Sufficient Statistics for Welfare Analysis: A Bridge Between Structural and Reduced-Form Methods

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MOTIVATION

- Two competing paradigms for policy evaluation and welfare analysis: “structural” vs. “reduced-form”

- Structural approach generally involves two steps: estimate primitives of a model and then simulate effects of policies on welfare
    - Critique: strong assumptions needed to identify full primitive structure (e.g., Imbens 2009)

- Reduced-form: estimate causal effects (“treatment effects”) by isolating exogenous sources of variation for identification
    - Critique: Estimates not useful for welfare analysis because they are not deep parameters; endogenous to policy regime (e.g., Heckman and Vytlacil 2005, Deaton 2009)

SUFFICIENT STATISTICS

- Past decade of work in public economics provides a strategy that bridges the gap between the two methods

  - Idea: Instead of primitives, identify "sufficient statistics" for welfare analysis that can be estimated using reduced-form methods

  - Any set of primitives (ω) consistent with sufficient statistics (β) generates the same value of welfare gain (dW/dt)

THE SUFFICIENT STATISTIC APPROACH

Structural Primitives	**Sufficient Statistics**	**Welfare Change**
ω_1, ω_2, . . . ω_N →	$\beta_1(t)$, $\beta_2(t)$ →	$\frac{dW}{dt}(t)$
ω=prefs., constraints	$\beta = f(\omega,t)$ $y = \beta_1 X_1 + \beta_2 X_2 + \varepsilon$	dW/dt used for policy analysis
ω not uniquely identified	β identified using program evaluation	

Sufficient Statistics vs. Structural Methods

- Advantages of sufficient statistic approach

  - need to identify fewer parameters
  - weaker modeling assumptions
  - applicable when positive model unknown (behavioral econ)

- Disadvantages of sufficient statistic approach

  - new formula must be derived for each question
  - easily misapplied because no model evaluation required
  - out of sample predictions may be less reliable

→ Sufficient statistic methods provide a useful complement to (rather than a substitute for) structural methods

OUTLINE

1. Motivating Examples: Revenue and Deadweight Cost of Taxes
2. General Framework
3. Application 1: Social Insurance
4. Application 2: Income Taxation
5. Application 3: Behavioral Models

Motivating Example 1: Estimation of Revenue from a Gas Tax

- Suppose government increases gas tax by 10 cents per gallon
- How much extra revenue will this generate?
  - Let x_1 = gas consumption and t = gas tax → revenue $R = tx_1$
  - For this question, sufficient to estimate dx_1/dt because

$$dR/dt = x_1 + t \cdot dx_1/dt$$

- dx_1/dt is a reduced-form response that can be estimated using quasi-experimental methods
  - Not a structural parameter: complex function of preferences and technology
  - But <u>sufficient</u> to answer this particular question → do not need to identify full structural model.

Motivating Example 2: Deadweight Loss (Harberger 1964)

- Revenue example is an accounting calculation; more interesting economic applications involve calculation of changes in utilities/welfare
- Precursor to modern sufficient statistic literature: Harberger's partial-equilibrium analysis of deadweight cost of taxation
- Objective: calculate deadweight loss of a tax.
  - Consider an environment with *N* markets in competitive equilibrium
  - Individuals have quasilinear utility
  - Government levies a unit tax *t* on good x_1
  - How much surplus is lost because of transactions that fail to occur b/c of the tax *t*?

Harberger (1964): Deadweight Loss

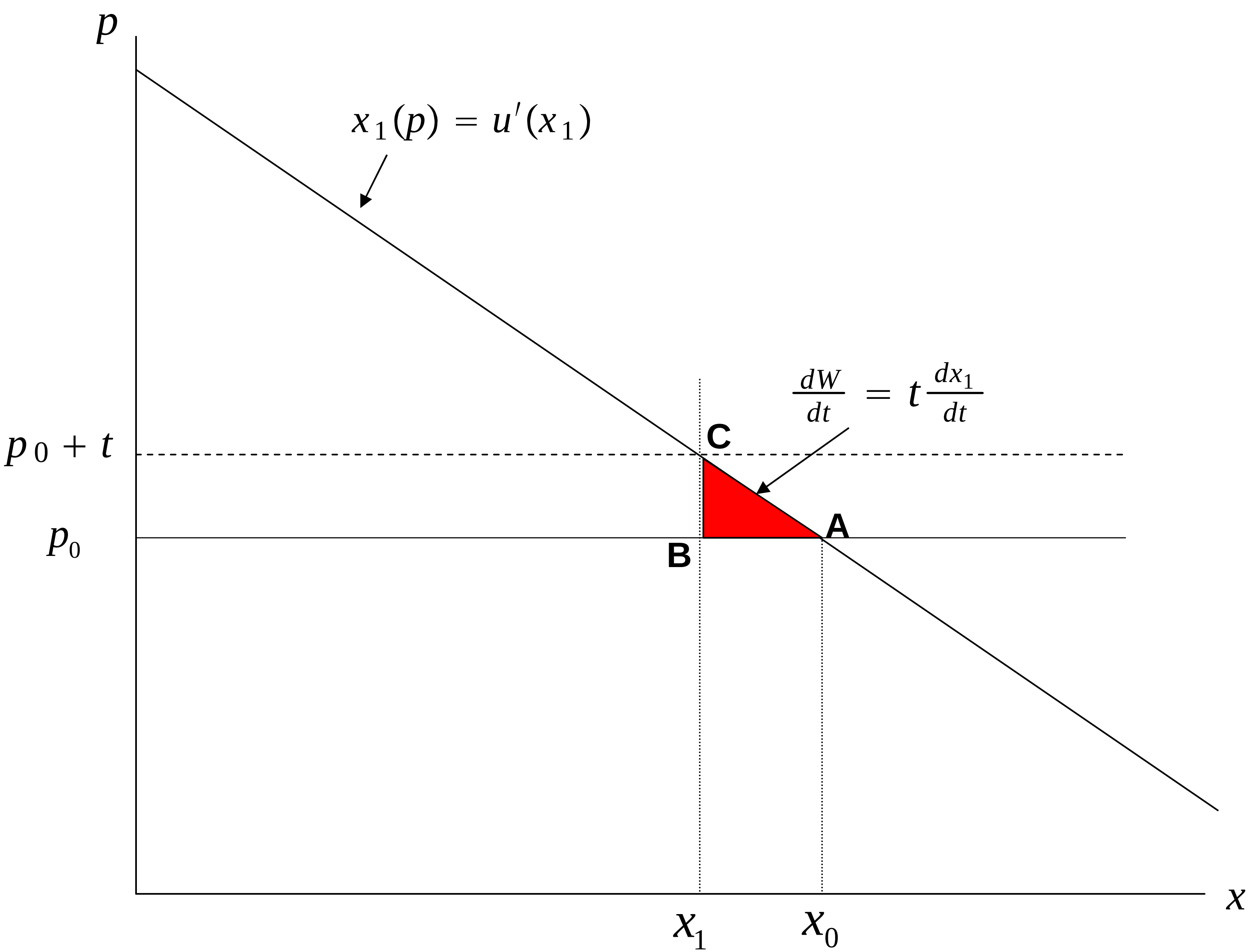
- Two approaches to answer this question

1. Specify an *N* good supply+demand system and recover preferences + technology by estimating supply and demand curves

    - Challenging to implement: need 2*N* instruments

2. Harberger "triangle" formula

Harberger Triangle with Fixed Producer Prices



Harberger (1964): Deadweight Loss

$$\frac{dW}{dt} = t\frac{dx_1}{dt}$$

- Reduced-form effect of tax increase on demand for taxed good (dx_1/dt) is also a sufficient statistic for *dW/dt*
  - Do not need to identify primitives of model or estimate substitution patterns across all goods
  - Tax induces changes in demand in all markets, but these responses do not have a first-order effect on W b/c of optimization
- Note that sufficient statistic is *total* derivative, including all GE effects:

$$\frac{dx_1}{dt} = \frac{\partial x_1}{\partial p_1}\frac{\partial p_1}{\partial t} + \frac{\partial x_1}{\partial p_2}\frac{\partial p_2}{\partial t} + \ldots + \frac{\partial x_1}{\partial p_J}\frac{\partial p_J}{\partial t}$$

- DWL of non-marginal tax change: integrate tdx_1/dt from t_1 to t_2

Harberger (1964): Deadweight Loss

$$\frac{dW}{dt} = t\frac{dx_1}{dt}$$

- Same formula applies with heterogeneity and discrete choice
  - Only need estimate of *aggregate* demand response to tax change
  - With discrete choices, individual demand fn.'s not smooth but expected welfare is → envelope conditions

Modern Sufficient Statistic Approach: A Six Step Rubric

1. Specify model structure (prefs, technology) and social welfare function:

$$W(t) = \max_x U(x) + \sum_{m=1}^{M} \lambda_m G_m(x,t)$$

2,3. Write dW/dt in terms of marginal utilities using envelope conditions

4. Recover marginal utilties from observed choices using comparative statics of model to obtain sufficient statistic formula

$$\frac{dW}{dt}(t) = f(t, \frac{dx_1}{dt}, \frac{dx_1}{dZ}, \frac{dx_2}{dt}, \frac{dx_2}{dZ}, \ldots)$$

5. Empirical implementation: mapping non-marginal LATE estimates to sufficient statistics

6. Model evaluation: do structural assumptions fit the data?

Recent Examples of Structural, Reduced-Form, and Sufficient Statistic Studies

	Structural	Reduced Form	Sufficient Statistic
Social Insurance	Wolpin (1987) Hansen and Imrohoglu (1992) Chetty (2003) Golosov and Tsyvinski (2006) Lentz (2007) Einav, Finkelstein, Schrimpf (2008)	Hamermesh (1982) Manning et al. (1987) Meyer (1990) Cutler and Gruber (1996) Autor and Duggan (2003) Lalive et al. (2007)	Gruber (1997) Chetty (2006) Shimer and Werning (2007) Chetty and Saez (2008a) Einav, Finkelstein, Cullen (2008)
Taxation	Slemrod et al. (1994) Hoynes (1996) Keane and Moffitt (1998) Blundell et al. (2000) Golosov and Tsyvinksi (2006) Weinzierl (2008)	Eissa and Liebman (1996) Gruber and Wise (1999) Goolsbee (2000) Friedberg (2000) Meyer and Rosenbaum (2001) Blau and Khan (2007)	Feldstein (1999) Piketty (1997) Diamond (1998) Saez (2001) Goulder and Williams (2003) Chetty (2008)
Behavioral Models	Angeletos et al. (2001) İmrohoroğlu, İmrohoroğlu, Joines (2003) Liebman and Zeckhauser (2004) DellaVigna and Paserman (2005) Amador, Werning, and Angeletos (2006)	Madrian and Shea (2002) Shapiro (2006) Ashraf, Karlan, and Yin (2006) Chetty and Saez (2008b) DellaVigna (2008)	Bernheim and Rangel (2008) Chetty, Looney, Kroft (2008)

Static Model of Social Insurance

- Two states: high and low (unemployed, sick ,etc.).
  - Income in high state: $A + w_h$; in low state: $A + w_l$
  - Consumption in high state: c_h; in low state: c_l
- Agent can control probability of high state via effort *e* at cost $\psi(e)$
  - Reflects search effort, investment in health, etc.
  - Choose units so that probability of high state is $p(e) = e$

Static Model of Social Insurance (Baily 1978)

- Imperfect private insurance: individuals can transfer \$$z$ from high state to low state via informal risksharing at cost $q(b_p)$

    - \$1 increase in c_l → $(1-e)/e + q(b_p)$ reduction in c_h

- Social insurance: government pays a benefit b in low state financed by a tax $t(b)=b \cdot (1-e)/e$

- Social welfare:

$$W(b) = eu(A + w_h - \frac{1-e}{e} b_p - q(b_p) - t(b)) \\ + (1-e)u(A + w_l + b_p + b) - \psi(e)$$

- Marginal welfare gain has marginal-utility representation:

$$\frac{dW}{db} = (1-e)\{u'(c_l) - (1 + \frac{\varepsilon_{1-e,b}}{e})u'(c_h)\}$$

- To convert to money-metric, compare welfare gain of increasing insurance program and wage bill in high state:

$$M_W(b) = \frac{\frac{dW}{db}(b)/(1-e)}{\frac{dW}{dw_h}(b)/e} = \frac{u'(c_l) - u'(c_h)}{u'(c_h)} - \frac{\varepsilon_{1-e,b}}{e}$$

Chetty (2008)

- Uses comparative statics of effort choice (*e*) to back out marginal utils.
- First order condition for effort:

$$\psi'(e) = u(c_h) - u(c_l)$$

- Effects of cash grant (e.g. severance pay) and higher benefit level:

$$\partial e/\partial A = \{u'(c_h) - u'(c_l)\}/\psi''(e) \leq 0$$
$$\partial e/\partial b = -u'(c_l)/\psi''(e)$$

- It follows that

$$\frac{u'(c_l) - u'(c_h)}{u'(c_h)} = \frac{-\partial e/\partial A}{\partial e/\partial A - \partial e/\partial b}$$
$$\Rightarrow M_W(b) = \frac{-\partial e/\partial A}{\partial e/\partial A - \partial e/\partial b} - \frac{\varepsilon_{1-e,b}}{e}$$

- Liquidity effect (de/dA) measures completeness of private insurance; moral hazard effect (de/dw_h) measures efficiency cost of insurance.

Card, Chetty, and Weber (2007)

Effect of Severance Pay on Unemployment Durations in Austria

Calibration of Chetty (2008) formula

- Plug reduced-form estimates of de/dA and de/db into formula to calculate dW/db

- Welfare gain from raising benefit level by 10% from current level in U.S. (50% wage replacement) is $5.9 bil = 0.05% of GDP

- In structural models calibrated to match sufficient statistics, dW/db falls rapidly with b

- Small dW/db suggests we are near optimal benefit level

Recent Examples of Structural, Reduced-Form, and Sufficient Statistic Studies

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Feldstein (1995, 1999)

- Following Harberger, large literature in labor estimated effect of taxes on hours worked to assess efficiency costs of taxation

- Feldstein observed that labor supply involves multiple dimensions, not just choice of hours: training, effort, occupation

- Structural approach: account for each of the potential responses to taxation separately and then aggregate

- Feldstein's solution: elasticity of taxable income with respect to taxes is a sufficient statistic for calculating deadweight loss

$$\frac{dW}{dt} = t\frac{dTI}{dt}$$

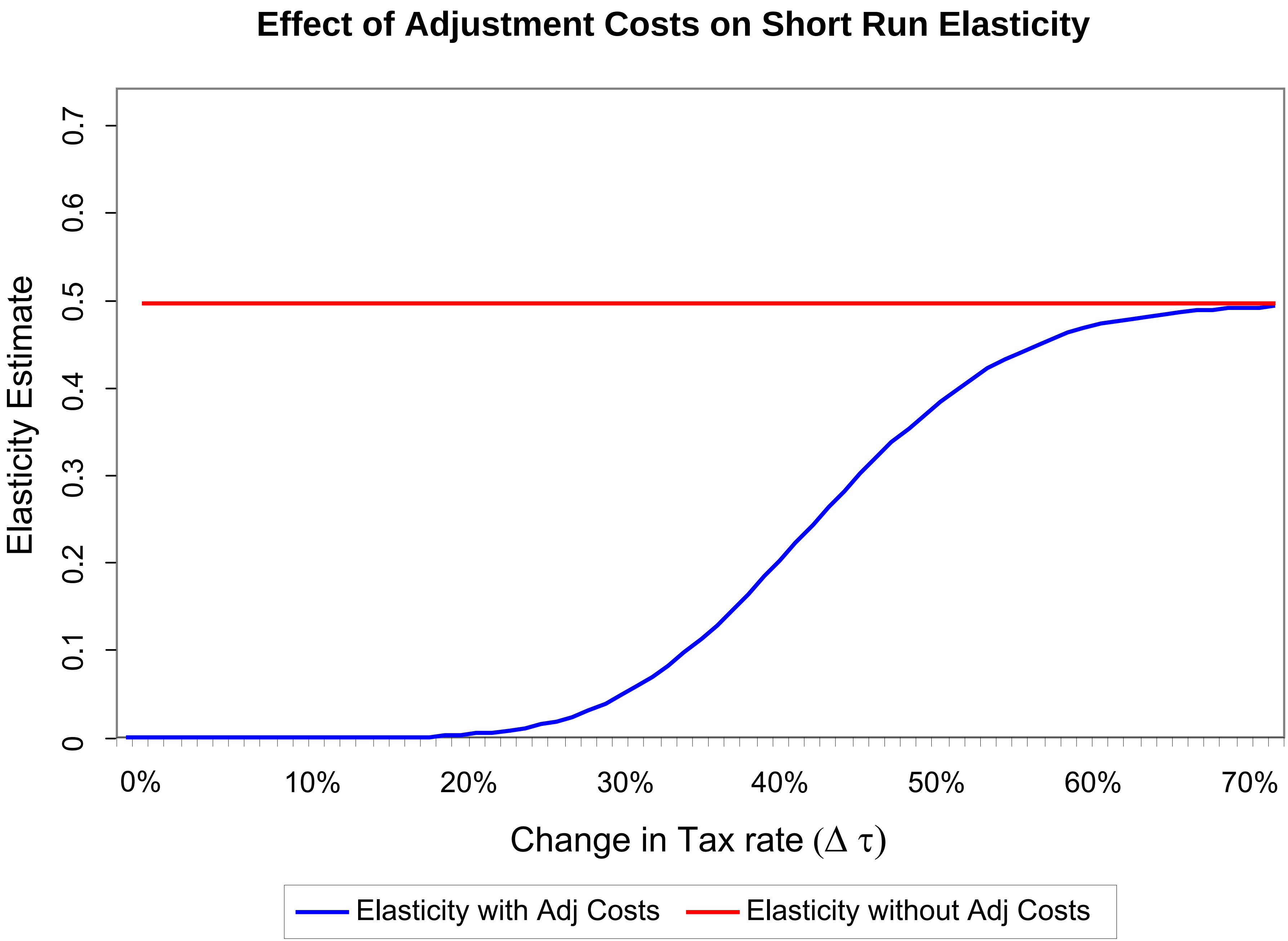
→ Large literature focused on estimating taxable income elasticity

Chetty, Friedman, Olsen, and Pistaferri (2009)

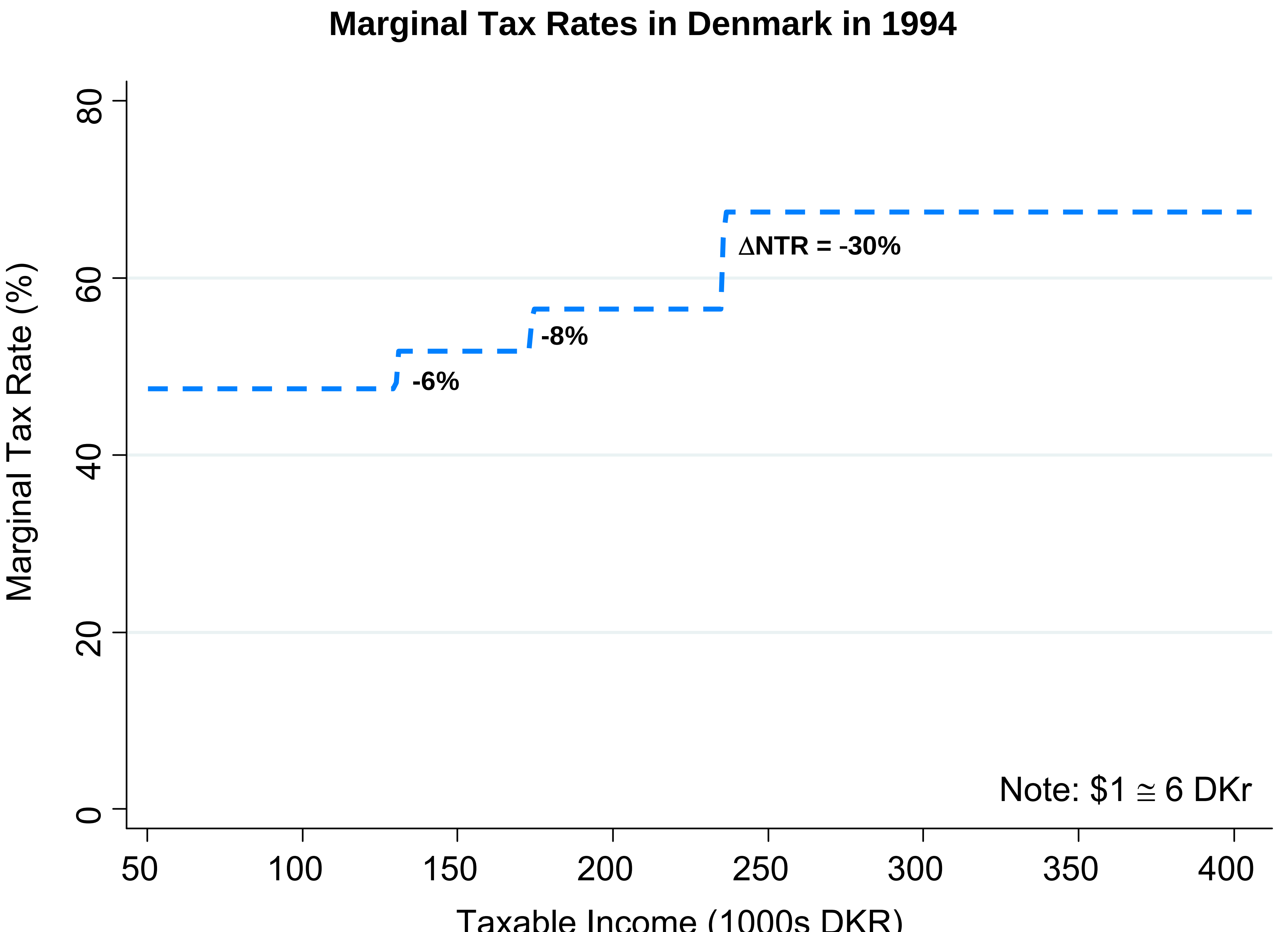
- Existing microeconometric literature on labor supply generally finds near-zero response of taxable income to tax rate
  - Uses *short-run* changes in behavior to identify elasticities
  - E.g. change in behavior in year after a tax reform
  - Short-run response could be attenuated b/c of adjustment frictions
- Elasticity that is a sufficient statistic for long-run efficiency cost calculations in a model with adjustment costs is long-run elasticity
- Illustrates danger of implementing sufficient statistic approach without determining if model used to derive the suff stat formula is actually valid

