Do higher property values increase fire suppression costs?

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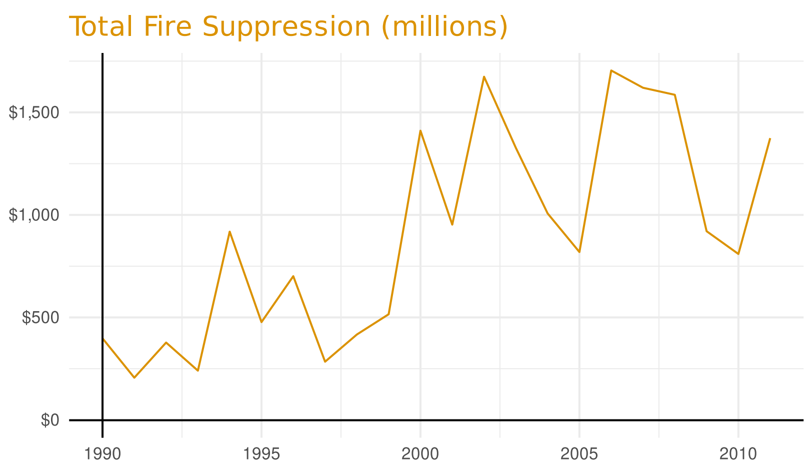
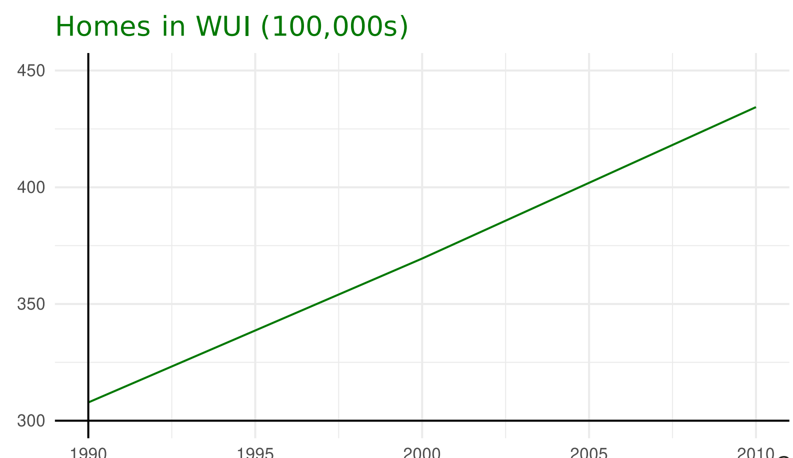
Over the last ten years, the US spent **$21.4 billion** on fire suppression

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



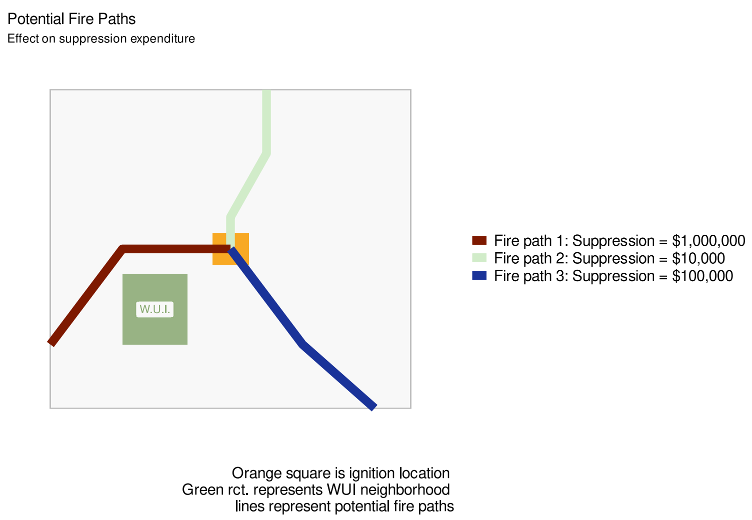


[2] What is **causing** these higher costs?

