Method	OLS on lnW clustered std err	OLS on lnW clustered std err		
Model Spec	X_t, B_t	X_t, B_t S_t, E_t, M_t, K_t		
R-squared	0.28	0.40		
Marginal Effect of Overweight to Normal (in cents)	White: 0.31 Black: 0.08	0.27 0.12		

Replicated Results (from literature):

Estimated Effects of Body Mass on Wages using OLS model

Variable	Model 1		Model 2		Model 3		Model 4
BMI_t	**-0.008**	(0.002) ***	**-0.007**	(0.002) ***	**-0.006**	(0.002) ***	
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Method	OLS on lnW clustered std err		OLS on lnW clustered std err		OLS on lnW clustered std err		
Model Spec	X_t, B_t		X_t, B_t S_t, E_t, M_t, K_t		X_t, B_t $S_t, E_t, M_t, K_t, P_t^e$		
R-squared	0.28		0.40		0.42		
Marginal Effect of Overweight to Normal (in cents)	White: 0.31 Black: 0.08		0.27 0.12		0.25 0.12		

Replicated Results (from literature):

Estimated Effects of Body Mass on Wages using OLS model

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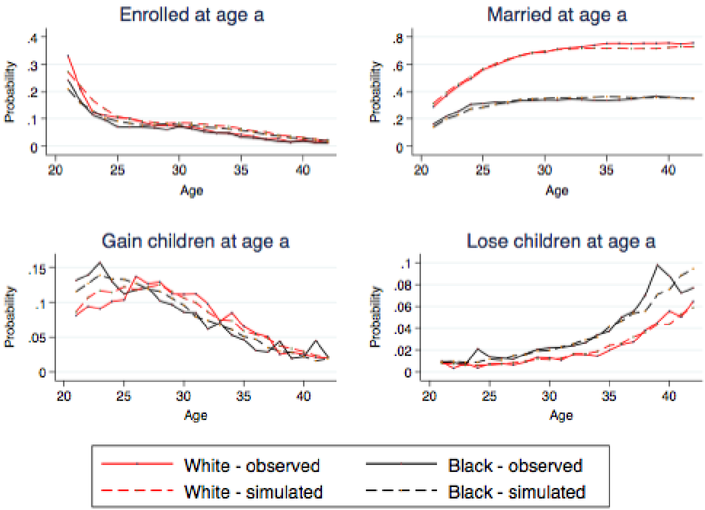
Method	OLS on lnW clustered std err	OLS on lnW clustered std err	OLS on lnW clustered std err	OLS on lnW clustered std err fixed effects
Model Spec	X_t, B_t	X_t, B_t S_t, E_t, M_t, K_t	X_t, B_t $S_t, E_t, M_t, K_t, P_t^e$	X_t, B_t $S_t, E_t, M_t, K_t, P_t^e$
R-squared	0.28	0.40	0.42	0.35
Marginal Effect of Overweight to Normal (in cents)	White: 0.31 Black: 0.08	0.27 0.12	0.25 0.12	0.12 -0.02

Single Equation QR and CDE Results for Females:

The Role of Body Mass on Wages across the Support of Wages

Variable	25^{th}		50^{th}		75^{th}	
BMI_t	**-0.054**	(0.008) ***	**-0.068**	(0.006) ***	**-0.083**	(0.010) ***
$BMI_t \times$ Black	**0.028**	(0.009) **	**0.043**	(0.007) ***	**0.049**	(0.012) ***
Model Spec			X_t, B_t $S_t, E_t, M_t, K_t, P_t^e$			
Marginal Effect of Improvement from Overweight to Normal Weight (at the point estimates)						
White	0.19		0.24		0.28	
Black	0.08		0.11		0.18	
QR Average			White: 0.24		Black: 0.10	
CDE Average			White: 0.23		Black: 0.12	

