

The Impact of Cancer Screening on Detection: Evidence from Canadian and U.S. Screening Guidelines

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May 13, 2009

Overview

- Medical treatment guidelines codify “best practices” and aid physicians and patients in choosing the optimal medical treatment
- Optimal age(s) to screen asymptomatic individuals depends on the balance of costs and benefits (current debate over PSA screening)
 - Morbidity and mortality benefits
 - Direct screening, false positives, and treatment costs
- RCTs and observational studies are complementary
 - Sensitivity/specificity vs. impact of guidelines
 - Internal vs. external validity

Research Question

- What is the impact of cancer screening on detection?
 - In an observational study, individuals or groups with higher expected incidence are more likely to be screened
 - We need exogenous (unconfounded) variation in screening rates
 - Use changes in screening rates at ages that clinical guidelines recommend initiating screening
- Research project encompasses breast, colorectal and prostate cancers

Methodology

- Regression Discontinuity Design
 - Exploit the sharp discontinuity in screening rates at the recommended initiation age
 - Compares incidence for age groups on either side of this threshold
- Assumes:
 - Individuals can't manipulate their age to be falsely "eligible" for screening
 - Smoothness in the covariates across the cutoff
 - Smoothness in the outcomes, in the absence of treatment
- Estimate of causal treatment effect =
$$\frac{[\lim_{x \downarrow c} E(Y|X=x) - \lim_{x \uparrow c} E(Y|X=x)]}{[\lim_{x \downarrow c} E(S|X=x) - \lim_{x \uparrow c} E(S|X=x)]}$$
- Typical RD issue of statistical power

Methodology

- Step 1: Do screening rates differ on either side of the initiation age?
 - “Compliance” with screening guidelines
 - Provides “as good as random” variation in screening at the age threshold
- Step 2: What is the impact of screening on incidence at this age threshold?
 - Informative with respect to optimal screening ages and cost-benefit analyses of different screening policies

