# PoliSci 4782 Political Analysis II

## Model Dependence

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# Questions about Model Dependence

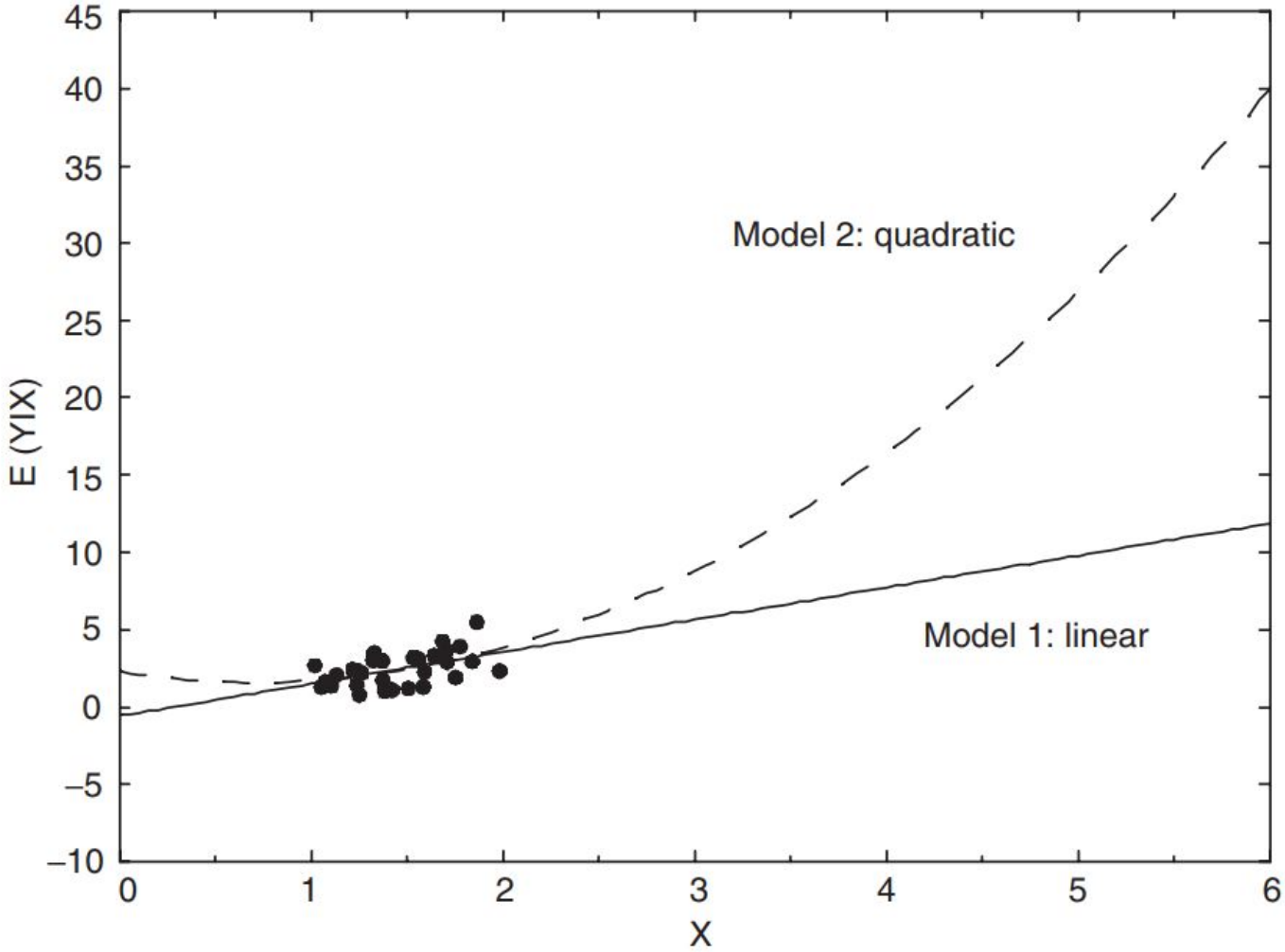
Model dependence: small changes in model $\rightsquigarrow$ substantial change in result

- What causes model dependence?
- Why is model dependence bad?
- How can we correct model dependence (by matching)?