Comparison of Observed Data to Model Predictions



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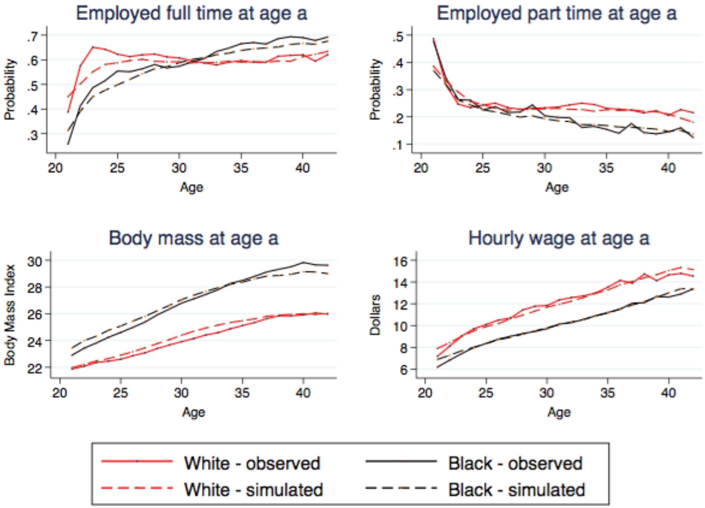

Simulations to determine contemporaneous effect

Consider an improvement in health (i.e., a reduction in body mass)

- Calculate (simple) marginal effect of
  - an x% decrease in BMI,
  - or one unit decrease in BMI,
  - or going from overweight (BMI 27.5) to normal weight (BMI 24)

on wages (i.e., the contemporaneous effect).

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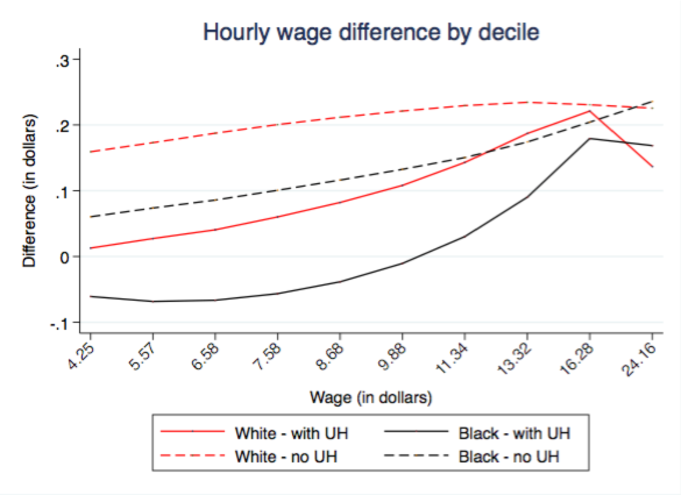
on wages (i.e., the contemporaneous effect).

That is, hold all other determinants of wage constant
(regardless of how those might have been influenced
by the history of one's body mass)

Contemporaneous Effect of BMI Reduction on Wages

(without and with unobserved heterogeneity)



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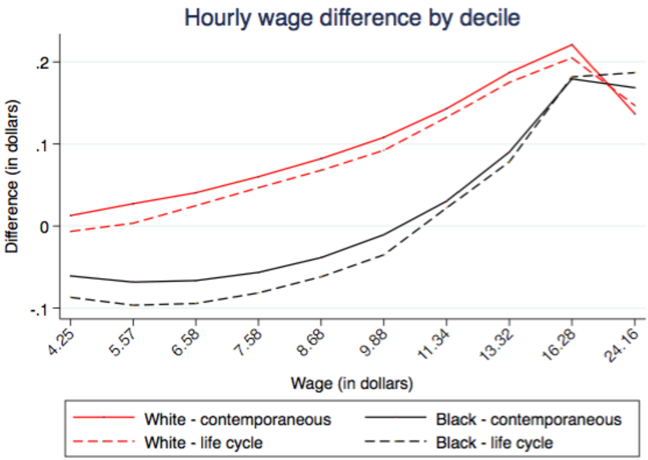
  - age 40 average wage
  - age 40 distribution of wages?