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:

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

Path 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

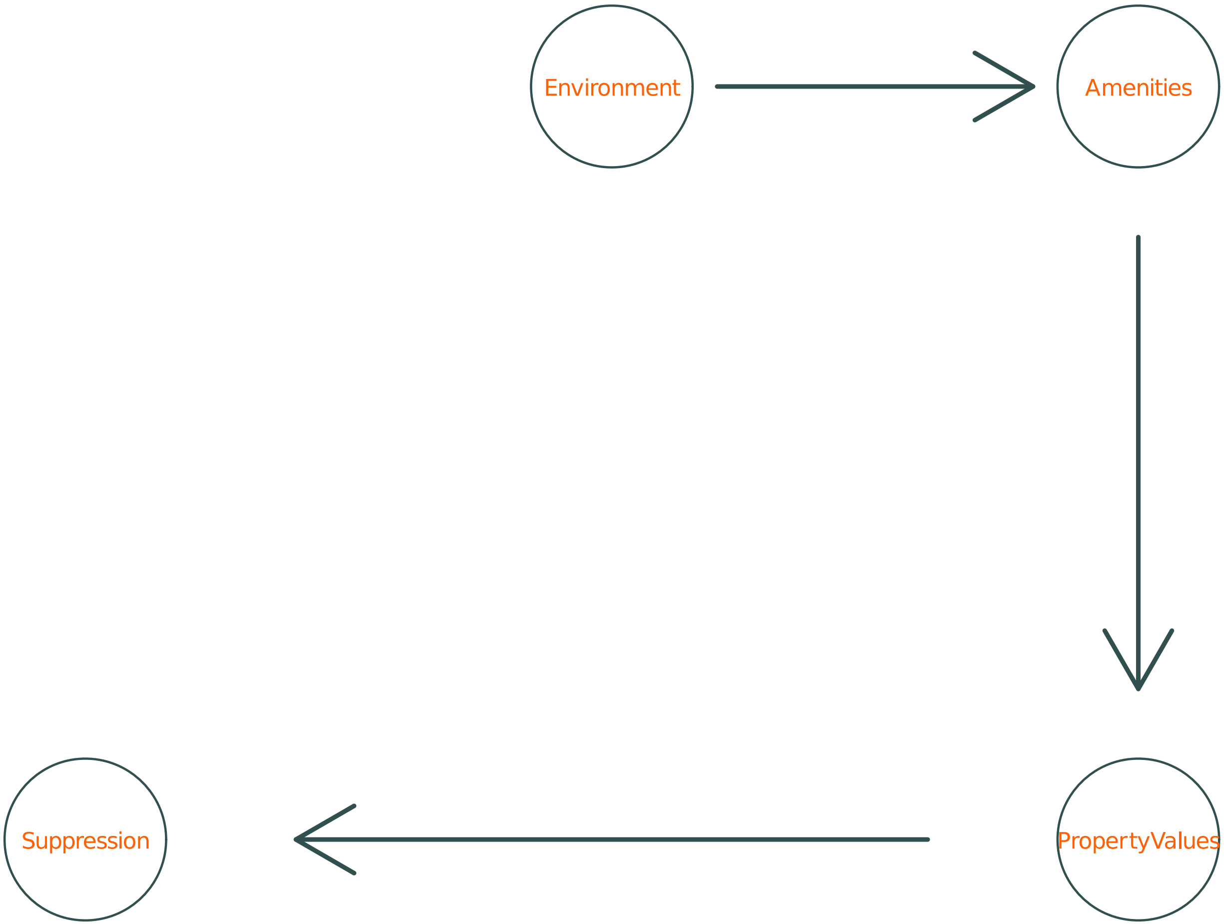
- Uses **C**ompact **C**onvolution **T**ransformer (**CCT**), to model nonlinear confounders in a regression model (e.g., Slope, Fuels, Canopy Cover, Accessibility ...)
- Produces causal estimates of property value on fire suppression costs, controlling for machine-learned fire risk attributes