Chetty, Friedman, Olsen, and Pistaferri (2009)

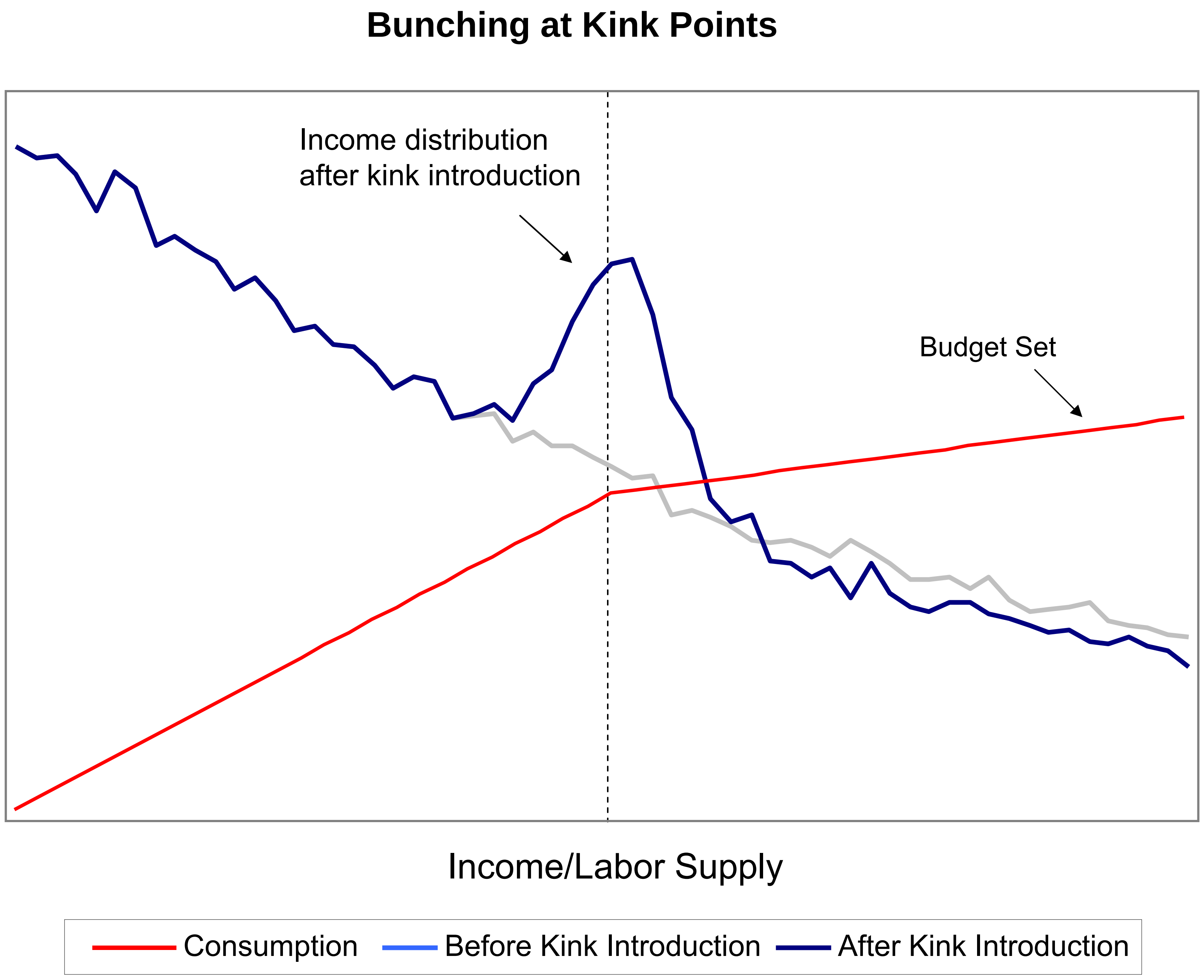
- How to estimate "long run" elasticity credibly?
- One strategy: time-series/macro approach. Problems with identification.
- Our approach: compare small and large tax changes.
- In a model with adjustment costs, *short-run* response to large tax change is a sufficient stat for *long-run* response and deadweight loss.



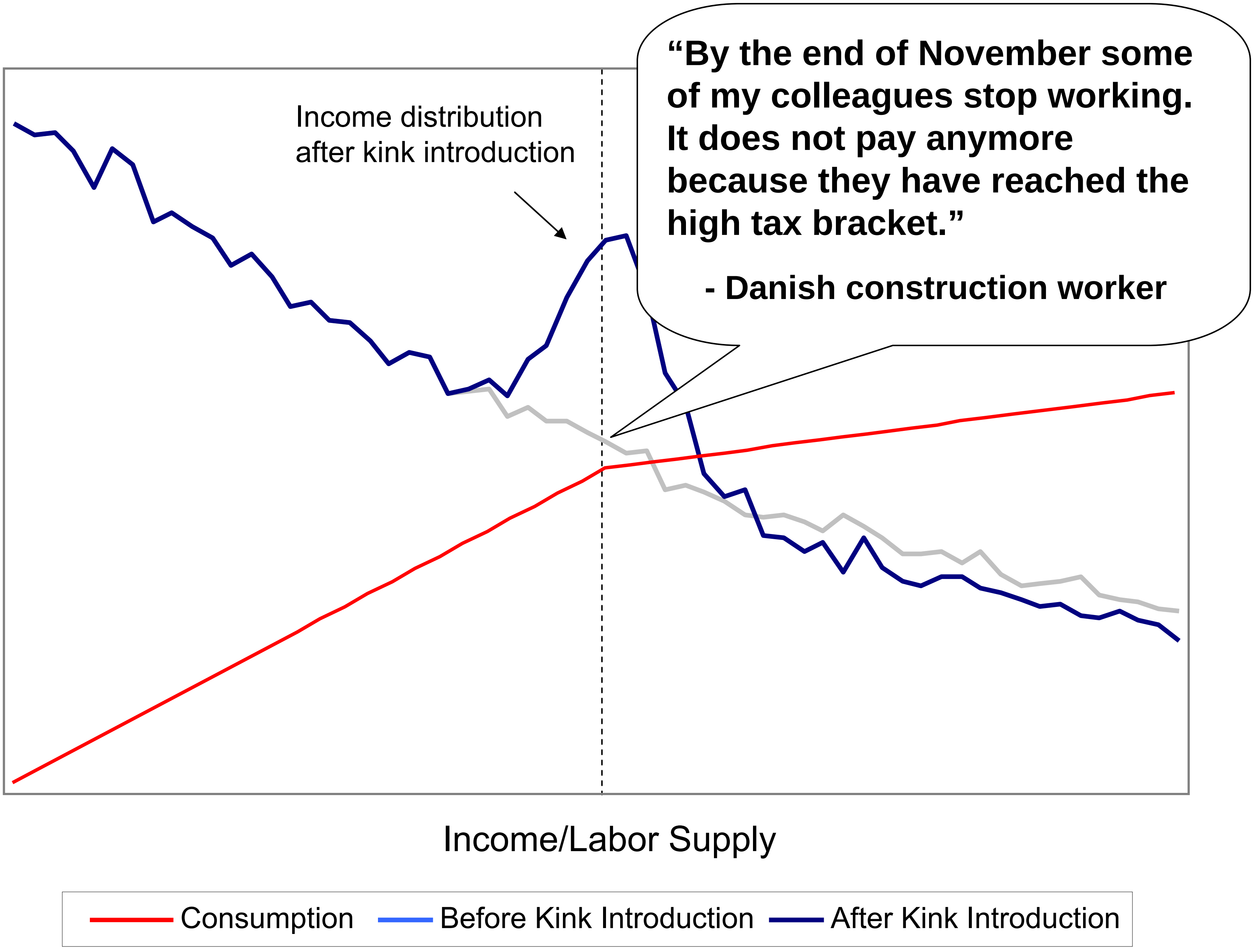
Effect of Adjustment Costs on Short Run Elasticity
Elasticity Estimate
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0%
10%
20%
30%
40%
50%
60%
70%
Change in Tax rate (Δ τ)
Elasticity with Adj Costs
Elasticity without Adj Costs



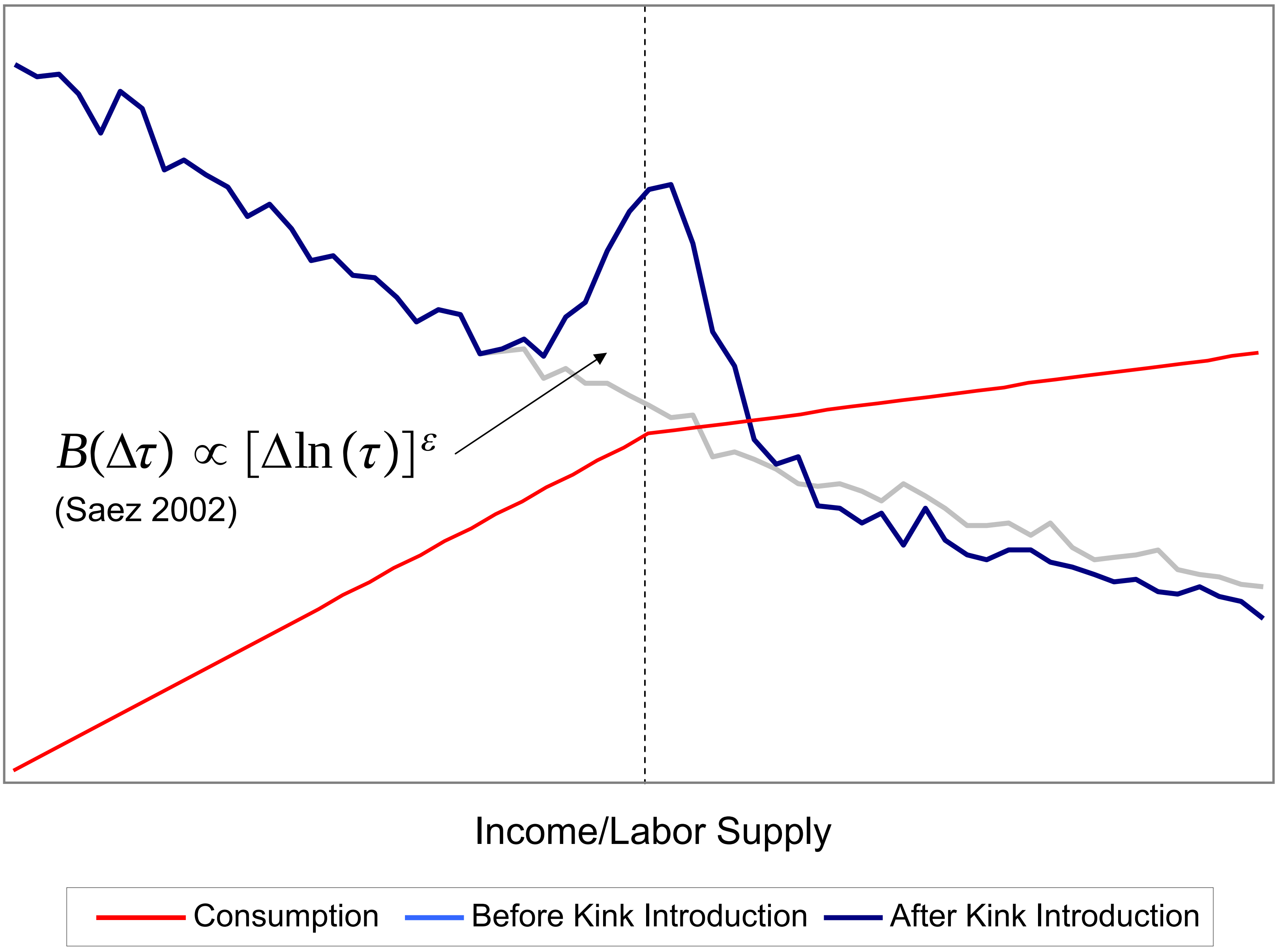
Marginal Tax Rates in Denmark in 1994
Marginal Tax Rate (%)
0
20
40
60
80
ΔNTR = -30%
-8%
-6%
Note: $1 ≃ 6 DKr
50
100
150
200
250
300
350
400
Taxable Income (1000s DKR)

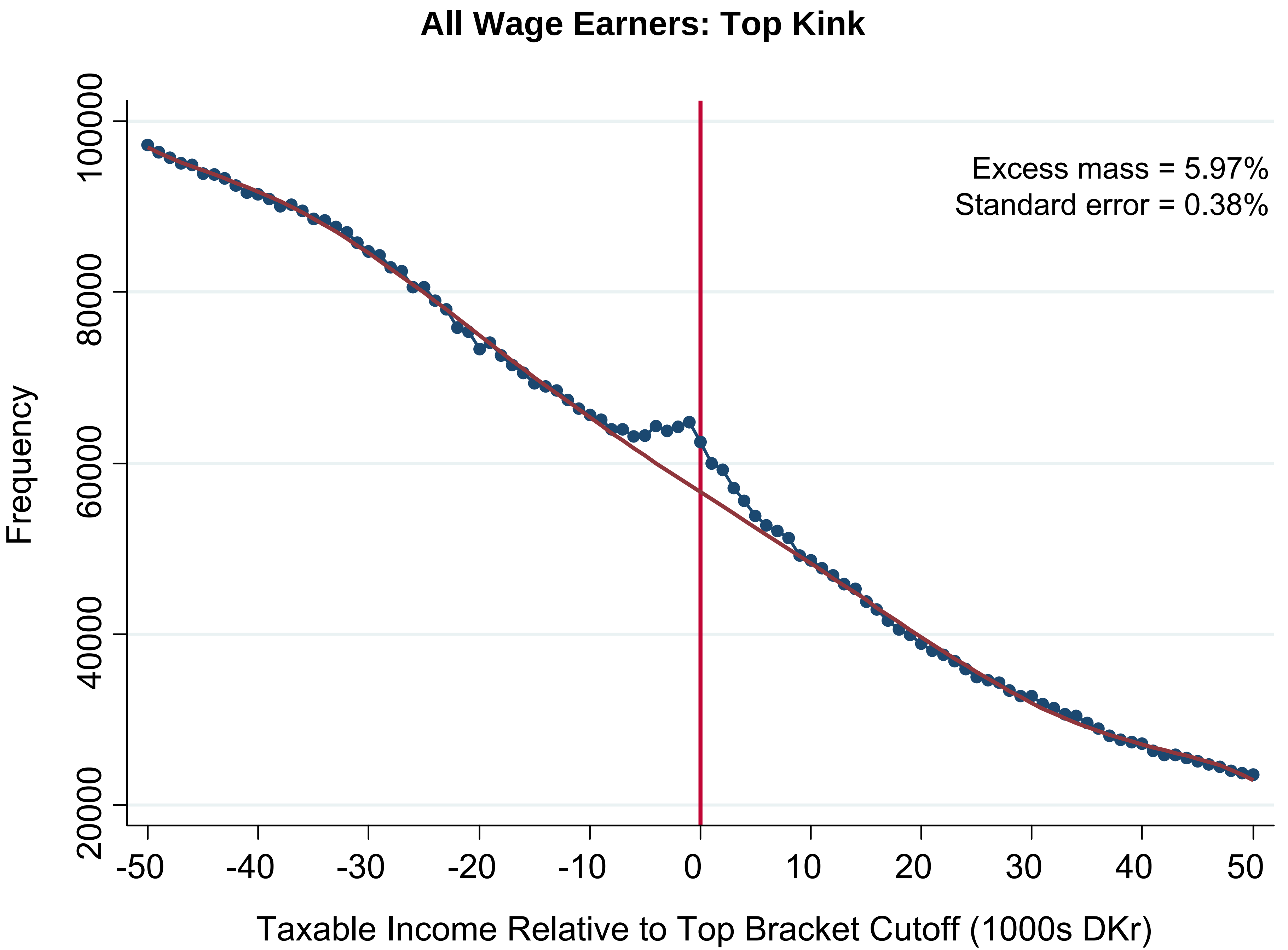

Bunching at Kink Points
Income distribution
after kink introduction
Budget Set
Income/Labor Supply
Consumption
Before Kink Introduction
After Kink Introduction