Breast Cancer Screening Guidelines

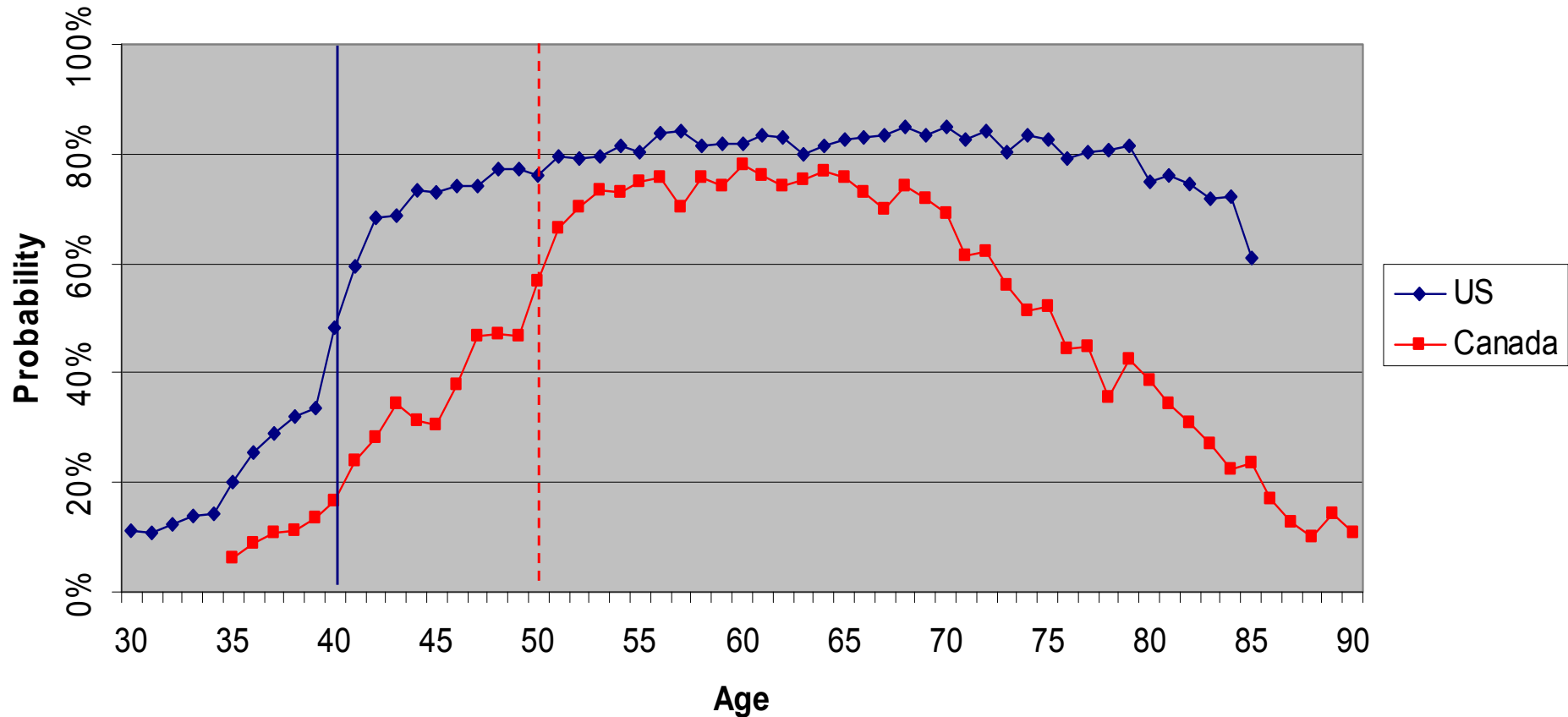
Asymptomatic Women

- Canada
 - Age 50-69: Mammography, 1-2 years
- U.S.
 - Age 40+: Mammography 1-2 years
- In general, screening guidelines
 - Are based on evidence from clinical trials
 - Describe some/all: test, start age, periodicity, end age
 - Are rated (i.e., A to D) depending on the strength of the clinical evidence

Cancer Screening Data

- Nationally-representative population surveys (individual-level data)
 - Canadian Community Health Survey (CCHS), 2001 - 2005
 - U.S. Behavioral Risk Factor Surveillance System (BRFSS) 2000 - 2006
 - U.S. National Health Interview Survey (NHIS) 2000 - 2005

Mammography Probabilities In past 2 years, Women