References:


- King G, Zeng L. When can history be our guide? The pitfalls of counterfactual inference. *International Studies Quarterly*. 2007, 51(1): 183-210.
- Ho D.E, Imai K, King G, Stuart EA. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*. 2007, 15(3): 199-236.

# Graphic Illustration




Source: King & Zeng (2007). p184

# Distinction between Model-free and Model-based Inference

## Model-free Inference

To estimate $E(Y|X = x_0)$, average many observed Y with value $x_0$ (information is directly provided by data)

## Model-based Inference

To estimate $E(Y|X = x_0)$, fit a model of $E(Y|X)$ to many observed Y with other values of $X$ and then project $E(Y|X = x_0)$

In the latter case, if multiple models fit about equally well but project $E(Y|X = x_0)$ differently, we have model dependence.

# Defining Model Dependence

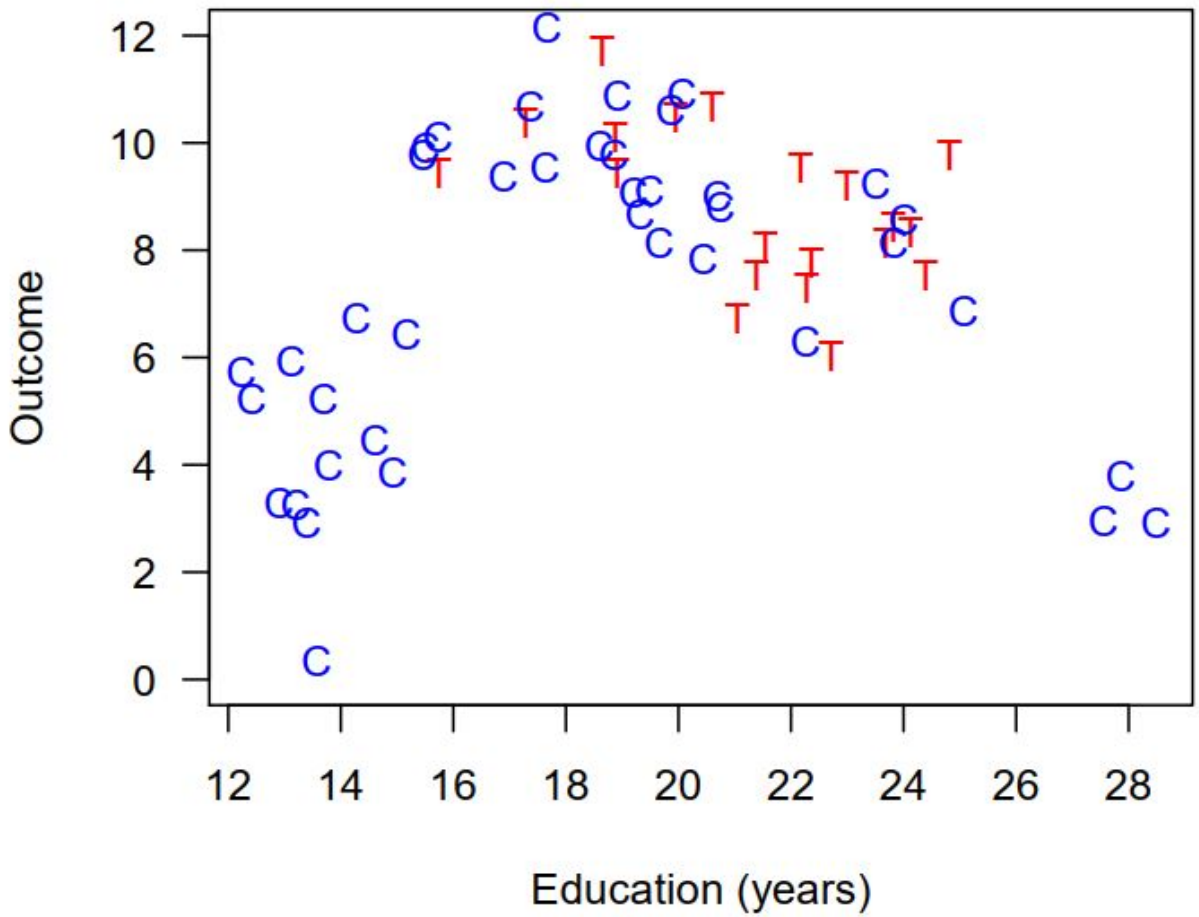
- In the model-based inference, if multiple models fit about equally well but project $E(Y|X = x_0)$ differently, we have model dependence.
- The maximum degree of model dependence is a function of the distance from the projected point (counterfactual) to the data.
- That said, the further we need to extrapolate to estimate the counterfactual, the greater model dependence we have.