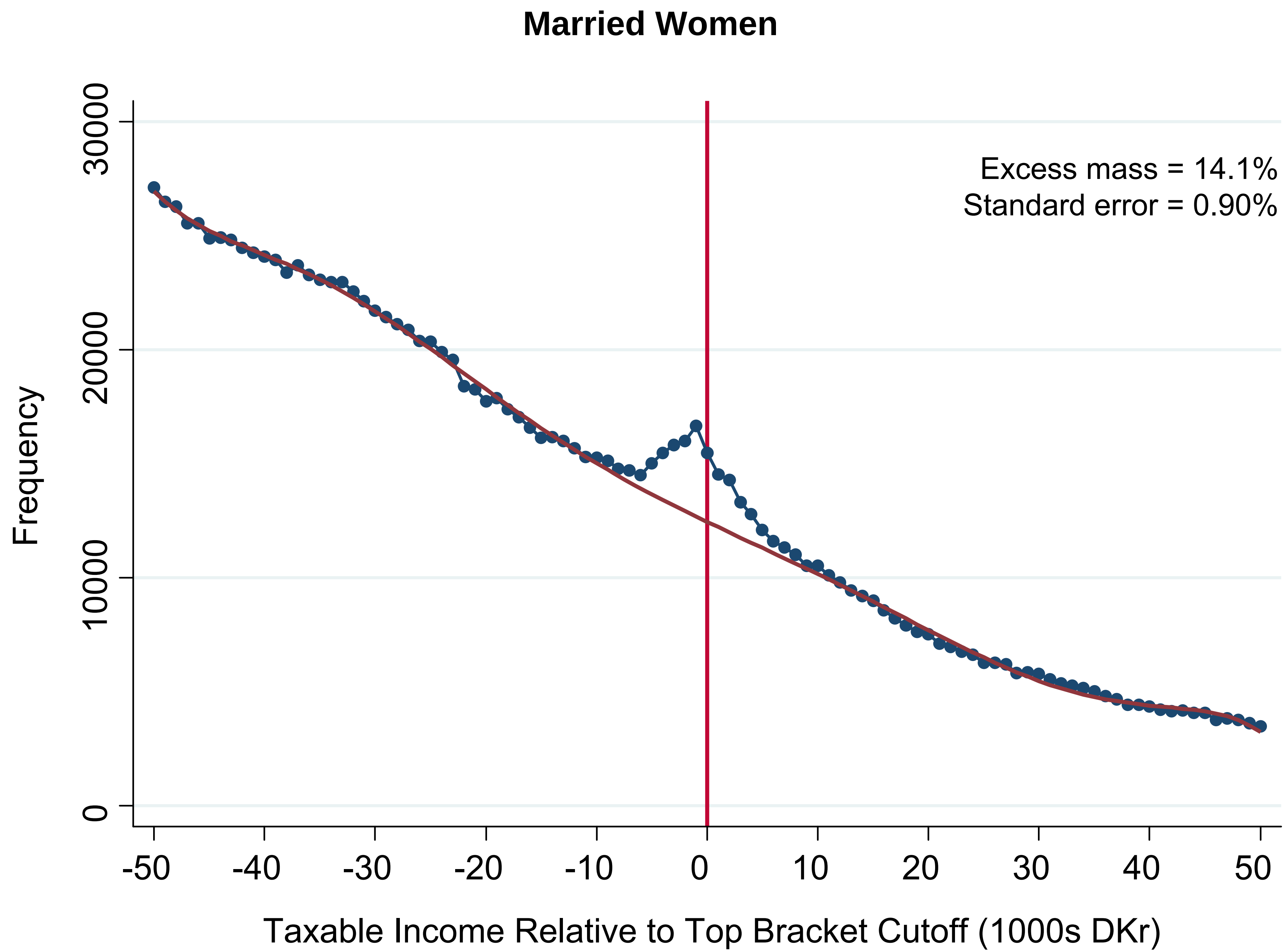
Bunching at Kink Points

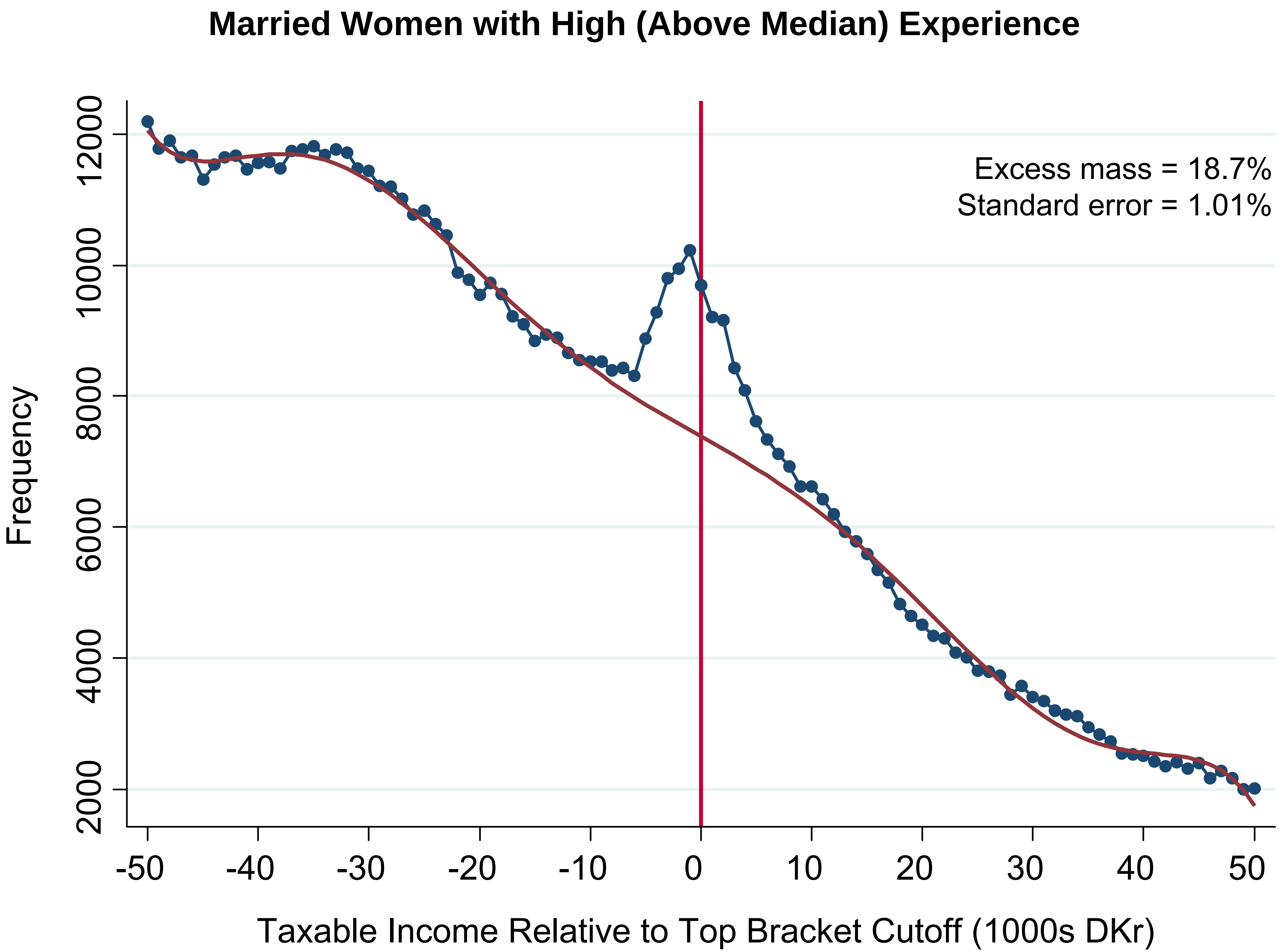


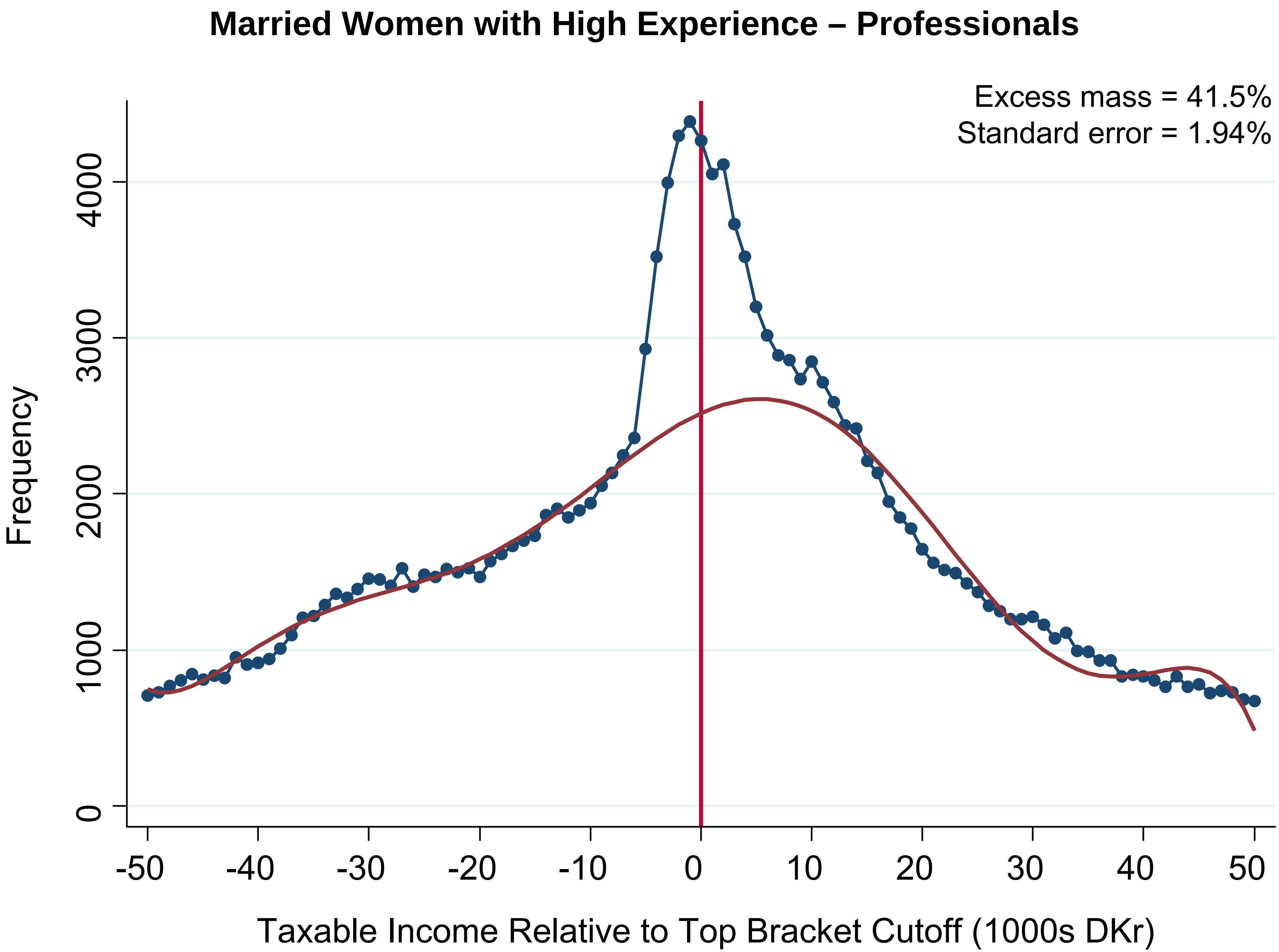
Bunching at Kink Points




All Wage Earners: Top Kink
Excess mass = 5.97%
Standard error = 0.38%
Frequency
100000
80000
60000
40000
20000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Top Bracket Cutoff (1000s DKr)


Married Women
Excess mass = 14.1%
Standard error = 0.90%
Frequency
0
10000
20000
30000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Top Bracket Cutoff (1000s DKr)

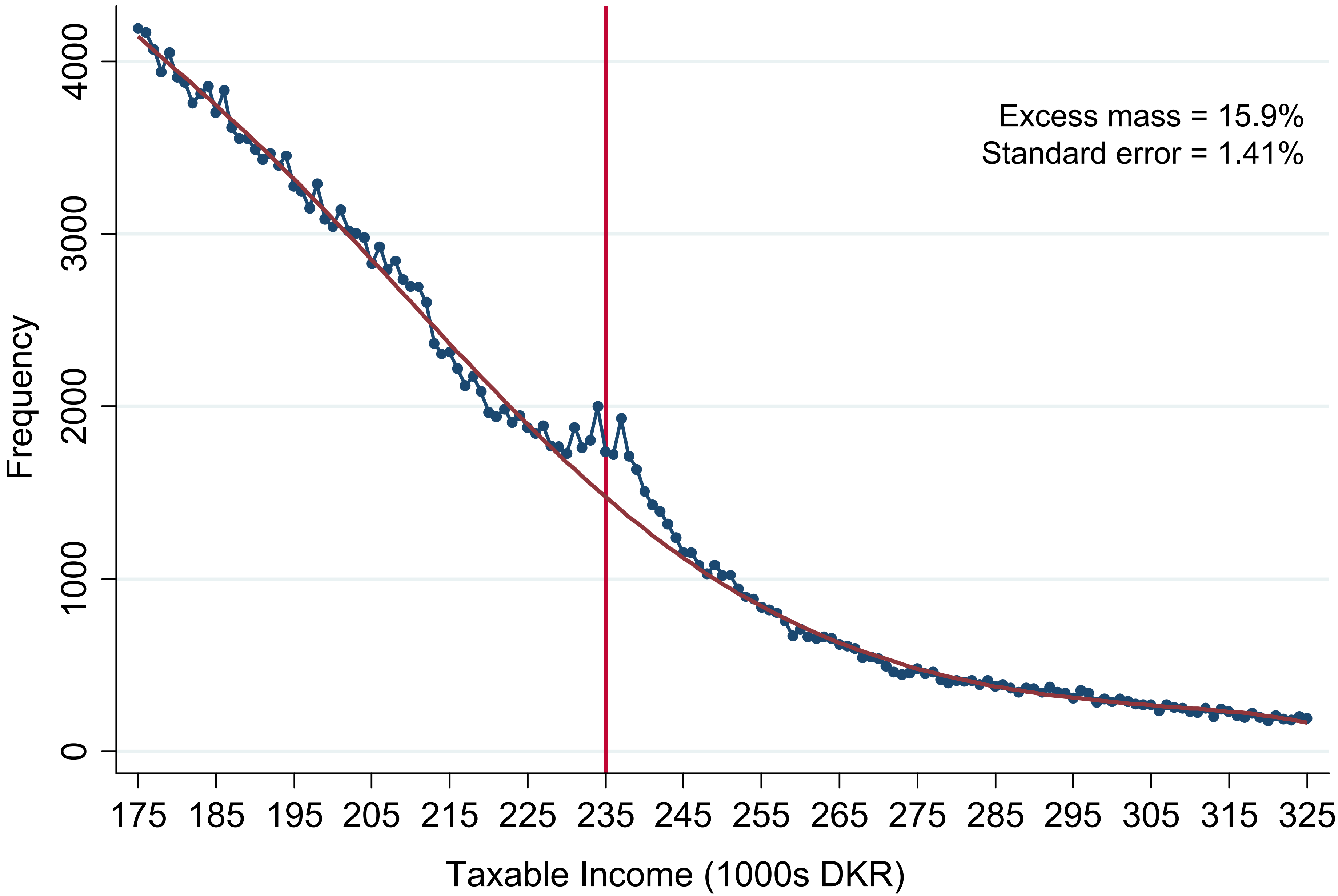

Married Women with High (Above Median) Experience
Excess mass = 18.7%
Standard error = 1.01%
Frequency
12000
10000
8000
6000
4000
2000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Top Bracket Cutoff (1000s DKr)

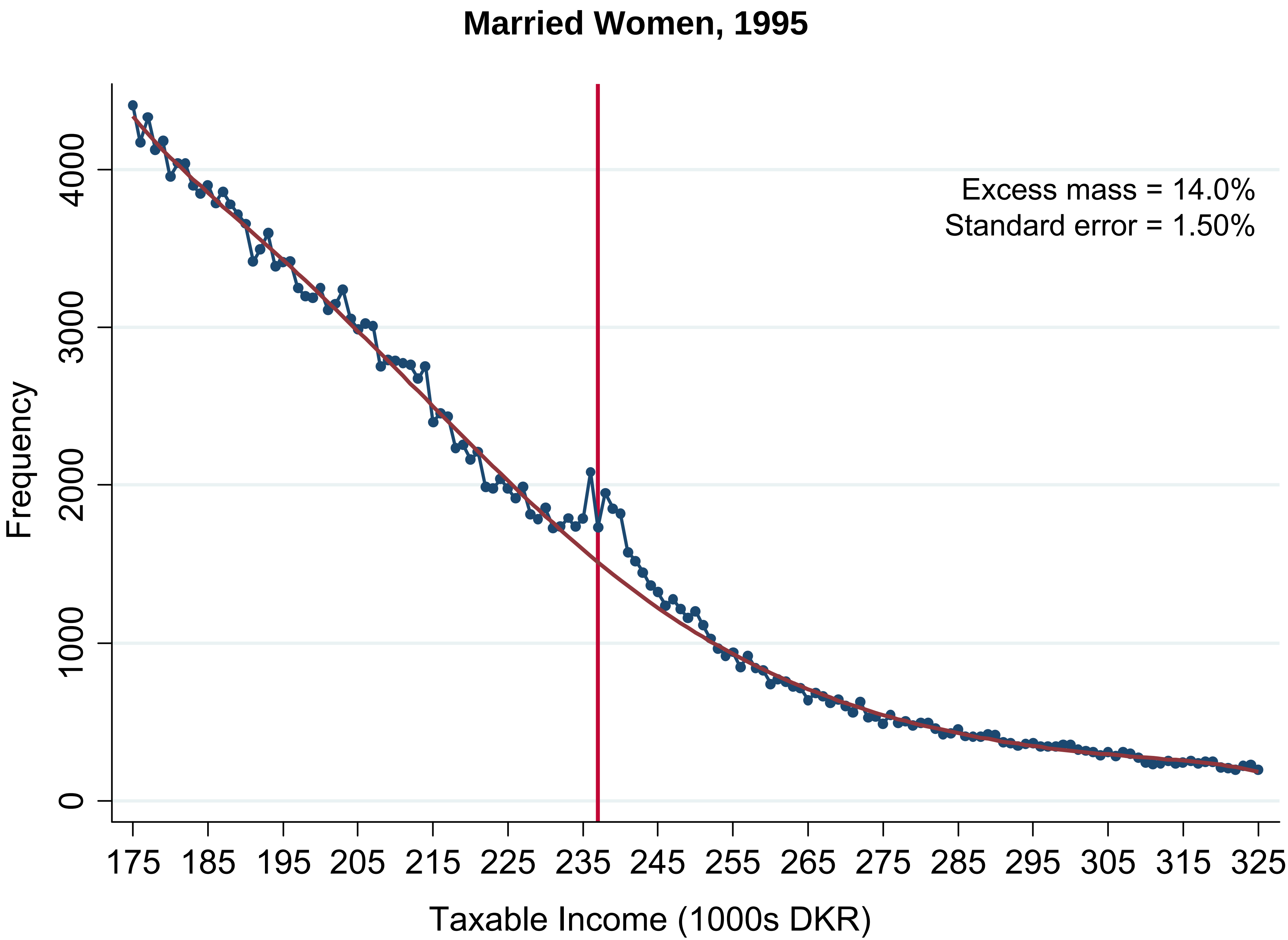


Married Women with High Experience – Professionals
Excess mass = 41.5%
Standard error = 1.94%
Frequency
0
1000
2000
3000
4000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Top Bracket Cutoff (1000s DKr)

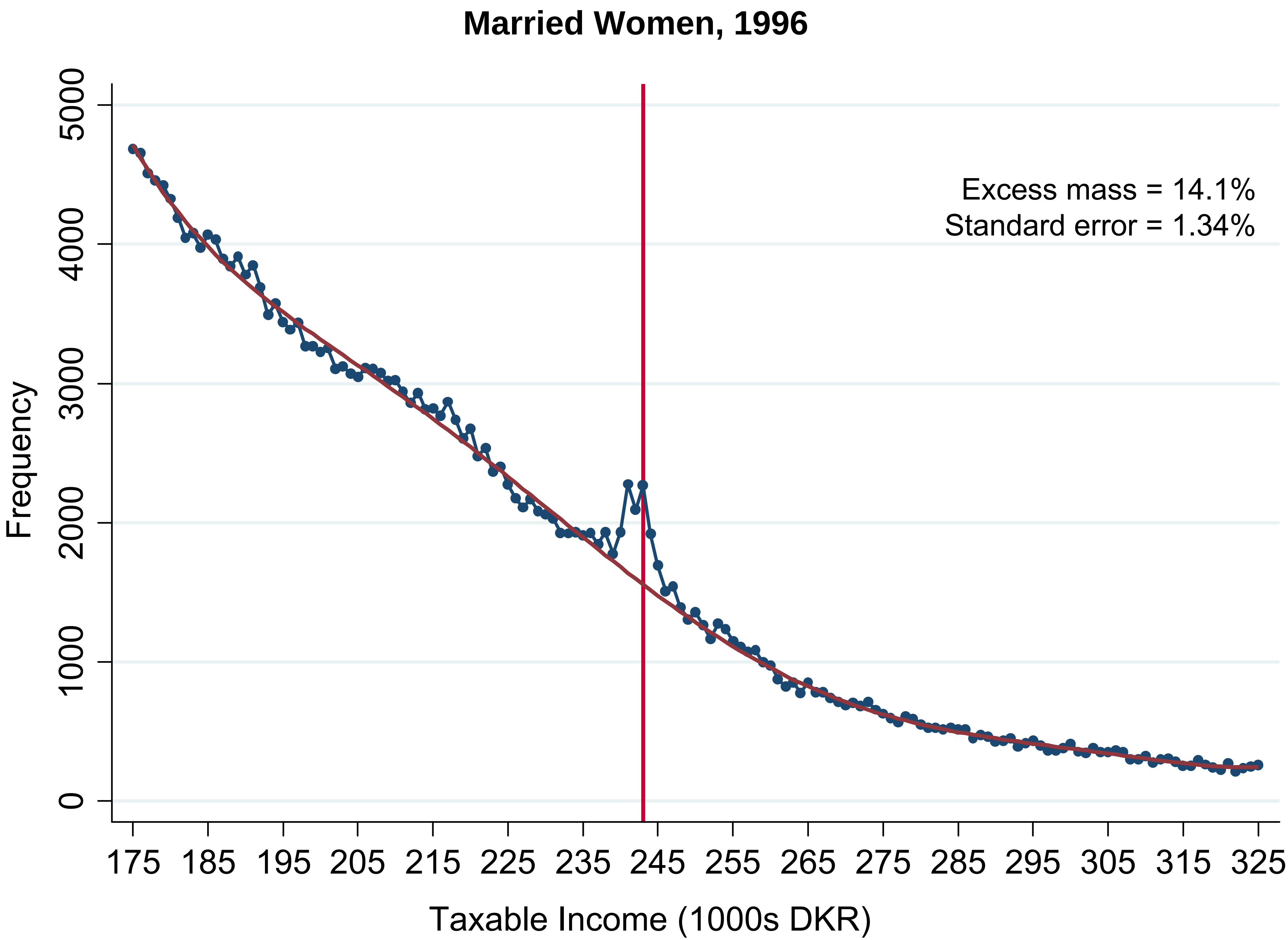
All Wage Earners – Military
Excess mass = 1.25%
Standard error = 0.61%
Frequency
2000
4000
6000
8000
10000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Top Bracket Cutoff (1000s DKr)

