Reconciling Seemingly Contradictory Results from the Oregon Health Insurance Experiment and the Massachusetts Health Reform

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“Doing More When You’re Running LATE: Applying Marginal Treatment Effect Methods to Examine Treatment Effect Heterogeneity in Experiments.” *NBER WP 22363.*

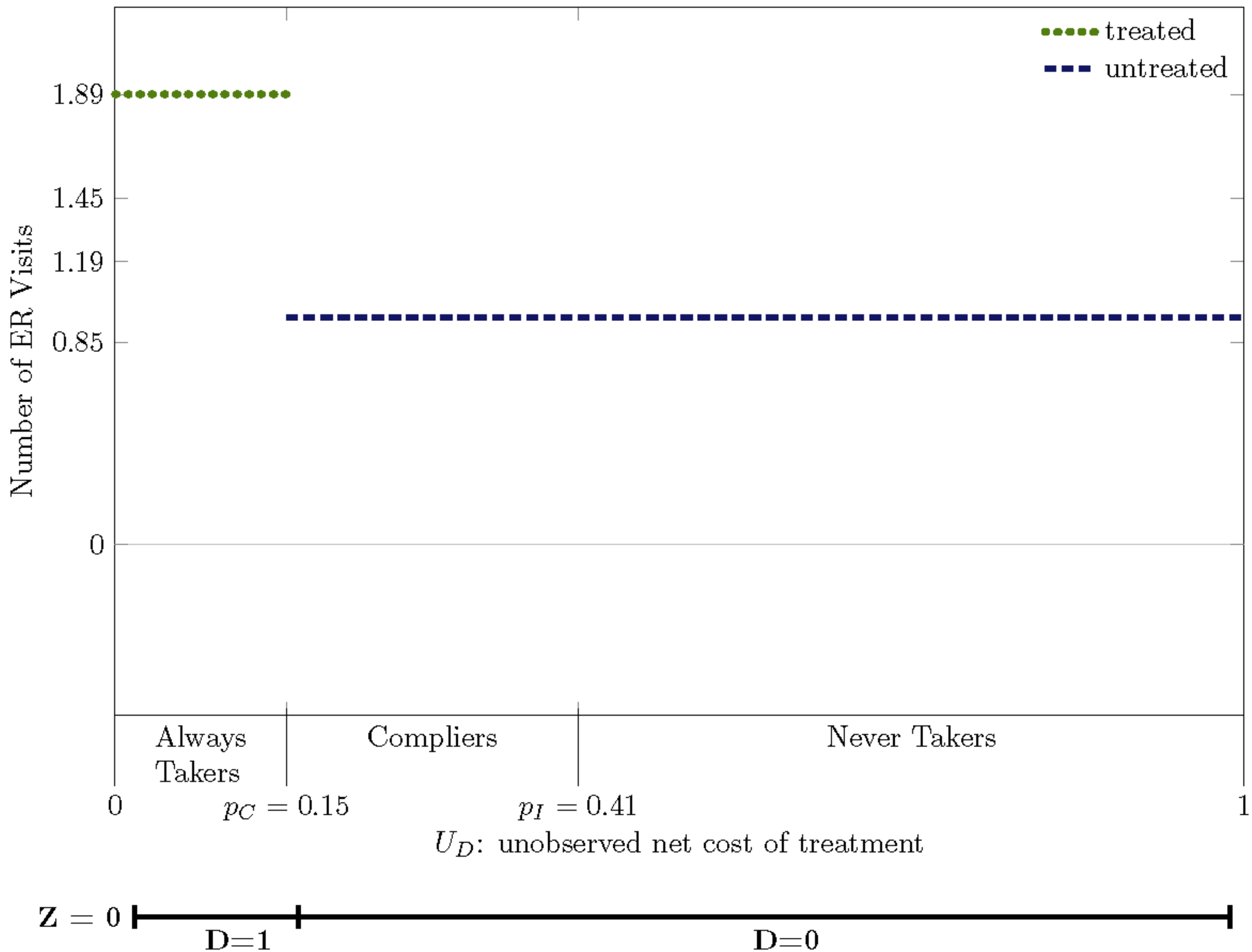
“How to Examine External Validity Within an Experiment.” *NBER WP 24834.*

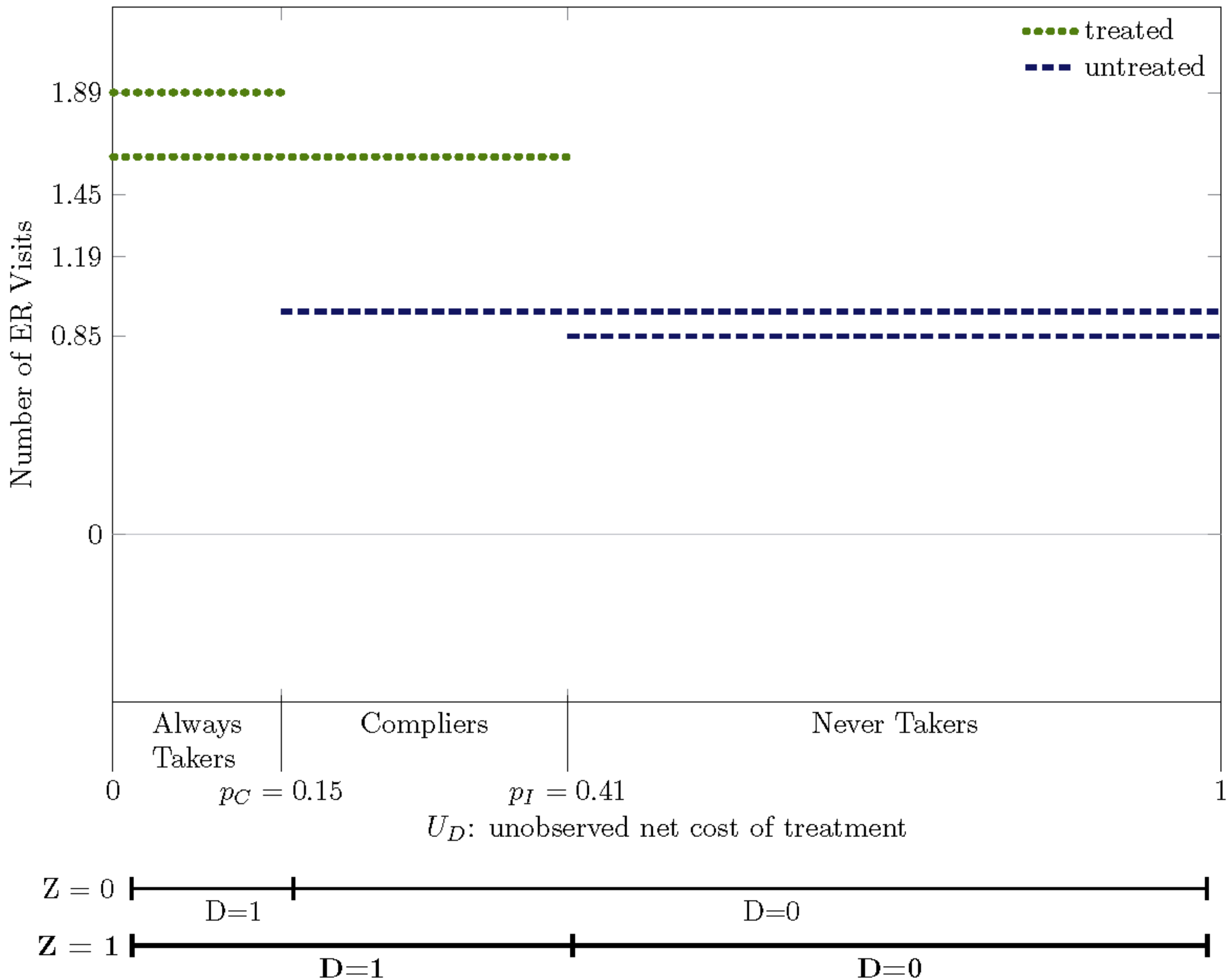
“Behavior within a Clinical Trial and Implications for Mammography Guidelines” *NBER WP 25049.*

“Extrapolation using Selection and Moral Hazard Heterogeneity from within the Oregon Health Insurance Experiment.” *NBER WP 24647.*

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

1. **I find selection and treatment effect heterogeneity within Oregon**
2. I use it to reconcile Oregon and Massachusetts LATEs
3. I show that self-reported health & previous ER utilization explain heterogeneity and reconciliation


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment
$\mathbf{Z} = 0$
D=1
D=0



treated
untreated
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1.45
1.19
0.85
0
Number of ER Visits
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Compliers
Never Takers
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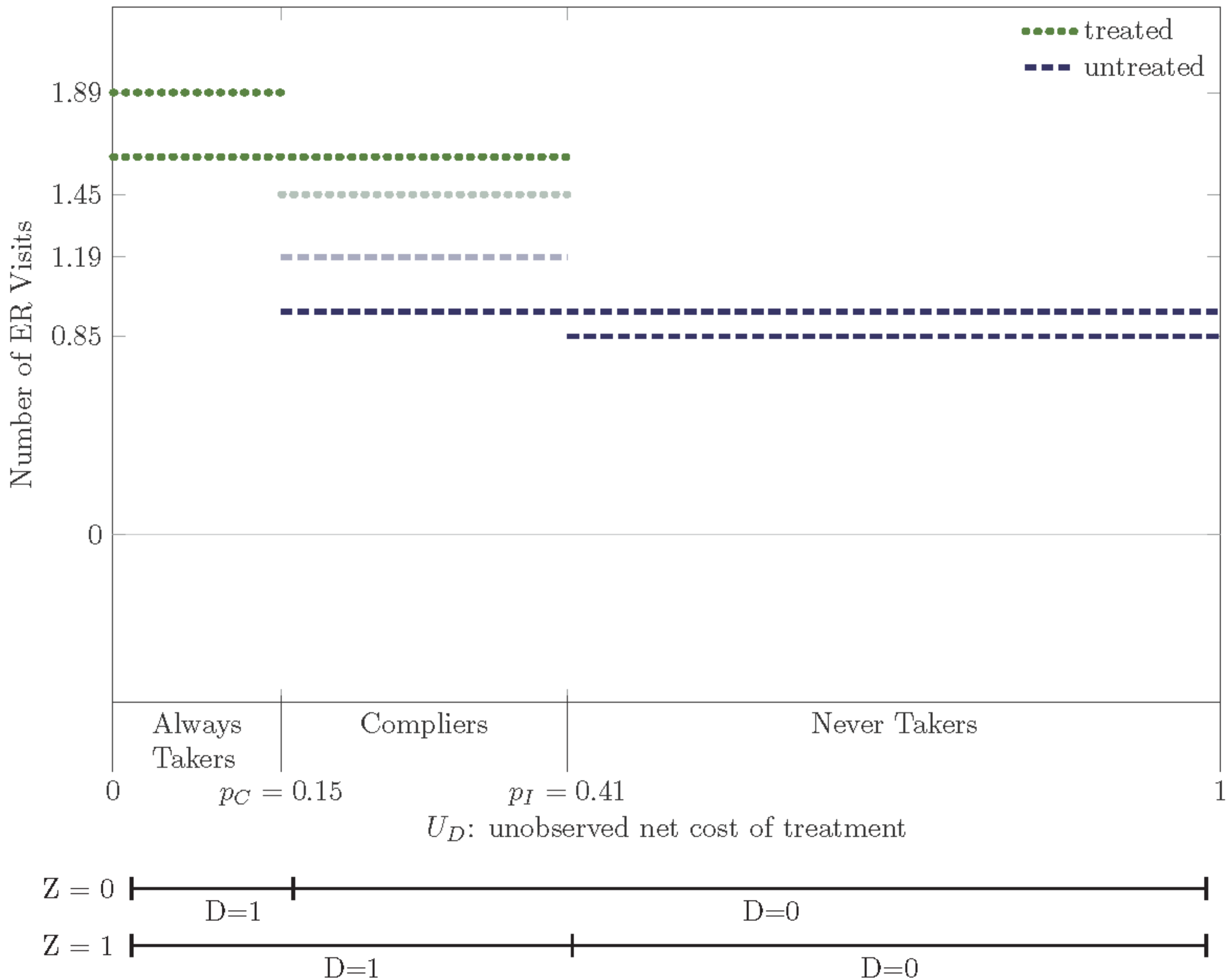
D=1
D=0


