Do higher property values increase fire suppression costs?

Connor Lennon

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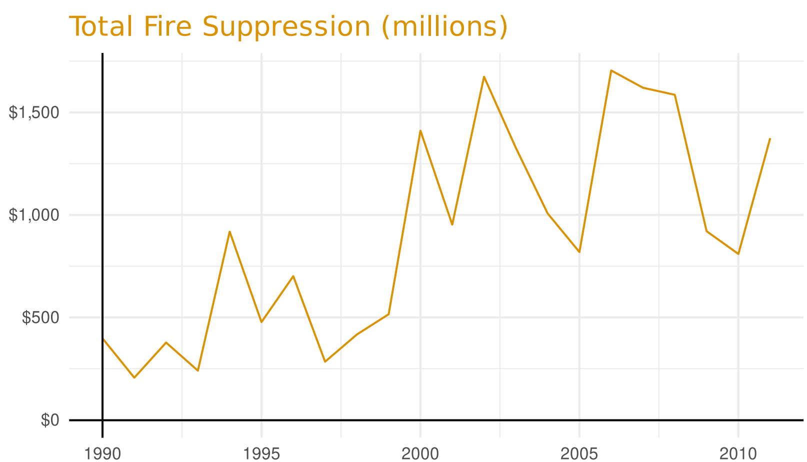
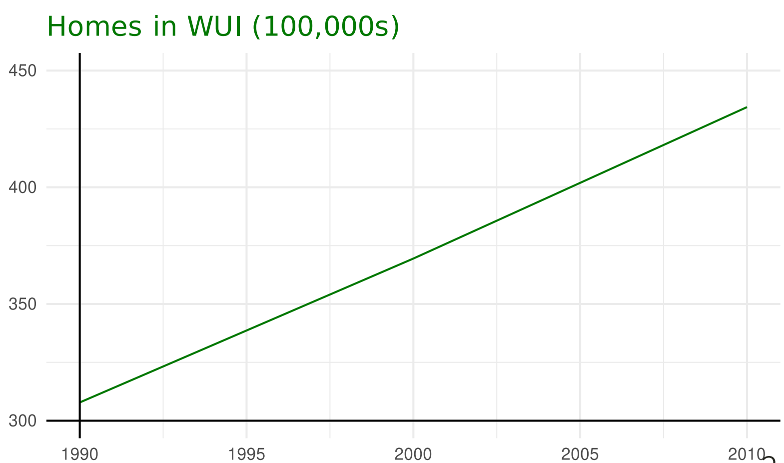
Over the last ten years, the US spent **$21.4 billion** on fire suppression

Increasing number of homes are being built in the **W**ildland **U**rban **I**nterface (**WUI**)



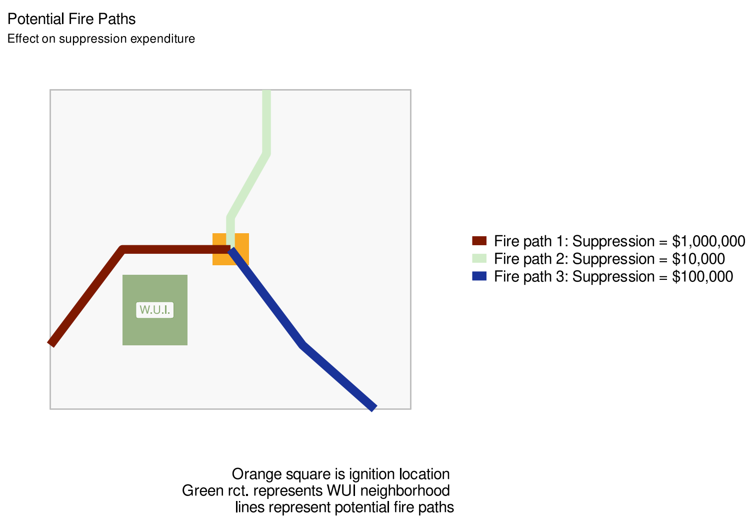


[2] What is **causing** these higher costs?

What causes fires to be **more** or **less** expensive to suppress in the first place?

Major policy concern: association between **property values** and **expense of fire suppression** (observed by existing literature) $\rightarrow$ **regressive!**

Is this association due to a bias towards protecting wealth directly or due to expensive homes being built in places that are expensive to fight fires?



Complication: Dynamic expectations. Which paths a fire could take impact expected costs. Suppression decisions impact actual paths AND costs. Expected paths affect suppression decisions, homes at risk, and costs. **Simultaneity** problem arises if statistically analyzed ex-post, but disappears if examined using ex-ante data.