Married Women, 1994

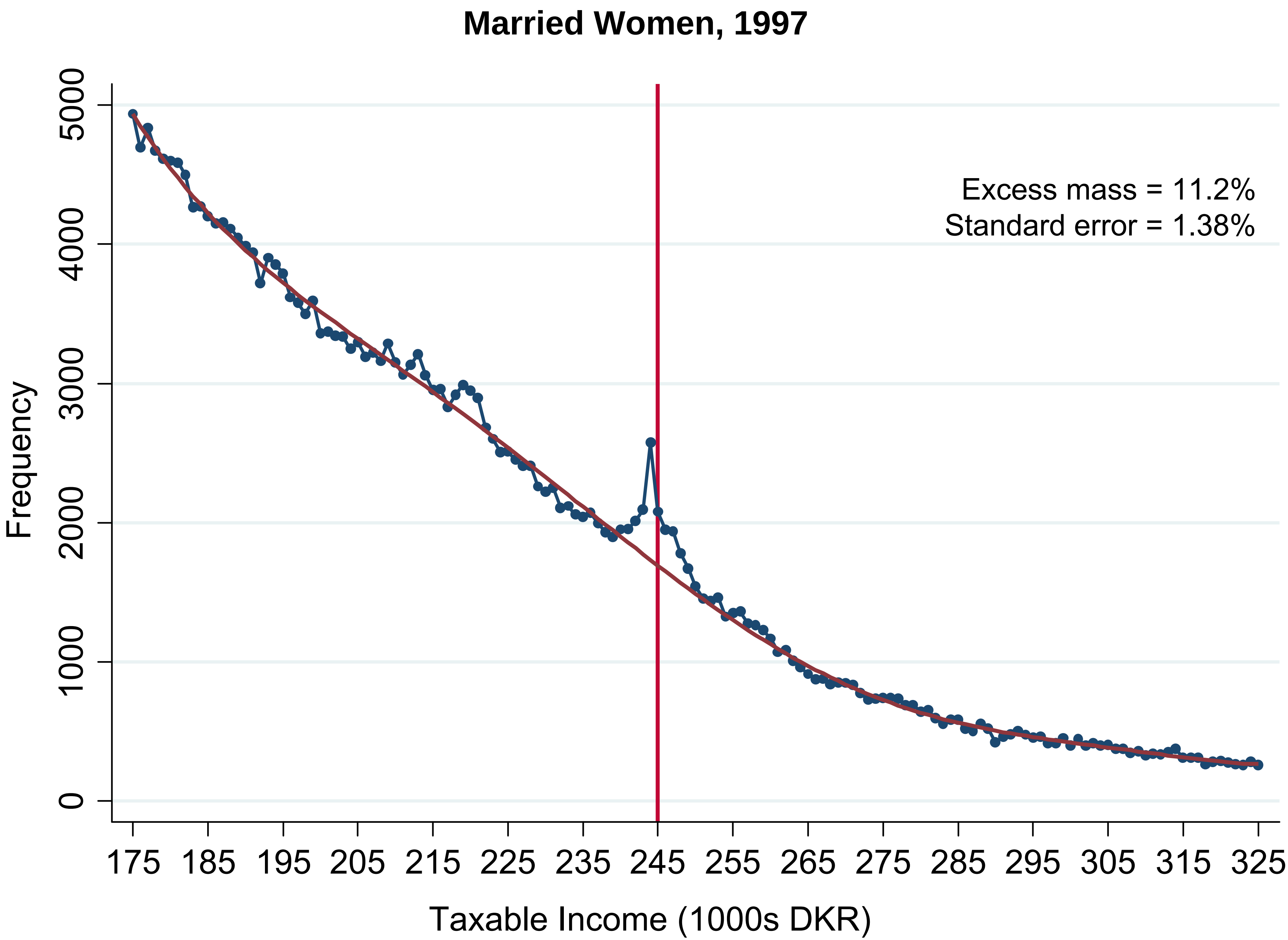




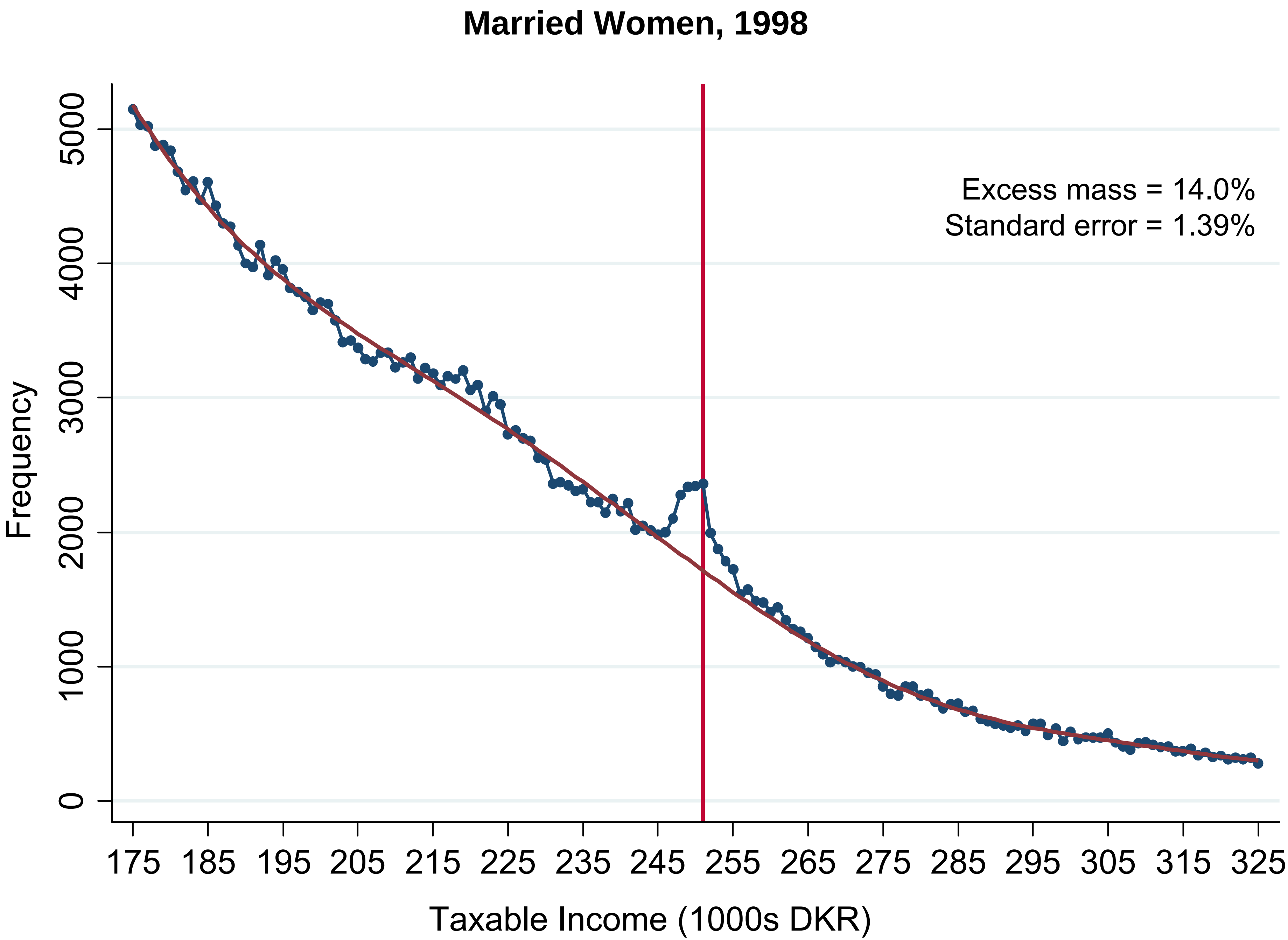
Married Women, 1995
Excess mass = 14.0%
Standard error = 1.50%
Frequency
0
1000
2000
3000
4000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)



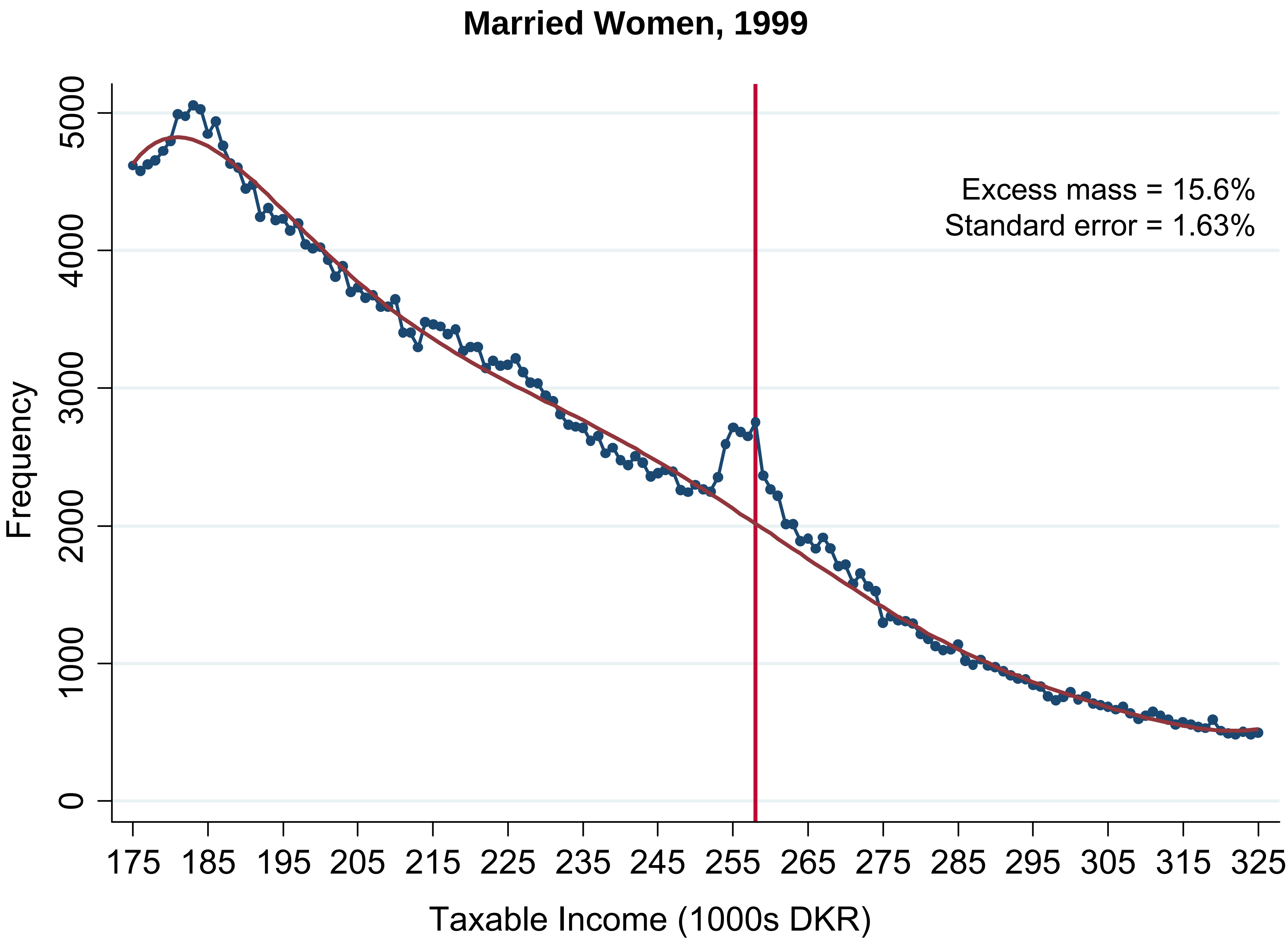
Married Women, 1996
Excess mass = 14.1%
Standard error = 1.34%
Frequency
0
1000
2000
3000
4000
5000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)



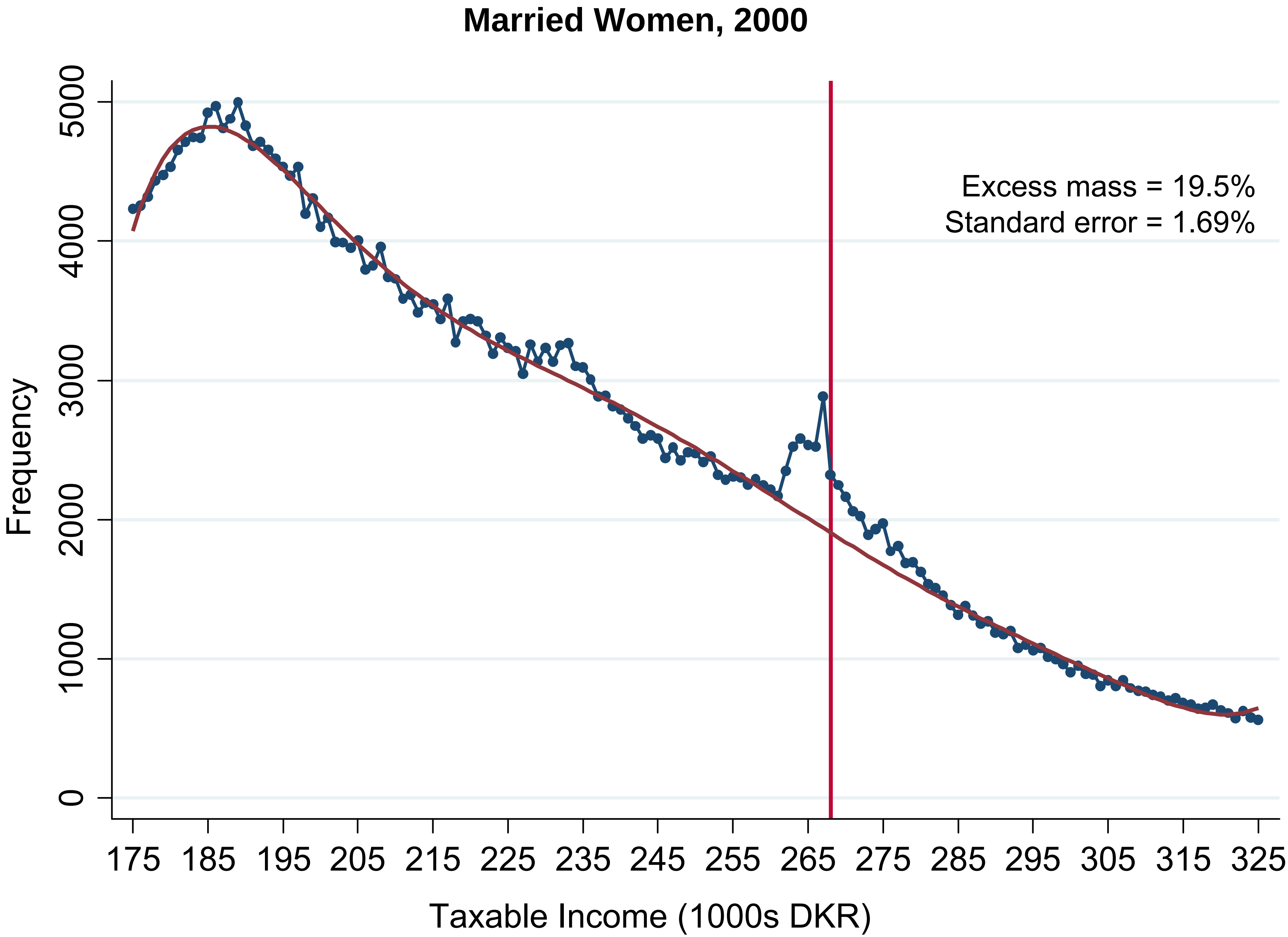
Married Women, 1997
Excess mass = 11.2%
Standard error = 1.38%
Frequency
0
1000
2000
3000
4000
5000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)

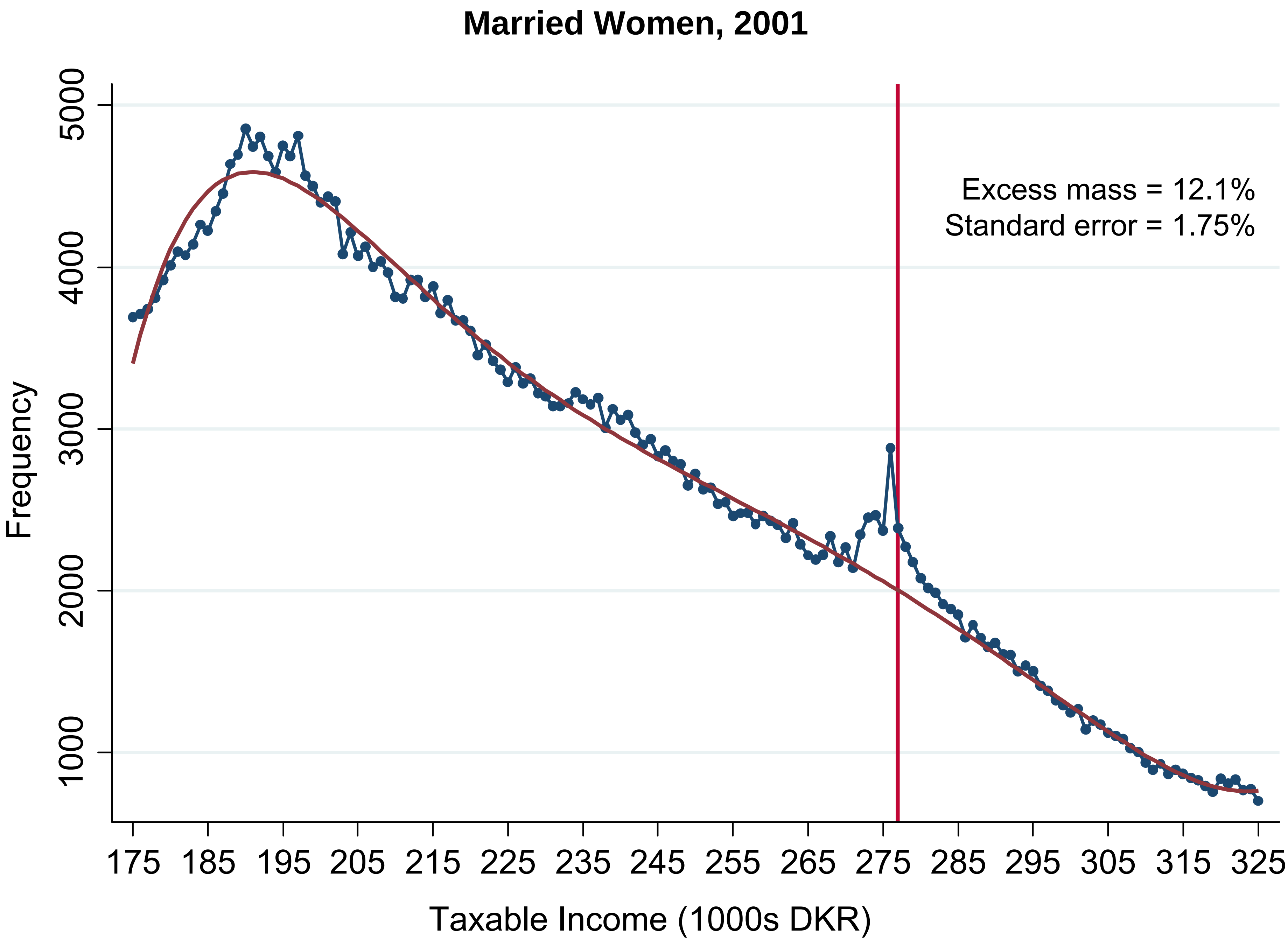


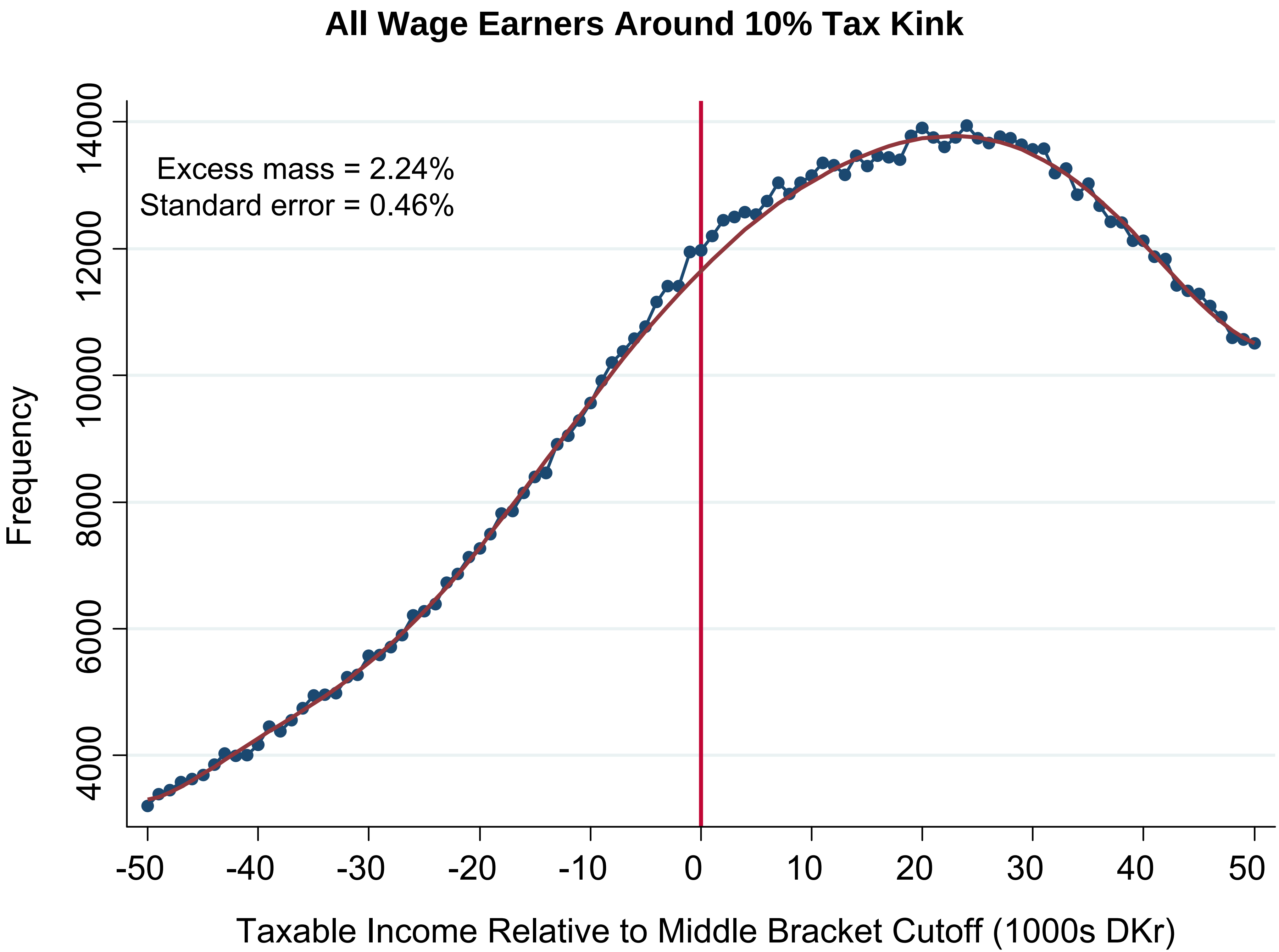
Married Women, 1998
Excess mass = 14.0%
Standard error = 1.39%
Frequency
0
1000
2000
3000
4000
5000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)