Regression Analysis

- The first step: is there a discontinuity?
- Logistic regression:

$$\text{Screen in past 2 years} = \alpha + \beta_1 \text{agecutoff} + \dots + \varepsilon$$

- Gender-appropriate subsample, 20 years around age cutoff
- Age, age^2 , age^3 , age^4
- Race (white/non-white)
- Household income quartiles
- Marital status (5 categories)
- Education (4 categories)
- Sex (where applicable)
- Any health insurance (in U.S.)

Mammogram in Last 2 Years

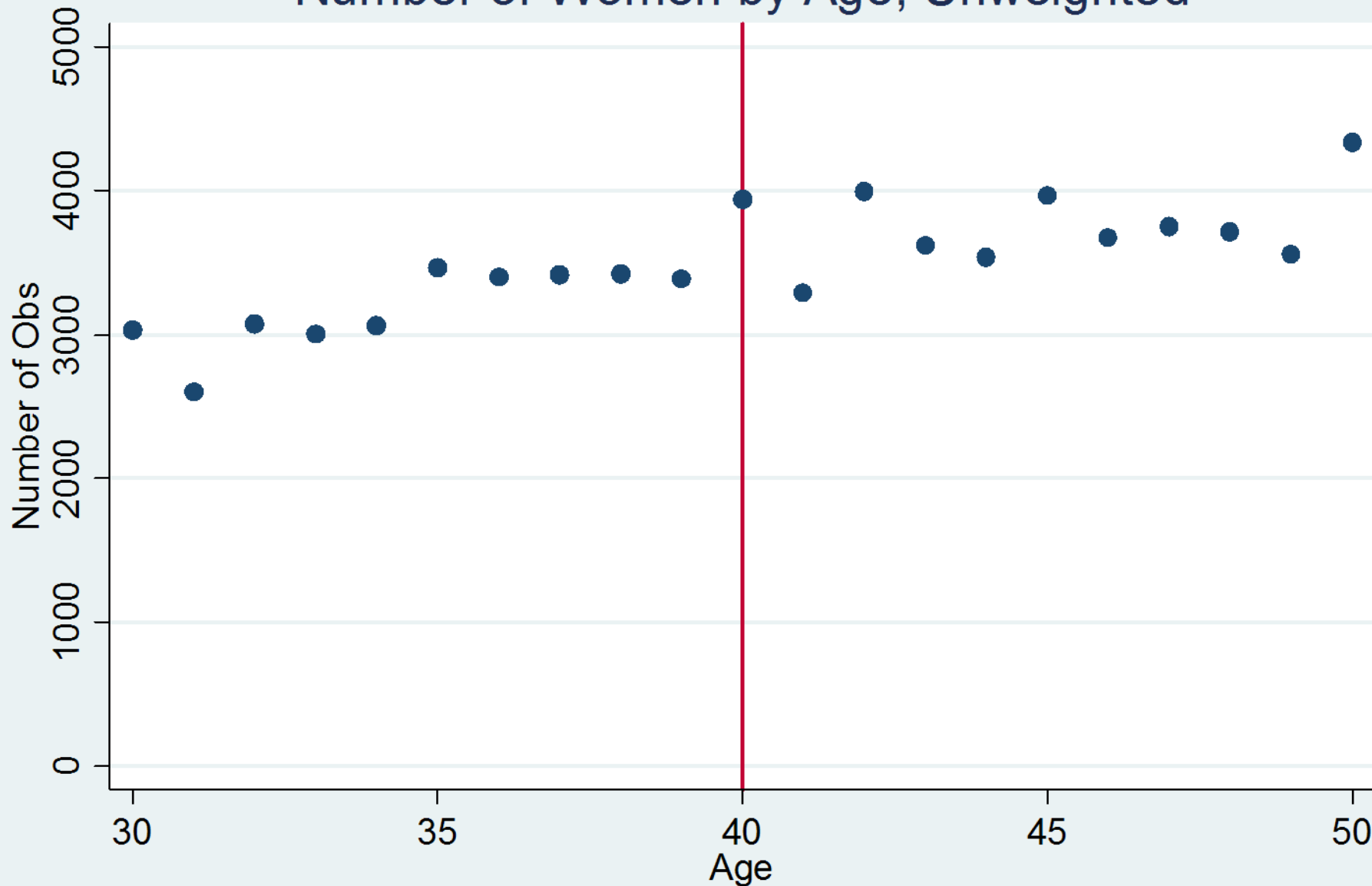
| | OR | Marginal Effect |
|-------------------------|---------|-----------------|
| Canada Age 40-60 | | |
| Age \geq 50 | 1.489** | 9.9% points |
| N | 20,554 | |
| U.S. Age 30-50 | | |
| Age \geq 40 | 1.55*** | 10.7% points |
| N | 78,513 | |