[3] Outline

Research goal: Decompose the fire manager's problem to identify:

1: Do fire managers preferentially assign more resources to fires near expensive properties?

2: How much of this correlation between fire suppression and property values is due to physical attributes common to expensive properties and higher suppression costs?

Note: Could be a combination of both!

Methods: Double/Debiased Machine Learning

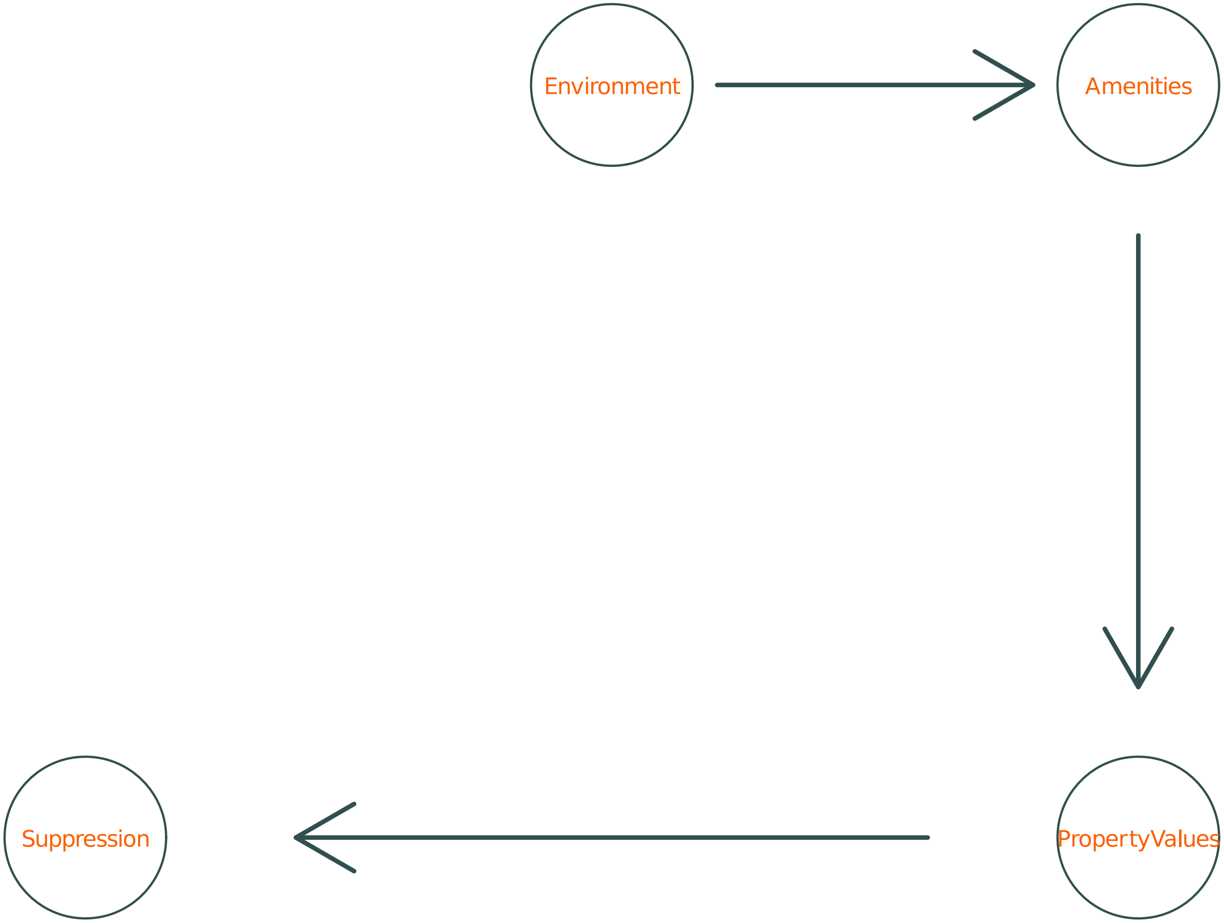
- Uses **C**ompact **C**onvolutional **T**ransformer (**CCT**), to model nonlinear confounders in a regression model (e.g., Slope, Fuels, Canopy Cover, Accessibility ...)
- Produces causal estimates of property value on fire suppression costs, controlling for machine-learned fire risk attributes