Today's simulation: the impact of being overweight over the life cycle compared to being normal weight over the life cycle.

Life-Cycle Effect of BMI Reduction on Wages



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Life cycle "better health" has an impact... *Why? How?*

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  - the probability of enrollment increases early but decreases later
  - the probability of full time employment decreases (by 2 and 4 percentage points); greater reduction for blacks as they age
  - white females substitute part time employment for full time employment; black females substitute this way also, but are more likely to be non-employed

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- Marriage and children histories reduce wages.

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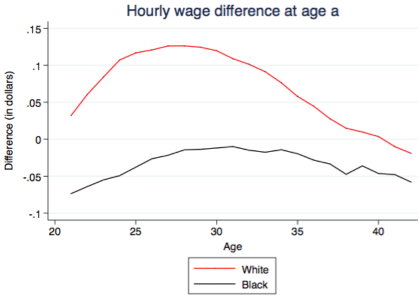
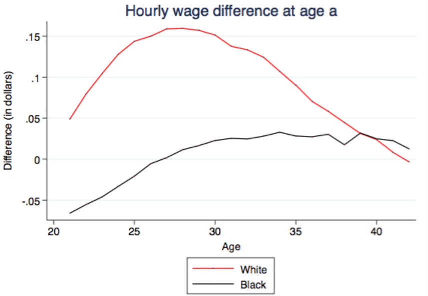
  - Females are more likely to be married, and to be married longer, when in better health. Whites marry earlier.
  - White females have fewer children in the household. Blacks have fewer earlier.
- Marriage and children histories reduce wages.
- But these also impact schooling and work decisions over time.

Impacts of BMI Reduction on Wages over the Life Cycle



a.) Unconditional on employment



b.) Conditional on being employed

Concluding Remarks...

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Individual's Optimization Problem — 1

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

$s = 0, 1$	$e = 0, 1, 2$	$m = 0, 1$	$k = 0, 1, 2$
(not in school, in school)	(not employed, employed full time employed part time)	(not married, married)	(no change in # of kids, increase hh size, decrease hh size)

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

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$$C_t + P_t^b \cdot \underbrace{C_t^{I*}}_{\text{optimal caloric intake}}$$

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$$C_t + P_t^b \cdot \underbrace{C_t^{I*}}_{\text{optimal caloric intake}} = \overbrace{w_t \cdot 1000 \cdot e \cdot (1 - d_t^{s0mk})}^{\text{earned income}} + \overbrace{Y_t \cdot d_t^{se1k} + N_t}^{\text{non-earned income}}$$

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Individual's Optimization Problem — 3

lifetime value of alternative *semk* at period *t*

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

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

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

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body mass distribution

$$B_{t+1} \sim F_b(B_t, C_t^{I*}, L_t^{E*}; X_t, \epsilon_t^b)$$

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body mass distribution

$$B_{t+1} \sim F_b(B_t, C_t^{I*}, L_t^{E*}; X_t, \epsilon_t^b)$$

wage distribution

$$w_{t+1} \sim F_w(S_{t+1}, E_{t+1}, M_{t+1}, K_{t+1}, B_{t+1}, X_{t+1}, P_{t+1}^e, \epsilon_{t+1}^w)$$

Information

(An) Empirical Model of Wages

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

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$$ln(w_t)|e_t \neq 0 \; = \; \alpha_0 + \alpha_1 S_t$$ ← schooling (entering t)

work experience and part time indicator → $$+\alpha_2 E_t + \alpha_3 \mathbf{1}[\text{parttime}]$$

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productivity → $+\alpha_4 B_t$

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productivity → $+\alpha_4 B_t + \alpha_5 M_t + \alpha_6 K_t$

interactions → $+\alpha_7'[S_t, E_t, M_t, K_t, B_t] \times \mathbf{1}[\text{black}]$