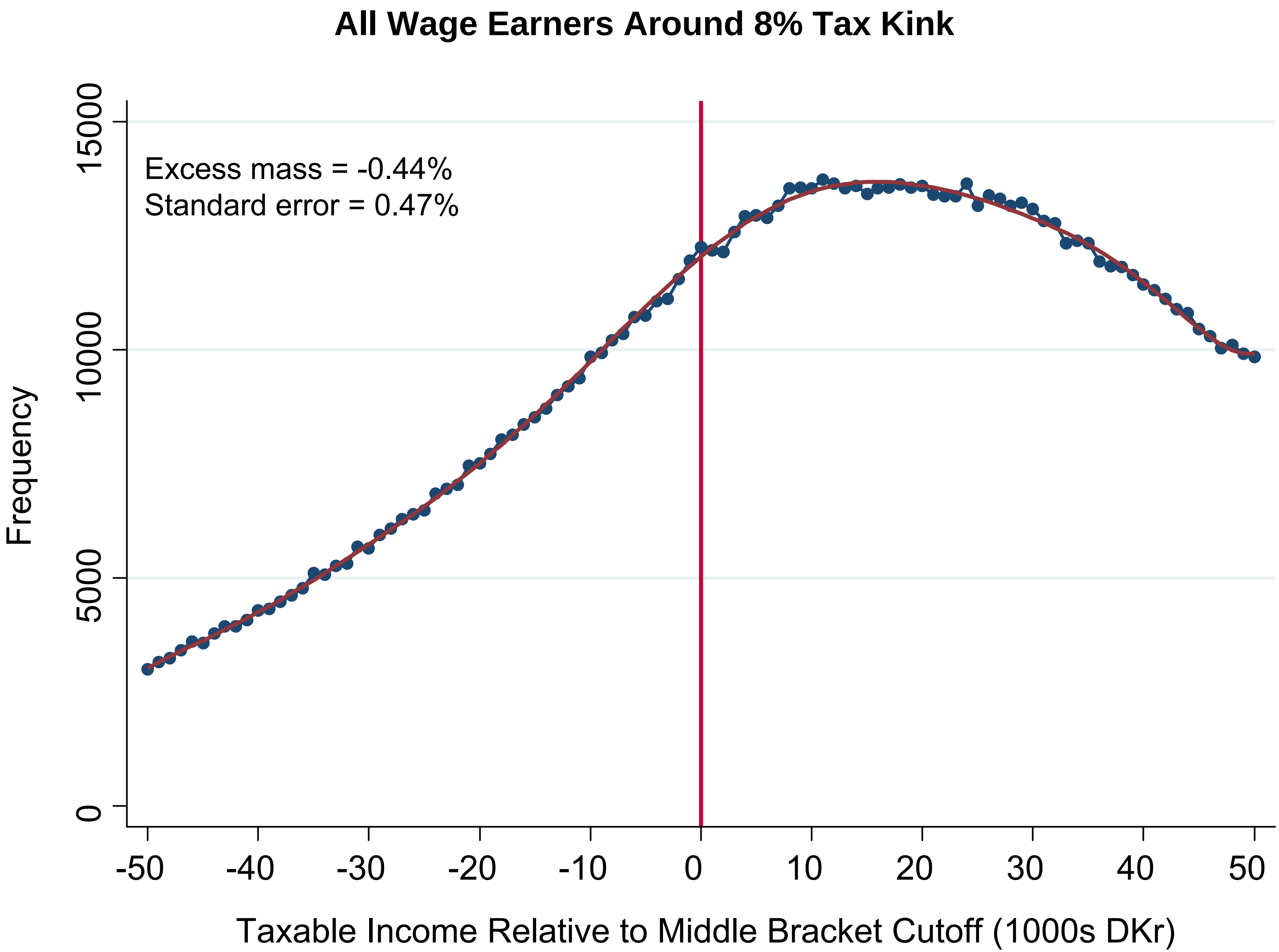


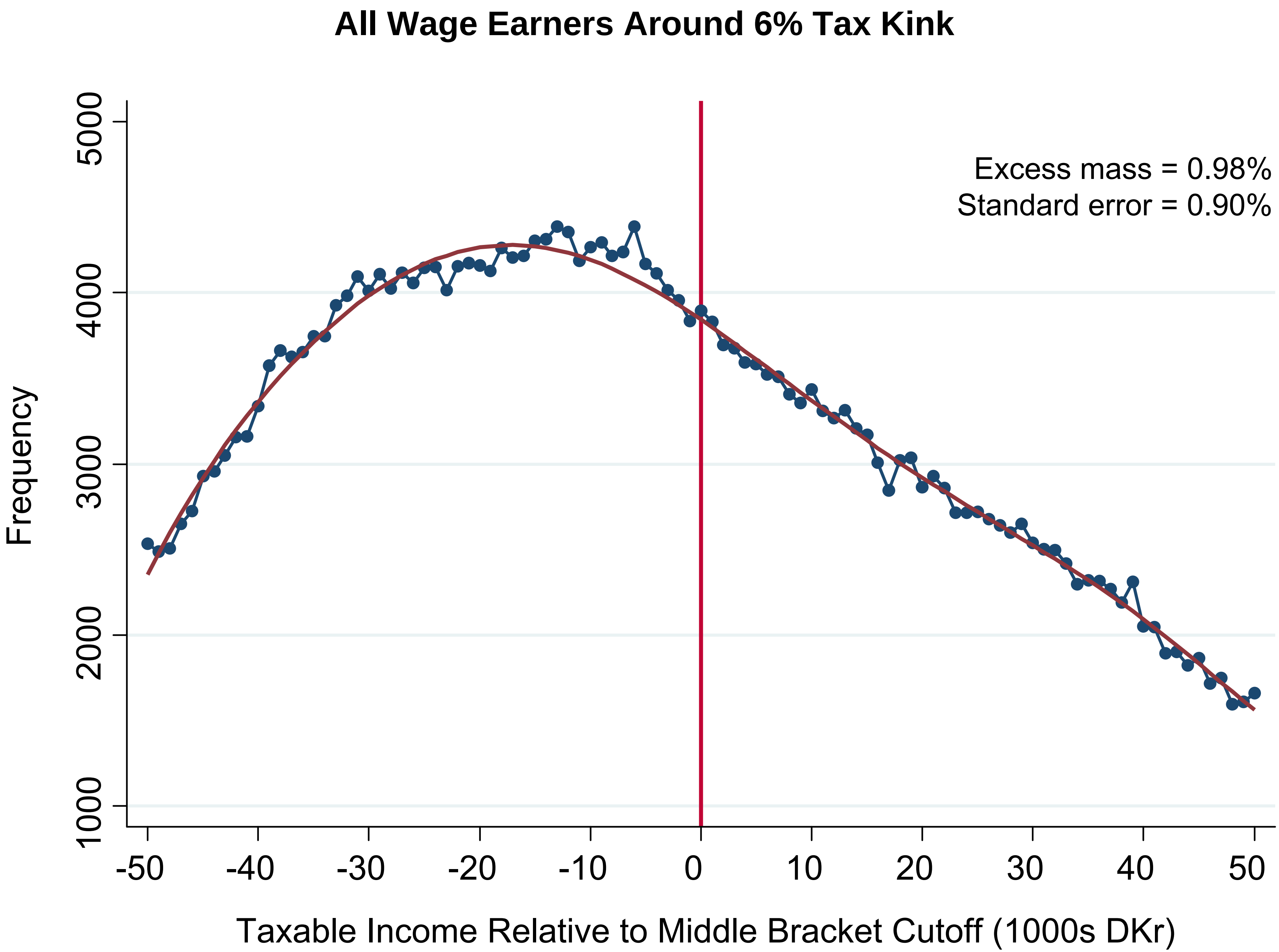
Married Women, 1999
Excess mass = 15.6%
Standard error = 1.63%
Frequency
0
1000
2000
3000
4000
5000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)


Married Women, 2000
Excess mass = 19.5%
Standard error = 1.69%
Frequency
0
1000
2000
3000
4000
5000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)

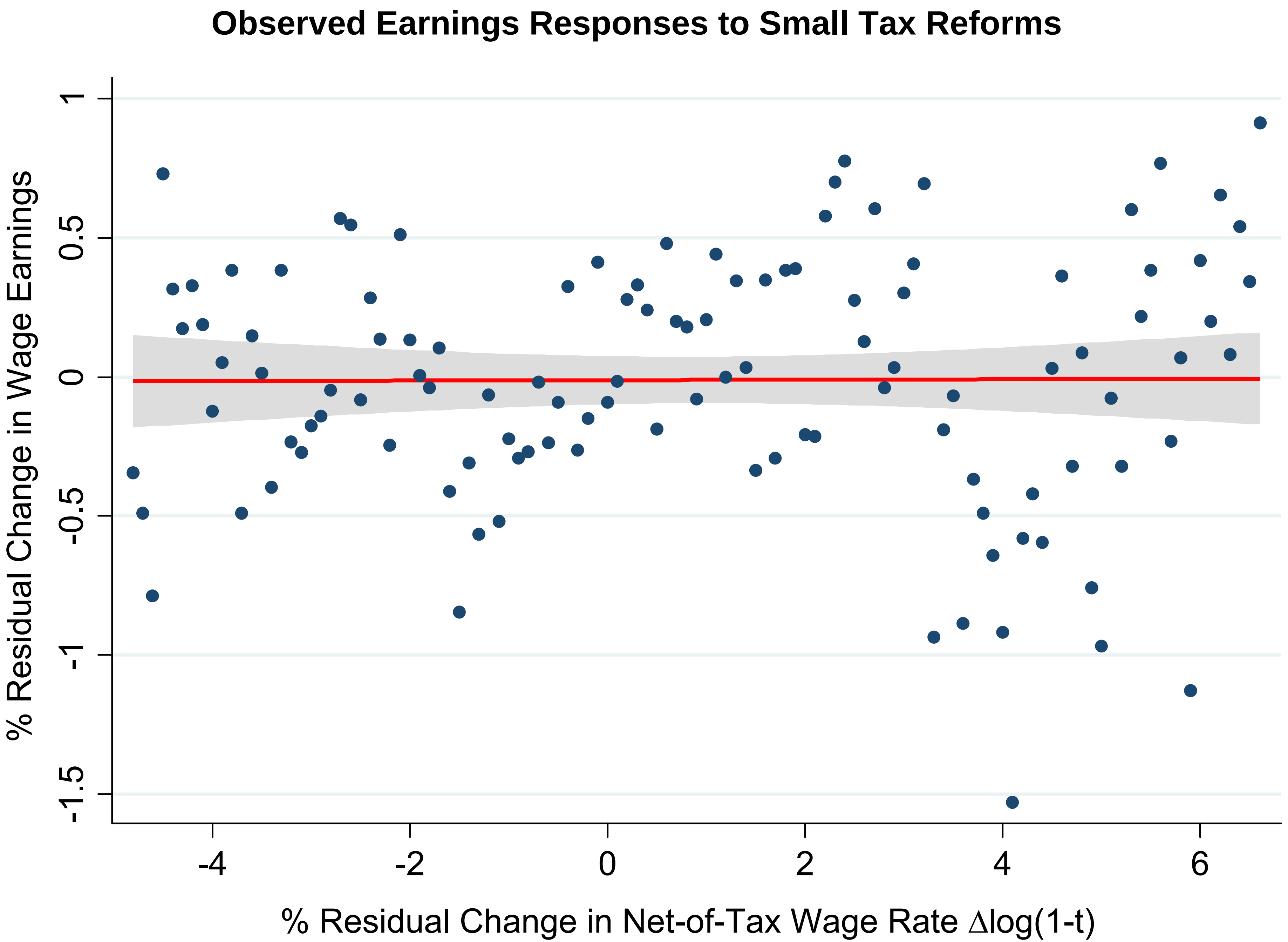

Married Women, 2001
Excess mass = 12.1%
Standard error = 1.75%
Frequency
5000
4000
3000
2000
1000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Taxable Income (1000s DKR)


All Wage Earners Around 10% Tax Kink
Excess mass = 2.24%
Standard error = 0.46%
Frequency
4000
6000
8000
10000
12000
14000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Middle Bracket Cutoff (1000s DKr)


All Wage Earners Around 8% Tax Kink
Excess mass = -0.44%
Standard error = 0.47%
Frequency
0
5000
10000
15000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Middle Bracket Cutoff (1000s DKr)



All Wage Earners Around 6% Tax Kink
Excess mass = 0.98%
Standard error = 0.90%
Frequency
1000
2000
3000
4000
5000
-50
-40
-30
-20
-10
0
10
20
30
40
50
Taxable Income Relative to Middle Bracket Cutoff (1000s DKr)



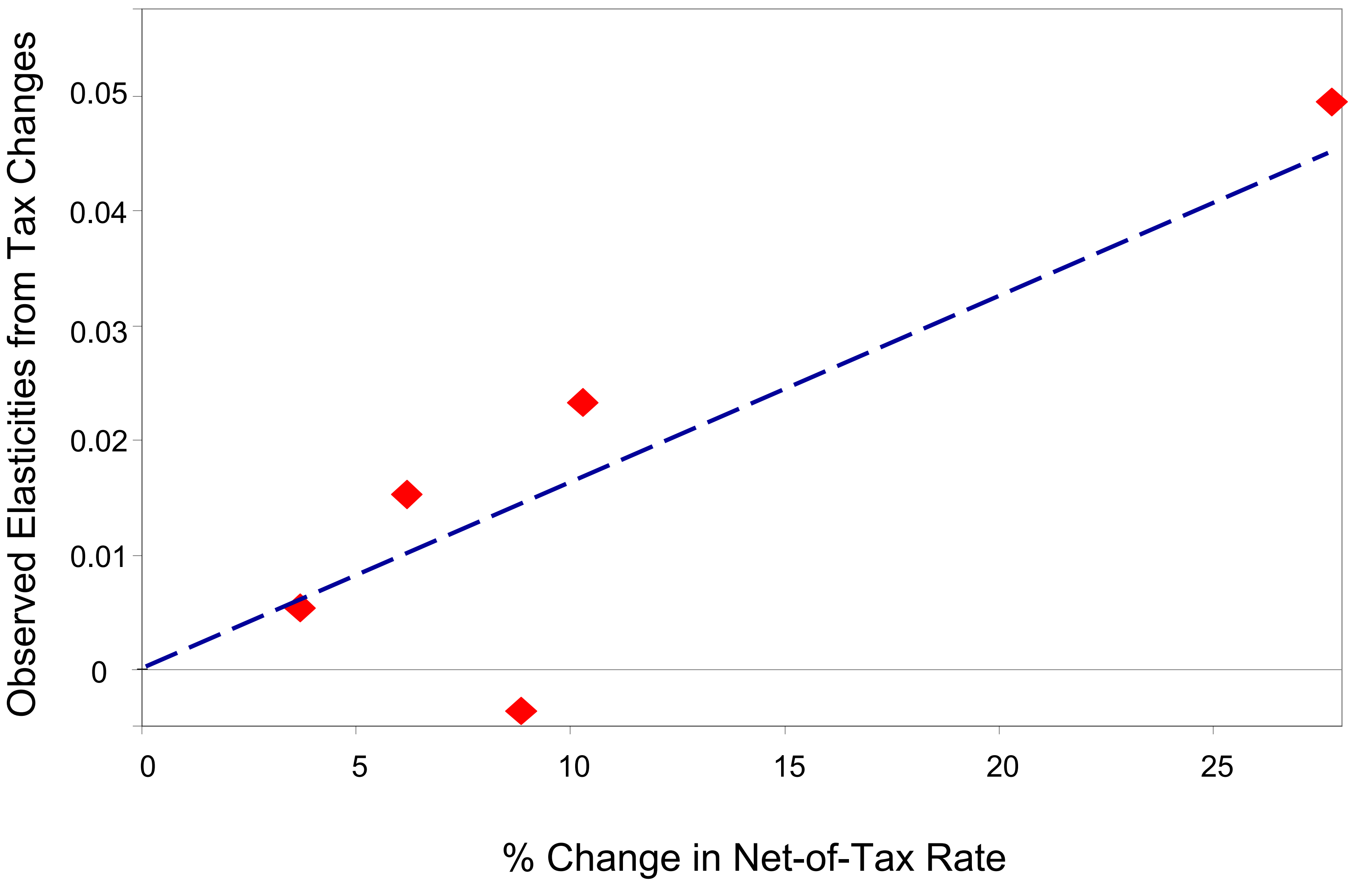
Observed Earnings Responses to Small Tax Reforms
% Residual Change in Wage Earnings
1
0.5
0
-0.5
-1
-1.5
-4
-2
0
2
4
6
% Residual Change in Net-of-Tax Wage Rate Δlog(1-t)

Observed Elasticity Estimates Using Small Tax Reforms

	Dependent Variable: % Change in Labor Income:				
Subgroup:	Female Wage Earners		Married Females	Married Fem. Professionals w/ High Exp.	Teachers
Variable:	(1)	(2)	(3)	(4)	(5)
% Change in NTR	-0.014	0.002	0.006	0.009	-0.024
	(0.008)	(0.006)	(0.010)	(0.033)	(0.031)
Labor Income Spline	x	x	x	x	x
Total Income Spline	x		x	x	x
Year Fixed Effects	x	x	x	x	x
Age Fixed Effects	x	x	x	x	x
Region Fixed Effects	x		x	x	x
Occupation Fixed Effs.	x		x	x	x
Sample Size	6,281,767	6,286,833	3,203,742	212,815	253,283

Observed Elasticity vs. Size of Tax Change

Married Female Wage Earners



Recent Examples of Structural, Reduced-Form, and Sufficient Statistic Studies

	Structural	Reduced Form	Sufficient Statistic
Social Insurance	Wolpin (1987) Hansen and Imrohoglu (1992) Chetty (2003) Golosov and Tsyvinski (2006) Lentz (2007) Einav, Finkelstein, Schrimpf (2008)	Hamermesh (1982) Manning et al. (1987) Meyer (1990) Cutler and Gruber (1996) Autor and Duggan (2003) Lalive et al. (2007)	Gruber (1997) Chetty (2006) Shimer and Werning (2007) Chetty and Saez (2008a) Einav, Finkelstein, Cullen (2008)
Taxation	Slemrod et al. (1994) Hoynes (1996) Keane and Moffitt (1998) Blundell et al. (2000) Golosov and Tsyvinksi (2006) Weinzierl (2008)	Eissa and Liebman (1996) Gruber and Wise (1999) Goolsbee (2000) Friedberg (2000) Meyer and Rosenbaum (2001) Blau and Khan (2007)	Feldstein (1999) Piketty (1997) Diamond (1998) Saez (2001) Goulder and Williams (2003) Chetty (2008)
Behavioral Models	Angeletos et al. (2001) İmrohoroğlu, İmrohoroğlu, Joines (2003) Liebman and Zeckhauser (2004) DellaVigna and Paserman (2005) Amador, Werning, and Angeletos (2006)	Madrian and Shea (2002) Shapiro (2006) Ashraf, Karlan, and Yin (2006) Chetty and Saez (2008b) DellaVigna (2008)	Bernheim and Rangel (2008) Chetty, Looney, Kroft (2008)

Empirical Evidence

- Existing results on optimal tax/transfer policy are based on models that assume full optimization relative to government policies

- Growing body of evidence indicates that individuals fail to optimize relative to many parameters of the environment

Orig. Tag

Exp. Tag

Effect of Posting Tax-Inclusive Prices: Mean Quantity Sold

	TREATMENT STORE		
Period	Control Categories	Treated Categories	Difference
Baseline	26.48 (0.22)	25.17 (0.37)	-1.31 (0.43)
Experiment	27.32 (0.87)	23.87 (1.02)	-3.45 (0.64)
Difference over time	0.84 (0.75)	-1.30 (0.92)	**DD_{TS} = -2.14** (0.64)

	CONTROL STORES		
Period	Control Categories	Treated Categories	Difference
Baseline	30.57 (0.24)	27.94 (0.30)	-2.63 (0.32)
Experiment	30.76 (0.72)	28.19 (1.06)	-2.57 (1.09)
Difference over time	0.19 (0.64)	0.25 (0.92)	**DD_{CS} = 0.06** (0.90)
		DDD Estimate	***-2.20*** (0.58)

Figure 2a

Per Capita Beer Consumption and State Beer Excise Taxes

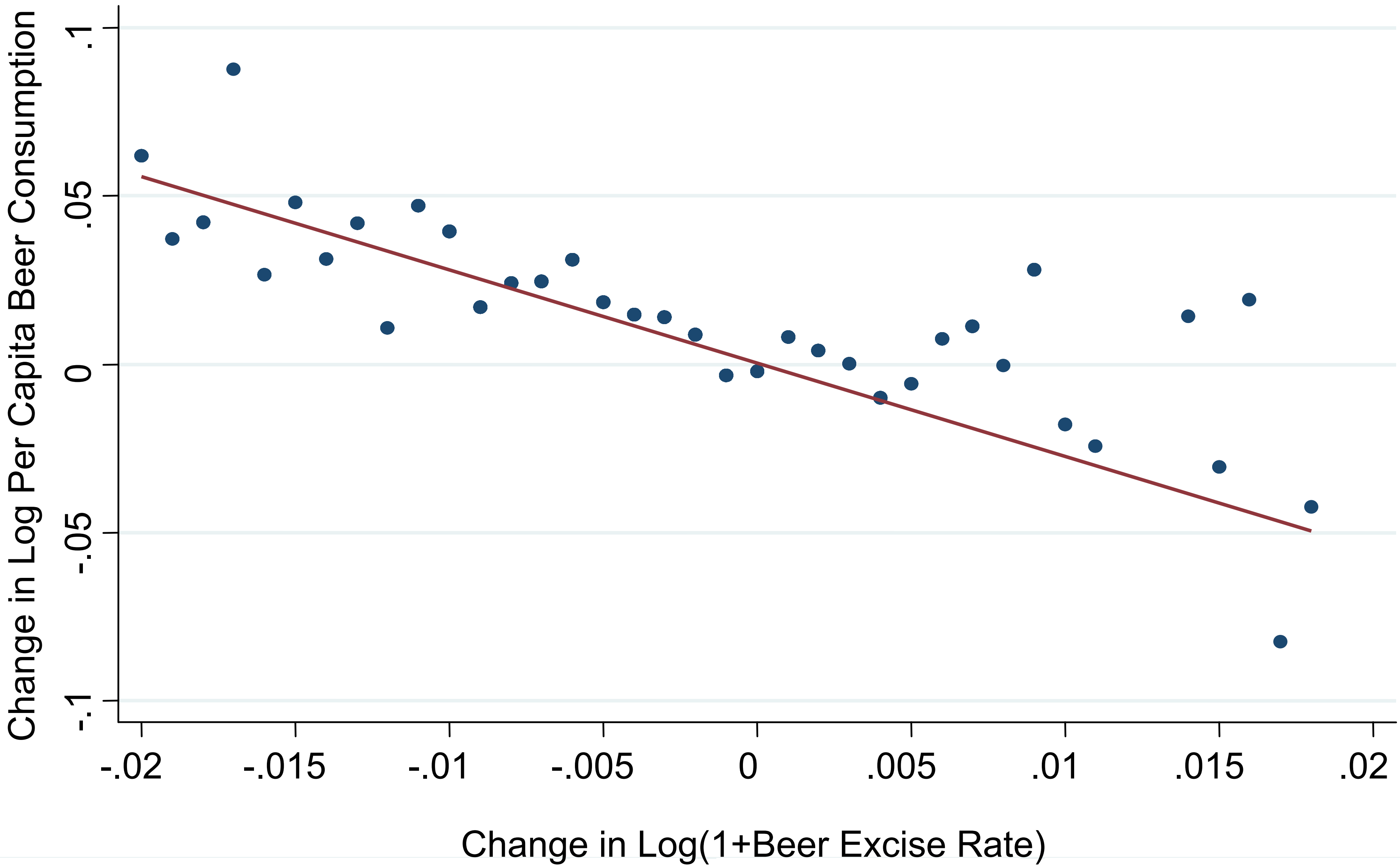


Figure 2b

Per Capita Beer Consumption and State Sales Taxes

Explaining EIC: 4 steps

Single With Two or More Children

The EIC (Earned Income Credit) is a tax refund that gives families as much as $4,500 per year.