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
Always Takers
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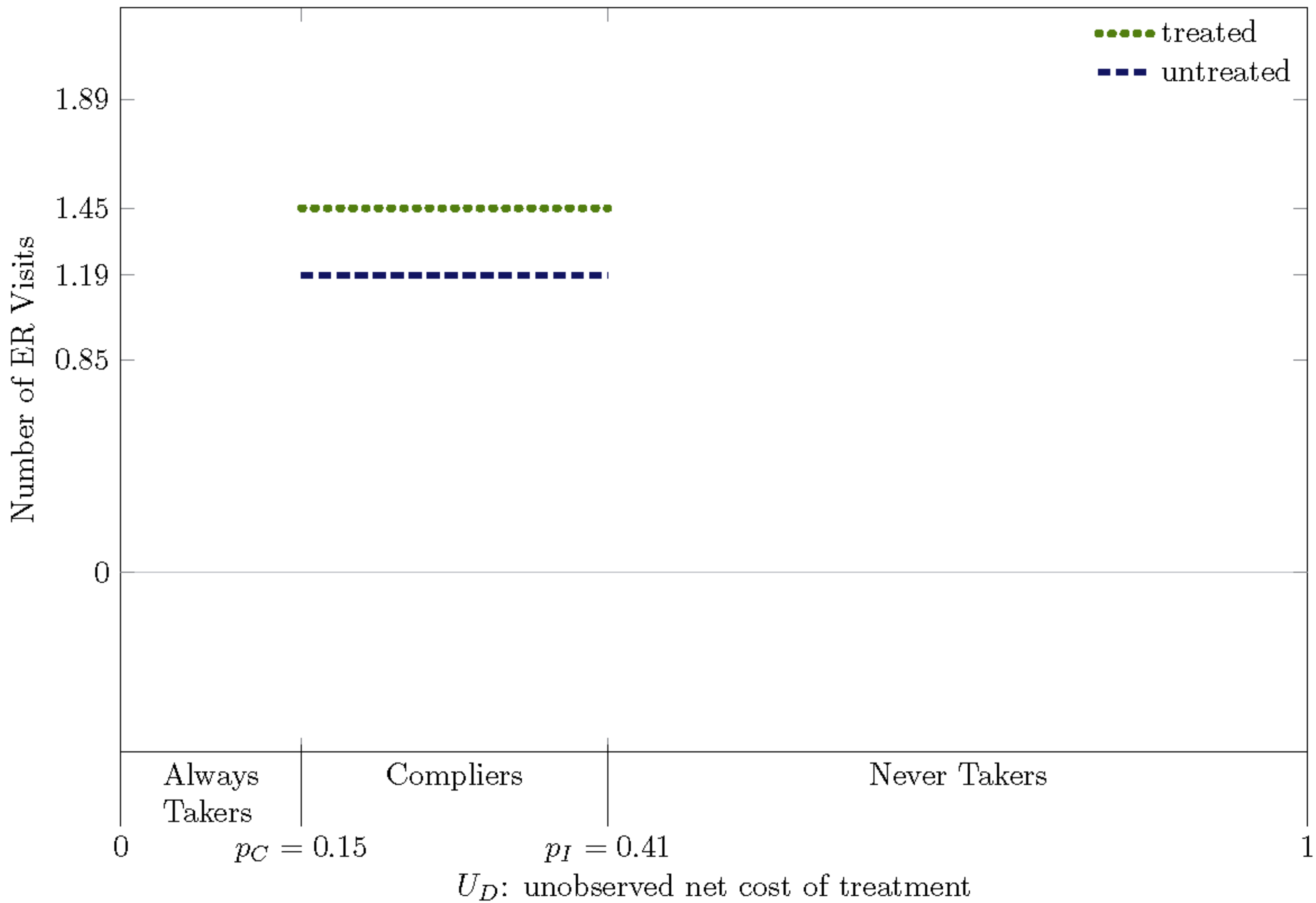
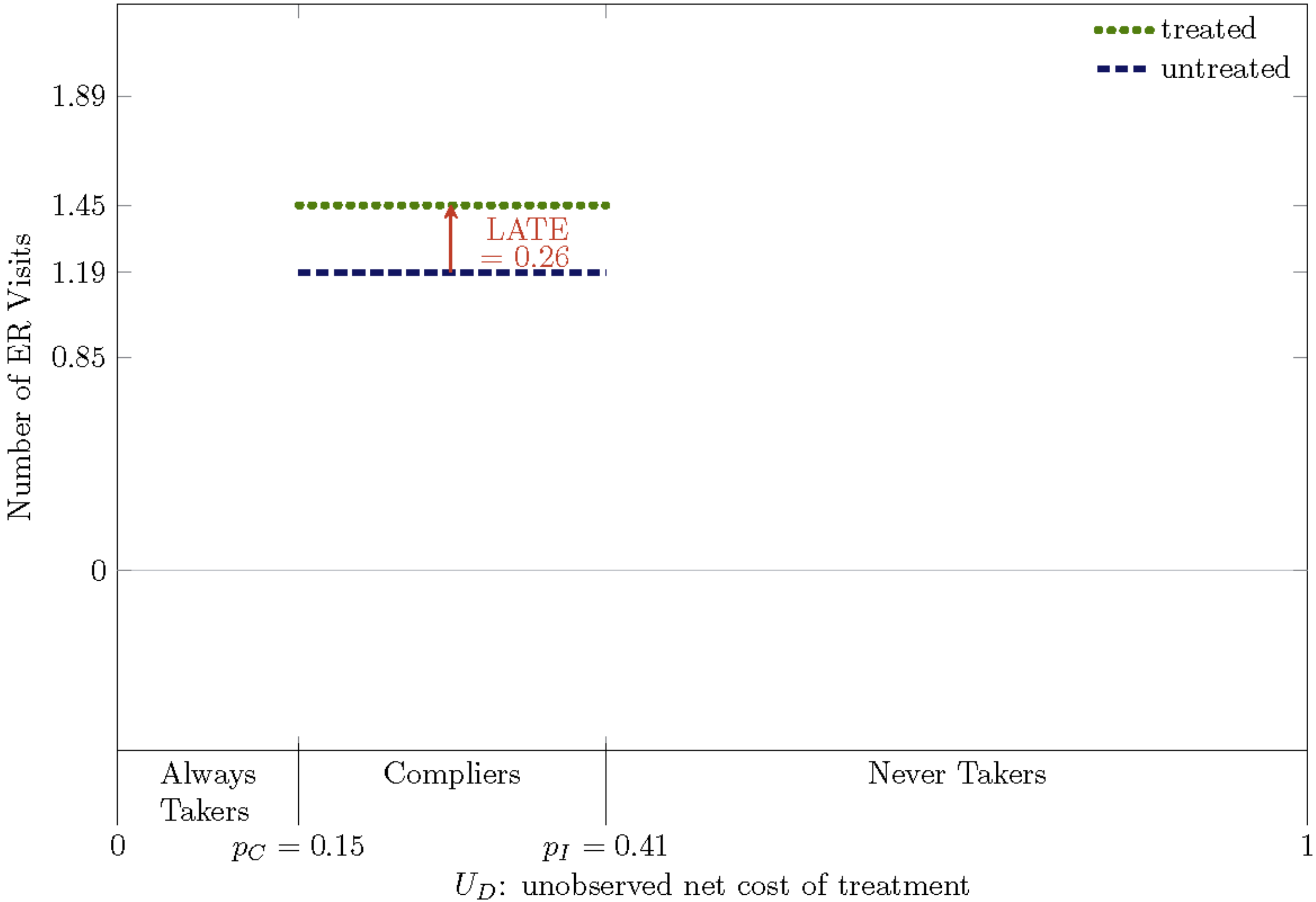
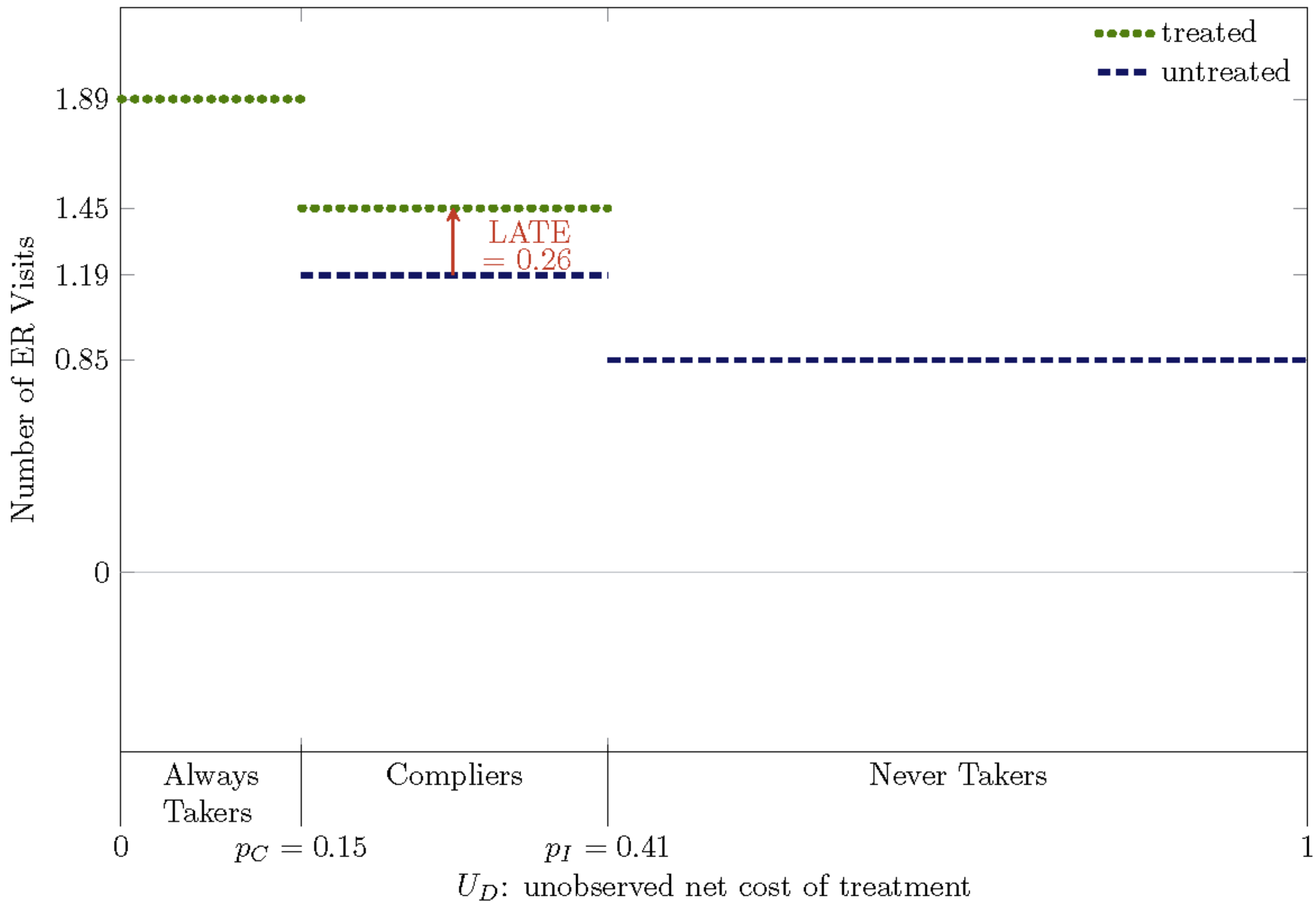
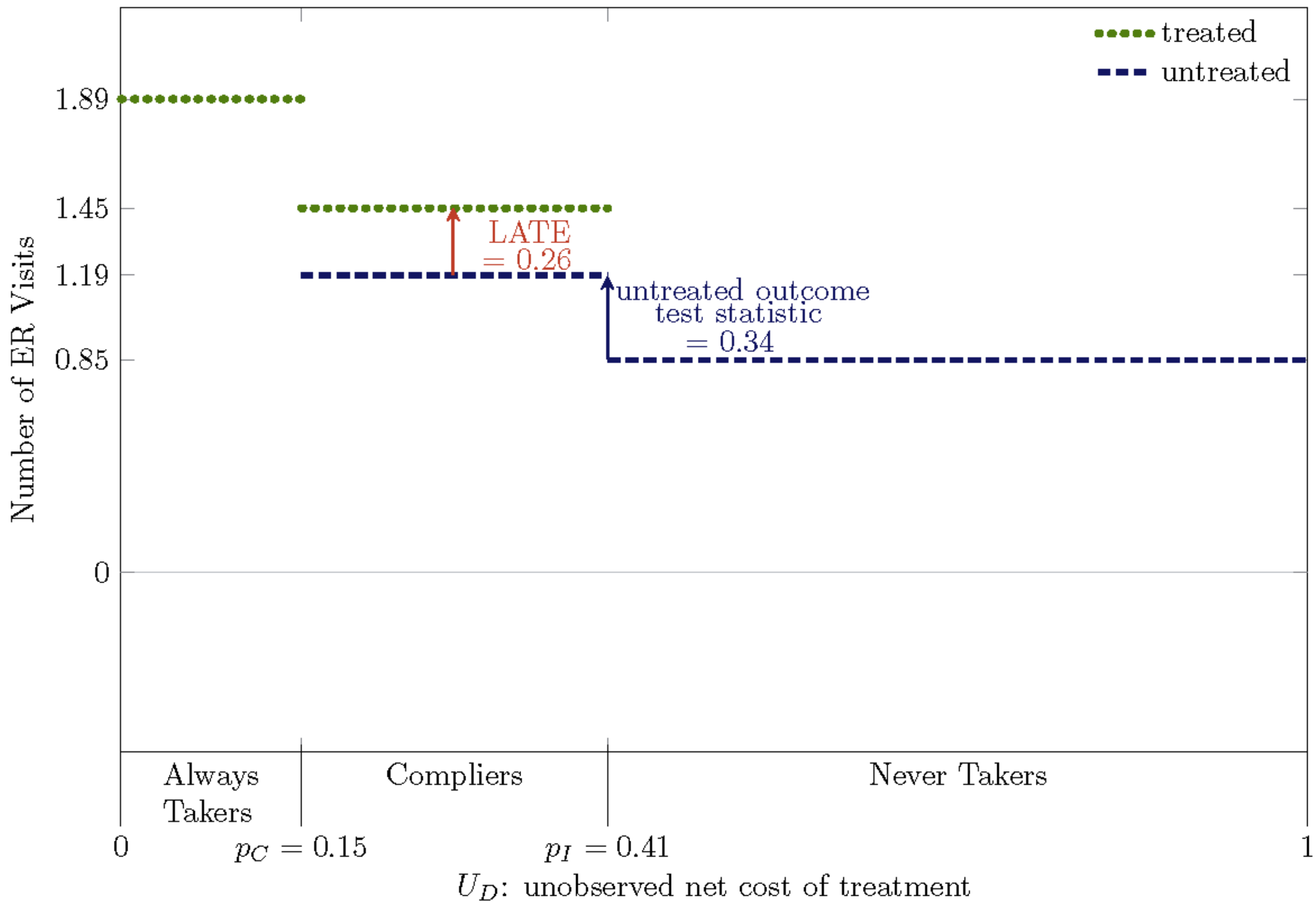
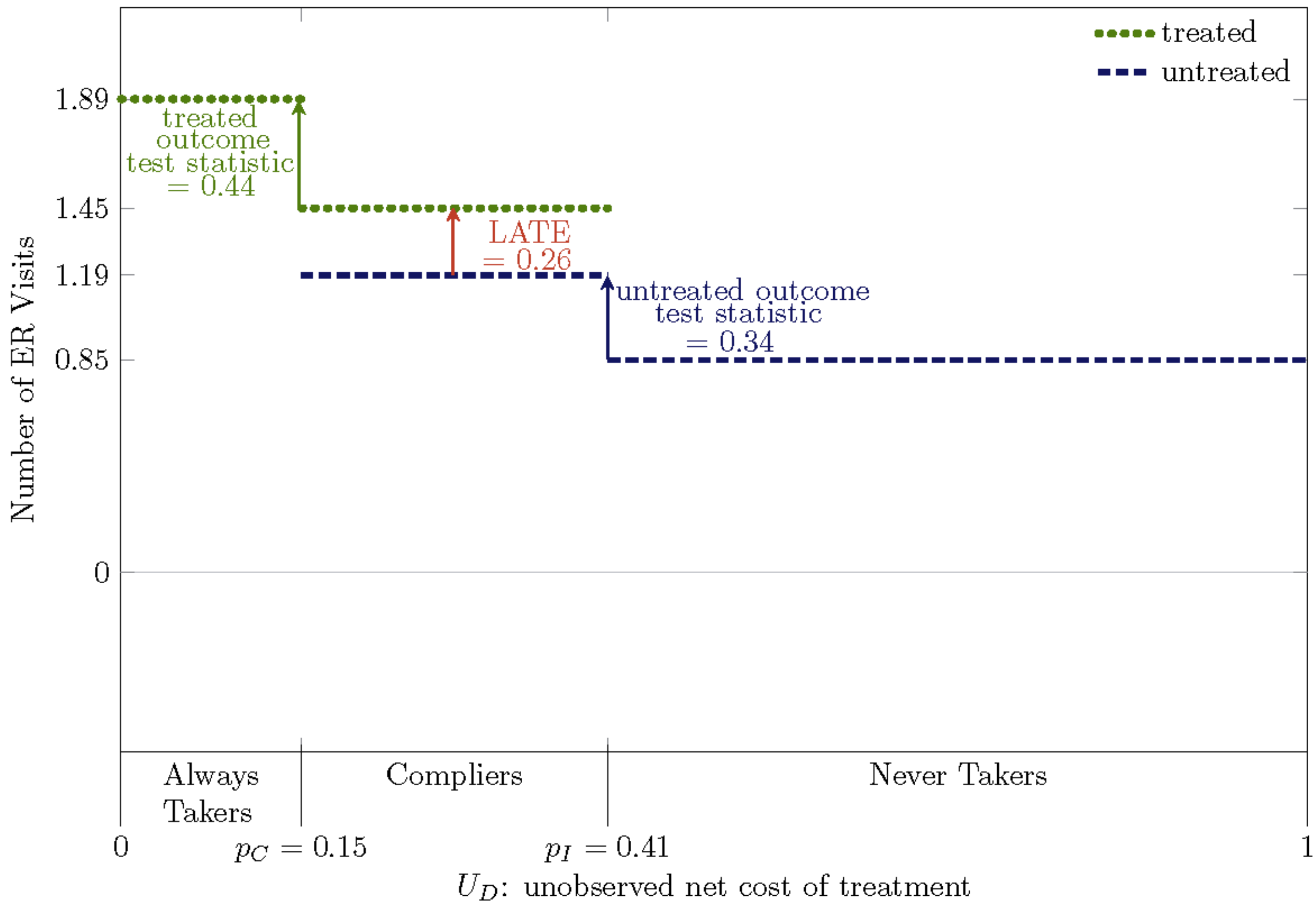