# Model Dependence Leads to Bias

Imbalance $\rightsquigarrow$ Model Dependence $\rightsquigarrow$ Researcher Discretion $\rightsquigarrow$ Bias

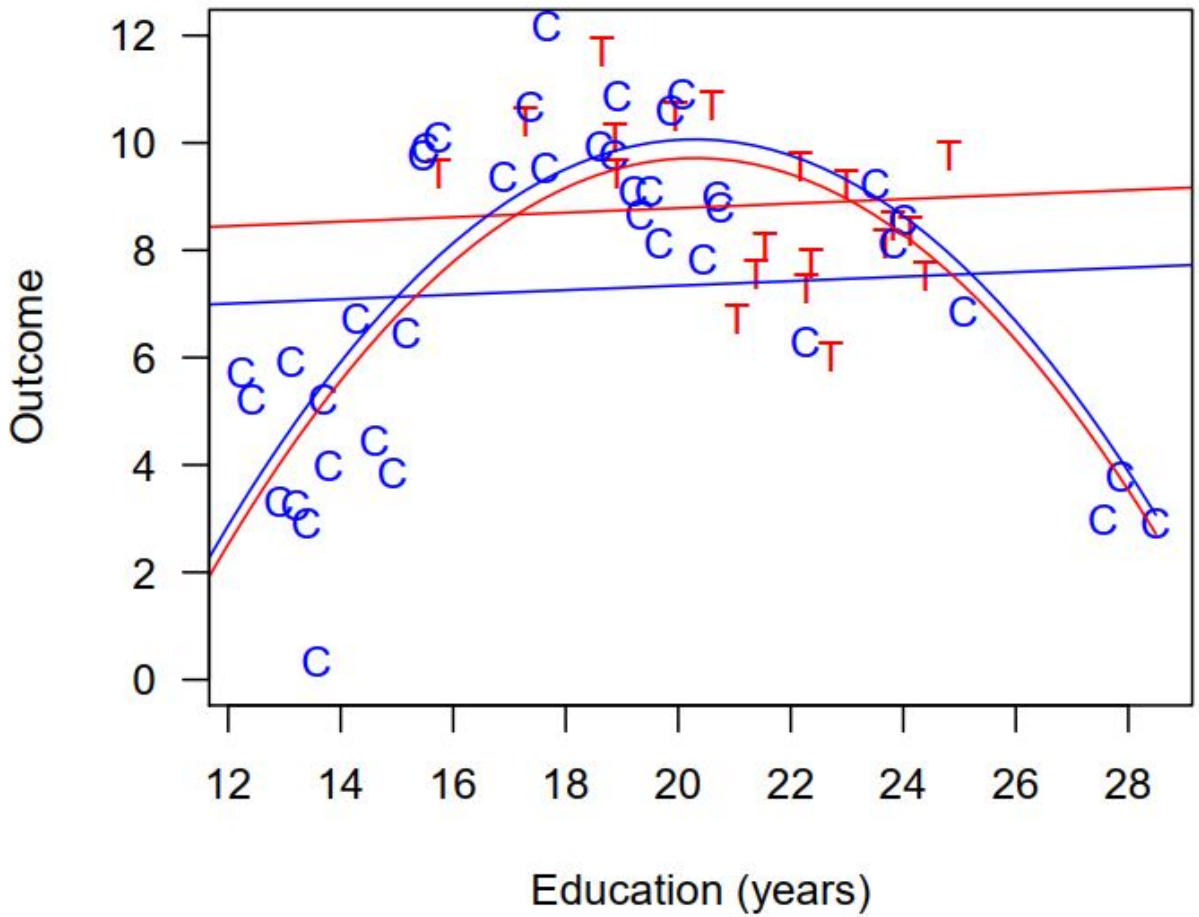
- Now can you explain why treatment imbalance is a source of estimation error in causal inference in last lecture?