We want to explain how the **EIC** works to help you decide how much to work and earn this year.

In 2006, you made $ 10,000 → you are getting an **EIC** of $ 4,000 in your refund.

- Your earnings this year (in 2007) will determine the size of your **EIC** refund next year
- The **EIC** has 3 ranges: 1) Increasing, 2) Peak, 3) Decreasing

1. Fill in earnings, EIC amount

2. Explain and dot graph

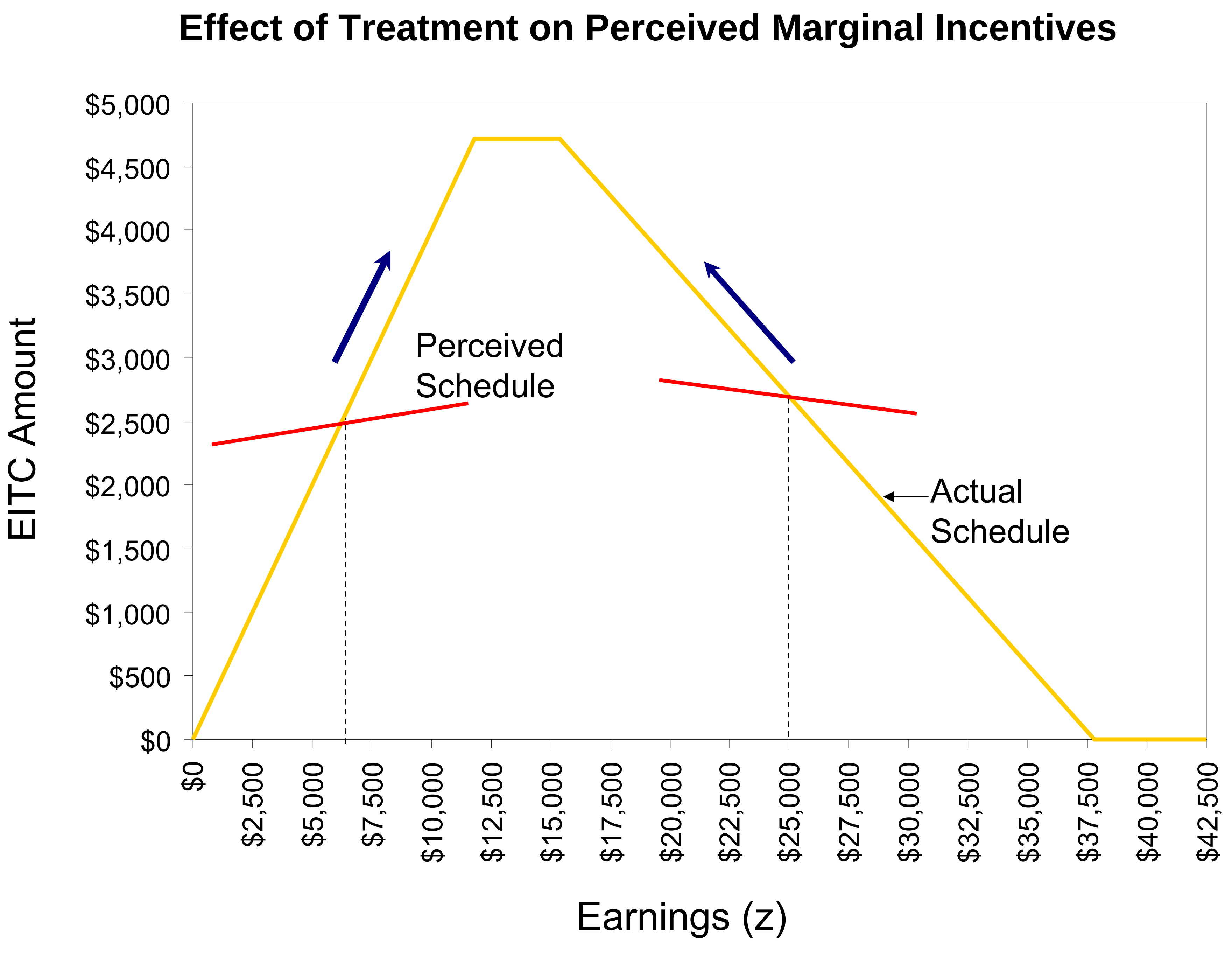
4. Take-home Message

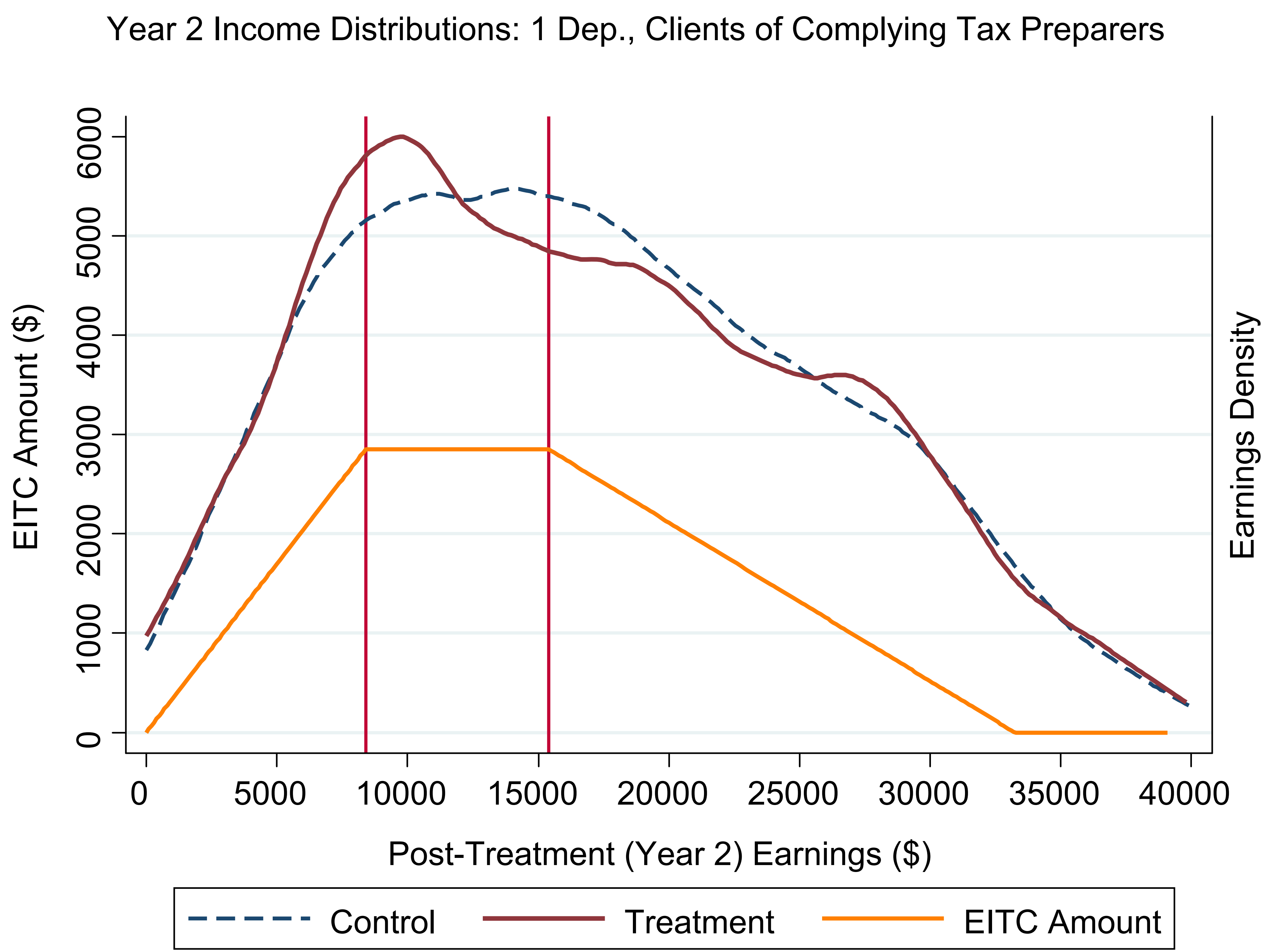
You are in the increasing range of the **EIC**. *Think about it like this:*

- (increasing) Suppose you earn $10 an hour, then you are really making $14.00 an hour.
- (peak) Your earnings are maxing-out the **EIC** amount
- (decreasing) If you earn $10 more, your **EIC** is reduced by $2.10

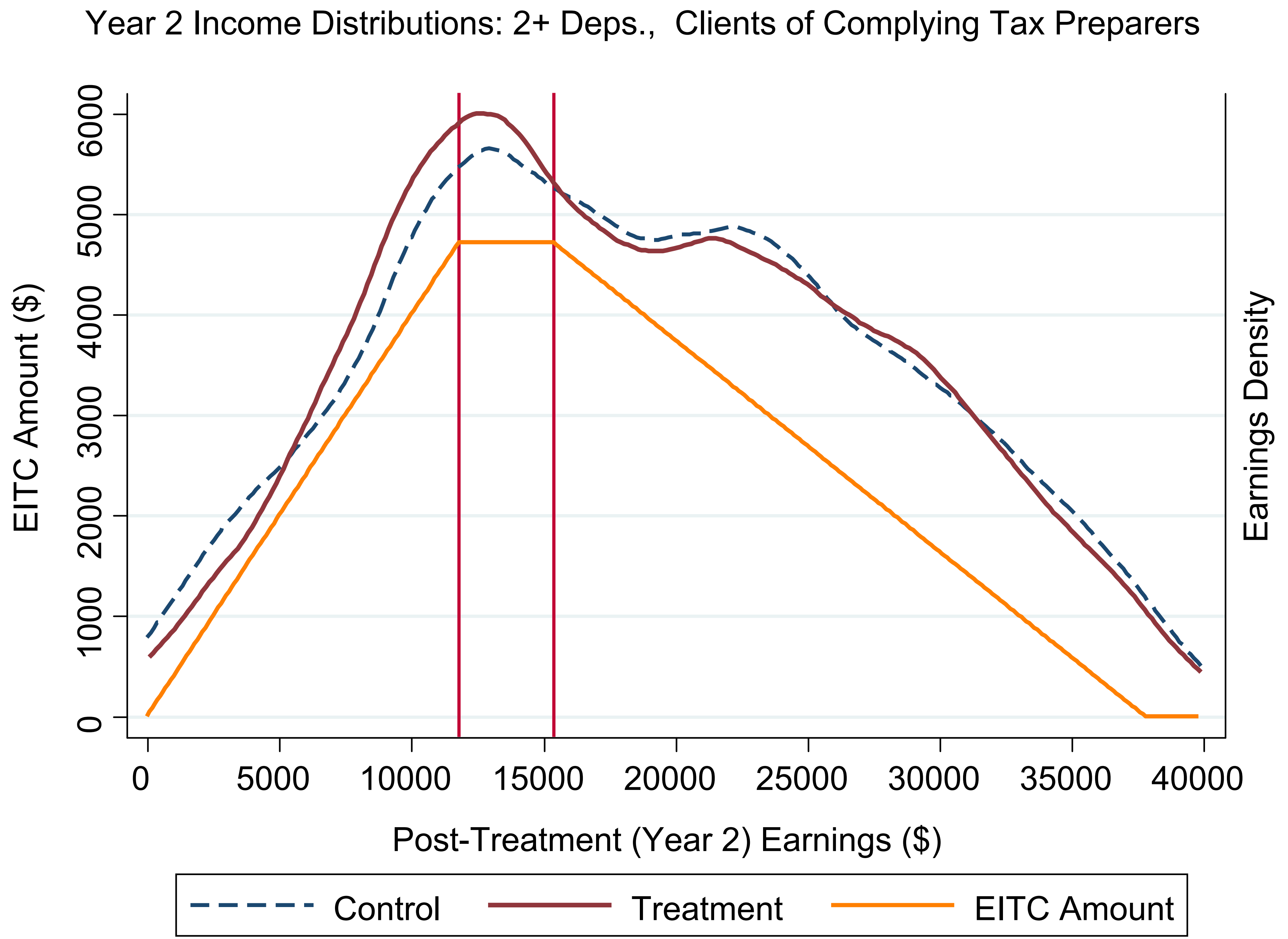
3. Table

EIC Range	If you earn between	EIC refund will be	If you earn $10 more, the EIC...
Increasing	$0-$11,790	$0 up to $4,716	Increases by $4
Peak	$11,790-$15,390	$4,716	Stays the same
Decreasing	$15,390-$37,780	$4,716 down to $0	Decreases by $2.10

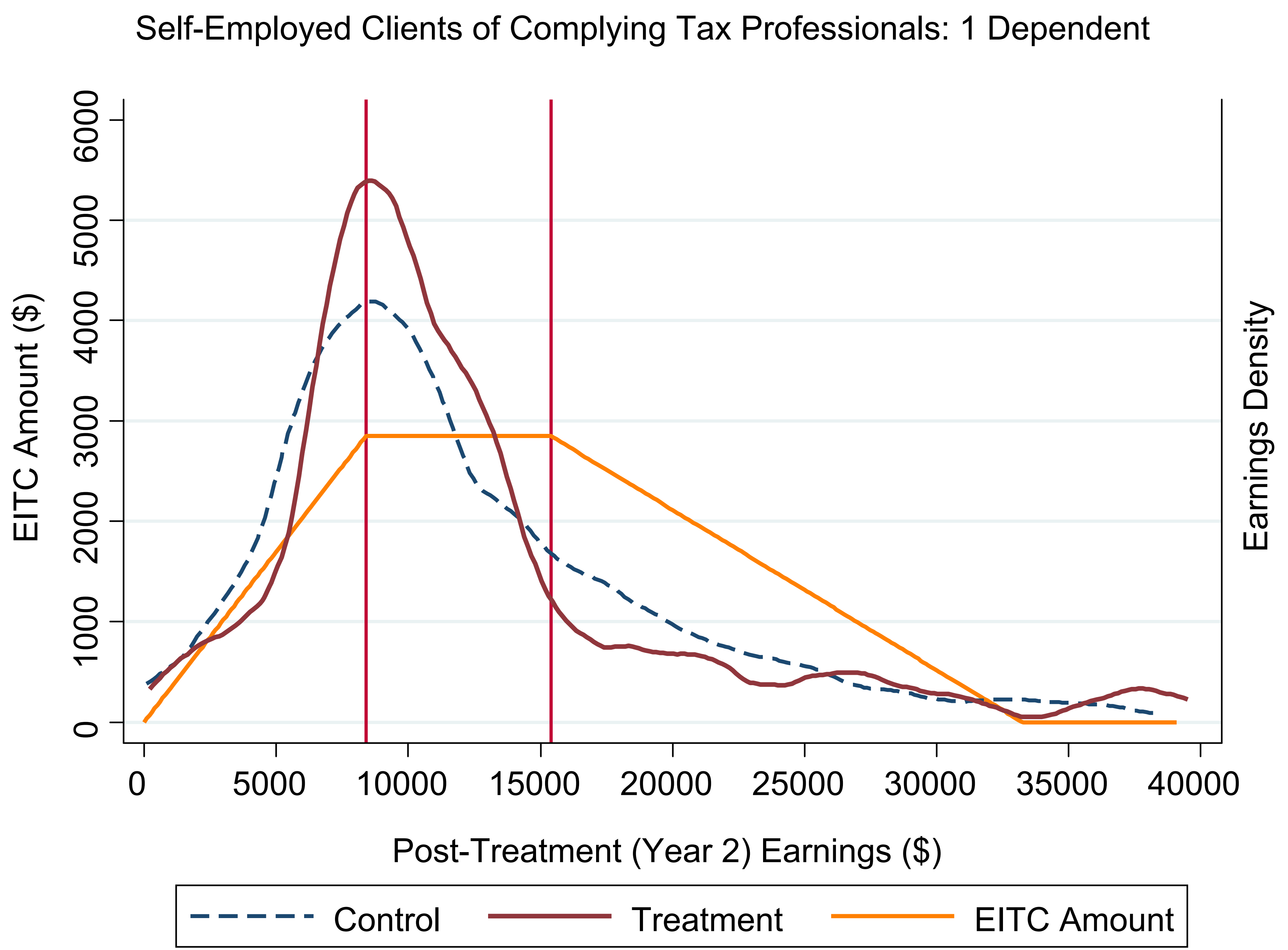

Effect of Treatment on Perceived Marginal Incentives
EITC Amount
$5,000
$4,500
$4,000
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
Perceived Schedule
Actual Schedule
$0
$2,500
$5,000
$7,500
$10,000
$12,500
$15,000
$17,500
$20,000
$22,500
$25,000
$27,500
$30,000
$32,500
$35,000
$37,500
$40,000
$42,500
Earnings (z)