[4] Causal System

Research Question

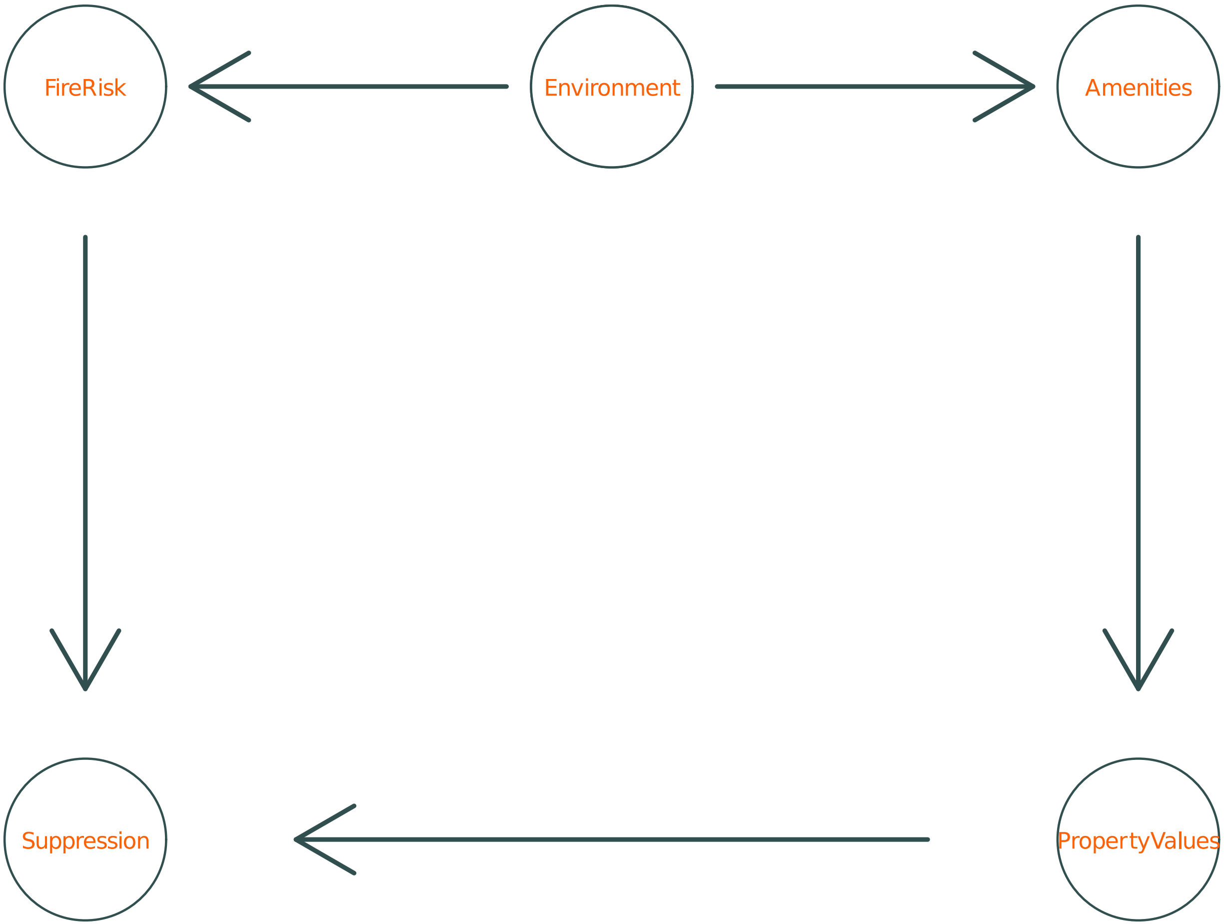
[4] Causal System

Basic Hedonics



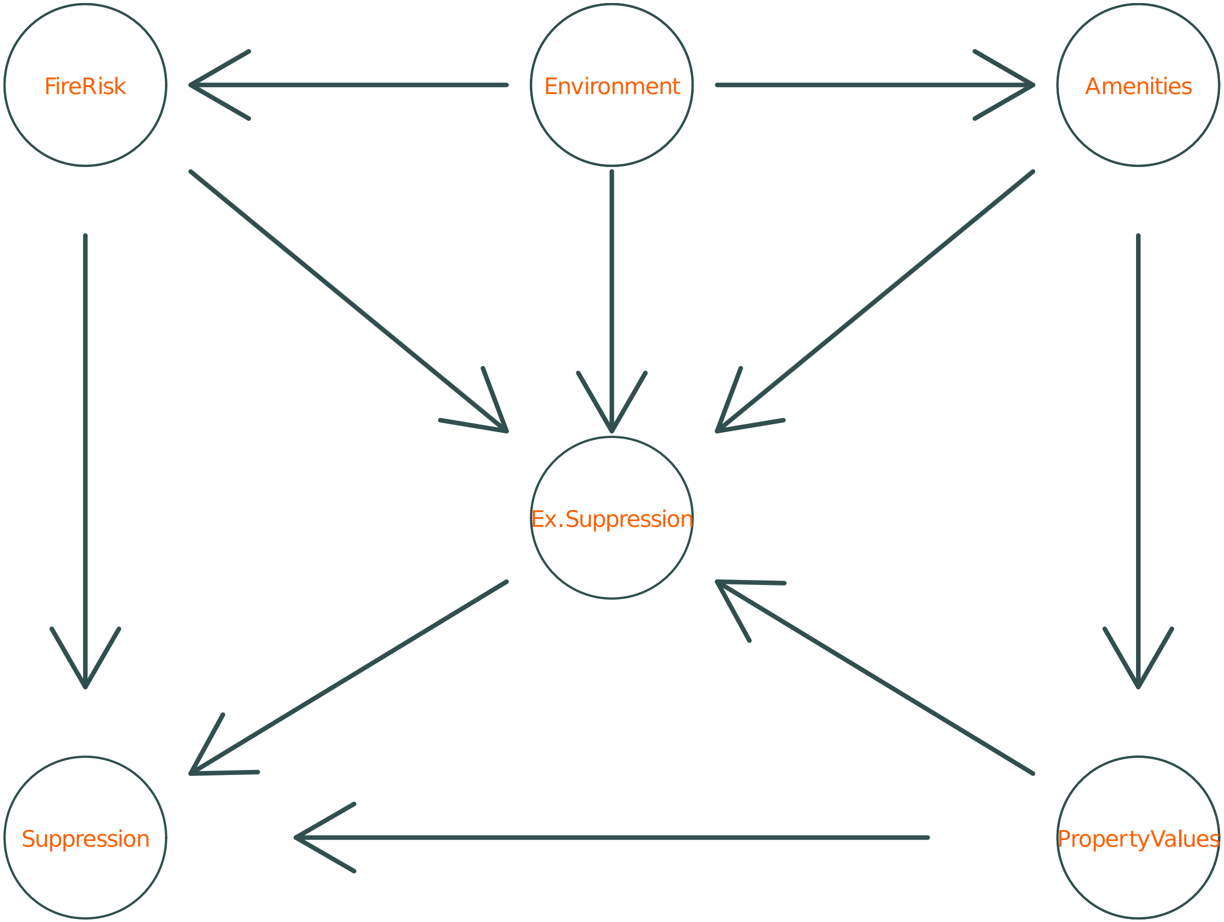
[4] Causal System

Basic Physics



[4] Causal System

Fire Manager's Expectation/Information (Unobserved)



☑ **Goal:** To disentangle physical components of expected fire suppression costs and amenities from a tendency to protect expensive property. Use models of fire spread and risk of damage to assets that fire managers expect to protect in order to identify important control variables - elevation, fuels, water-features, telephone, etc.

D/DML uses out-of-sample estimates from two **CCT** models performing nonlinear regressions of Property Values and Suppression Costs $f(\cdot), g(\cdot)$ respectively, using the control variable set X_i for each. For fire i :

$$log(Suppression\ Costs_i) = \theta log(Property\ Values_i) + g(X_i) + u_i \quad (1)$$

$$log(Property\ Values_i) = f(X_i) + v_i \quad (2)$$

Estimating θ with linear estimators in this system of equations produces estimation error in f in equation (2) that may produce bias. For D/DML estimation to yield valid causal estimates, two assumptions are required:

A₁ u_i and v_i exist, are additively separable from g, f and are unassociated to one another. I.e - unlearnable non-physical factors in property values (eg, interest rates at valuation time) are not associated with non-physical factors in fire-level suppression (eg, changes in wind speed during burn) except via changes in property values.

A₂ $\sum_{i \in N}(\hat{g}(X_i) - g(X_i))(\hat{f}(X_i) - f(X_i))$ converges at rate $\sqrt{N}$, or that either estimation error converges at least at rate $\sqrt[4]{N}$. This assumes the estimation errors of $\hat{f}$ and $\hat{g}$ are not systematically associated or **CCT** is a reasonable estimator for $f \text{ or } g$, and that X_i does not contain any bad controls

Nascent Results

My estimates indicate a smaller effect from property values on suppression costs than existing literature: for a **1% increase in property values**, costs **increase by .038%**. Compares to **reported .11%** increase in Gebert et al. 2007 (SCI) and **a .16% increase** when replicating SCI on data from 2020-2021. This difference is statistically significant.