# Model Dependence in Causal Inference



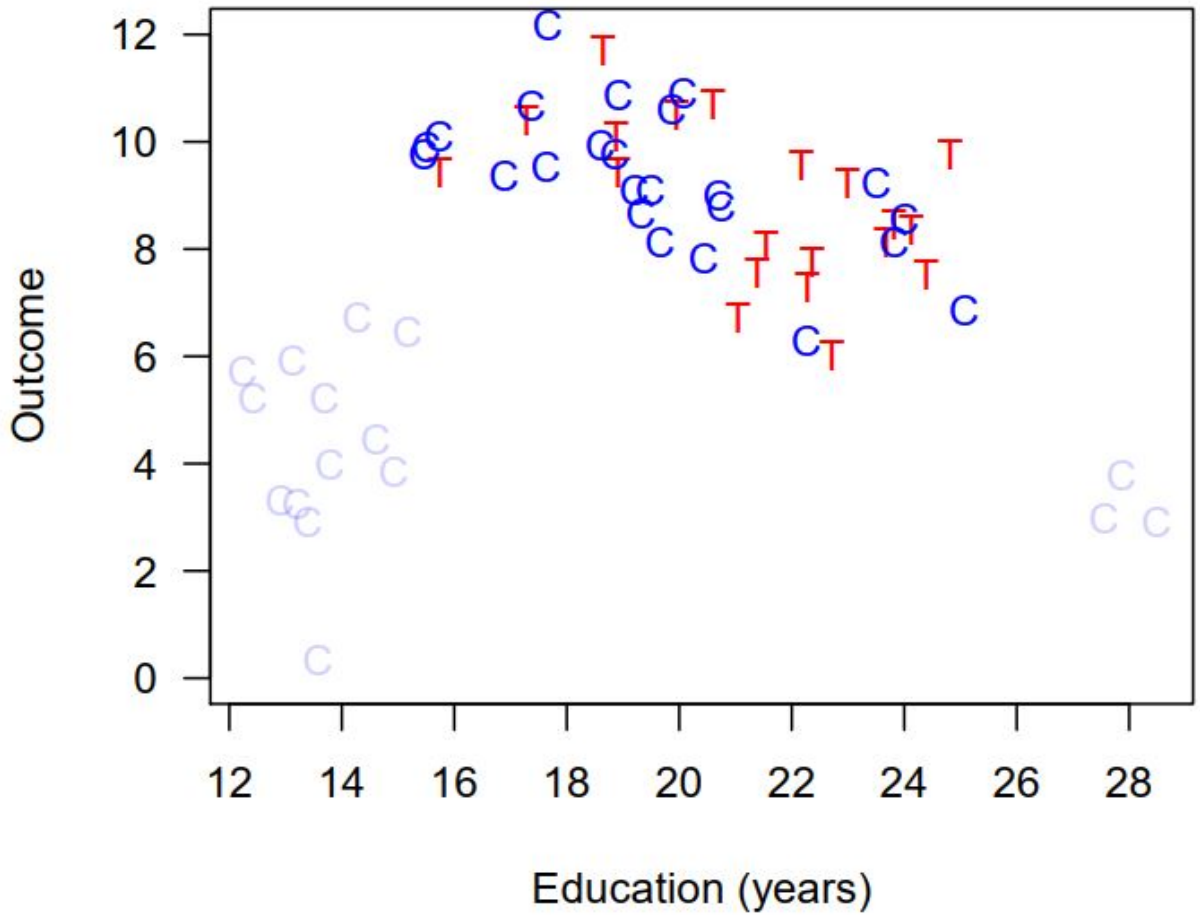

Source: Ho, Imai, King & Stuart (2007)