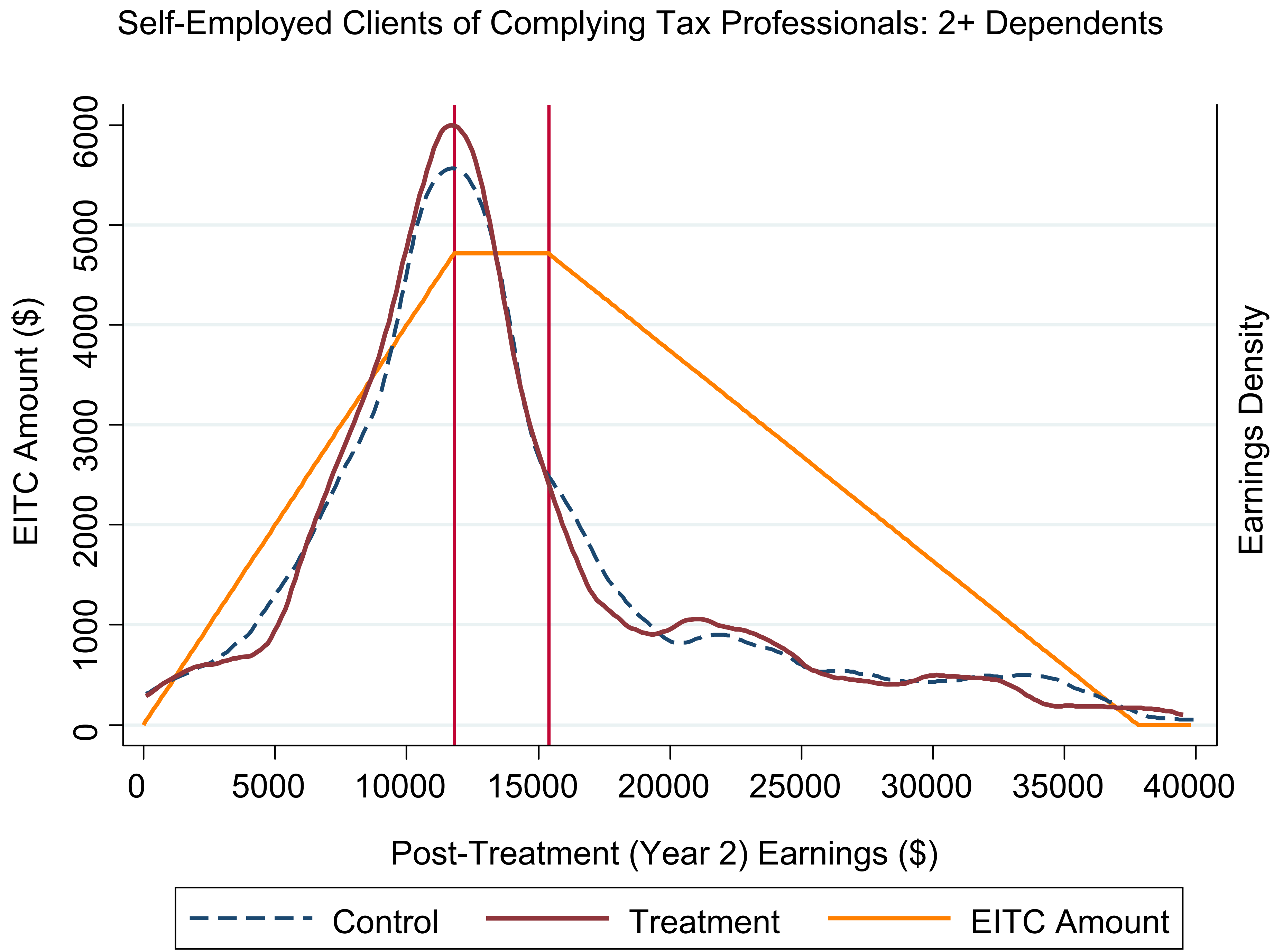


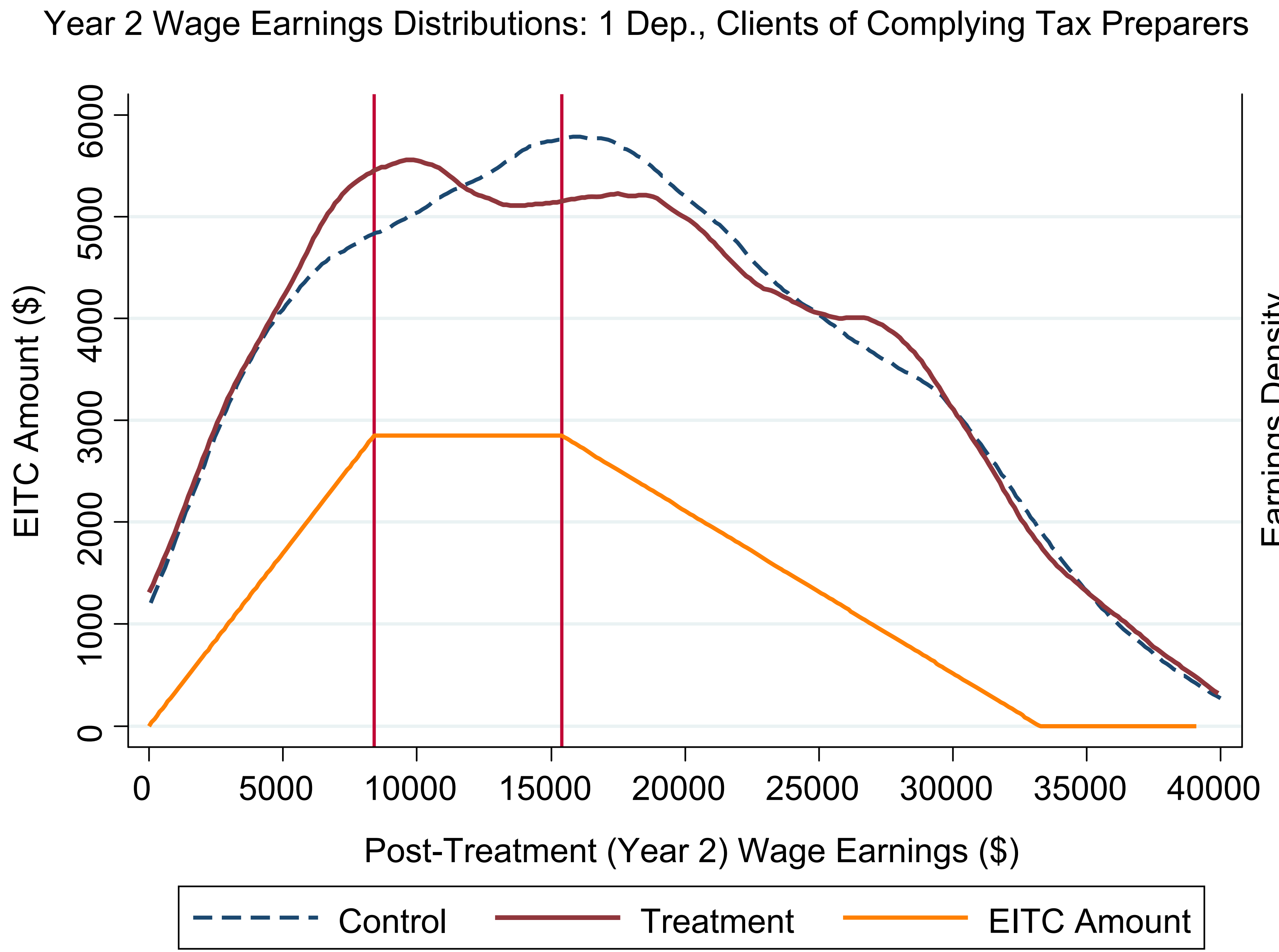
Year 2 Income Distributions: 1 Dep., Clients of Complying Tax Preparers
EITC Amount ($)
Earnings Density
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
Post-Treatment (Year 2) Earnings ($)
Control
Treatment
EITC Amount



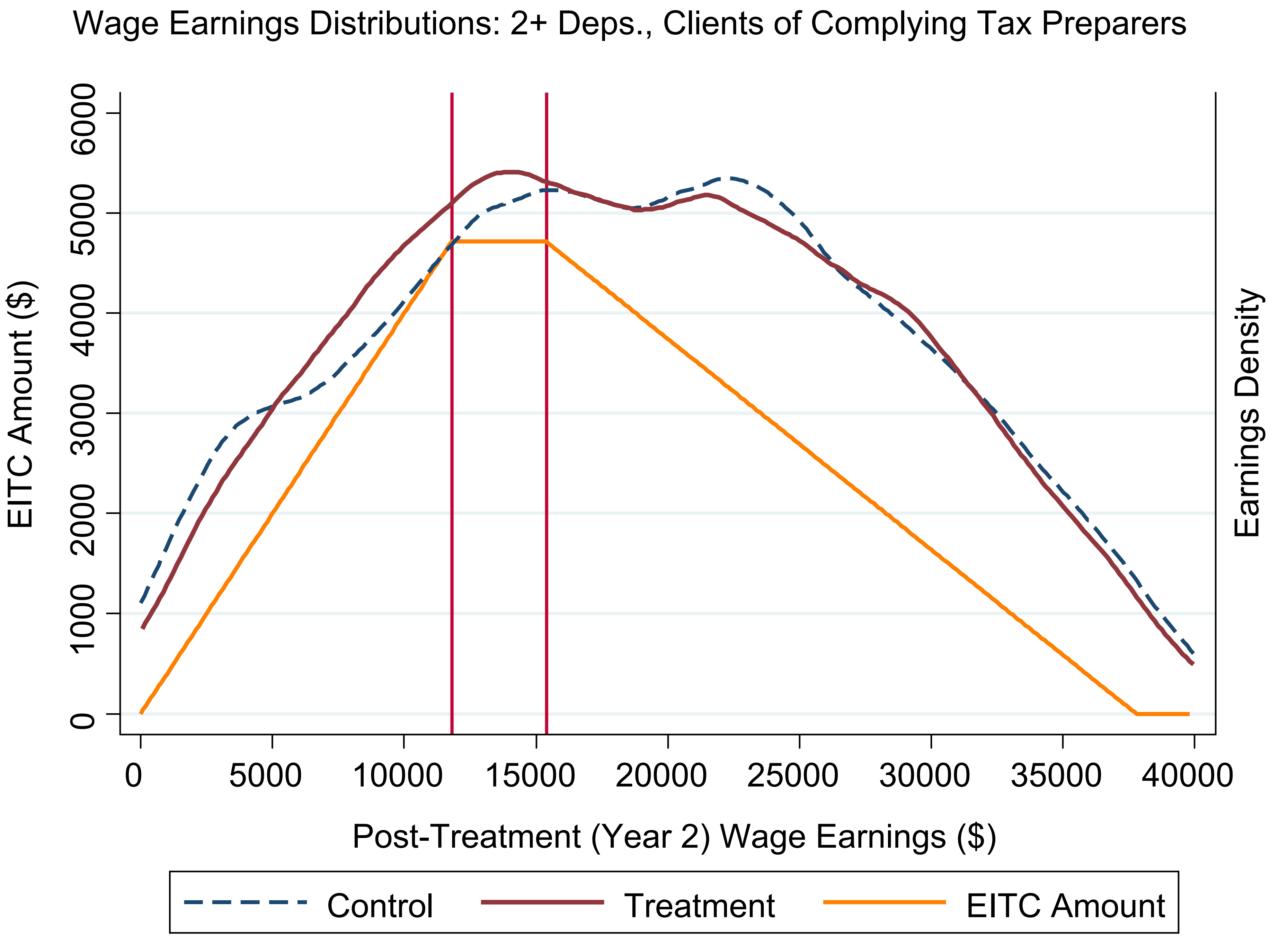
Year 2 Income Distributions: 2+ Deps., Clients of Complying Tax Preparers
EITC Amount ($)
Earnings Density
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
Post-Treatment (Year 2) Earnings ($)
Control
Treatment
EITC Amount


Self-Employed Clients of Complying Tax Professionals: 1 Dependent
EITC Amount ($)
Earnings Density
Post-Treatment (Year 2) Earnings ($)
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
Control
Treatment
EITC Amount


Self-Employed Clients of Complying Tax Professionals: 2+ Dependents
EITC Amount ($)
0
1000
2000
3000
4000
5000
6000
Earnings Density
0
5000
10000
15000
20000
25000
30000
35000
40000
Post-Treatment (Year 2) Earnings ($)
Control
Treatment
EITC Amount



Year 2 Wage Earnings Distributions: 1 Dep., Clients of Complying Tax Preparers
EITC Amount ($)
Earnings Density
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
Post-Treatment (Year 2) Wage Earnings ($)
Control
Treatment
EITC Amount



Wage Earnings Distributions: 2+ Deps., Clients of Complying Tax Preparers
EITC Amount ($)
Earnings Density
0
1000
2000
3000
4000
5000
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
Post-Treatment (Year 2) Wage Earnings ($)
Control
Treatment
EITC Amount

Chetty, Looney, Kroft (2008): Welfare Analysis in Behavioral Models

- How to do welfare analysis when agents make mistakes?

- Objective: Develop formulas for incidence and efficiency costs of taxes that allow for imperfect optimization relative to taxes

- Many potential positive models for information/salience effects (cognitive costs, heuristics, psychological factors)

- Therefore develop a method of welfare analysis that does not rely on a specific positive model of optimization errors

Setup

- Two goods, x_1 and x_2; normalize price of x_2 to 1
- Good x_2 untaxed. Government levies a tax t on x_1; tax not included in the posted price (not salient).
- Representative consumer has quasilinear utility:

$$U(x_1) = u(x_1) + Z - (p+t)x_1$$

- Key deviation from standard neoclassical model: do **not** assume that x_1 is chosen to maximize $U(x_1)$
- Instead, take demand $x_1(p,t)$ as an empirically estimated object, permitting $dx_1/dp \neq dx_1/dt$
- Place no structure on demand functions except for feasibility:

$$(p+t)x_1(p,t) + x_2(p,t,Z) = Z$$

Calculation of Excess Burden

- Social welfare function to calculate excess burden:

$$W(t) = \{u(x_1) + Z - (p+t)x_1\} + tx_1$$

- Here, no envelope condition for x_1
- Totally differentiate W(t) to obtain

$$\frac{dW}{dt} = [u'(x_1) - p]\frac{dx_1}{dt}$$

- Challenge: identifying $u'(x_1)$ when agents do not optimize perfectly
  - In neoclassical model, know that $u'(x_1) = p+t$ from f.o.c.
  - One strategy: specify structural model of how x_1 deviates from optimal choice, then back out $u'(x_1)$
  - Alternative: make an assumption to narrow class of models and identify sufficient stats.

Preference Recovery Assumption

A1 When tax inclusive prices are fully salient, the agent chooses the same allocation as a fully optimizing agent:

$$x_1(p,0) = \arg\max_x u(x) + Z - px$$

→ Two steps in efficiency calculation:

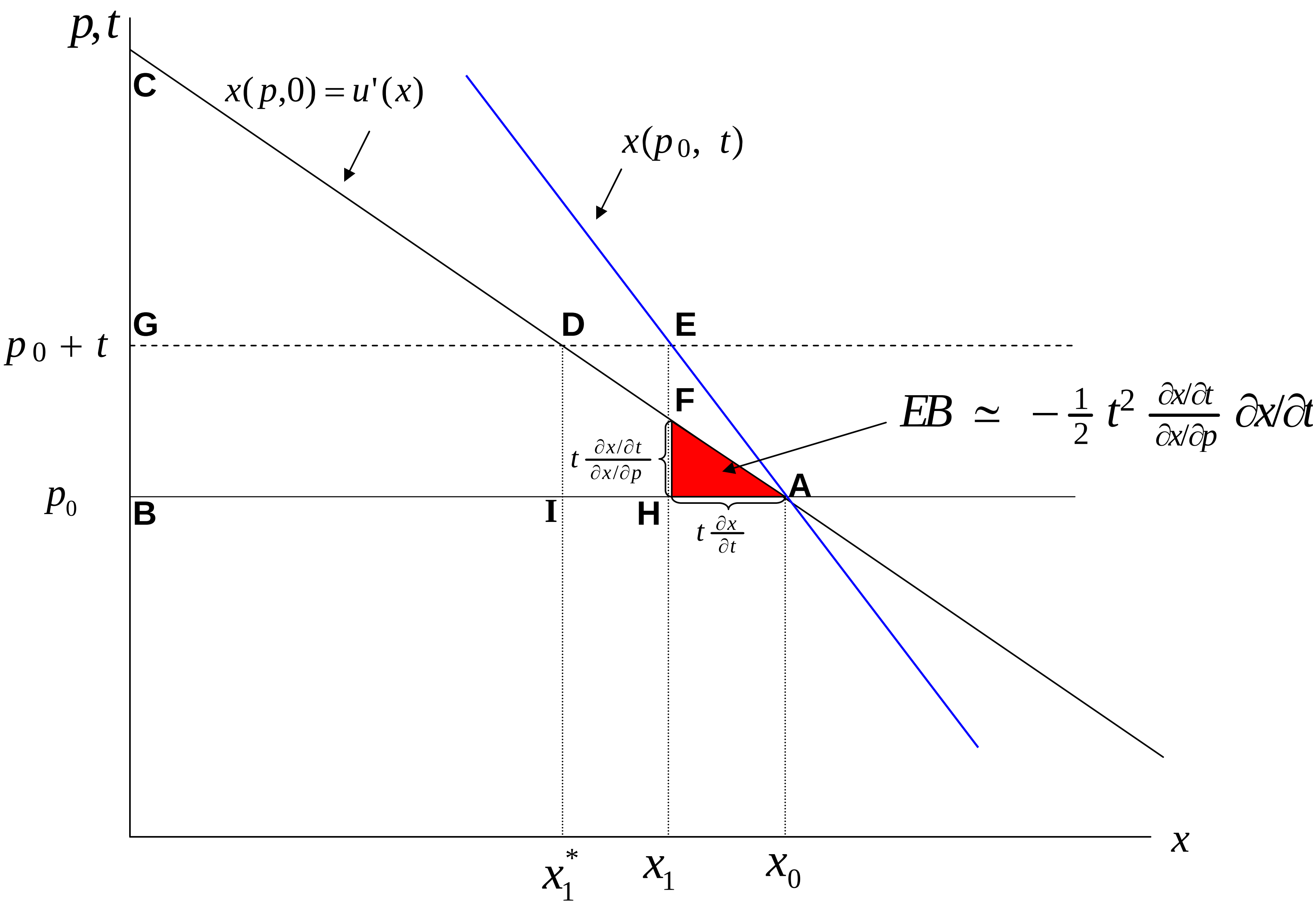
1. Use **price-demand** x(p,0) to recover utility as in standard model

2. Use **tax-demand** $x(p_0,t)$ to calculate W(t) and DWL

- Easy to illustrate graphically in case of quasilinear utility

Figure 4

Excess Burden with Quasilinear Utility and Fixed Producer Prices



Deadweight Loss with Optimization Errors

- When utility is quasilinear, excess burden of a small tax t is

$$EB \simeq -\frac{1}{2} t^2 \theta \frac{\partial x}{\partial t} \quad \textit{where} \quad \theta = \frac{\partial x}{\partial t} / \frac{\partial x}{\partial p}$$

- Simple modification of Harberger formula: price (or wage) and tax elasticities are together sufficient statistics

- Similar modification of standard formula for tax incidence

- Formula permits **arbitrary** optimization errors w.r.t. taxes

  - Nests Liebman and Zeckhauser (2004) schmeduling model, Slemrod (2006) overestimation of estate taxes

  - But requires optimization w.r.t. prices

Potential Applications in Environmental and Resource Economics

1. Program evaluation estimates useful for design of optimal corrective policies (Chay, Greenstone, etc.)

2. Valuation studies using capitalization in house prices already common; combined with mobility responses, may be able to permit heterogeneity

3. Behavioral applications

   - Gallagher and Muehlegger (2008): sales tax rebates for hybrid vehicle purchases have 7 times as large an effect as income tax rebate of equivalent amount

   - Chetty, Gerard, and Saez (in progress): experiments of real time feedback on electricity consumption with Google

   - What are the welfare implications of Pigouvian taxes and environmental regulation when people do not optimize perfectly?

Combining Structural and Sufficient Statistic Methods

1. Use structural model for overidentification tests: is there a plausible structure consistent with estimated sufficient stats?

2. Test whether structural prediction for marginal welfare gains match sufficient statistic prediction

3. Calibrate structural model to match key moments for welfare and make out of sample predictions

→ Pick a point on interior of continuum between program evaluation and fully structural work.

SUFFICIENT STATISTIC VS. STRUCTURAL APPROACHES

Advantages:

1. Simplifies identification: permits focus on estimating dx_1/dt using transparent, design-based methods (e.g. experiments)

    - Can therefore be implemented with fewer assumptions than structural method (e.g. arbitrary heterogeneity)

2. Can be applied when positive model unclear

Disadvantages:

1. Can only be used for local welfare analysis around observed policies unless paired with structural model

2. "Black box": welfare analysis never "theory free."