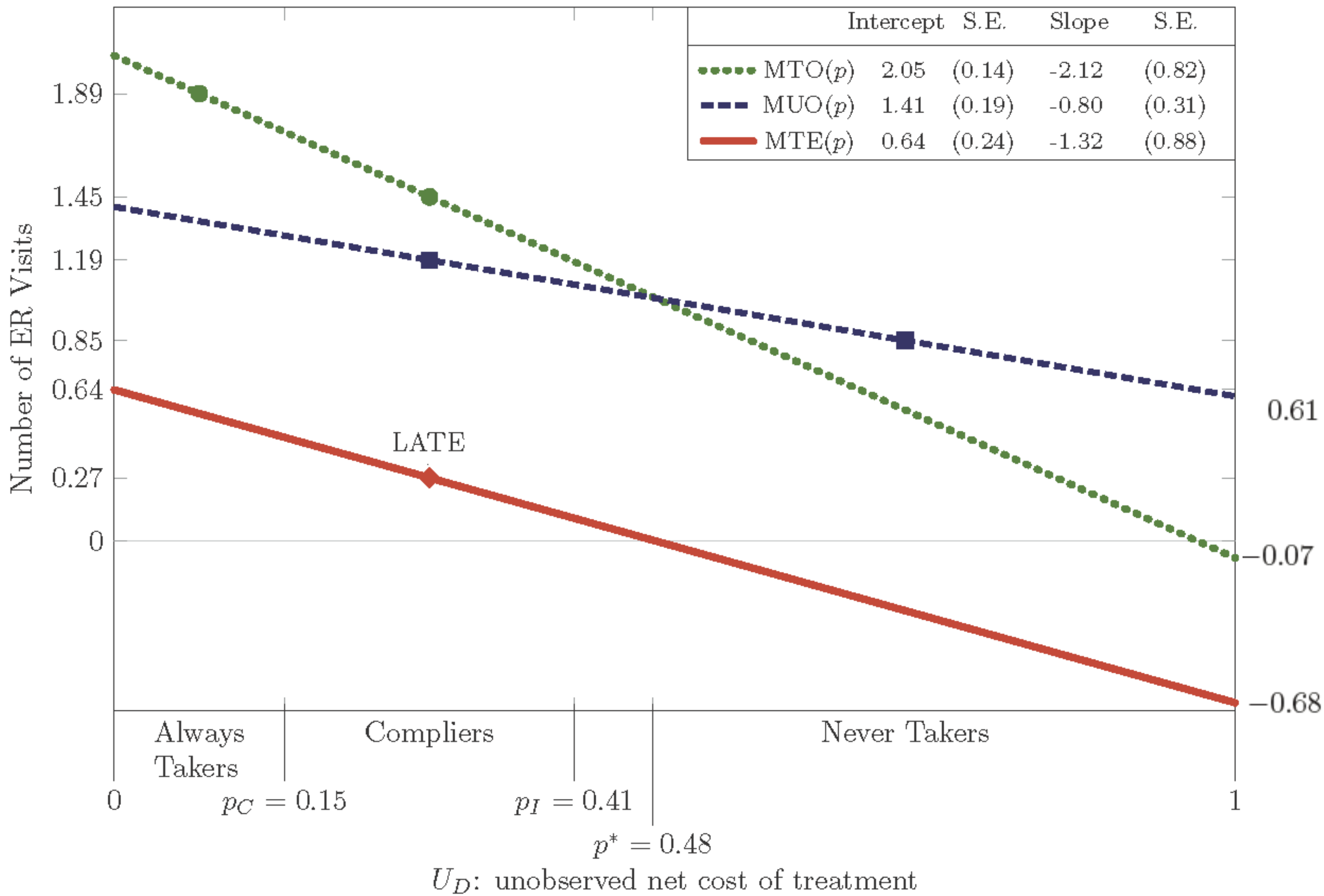
treated
untreated
Number of ER Visits
1.89
1.45
1.19
0.85
0
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
LATE
= 0.26
Always
Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
LATE
= 0.26
Always
Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
LATE
= 0.26
untreated outcome
test statistic
= 0.34
Always
Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment


treated
untreated
1.89
1.45
1.19
0.85
0
Number of ER Visits
treated outcome test statistic = 0.44
LATE = 0.26
untreated outcome test statistic = 0.34
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment



Intercept S.E. Slope S.E.
MTO(p) 2.05 (0.14) -2.12 (0.82)
MUO(p) 1.41 (0.19) -0.80 (0.31)
MTE(p) 0.64 (0.24) -1.32 (0.88)
Number of ER Visits
1.89
1.45
1.19
0.85
0.64
0.27
0
0.61
−0.07
−0.68
LATE
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
$p^* = 0.48$
U_D: unobserved net cost of treatment