Data: CCHS 2005, BRFSS 2006; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$. Logistic regression. Age trends: age, age², age³. Demographics: white, non-white, household income (4), marital status (5), education (4), any health insurance (U.S.).

Cancer Incidence Data

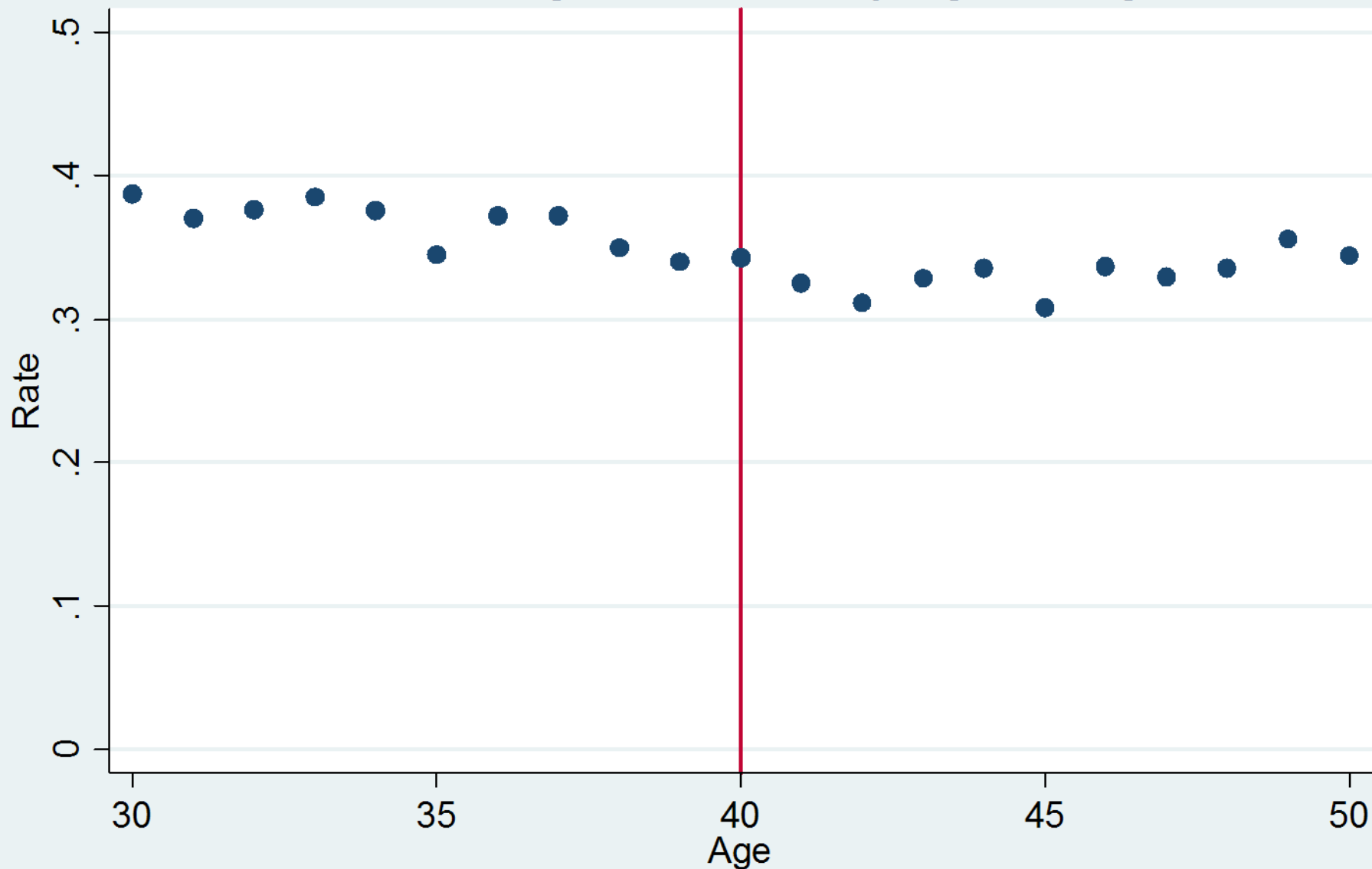
- U.S. Surveillance Epidemiology and End Results (SEER) database
 - Cancer incidence from 25% of the U.S. population (13 states)