    - Primitives not identified → cannot determine if assumptions consistent with data

Heterogeneity

- Benefit of sufficient statistic approach is particularly evident in a model that permits heterogeneity across individuals

- *N* agents with wealth Z_i and utility functions

$$u^i(x^i) + y$$

- Social welfare:

$$W(t) = \left\{\sum_{i=1}^{N} \max_{x^i}[u^i(x^i) + Z^i - tx_1^i] - c(x)\right\} + t\sum_{i=1}^{N} x_1^i$$

- Structural method requires estimation of demand systems for all agents

- Sufficient statistic formula is *unchanged* – still need only slope of aggregate demand dx_1/dt

$$\frac{dW}{dt} = -\sum_{i=1}^{N} x_1^i + \sum_{i=1}^{N} x_1^i + t\frac{d\sum_{i=1}^{N} x_1^i}{dt} = t\frac{dx_1}{dt}$$

Discrete Choice

- Now suppose individuals can choose only one of the *J* products
  - E.g. car models, modes of transportation, or neighborhoods
- Each product *j* characterized by a vector of *K* observable attributes

$$x_j = (x_{1j,\ldots,}x_{Kj})$$

and an unobservable attribute ζ_j

- Agent *i*'s utility from choice *j* is

$$u_{ij} = v_{ij} + \varepsilon_{ij}$$
$$\text{with } v_{ij} = Z^i - p_j + \zeta_j + \phi^i(x_j)$$

- Let P_{ij} denote probability *i* chooses product *j*, P_j total expected demand for product *j*, and $c_j(P_j)$ cost of production

- Assume ε_{ij} has a type 1 extreme value distribution (mixed logit)
- Then probability individual *i* chooses product *j* is

$$P_{ij} = \frac{\exp(v_{ij})}{\sum_j \exp(v_{ij})}$$

and consumer *i*'s expected surplus is

$$S_i(p_1, \ldots, p_J) = E\max(u_{i1}, \ldots, u_{iJ}) = \log(\sum_j \exp v_{ij})$$

- Aggregating over consumers and including producer profits gives

$$W = \sum_i \log(\sum_j \exp(v_{ij})) + pP - c(P)$$

- Structural approach to policy analysis: identify ϕ_i and $c(P)$ using methods e.g. in Berry (1994) or BLP (1995)

- Sufficient statistic: two examples

1. Tax on good 1. Then easy to establish that

$$\frac{dW}{dt} = t\frac{dP_1}{dt}$$

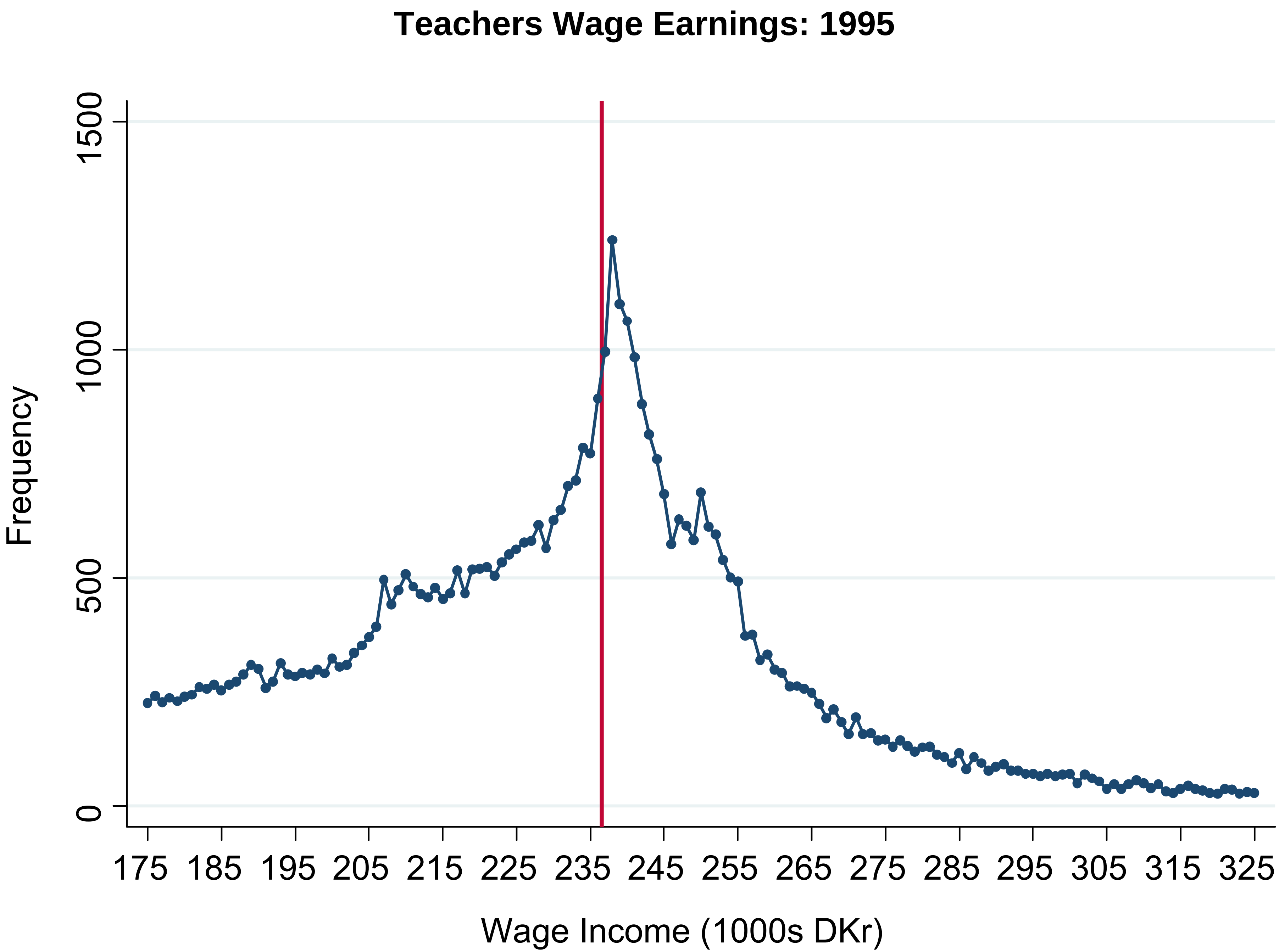
2. Tax on all products in the market.

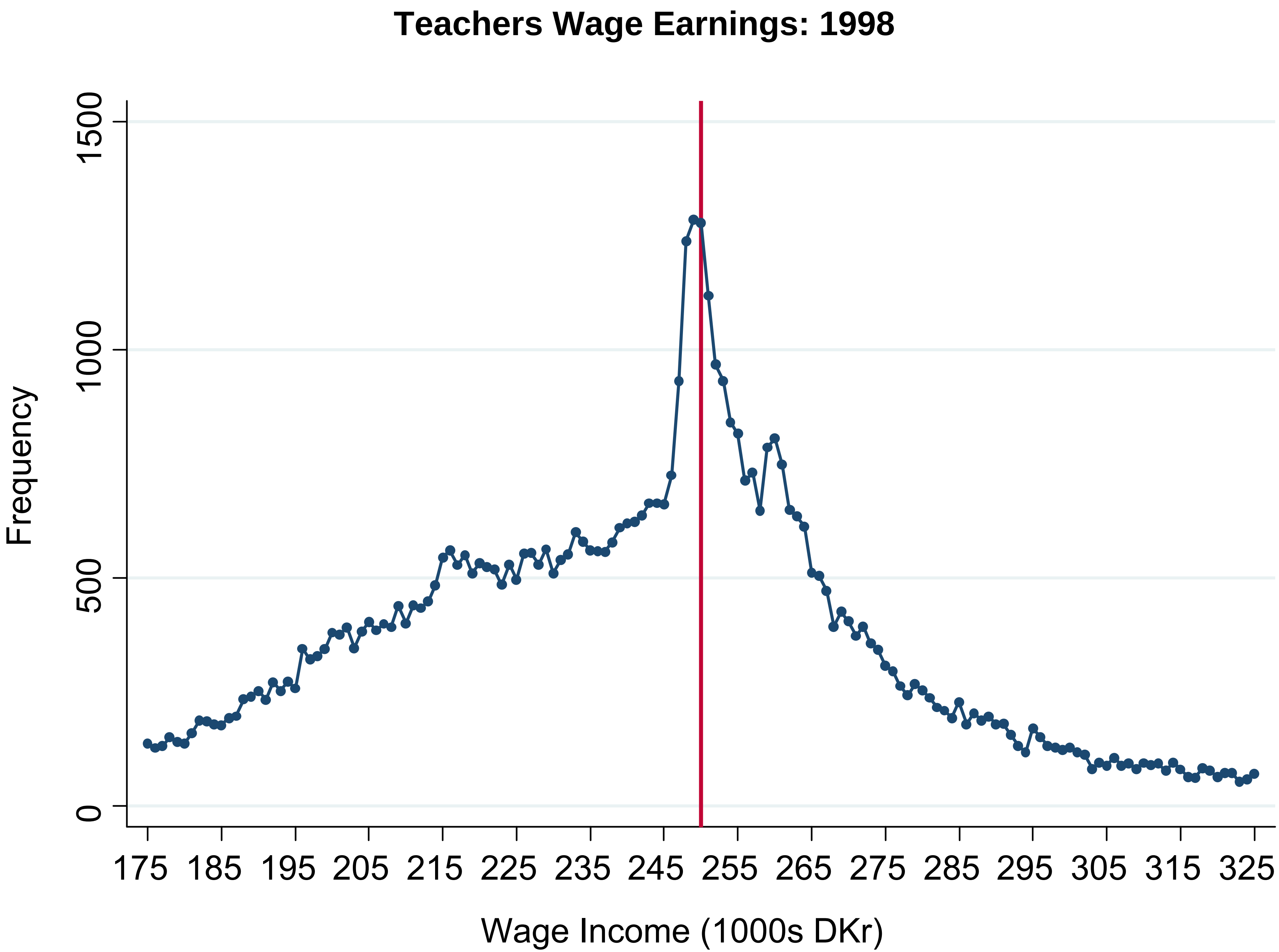
$$\frac{dW}{d\tau} = \tau\sum_j p_j \frac{dP_j}{d\tau} = \tau\frac{dE_P}{d\tau}$$

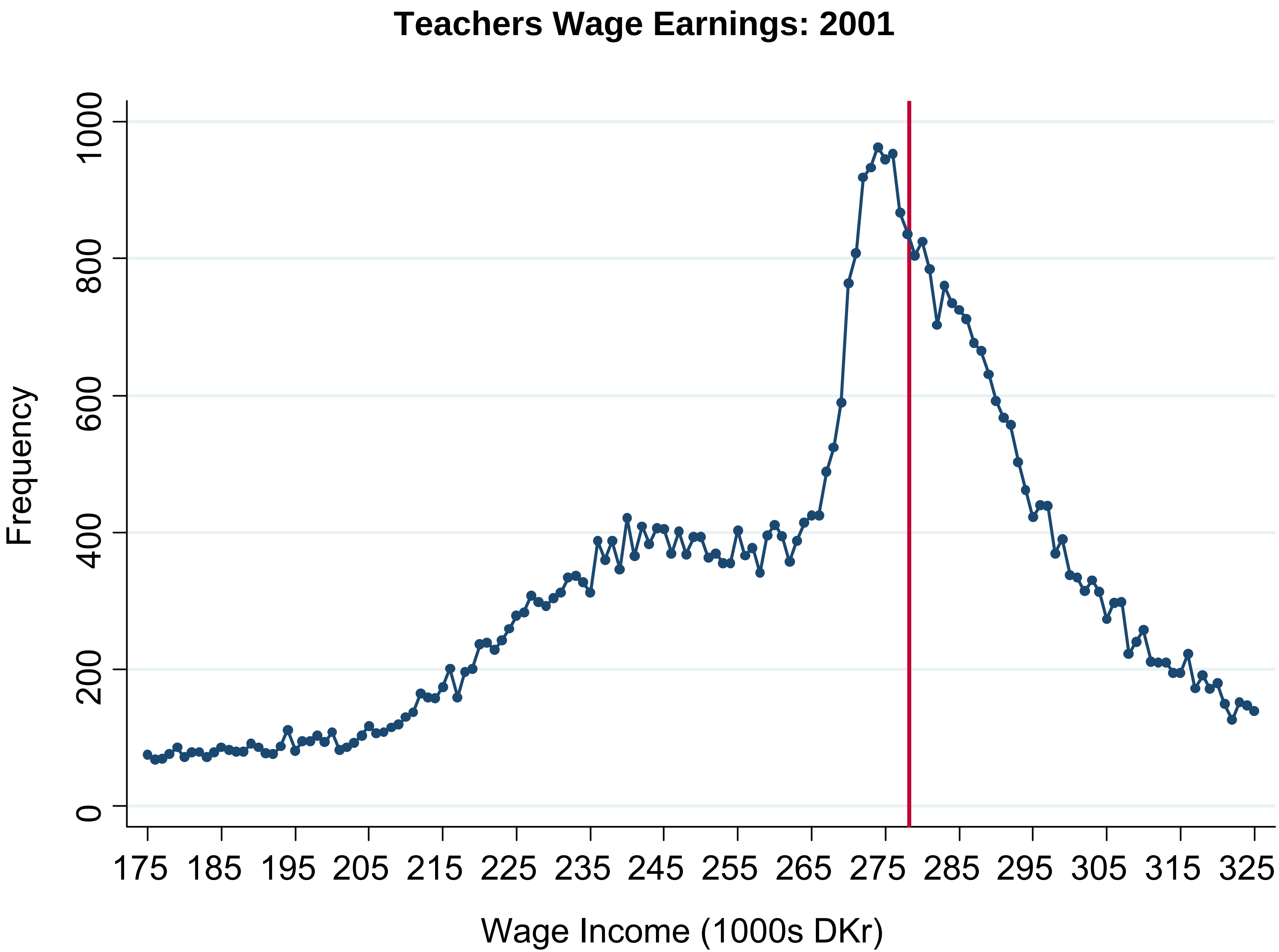
where E_p = total expenditure on products in the market

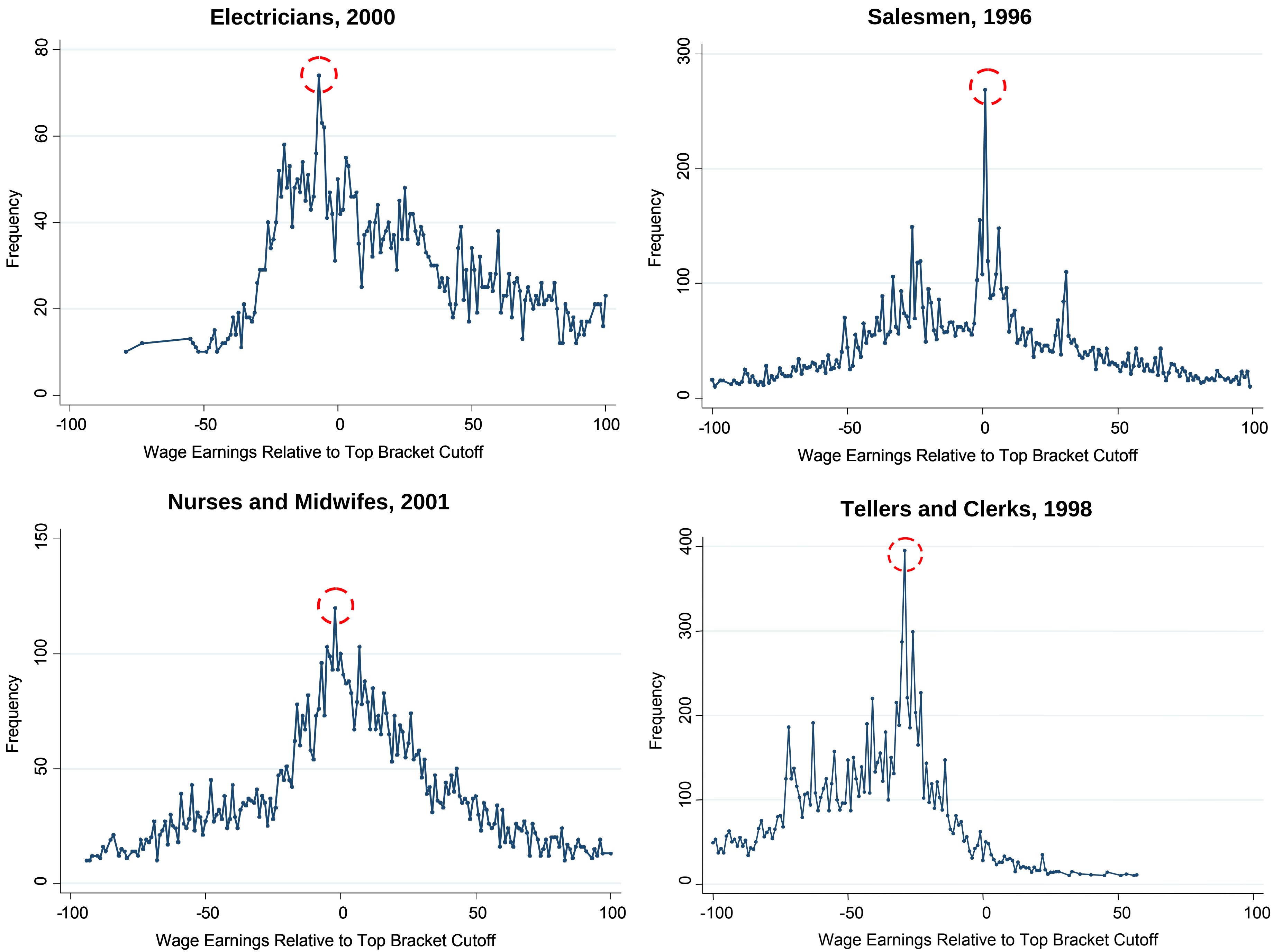
- Do not need to estimate substitution patterns within market

- Microeconomic demands not smooth but expected welfare is → use similar envelope conditions

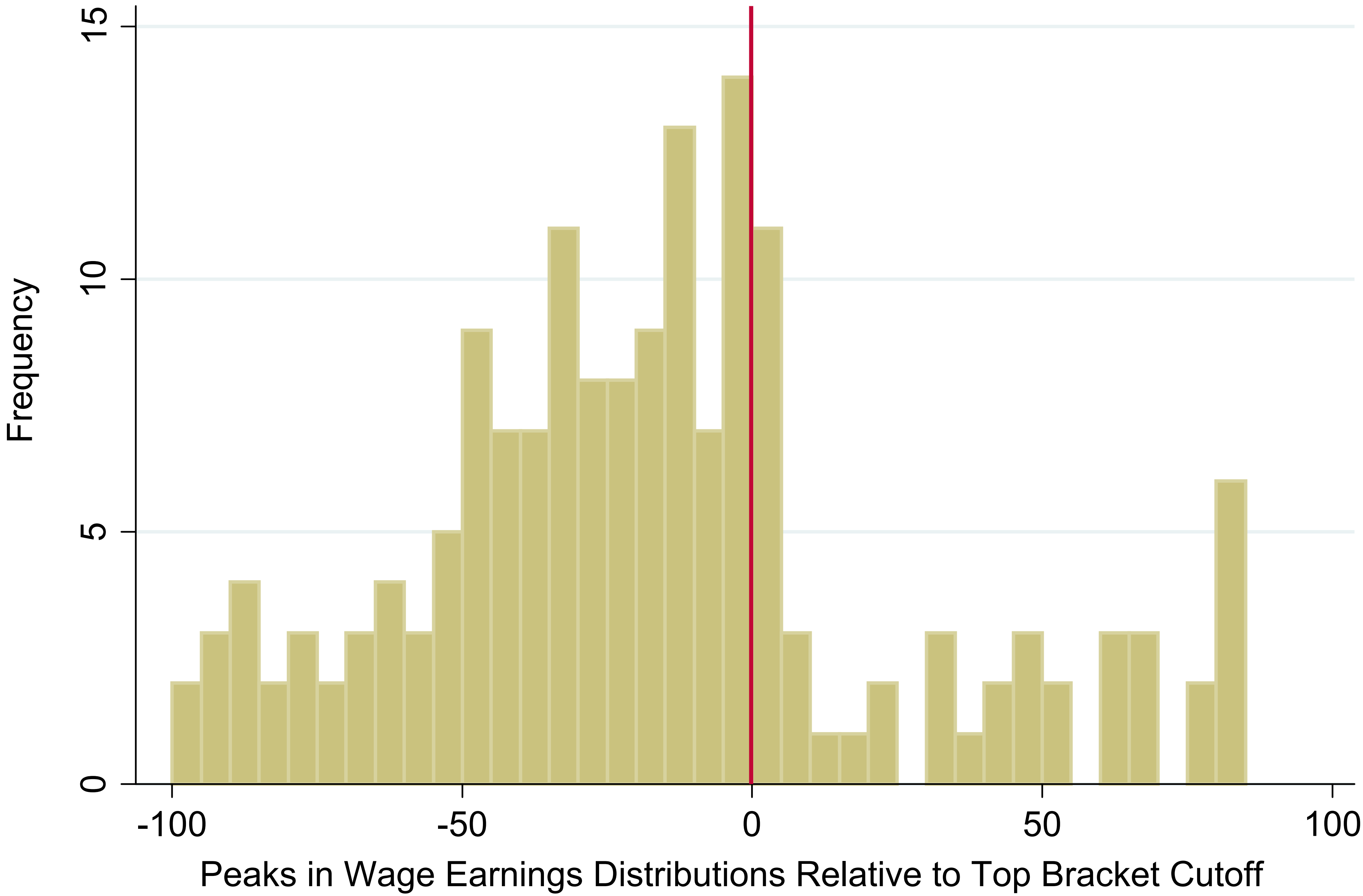

Teachers Wage Earnings: 1995
Frequency
1500
1000
500
0
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Wage Income (1000s DKr)


Teachers Wage Earnings: 1998
Frequency
0
500
1000
1500
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Wage Income (1000s DKr)


Teachers Wage Earnings: 2001
Frequency
0
200
400
600
800
1000
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
Wage Income (1000s DKr)


Electricians, 2000
Frequency
0
20
40
60
80
-100
-50
0
50
100
Wage Earnings Relative to Top Bracket Cutoff
Salesmen, 1996
Frequency
0
100
200
300
-100
-50
0
50
100
Wage Earnings Relative to Top Bracket Cutoff
Nurses and Midwifes, 2001
Frequency
0
50
100
150
-100
-50
0
50
100
Wage Earnings Relative to Top Bracket Cutoff
Tellers and Clerks, 1998
Frequency
0
100
200
300
400
-100
-50
0
50
100
Wage Earnings Relative to Top Bracket Cutoff

Distribution of Modes in Occupation Wage Earnings Distributions



Intellectual History

- Idea that it is adequate to estimate "sufficient statistics" to answer some questions dates to Marschak (1954) and Koopmans (1954)

- But applied to a wide range of policy questions only in past decade

    - 1950-70s – simple structural models fit to macro and micro data

    - 1980s: concerns about identification of non-linear structural models with heterogeneity (e.g. Ashenfelter 1978, LaLonde 1985)

        → Quasi-experimental methods (e.g. Angrist 1990, Card and Krueger 1995; Imbens and Wooldridge 2008)

    - 1990s: Large body of "program evaluation" estimates developed

→ Most recent literature integrates program evaluation estimates with structural models to make statements about welfare