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

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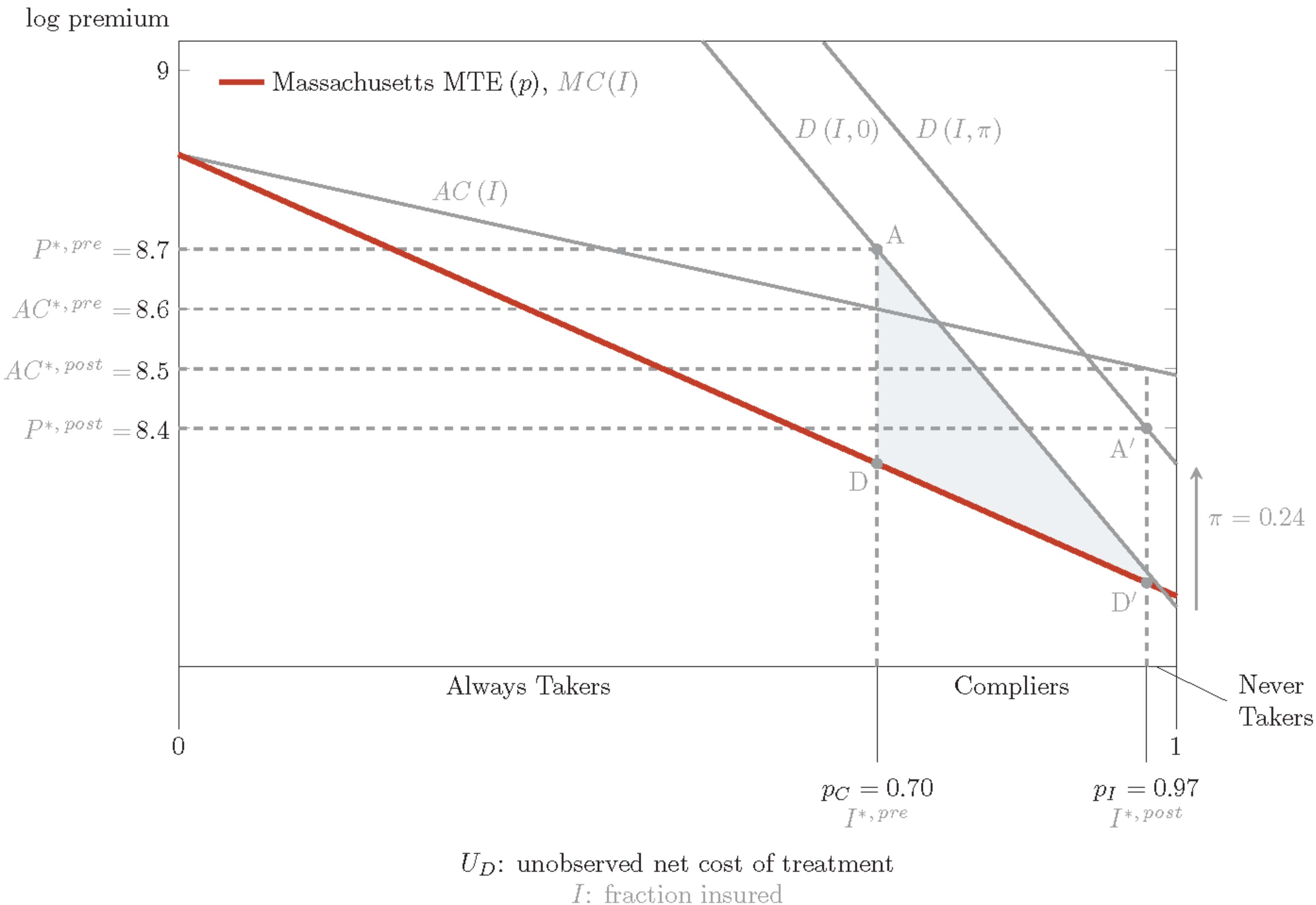
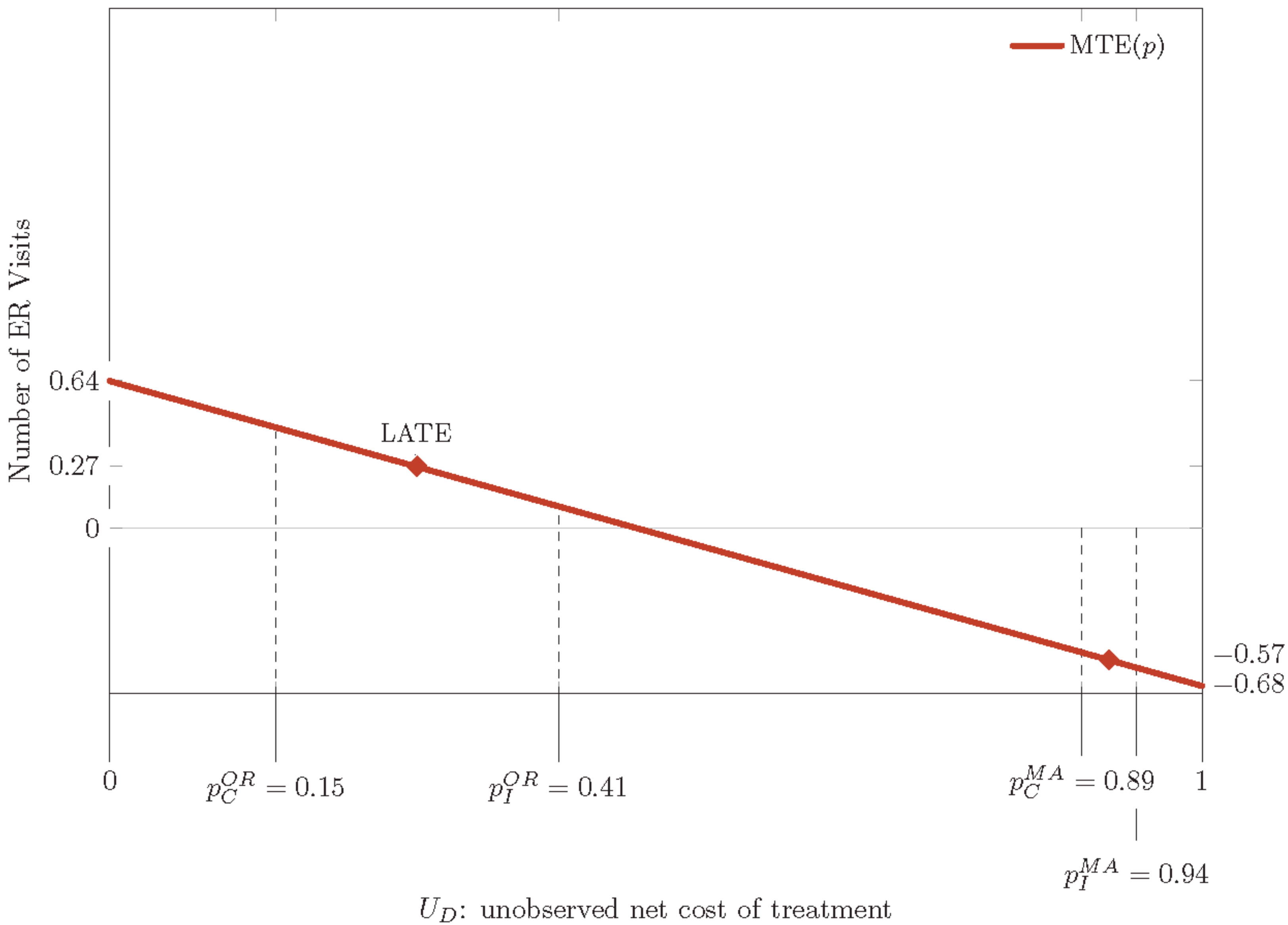


log premium
9
Massachusetts MTE (p), $MC(I)$
$D(I,0)$
$D(I,\pi)$
$AC(I)$
$P^{*,pre} = 8.7$
$AC^{*,pre} = 8.6$
$AC^{*,post} = 8.5$
$P^{*,post} = 8.4$
A
A′
D
D′
$\pi = 0.24$
Always Takers
Compliers
Never Takers
0
1
$p_C = 0.70$
$I^{*,pre}$
$p_I = 0.97$
$I^{*,post}$
U_D: unobserved net cost of treatment
I: fraction insured


MTE(p)
Number of ER Visits
0.64
0.27
0
LATE
−0.57
−0.68
0
$p_C^{OR} = 0.15$
$p_I^{OR} = 0.41$
$p_C^{MA} = 0.89$
1
$p_I^{MA} = 0.94$
U_D: unobserved net cost of treatment