# Model Dependence in Causal Inference



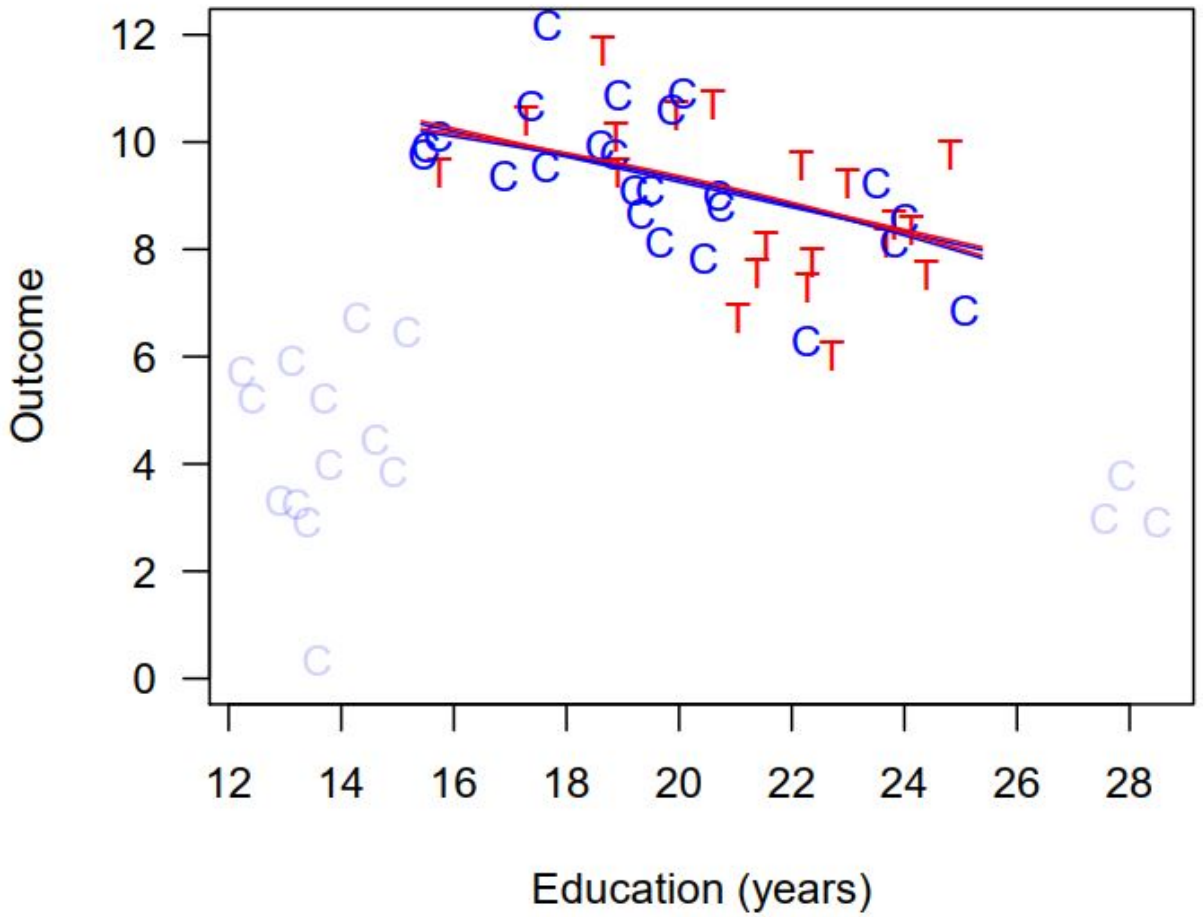

Source: Ho, Imai, King & Stuart (2007)

# What Does Matching (Pruning) Do?




Source: Ho, Imai, King & Stuart (2007)

# How Does Matching (Pruning) Reduce Model Dependence?




Source: Ho, Imai, King & Stuart (2007)

# Matching

The Treat Effect ($TE$) for the treated observation $i$:

$$\begin{aligned} TE_i &= Y_i(T = 1) - Y_i(T = 0) \\ &= \textit{observed} - \textit{unobserved} \end{aligned}$$

Estimate $Y_i(T = 0)$ only with observed $Y_j(T = 0)$ with matched control ($X_i \approx X_j$)

- Without matching, regression models estimate $Y_i(T = 0)$ by $E(Y|T, X)$ using all the data.
- Matching can be inserted to any research design as preprocessing.
- Matching reduce model dependence and makes control variables $X$ in statistical models less important.

# Coming Up

- Matching (techniques to address model dependence and improve causal inferences)