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$$ln(w_t)|e_t \neq 0 \;=\; \alpha_0 + \alpha_1 S_t \longleftarrow \text{schooling (entering } t\text{)}$$

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exogenous determinants and skill prices $\longrightarrow$ $+\alpha_8 X_t + \alpha_9 P_t^e + \alpha_{10} t$

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unobserved heterogeneity → $+\epsilon_t^w$

▸ Equations Table

(An) Empirical Model of Body Mass Transition

$$B_{t+1} = b(B_t, C_t^{I*}, L_t^{E*}; X_t, \epsilon_t^b)$$ ← biological production function

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

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replace with the determinants of these demand functions where decision is made after s_t, e_t, m_t, k_t decisions

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$$+\delta_6 X_t + \delta_7 P_t^b + \delta_8 w_t$$

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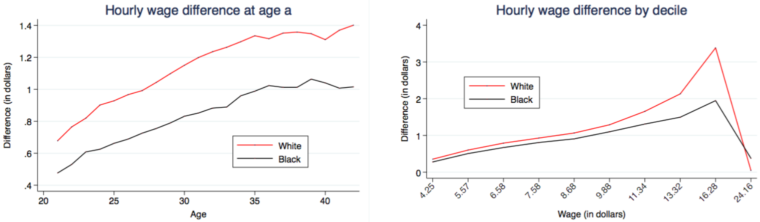
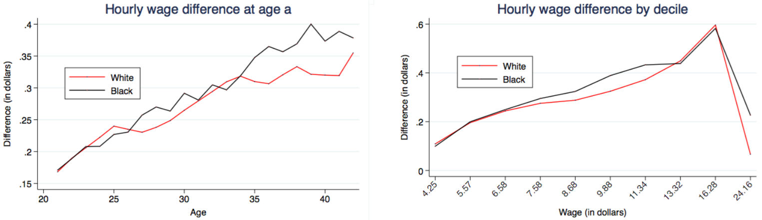
$$+\epsilon_t^b$$

Equations Table

Wage Impacts of Education and Experience



a.) Impact of one additional year of schooling



b.) Impact of one additional year of full-time work experience

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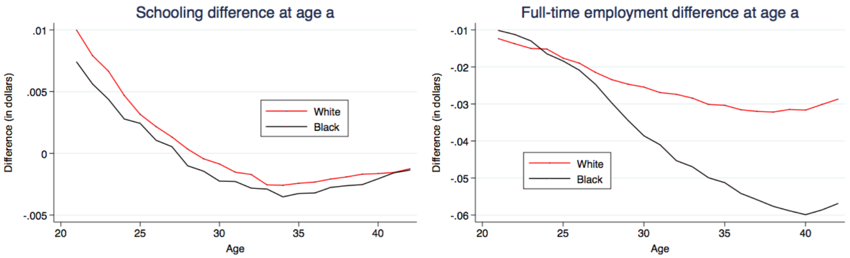
Education and Employment Impacts

(of BMI improvement from overweight to normal weight)



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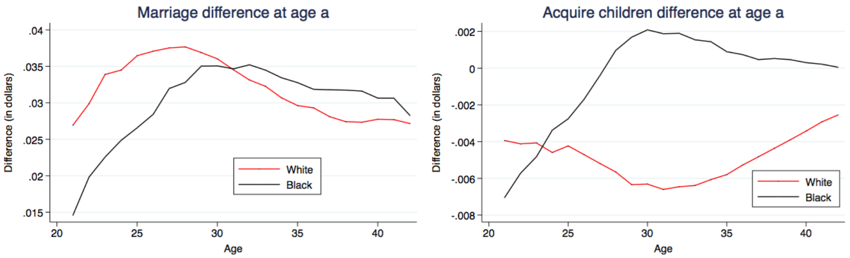
Marriage and Children Impacts

(of BMI improvement from overweight to normal weight)



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