 - Nationally representative
 - Detailed information on staging, size of the tumor and other measures of cancer severity
- North American Association of Central Cancer Registries (NAACCR)
 - Incidence data from nearly all state and provincial registries in the U.S. and Canada
- Both provide incidence by year of age

Number of Women by Age, Unweighted



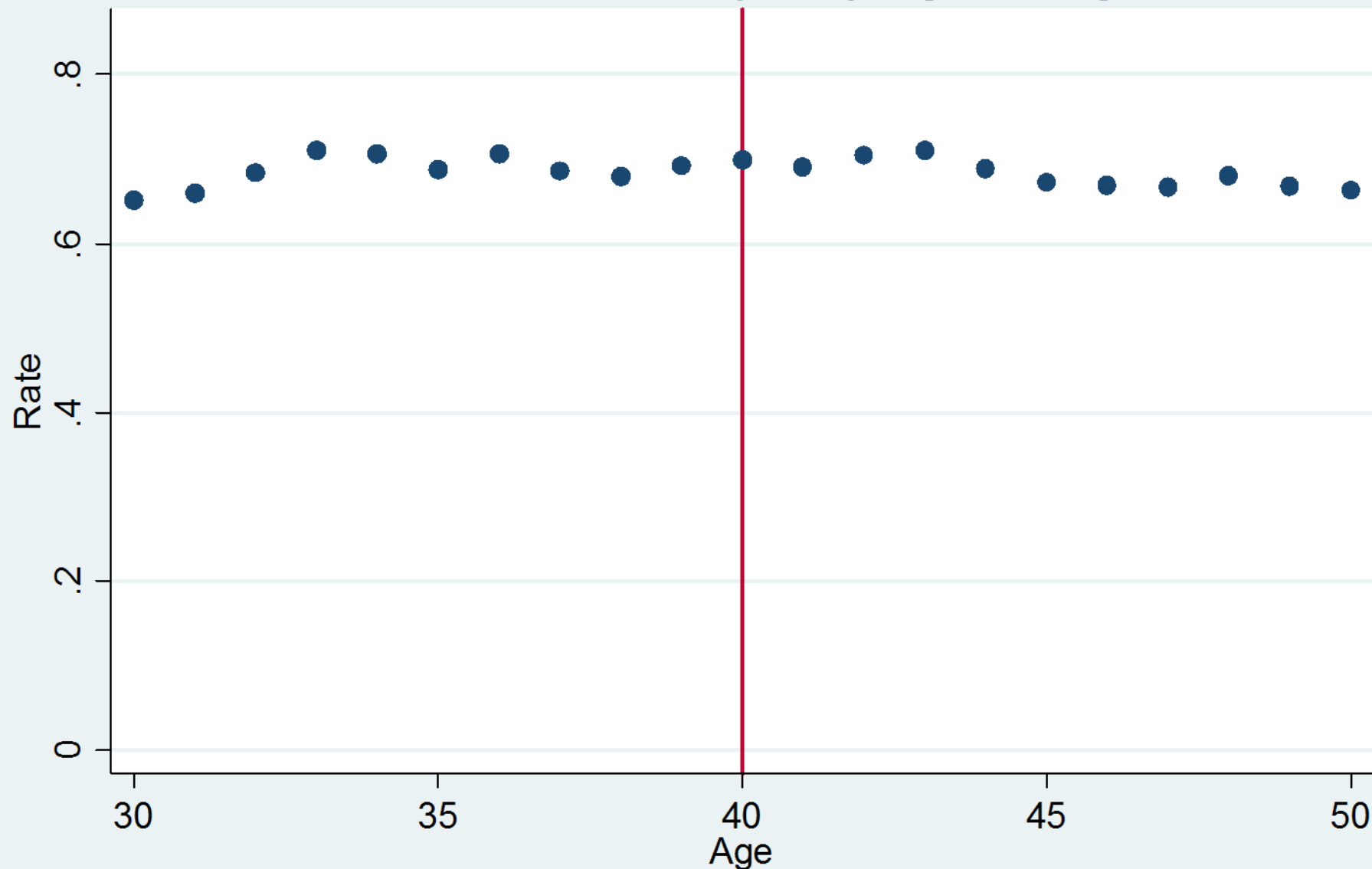
BRFSS 2000, 02, 04, 06; women ages 30-50