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

1. I find selection and treatment effect heterogeneity within Oregon
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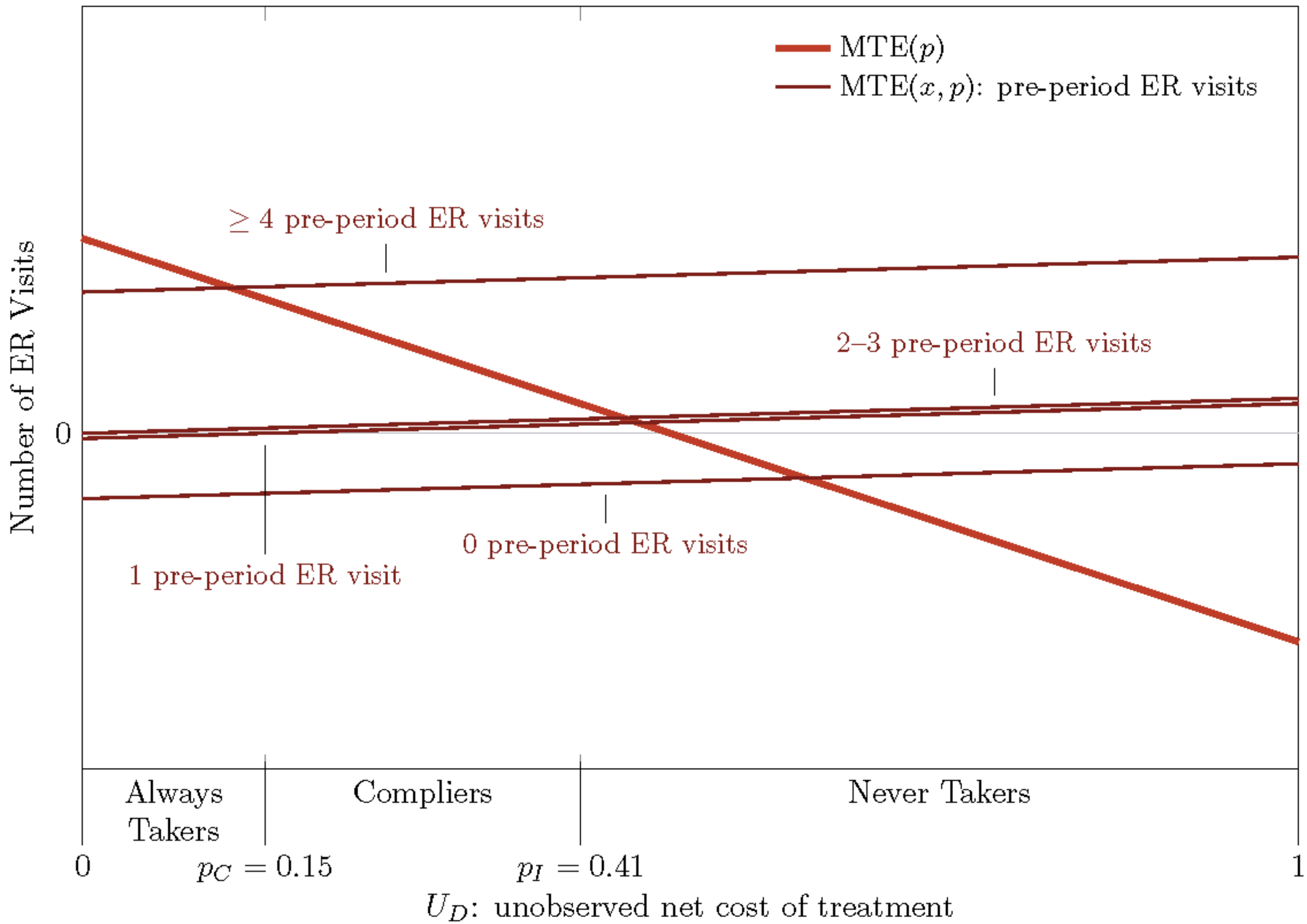
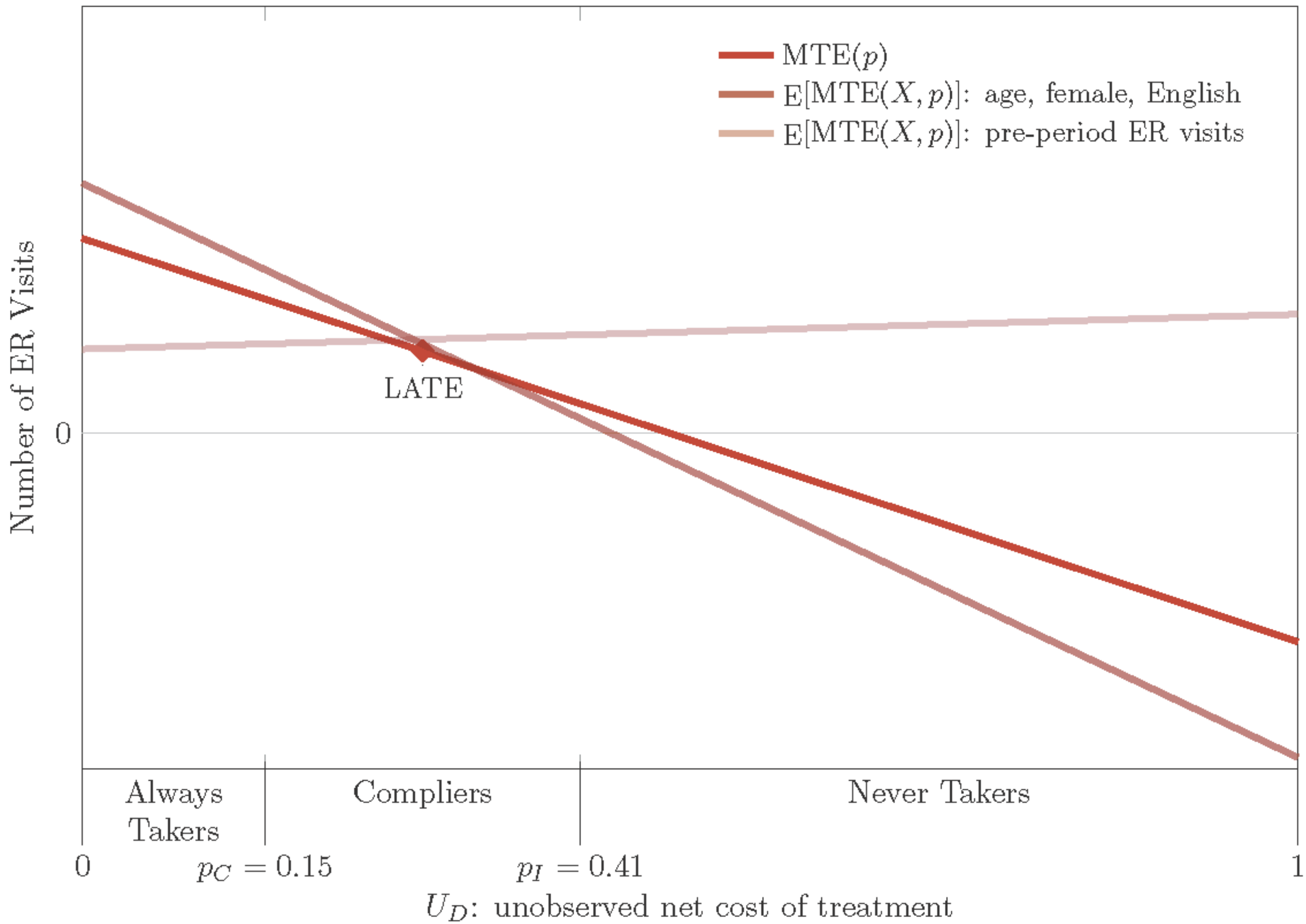
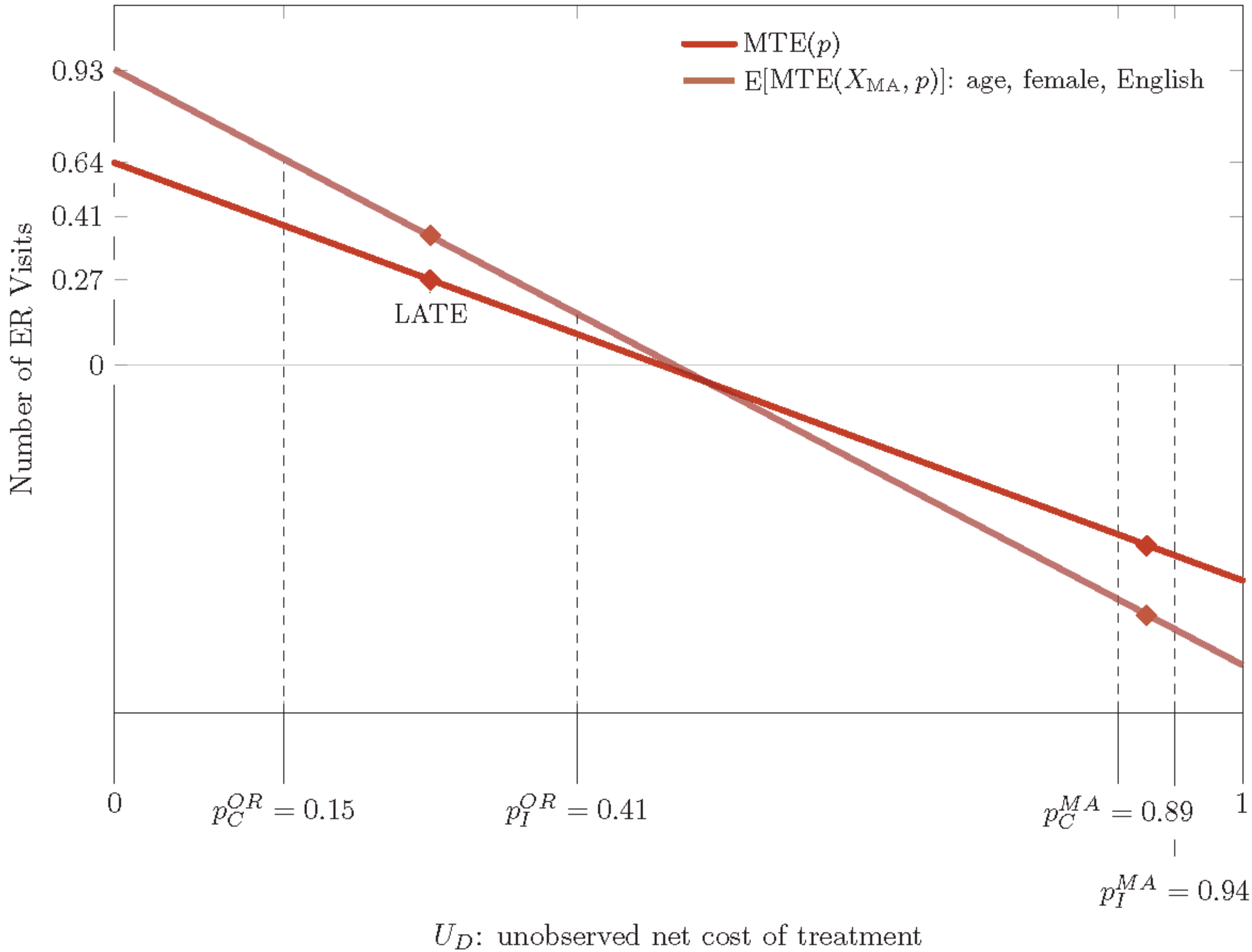
3. **I show that self-reported health & previous ER utilization explain heterogeneity and reconciliation**

		Means			Difference in Means	
		(1)	(2)	(3)		
		Always		Never		
	All	Takers	Compliers	Takers	(1) - (2)	(2) - (3)
Oregon Health Insurance Experiment of 2008						
Fair or Poor Health, Untreated[a]	0.42	-	0.55	0.34	-	0.20
Number of Pre-period ER Visits	0.87	1.36	0.88	0.73	0.48	0.15
Common Observables						
Age	40.69	39.45	42.41	40.25	-2.96	2.16
Female	0.56	0.72	0.53	0.53	0.19	0.003
English	0.91	0.90	0.92	0.91	-0.02	0.01
N	19,643	2,986	5,092	11,565		
Massachusetts Health Reform of 2006						
Fair or Poor Health, Untreated[a]	0.19	-	0.21	0.18	-	0.03
Common Observables						
Age	42.00	42.15	42.42	38.98	-0.26	3.43
Female	0.51	0.52	0.43	0.38	0.10	0.04
English	0.96	0.98	0.86	0.81	0.12	0.05
N	62,456	55,966	3,175	3,314		


MTE(p)
MTE(x, p): pre-period ER visits
≥ 4 pre-period ER visits
2–3 pre-period ER visits
0 pre-period ER visits
1 pre-period ER visit
Number of ER Visits
0
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment



MTE(p)
E[MTE(X, p)]: age, female, English
E[MTE(X, p)]: pre-period ER visits
Number of ER Visits
0
LATE
Always Takers
Compliers
Never Takers
0
$p_C = 0.15$
$p_I = 0.41$
1
U_D: unobserved net cost of treatment



MTE(p)
E[MTE(X_{MA}, p)]: age, female, English
Number of ER Visits
0.93
0.64
0.41
0.27
0
LATE
−0.57
−0.68
−0.79
−0.95
0
$p_C^{OR} = 0.15$
$p_I^{OR} = 0.41$
$p_C^{MA} = 0.89$
1
$p_I^{MA} = 0.94$
U_D: unobserved net cost of treatment

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

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Appendix

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

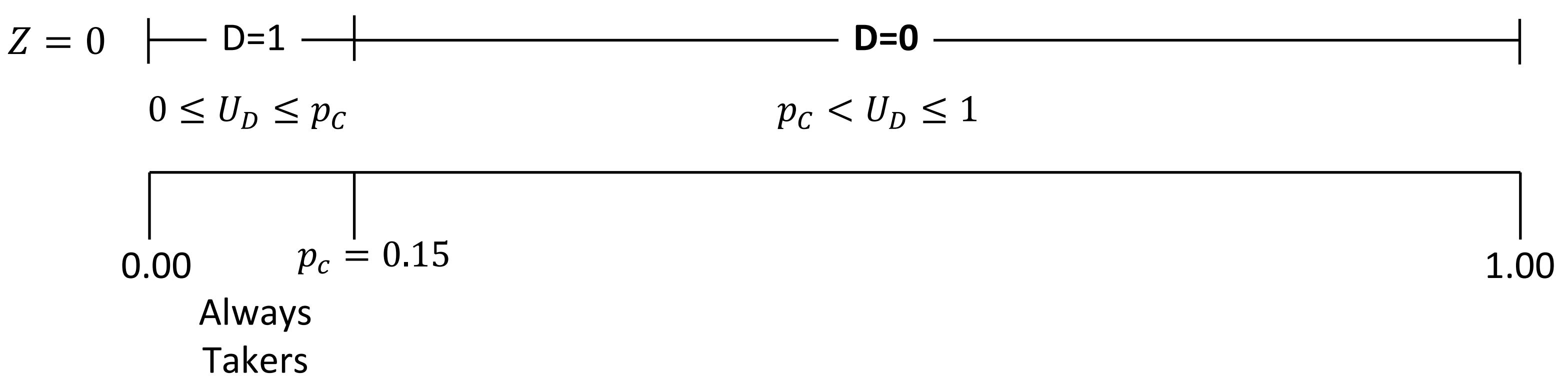
1. Findings
   - Selection & treatment effect heterogeneity within Oregon
     - Selection heterogeneity
     - Treatment effect heterogeneity under an ancillary assumption
   - Reconciling Oregon and Massachusetts LATEs
     - Massachusetts MTE(p) also slopes downward
     - MTE-reweighting from Oregon to Massachusetts can reconcile LATEs
   - Self-reported health & previous ER utilization explain heterogeneity and reconciliation
     - Reconciling LATEs using self-reported health
     - Previous ER utilization explains heterogeneity within Oregon
     - LATE-reweighting with common observables cannot reconcile LATEs
     - MTE-reweighting with common observables can reconcile LATEs