[4] Causal System

Research Question

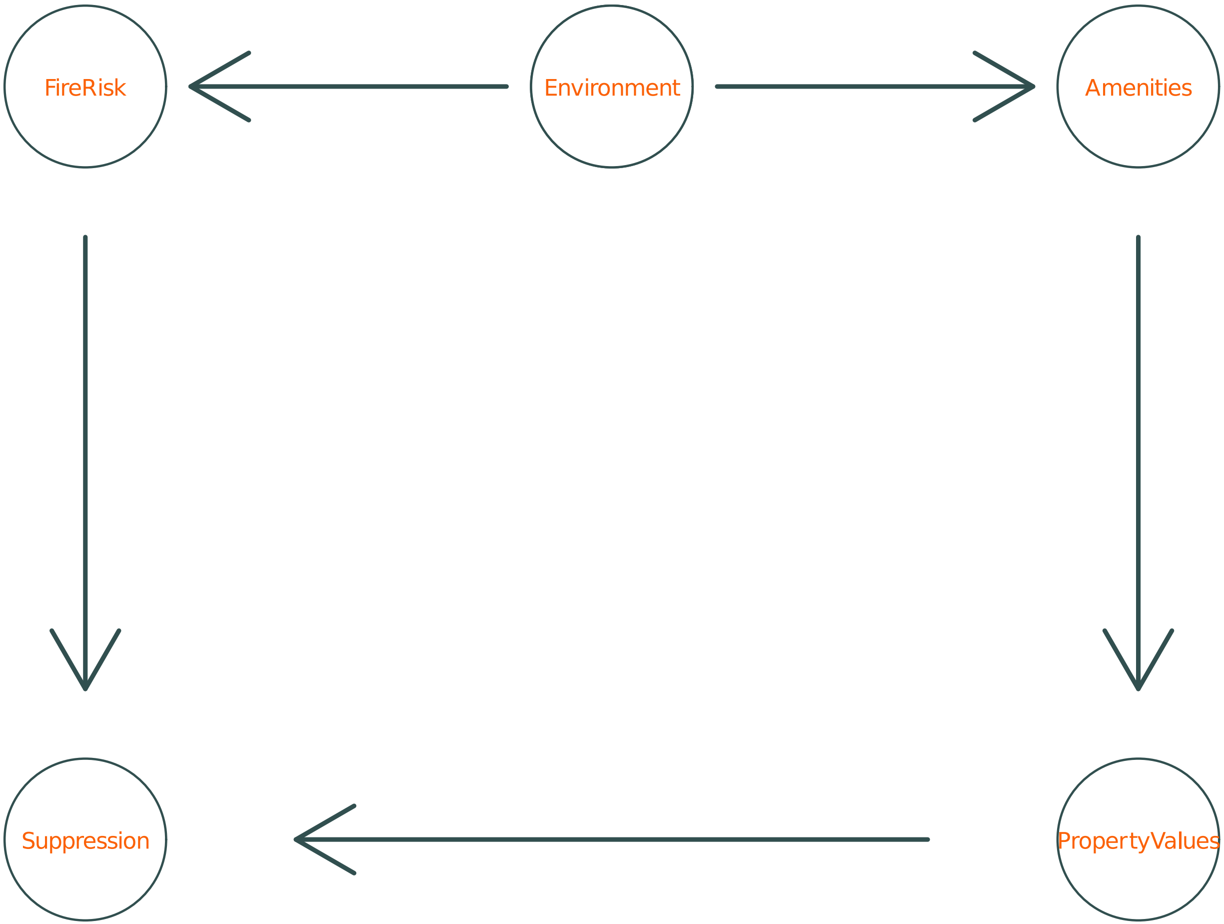
[4] Causal System

Basic Hedonics



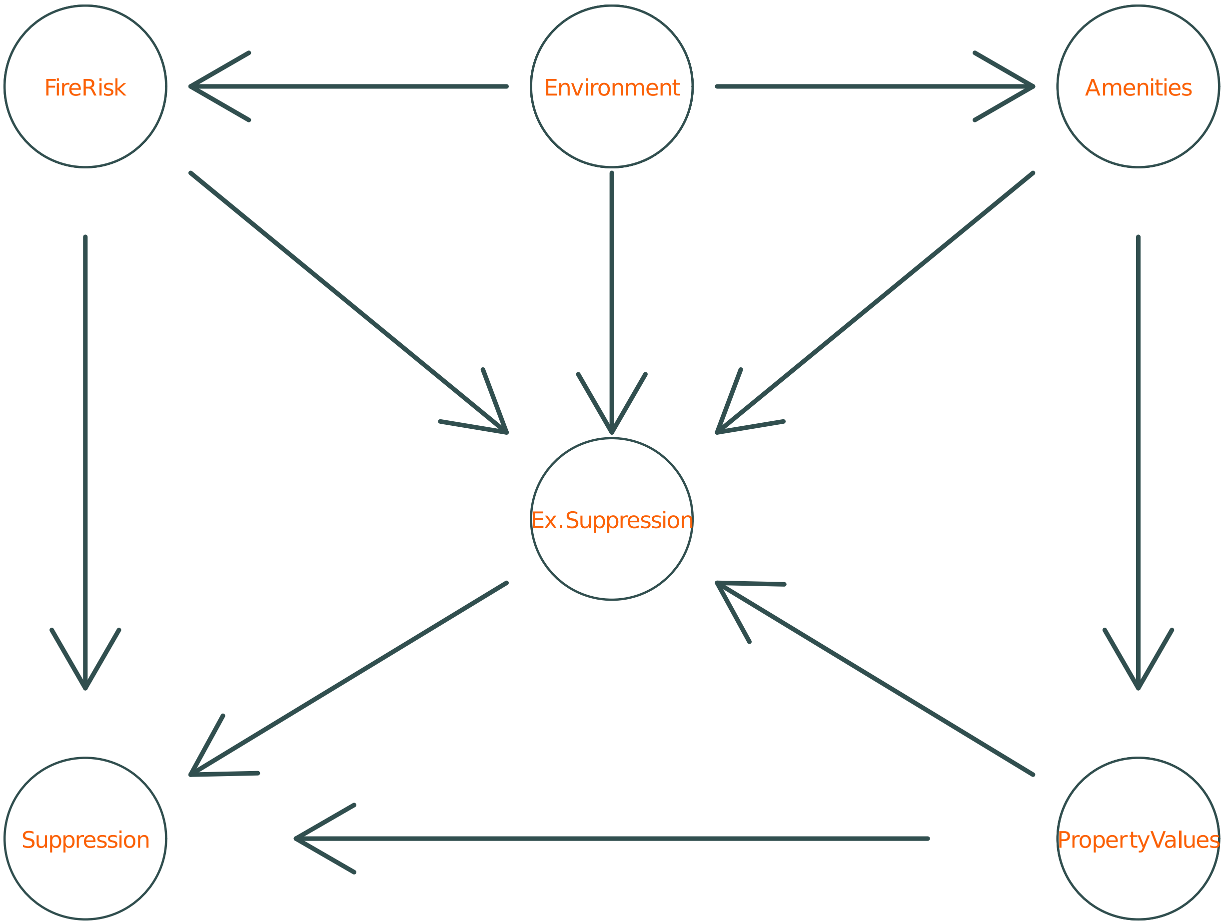
[4] Causal System

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:

A$_1$ 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.

A$_2$ $\sum_{i \in N}(\hat{g}(X_i) - g(X_i))(\hat{f}(X_i) - f(X_i))$ converges in sample size at rate $\sqrt{N}$, or that either estimation error converges at least at rate $\sqrt[4]{N}$. This assumes the estimation errors for f & g are not systematically associated or **CCT** is a reasonable estimator, and that X does not contain any bad controls

[6] Work to do

Presentations - need to work on this. In particular, would like to work on getting a tight 10 minute talk as well as a 20 minute version. Plan to present at economic micro group and metrics group

Drafts - an early draft done by mid November. I hope to circulate this draft to my committee, and have offers to get feedback from Matthew Wibbenmeyer and Margaret Walls. Depending on feedback, third draft, followed by final draft.

Defended April 1st, 2022.

Need to run full model on all 10 folds* (as of now, only applied to one fold, but results have small confidence band, and more iterations should reduce the size of this band)

Potentially repeat procedure for building-assigned income by tract? If of interest.

Likely useful to do some degree of ablation tests for my version of CCT. Others?

*:X Folds: Dataset split into fractions of 1/X, use X-1/X to train, 1/X to predict out of sample

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.