Percent College Graduate by Age, Weighted



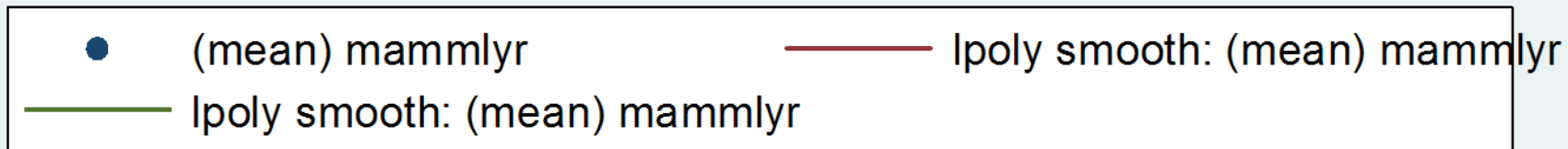
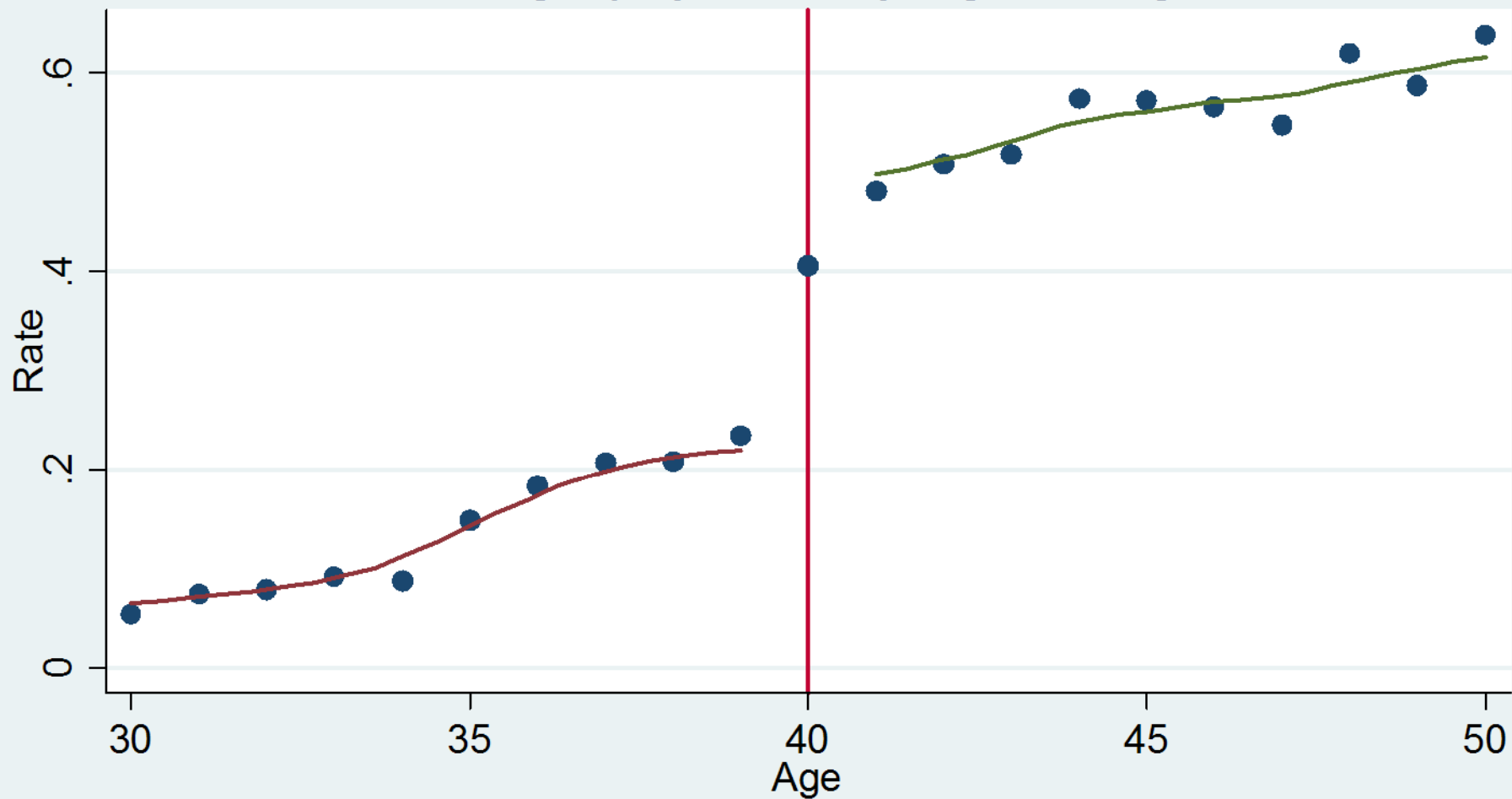
BRFSS 2000, 02, 04, 06; women ages 30-50