Number of ER Visits for Always Takers, Compliers and Never Takers

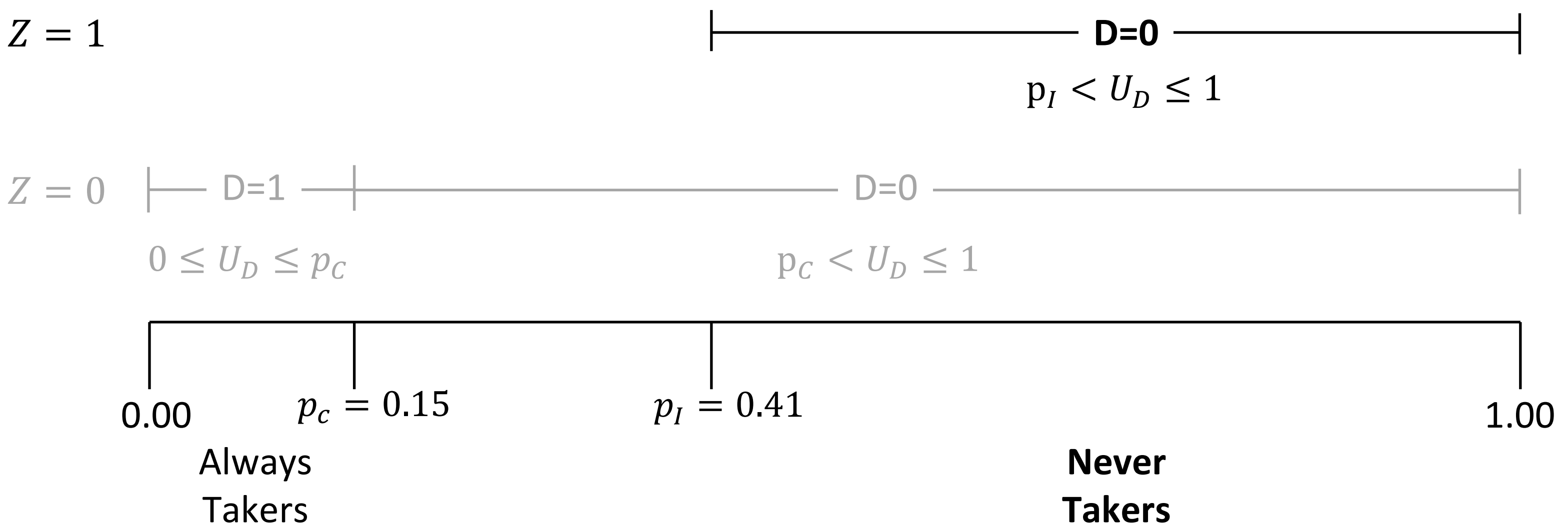
	Mean				
	(1) Always Takers	(2) Compliers	(3) Never Takers	Untreated Outcome Test (2) - (3)	Treated Outcome Test (1) - (2)
Number of ER Visits					
Treated	1.89	1.45	0.55		0.44
	(0.08)	(0.11)	(0.45)		(0.17)
Untreated	1.35	1.19	0.85	0.34	
	(0.17)	(0.11)	(0.03)	(0.13)	
Treatment Effect	0.54	0.27	-0.29		
(Treated - Untreated)	(0.19)	(0.15)	(0.45)		

U_D: unobserved net cost of treatment

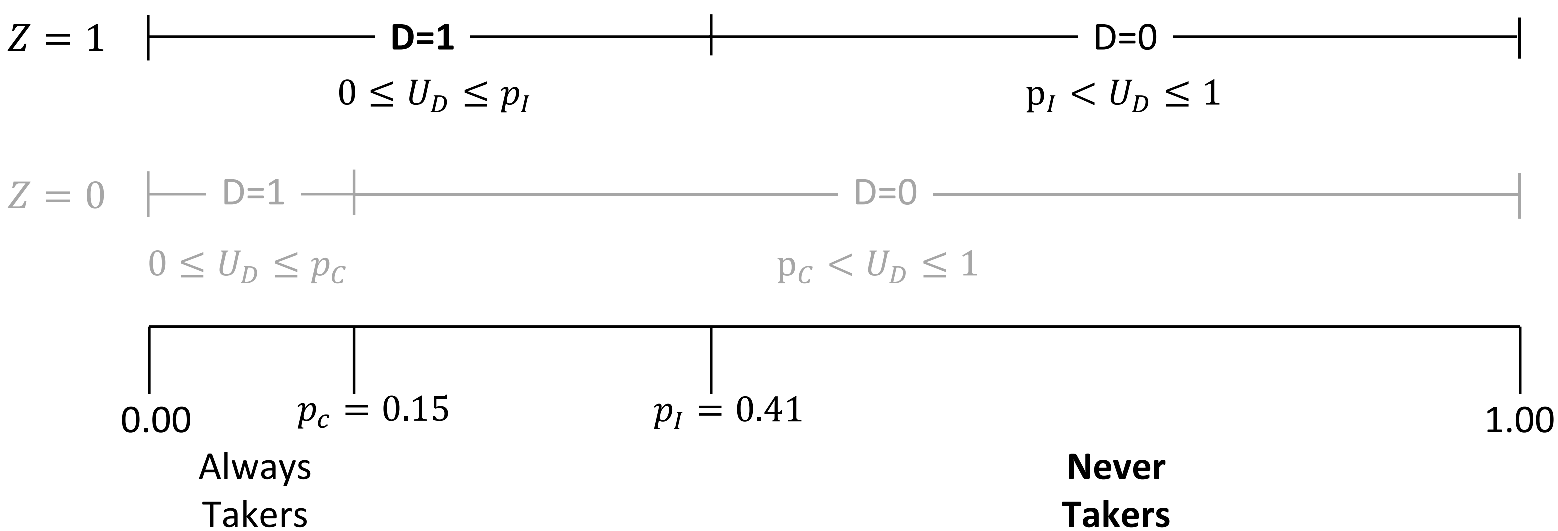
U_D: unobserved net cost of treatment



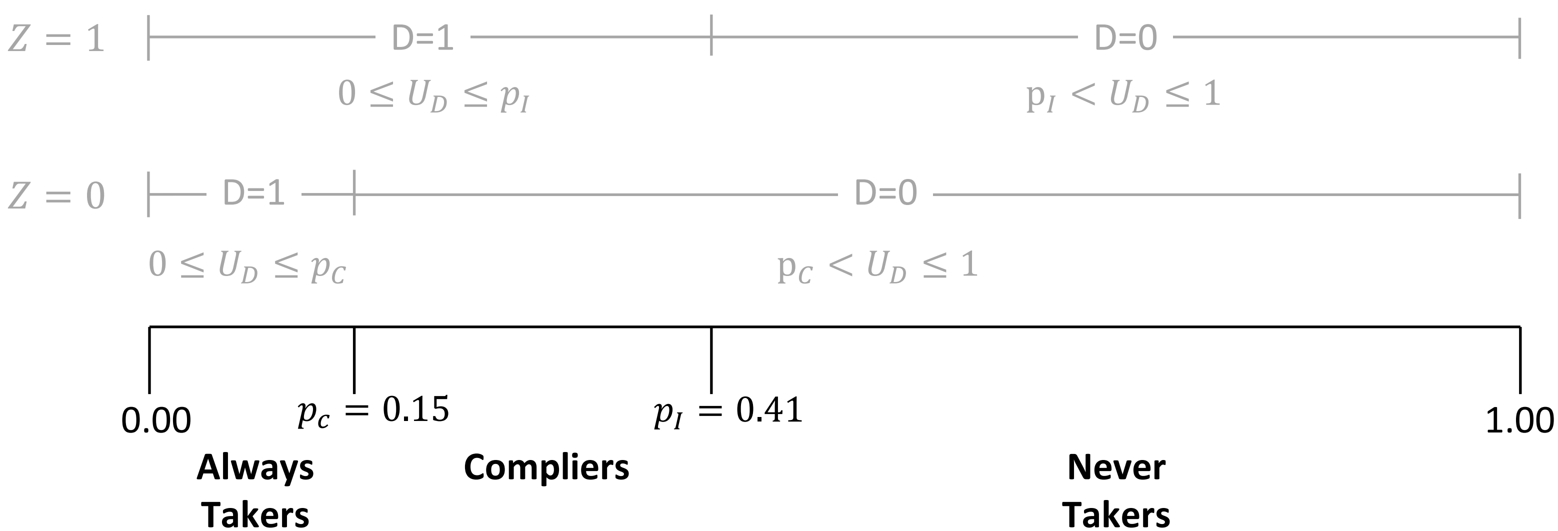
U_D: unobserved net cost of treatment



U_D: unobserved net cost of treatment



U_D: unobserved net cost of treatment



U_D: unobserved net cost of treatment

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D
\end{aligned}
$$

First Stage:

$$\begin{aligned} V &= V_U + (V_T - V_U)D \\ V_T - V_U &= \mu_D(Z) - \nu_D \end{aligned}$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

First Stage:

$$V = V_U + (V_T - V_U)D$$
$$V_T - V_U = \mu_D(Z) - \nu_D \qquad\qquad U_D = F(\nu_D),\ U_D \sim U[0,1]$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

Proof: $U_D \sim U[0,1]$

$$\begin{aligned} F_{U_D}(u) &= P(U_D \leq u) \\ &= P(F(\nu_D) \leq u) \\ &= P(\nu_D \leq F^{-1}(u)) && (F(\cdot) \text{ absolutely continuous by A.1}) \\ &= F(F^{-1}(u)) = u \end{aligned}$$

First Stage:

$$V = V_U + (V_T - V_U)D$$
$$V_T - V_U = \mu_D(Z) - \nu_D \qquad U_D = F(\nu_D),\, U_D \sim U[0,1]$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

A.2. (Independence) (U_D, γ_T) and $(U_D, \gamma_U) \perp Z$

First Stage:

$$\begin{aligned} V &= V_U + (V_T - V_U)D \\ V_T - V_U &= \mu_D(Z) - \nu_D \\ D &= 1\{0 \le V_T - V_U\} \\ \Rightarrow D &= 1\{U_D \le P(D = 1 \mid Z = z)\} \end{aligned}$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

A.2. (Independence) (U_D, γ_T) and $(U_D, \gamma_U) \perp Z$

Proof: $D = 1\{U_D \le \mathrm{P}(D = 1 \mid Z = z)\}$

$$\begin{aligned} D &= 1\{0 \le V_T - V_U\} \\ &= 1\{0 \le \mu_D(Z) - \nu_D\} \\ &= 1\{\nu_D \le \mu_D(Z)\} \\ &= 1\{F(\nu_D) \le F(\mu_D(Z))\} && \text{(definition of } F(\cdot) \text{ from A.1)} \\ &= 1\{U_D \le F(\mu_D(Z))\} && (U_D = F(\nu_D) \text{ by definition}) \\ &= 1\{U_D \le \mathrm{P}(D = 1 \mid Z = z)\}, \end{aligned}$$

where the last equality follows from

$$\begin{aligned} F(\mu_D(Z)) &= \mathrm{P}(\nu_D \le \mu_D(Z)) \\ &= \mathrm{P}(\nu_D \le \mu_D(z) \mid Z = z) && (U_D \perp Z \text{ by A.2}) \\ &= \mathrm{P}(0 \le \mu_D(Z) - \nu_D \mid Z = z) \\ &= \mathrm{P}(0 \le V_T - V_U \mid Z = z) \\ &= \mathrm{P}(D = 1 \mid Z = z). \end{aligned}$$

First Stage:

$$\begin{aligned} V &= V_U + (V_T - V_U)D \\ V_T - V_U &= \mu_D(Z) - \nu_D \\ D &= 1\{0 \leq V_T - V_U\} \\ \Rightarrow D &= 1\{U_D \leq P(D = 1 \mid Z = z)\} \end{aligned}$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

A.2. (Independence) (U_D, γ_T) and $(U_D, \gamma_U) \perp Z$

A.3. (Instrument Relevance) $\mu_D(Z)$: nondegenerate random variable

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D \qquad\qquad U_D = F(\nu_D),\ U_D \sim U[0,1] \\
D &= 1\{0 \leq V_T - V_U\} \\
\Rightarrow D &= 1\{U_D \leq P(D=1 \mid Z=z)\} \\
Z = 0: &\quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D=1 \mid Z=0) \\
Z = 1: &\quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D=1 \mid Z=1)
\end{aligned}
$$

Assumptions:

A.1. (Continuity) $F(\cdot)$: absolutely continuous with respect to the Lebesgue measure

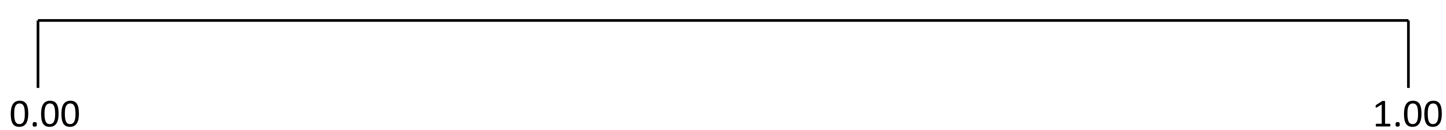
A.2. (Independence) (U_D, γ_T) and $(U_D, \gamma_U) \perp Z$

A.3. (Instrument Relevance) $\mu_D(Z)$: nondegenerate random variable

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D \\
D &= 1\{0 \le V_T - V_U\} \\
\Rightarrow D &= 1\{U_D \le P(D=1 \mid Z=z)\} \\
Z = 0: &\quad D = 1\{U_D \le p_C\}, \quad p_C = P(D=1 \mid Z=0) \\
Z = 1: &\quad D = 1\{U_D \le p_I\}, \quad p_I = P(D=1 \mid Z=1)
\end{aligned}
$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$



U_D: unobserved net cost of treatment

First Stage:

$$V = V_U + (V_T - V_U)D$$

$$V_T - V_U = \mu_D(Z) - \nu_D \qquad U_D = F(\nu_D),\ U_D \sim U[0,1]$$

$$D = 1\{0 \leq V_T - V_U\}$$

$$\Rightarrow D = 1\{U_D \leq P(D = 1 \mid Z = z)\}$$

$$\boldsymbol{Z = 0: \quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D = 1 \mid Z = 0)}$$

$$Z = 1: \quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D = 1 \mid Z = 1)$$

U_D: unobserved net cost of treatment

First Stage:

$$V = V_U + (V_T - V_U)D$$

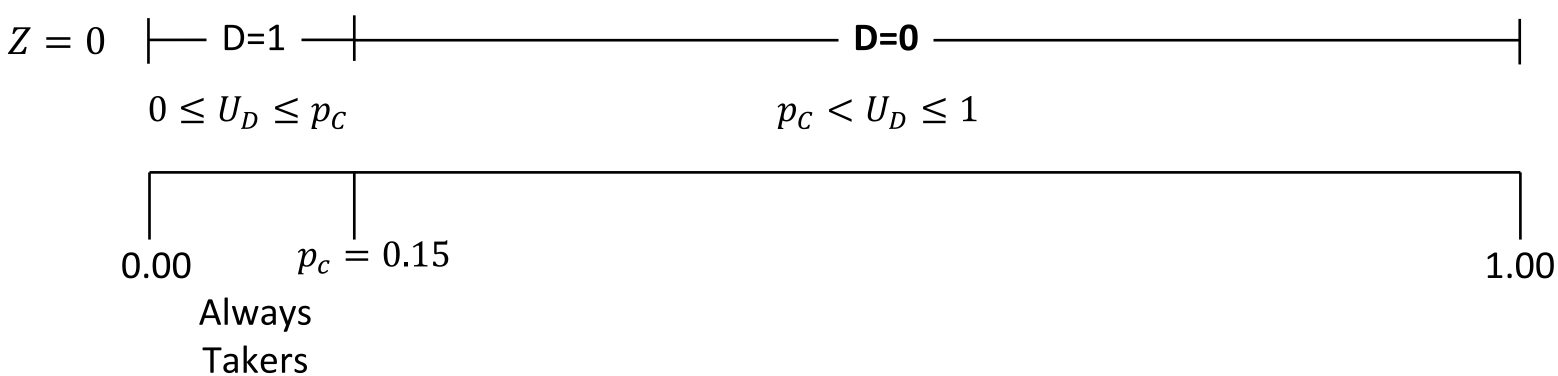
$$V_T - V_U = \mu_D(Z) - \nu_D \qquad U_D = F(\nu_D),\ U_D \sim U[0,1]$$

$$D = 1\{0 \leq V_T - V_U\}$$

$$\Rightarrow D = 1\{U_D \leq P(D = 1 \mid Z = z)\}$$

$$\boldsymbol{Z = 0: \quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D = 1 \mid Z = 0)}$$

$$Z = 1: \quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D = 1 \mid Z = 1)$$

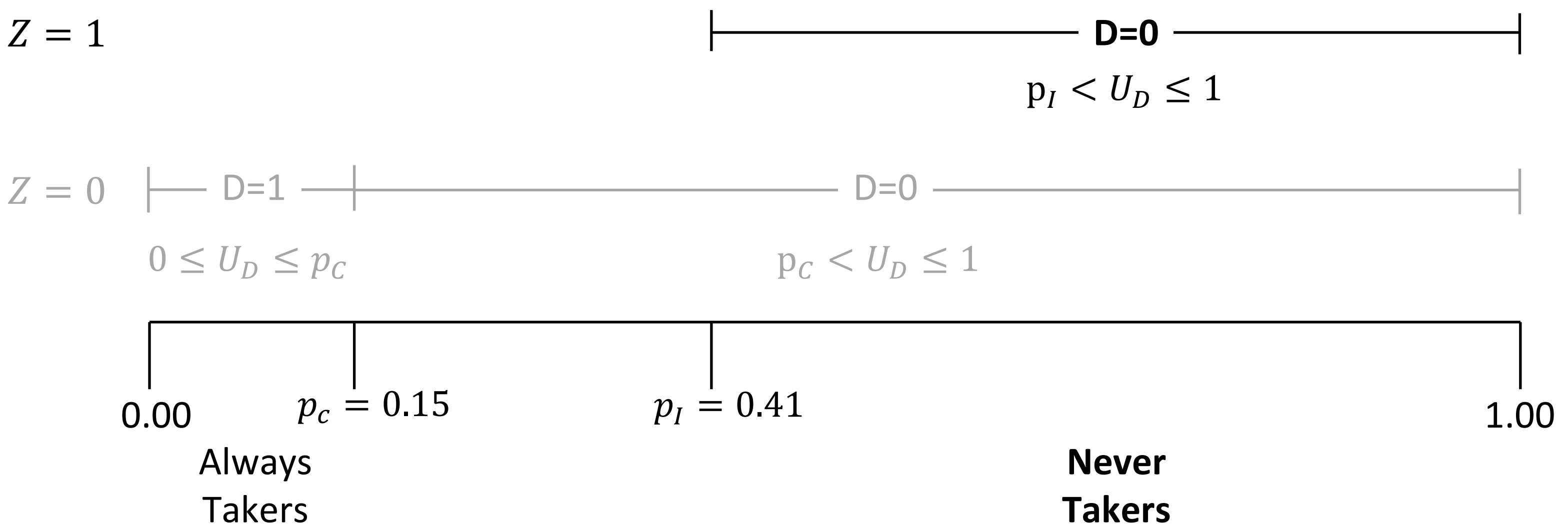


U_D: unobserved net cost of treatment

First Stage:

$$
\begin{aligned}
& V = V_U + (V_T - V_U)D \\
& V_T - V_U = \mu_D(Z) - \nu_D \\
& D = 1\{0 \leq V_T - V_U\} \\
\Rightarrow & D = 1\{U_D \leq P(D=1 \mid Z=z)\} \\
& Z = 0: \quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D=1 \mid Z=0) \\
& \boldsymbol{Z = 1: \quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D=1 \mid Z=1)}
\end{aligned}
$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$



U_D: unobserved net cost of treatment

First Stage:

$$
\begin{aligned}
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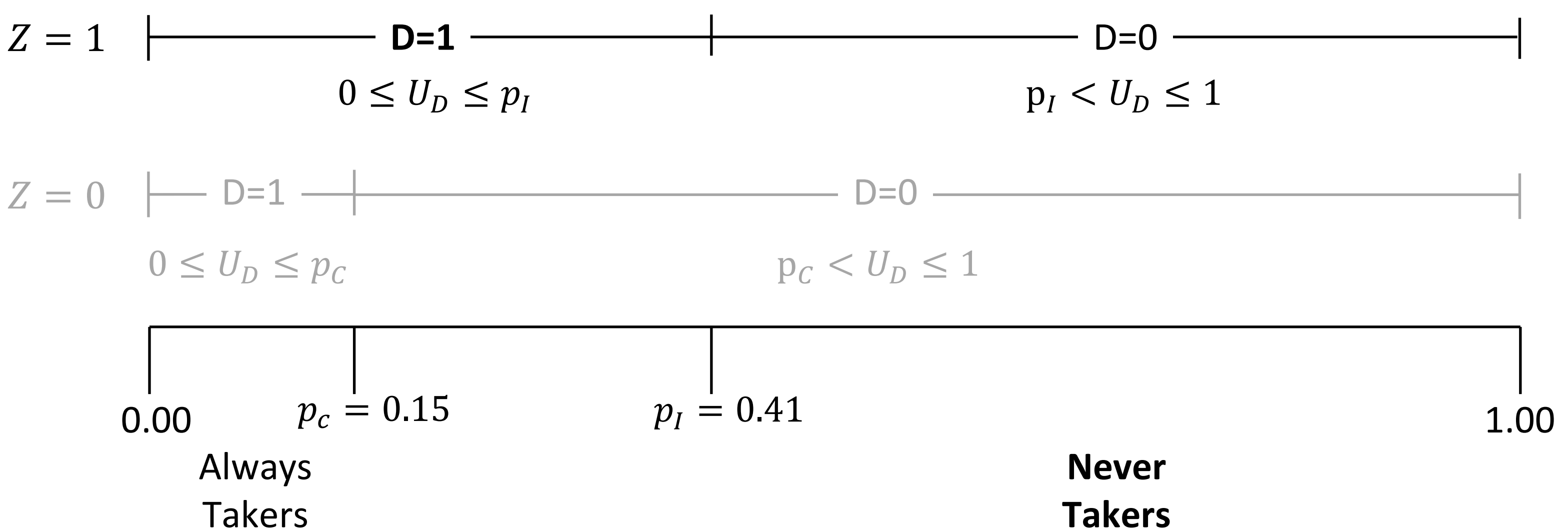
&V_T - V_U = \mu_D(Z) - \nu_D \\
&D = 1\{0 \leq V_T - V_U\} \\
\Rightarrow &D = 1\{U_D \leq P(D=1 \mid Z=z)\} \\
&Z = 0: \quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D=1 \mid Z=0) \\
&\boldsymbol{Z = 1: \quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D=1 \mid Z=1)}
\end{aligned}
$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$

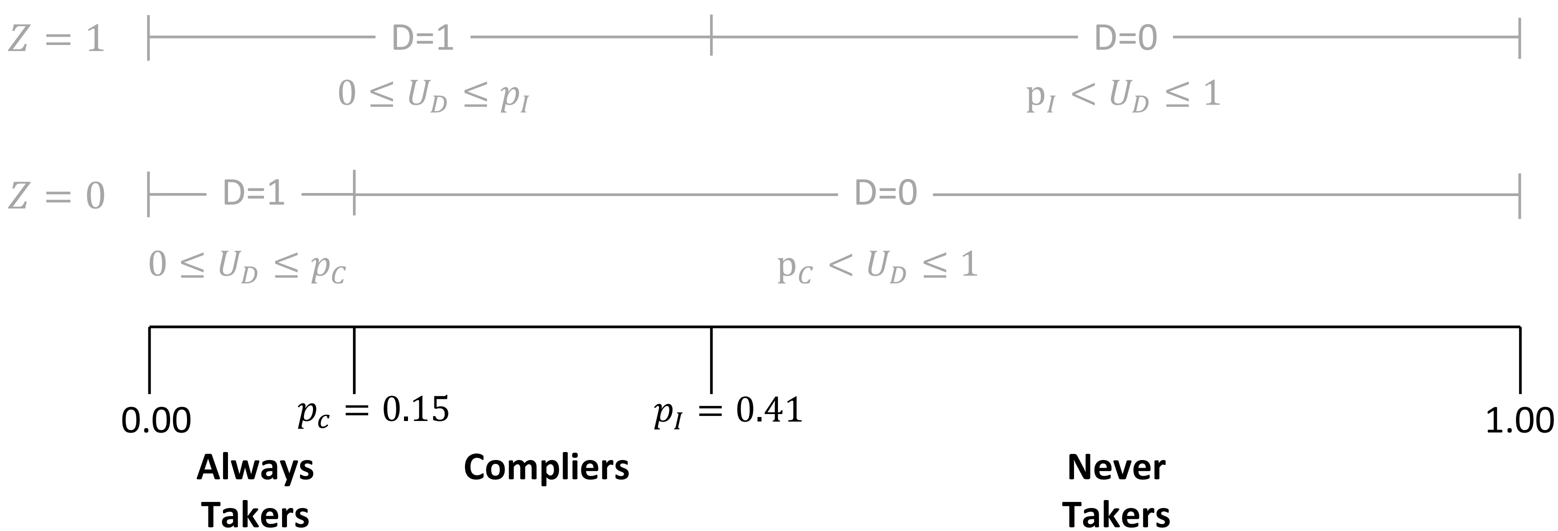


U_D: unobserved net cost of treatment

First Stage:

$$
\begin{aligned}
&V = V_U + (V_T - V_U)D \\
&V_T - V_U = \mu_D(Z) - \nu_D \\
&D = 1\{0 \leq V_T - V_U\} \\
\Rightarrow &D = 1\{U_D \leq P(D = 1 \,|\, Z = z)\} \\
&Z = 0: \quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D = 1 \,|\, Z = 0) \\
&Z = 1: \quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D = 1 \,|\, Z = 1)
\end{aligned}
$$

$$U_D = F(\nu_D),\ U_D \sim U[0,1]$$



U_D: unobserved net cost of treatment

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D && U_D = F(\nu_D),\, U_D \sim U[0,1] \\
D &= 1\{0 \leq V_T - V_U\} \\
\Rightarrow D &= 1\{U_D \leq P(D=1 \,|\, Z=z)\} \\
Z = 0: &\quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D=1 \,|\, Z=0) \\
Z = 1: &\quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D=1 \,|\, Z=1)
\end{aligned}
$$