Percent Married/Couple by Age, Weighted



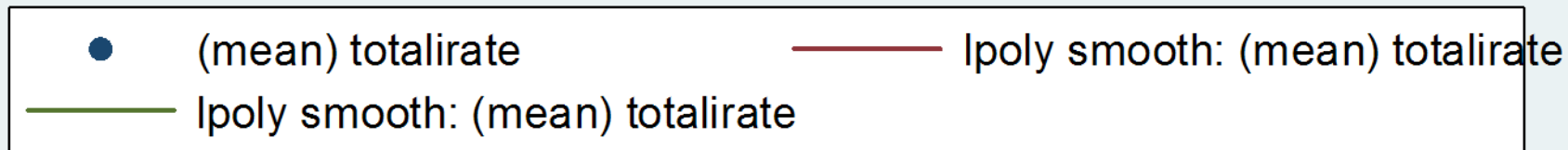
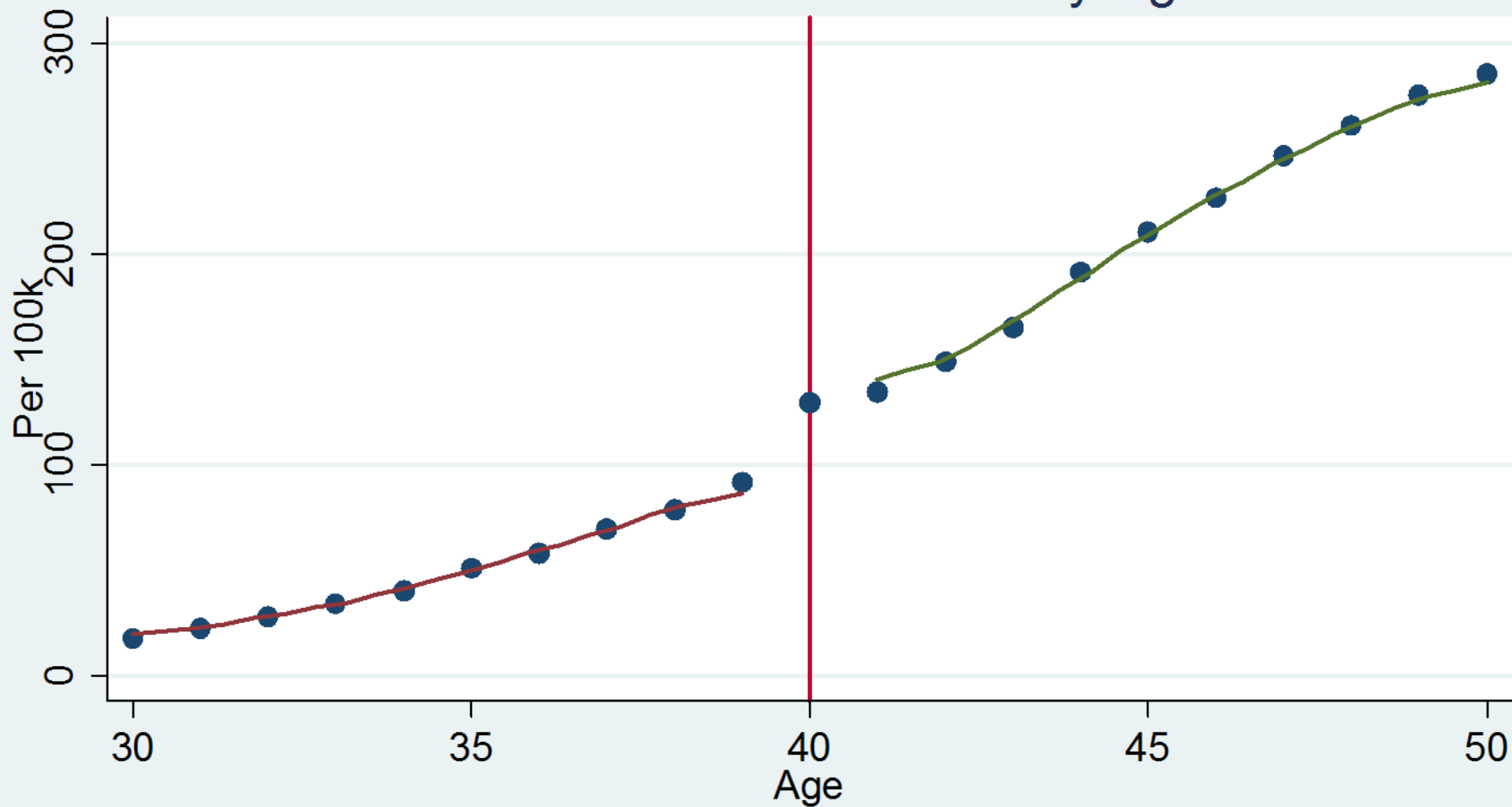
BRFSS 2000, 02, 04, 06; women ages 30-50

Mammography Rate by Age, Weighted



BRFSS 2000, 02, 04, 06; women ages 30-50

Breast Cancer Incidence by Age



SEER 2000-06, 15 states; women ages 30-50

Regression Analysis

- Local linear regression

$$Y = \alpha + \beta_1 D + \beta_2 (X-c) + \beta_3 D^*(X-c) + \dots + \varepsilon$$

– Controls for age, age², age³, education, income, marital status, health insurance