Second Stage:

$$
\begin{aligned}
Y &= Y_U + (Y_T - Y_U)D \\
Y_T &= g_T(U_D, \gamma_T) \\
Y_U &= g_U(U_D, \gamma_U) && Z \perp (\gamma_T, \gamma_U) \text{ by A.2.}
\end{aligned}
$$

Assumptions (Second Stage):

A.4. (Treated and Untreated) $0 < \mathrm{P}(D=1) < 1$

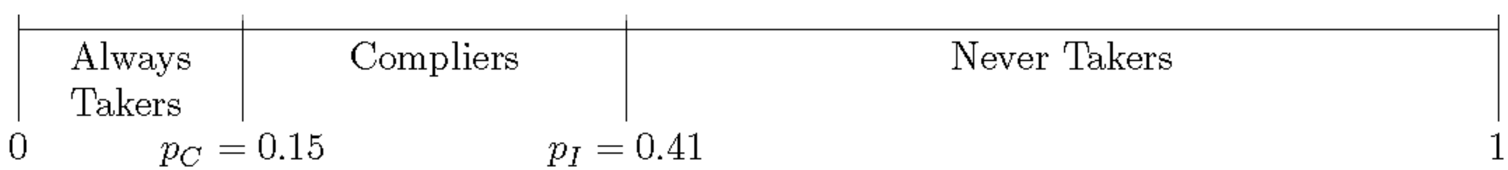
A.5. (Finite Average Outcomes) $E[Y_T], E[Y_U]$ are finite

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D \qquad\qquad U_D = F(\nu_D),\ U_D \sim U[0,1] \\
D &= 1\{0 \leq V_T - V_U\} \\
\Rightarrow D &= 1\{U_D \leq P(D=1\,|\,Z=z)\} \\
Z = 0: &\quad D = 1\{U_D \leq p_C\}, \quad p_C = P(D=1\,|\,Z=0) \\
Z = 1: &\quad D = 1\{U_D \leq p_I\}, \quad p_I = P(D=1\,|\,Z=1)
\end{aligned}
$$

Second Stage:

$$
\begin{aligned}
Y &= Y_U + (Y_T - Y_U)D \\
Y_T &= g_T(U_D, \gamma_T) \\
Y_U &= g_U(U_D, \gamma_U) \qquad\qquad Z \perp (\gamma_T, \gamma_U) \text{ by A.2.}
\end{aligned}
$$



U_D: unobserved net cost of treatment

Selection and Treatment Effect Heterogeneity

$$\begin{aligned}
\text{Selection + Treatment Effect Heterogeneity:} \quad & \mathrm{MTO}(x,p) = \mathrm{E}\left[Y_T \mid X = x, U_D = p\right] \\
\text{Selection Heterogeneity:} \quad & \mathrm{MUO}(x,p) = \mathrm{E}\left[Y_U \mid X = x, U_D = p\right] \\
\text{Treatment Effect Heterogeneity:} \quad & \mathrm{MTE}(x,p) = \mathrm{E}\left[Y_T - Y_U \mid X = x, U_D = p\right]
\end{aligned}$$

$$\begin{aligned}
\text{Selection Heterogeneity from Literature:} \quad & \mathrm{E}\left[Y_U \mid D = 1\right] - \mathrm{E}\left[Y_U \mid D = 0\right] \\
\text{Treatment Effect Heterogeneity from Literature:} \quad & \mathrm{E}\left[Y_T - Y_U \mid D = 1\right] - \mathrm{E}\left[Y_T - Y_U \mid D = 0\right]
\end{aligned}$$

Identifying Selection and Moral Hazard Heterogeneity

Untreated Outcome Test

$$\mathrm{E}[Y_U \mid p_C < U_D \leq p_I] - \mathrm{E}[Y_U \mid p_I < U_D \leq 1] = \int_0^1 (\omega(p, p_C, p_I) - \omega(p, p_I, 1))\, \mathrm{MUO}(p)\, \mathrm{d}p$$

Treated Outcome Test

$$\mathrm{E}[Y_T \mid 0 \leq U_D \leq p_C] - \mathrm{E}[Y_T \mid p_C < U_D \leq p_I] = \int_0^1 (\omega(p, 0, p_C) - \omega(p, p_C, p_I))\, \mathrm{MTO}(p)\, \mathrm{d}p$$

with weights $\omega(p, p_L, p_H) = 1\{p_L \leq p < p_H\}/(p_H - p_L)$

First Stage:

$$
\begin{aligned}
V &= V_U + (V_T - V_U)D \\
V_T - V_U &= \mu_D(Z) - \nu_D \qquad\qquad U_D = F(\nu_D),\, U_D \sim U[0,1] \\
D &= 1\{0 \leq V_T - V_U\} \\
\Rightarrow D &= 1\{U_D \leq P(D=1 \mid Z=z)\}
\end{aligned}
$$

Second Stage:

$$
\begin{aligned}
Y &= Y_U + (Y_T - Y_U)D \\
Y_T &= g_T(U_D, \gamma_T) \\
Y_U &= g_U(U_D, \gamma_U) \qquad\qquad Z \perp (\gamma_T, \gamma_U) \text{ by A.2.}
\end{aligned}
$$

Ancillary Assumption:

AA.1. (Linear Selection Heterogeneity and Linear Treatment Effect Heterogeneity)

$$
\begin{aligned}
\mathrm{MTO}(p) &= \mathrm{E}\left[Y_T \mid U_D = p\right] = \alpha_T + \beta_T p \\
\mathrm{MUO}(p) &= \mathrm{E}\left[Y_U \mid U_D = p\right] = \alpha_U + \beta_U p \\
\mathrm{MTE}(p) &= \mathrm{E}\left[Y_T - Y_U \mid U_D = p\right] = (\alpha_T - \alpha_U) + (\beta_T - \beta_U)\, p.
\end{aligned}
$$

MTE-Reweighting from Oregon to Massachusetts Can Reconcile LATEs

Integrate the weighted MTE, MTO and MUO functions over a general range of enrollment margin $p_L < U_D \leq p_H$

$$\mathrm{E}\left[Y_T \mid p_L < U_D \leq p_H\right] = \int_0^1 \omega(p, p_L, p_H)\mathrm{MTO}(p)\,\mathrm{d}p$$

$$\mathrm{E}\left[Y_U \mid p_L < U_D \leq p_H\right] = \int_0^1 \omega(p, p_L, p_H)\mathrm{MUO}(p)\,\mathrm{d}p$$

$$\mathrm{E}\left[Y_T - Y_U \mid p_L < U_D \leq p_H\right] = \int_0^1 \omega(p, p_L, p_H)\mathrm{MTE}(p)\,\mathrm{d}p.$$

using weights $\omega(p, p_L, p_H) = 1\{p_L < p \leq p_H\}/(p_H - p_L)$

First Stage:

$$
\begin{aligned}
&V = V_U + (V_T - V_U)D \\
&V_T - V_U = \mu_D(Z, X) - \nu_D \qquad\qquad U_D = F(\nu_D \mid X),\, U_D \sim U[0,1] \\
&D = 1\{0 \leq V_T - V_U\} \\
\Rightarrow &D = 1\{U_D \leq P(D = 1 \mid Z = z, X)\} \\
&Z = 0: \quad D = 1\{U_D \leq p_{CX}\}, \quad p_{CX} = P(D = 1 \mid Z = 0, X) \\
&Z = 1: \quad D = 1\{U_D \leq p_{IX}\}, \quad p_{IX} = P(D = 1 \mid Z = 1, X)
\end{aligned}
$$

Second Stage with Shape Restriction:

$$
\begin{aligned}
&Y = Y_U + (Y_T - Y_U)D \\
&Y_T = \delta_T' X + \lambda_T U_D + \xi_T \\
&Y_U = \delta_U' X + \lambda_U U_D + \xi_U \qquad\qquad Z \perp (\gamma_T, \gamma_U) \text{ by A.2.}
\end{aligned}
$$

Ancillary Assumption - Linearity of MTO(x,p), MUO(x,p) in p:

AA.2. $\mathrm{MTO}(x,p) = \mathrm{E}[Y_T \mid X = x, U_D = p] = \delta_T' x + \lambda_T p$

AA.3. $\mathrm{MTO}(x,p) = \mathrm{E}[Y_T \mid X = x, U_D = p] = \delta_T' x + \lambda_T p$

$\mathrm{MTO}(x,p) = \mathrm{E}[Y_T - Y_U \mid X = x, U_D = p] = (\delta_T' - \delta_T')x + (\lambda_T - \lambda_U)p$

Subgroup Analysis of Common Observables with LATE and MTE(p)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	Age $\geq$ median[a]	Age $<$ median[a]	Female	Male	English	Non-English
Oregon Health Insurance Experiment of 2008							
LATE	0.27	0.14	0.44	0.14	0.39	0.30	-0.15
	(0.15)	(0.18)	(0.25)	(0.21)	(0.21)	(0.16)	(0.34)
p_C	0.15	0.13	0.17	0.20	0.10	0.15	0.16
	(0.003)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.01)
p_I	0.41	0.43	0.39	0.43	0.38	0.41	0.38
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
MTE intercept	0.64	0.98	0.31	0.48	0.92	0.72	0.14
	(0.24)	(0.28)	(0.39)	(0.32)	(0.33)	(0.25)	(0.47)
MTE slope	-1.32	-3.01	0.48	-1.06	-2.20	-1.51	-1.07
	(0.88)	(1.04)	(1.49)	(1.08)	(1.40)	(0.92)	(2.07)
p^*	0.48	0.33	-0.63	0.45	0.42	0.48	0.13
	(2.84)	(0.85)	(10.37)	(1.49)	(3.47)	(4.53)	(11.99)
N	19,622	9,816	9,806	10,932	8,690	17,871	1,751

Subgroup Analysis of Common Observables with LATE and MTE(p)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	Age $\geq$ median[a]	Age $<$ median[a]	Female	Male	English	Non-English
Massachusetts Health Reform of 2006							
p_C	0.90	0.93	0.87	0.92	0.87	0.91	0.55
	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.02)
p_I	0.95	0.96	0.93	0.96	0.93	0.96	0.74
	(0.002)	(0.002)	(0.004)	(0.002)	(0.004)	(0.002)	(0.02)
N	62,456	40,492	21,964	38,808	23,648	59,233	3,223

Reconciling Seemingly Contradictory Results from Oregon and Massachusetts

- Build on selection/moral hazard in insurance
  - Einav, Finkelstein, and Cullen (2010)
  - Hackmann, Kolstad, and Kowalski (2015)
- Build on MTE and LATE
  - Bjorklund and Moffitt (1987)
  - Imbens and Angrist (1994)
  - Heckman and Vytlacil (1999, 2005, 2007)
  - Vytlacil (2002)
  - Brinch, Mogstad, Wiswall (2015)