- Wald estimate

$$(\Delta \text{Incidence} \mid X=c) / (\Delta \text{Screen} \mid X=c)$$

– Same controls

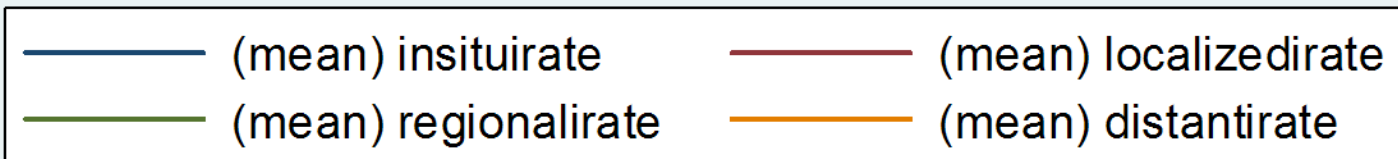
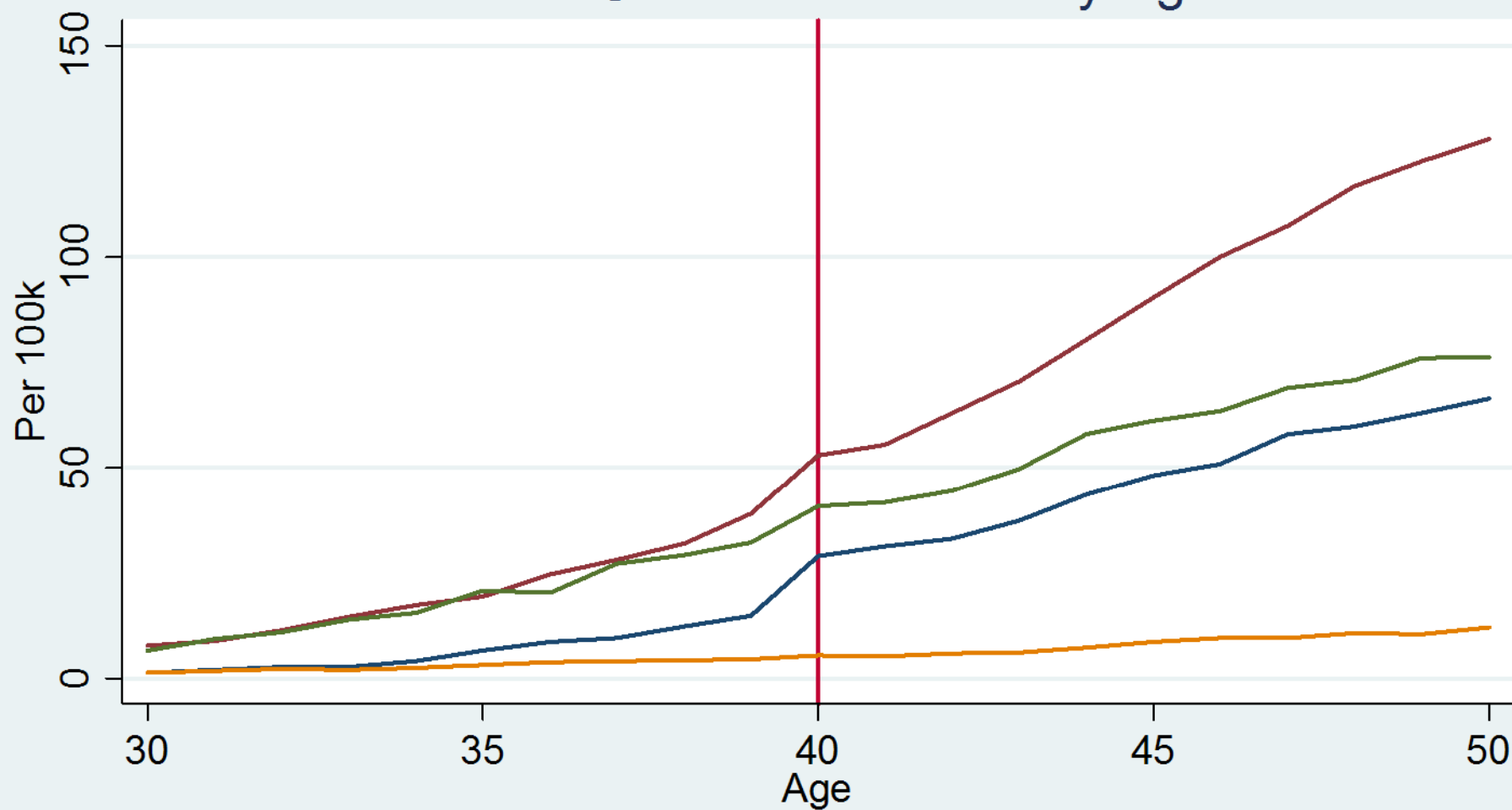
– Estimates change in incidence driven by the change in screening at the cutoff

Impact of Screening on Breast Cancer Incidence

| Ages 35-44 | | |
|------------------------------------------------|-----------------|--------------|
| Data merged | National | State |
| | | |
| Mammogram in last year | 14.05*** | 14.61*** |
| Incident BC per 100,000 | 23.6*** | 22.2** |
| Incident BC per 1% point increase in screening | 1.68*** | 1.52** |
| N | 70 | 831 |

* p<=.05, ** p<=.01, *** p<=.001; Data: U.S. BRFSS and SEER 2000-2006; Controls: age, age², age³, income quartiles, education (4), marital status (5), any HI. Regressions are local linear (first & second stage) and IV.

Breast Cancer Incidence by Age



SEER 2000-06, 15 states; women ages 30-50

Costs of Detection

- Direct breast cancer screening costs
 - 1% increase in screening at age 40 detects an additional ~ 1.6 cases of breast cancer per 100,000 individuals
 - A screening mammogram costs approximately \$100*
 - 1% increase in screening = 1000 individuals
- It costs approximately \$100,000 in direct screening to detect 1.6 cases of breast cancer
 - \$62,500 to detect 1 case