

# Do higher property values increase fire suppression costs?

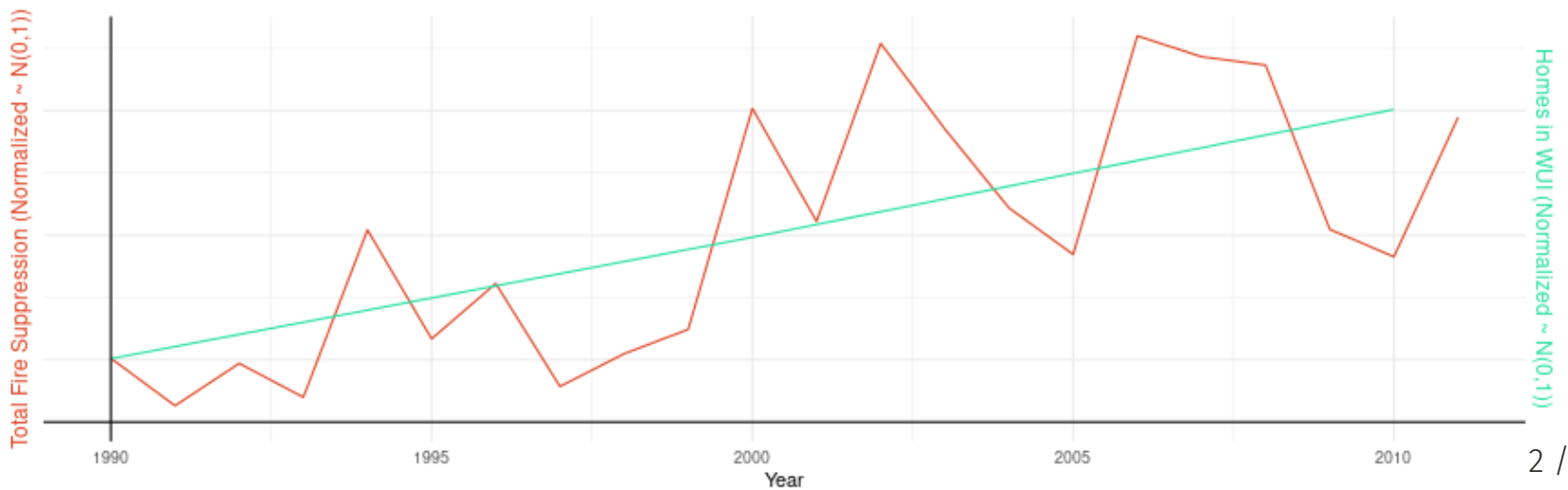
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Over the last ten years, the US spent **\$21.4** billion on fire suppression

Most recent data (1990-2010) shows rising numbers of **WUI** homes



# [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) → **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?

Potential Fire Paths  
Effect on suppression expenditure



## **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:

**H<sub>1</sub>** Do fire managers preferentially assign more resources to fires near expensive properties?

**H<sub>2</sub>** 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 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

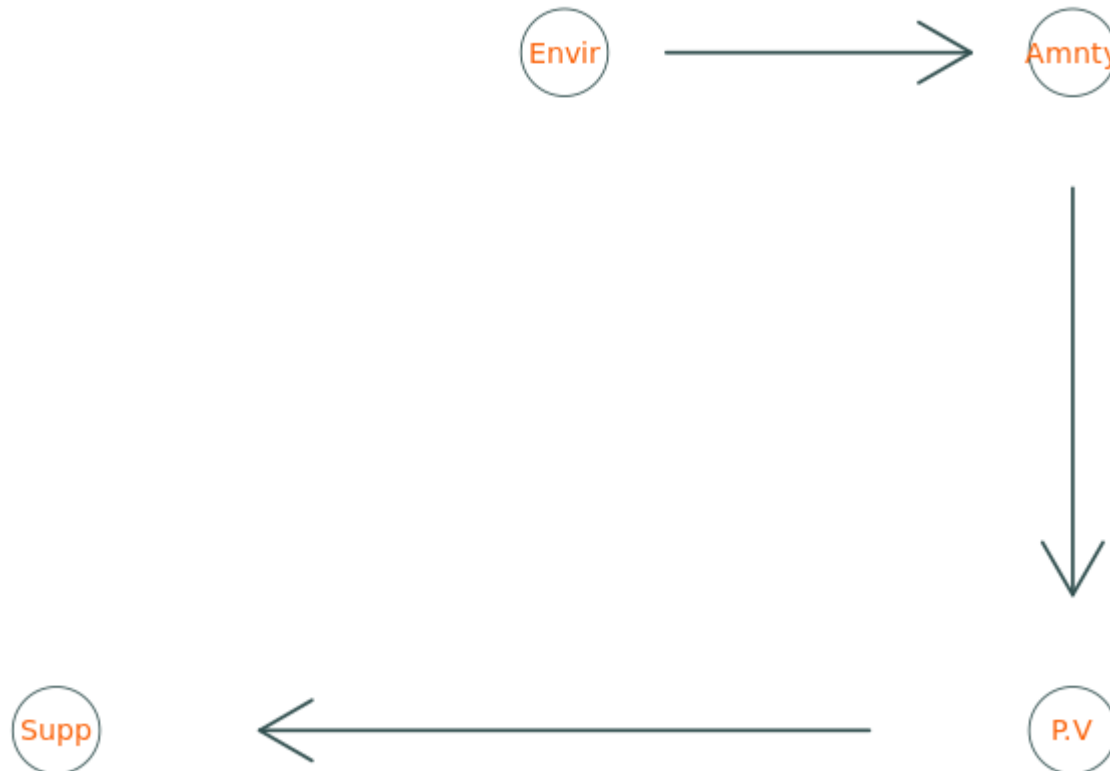
**P.V.**: Property Values | **Supp**: Suppression Costs



# [4] Causal System

## Basic Hedonics

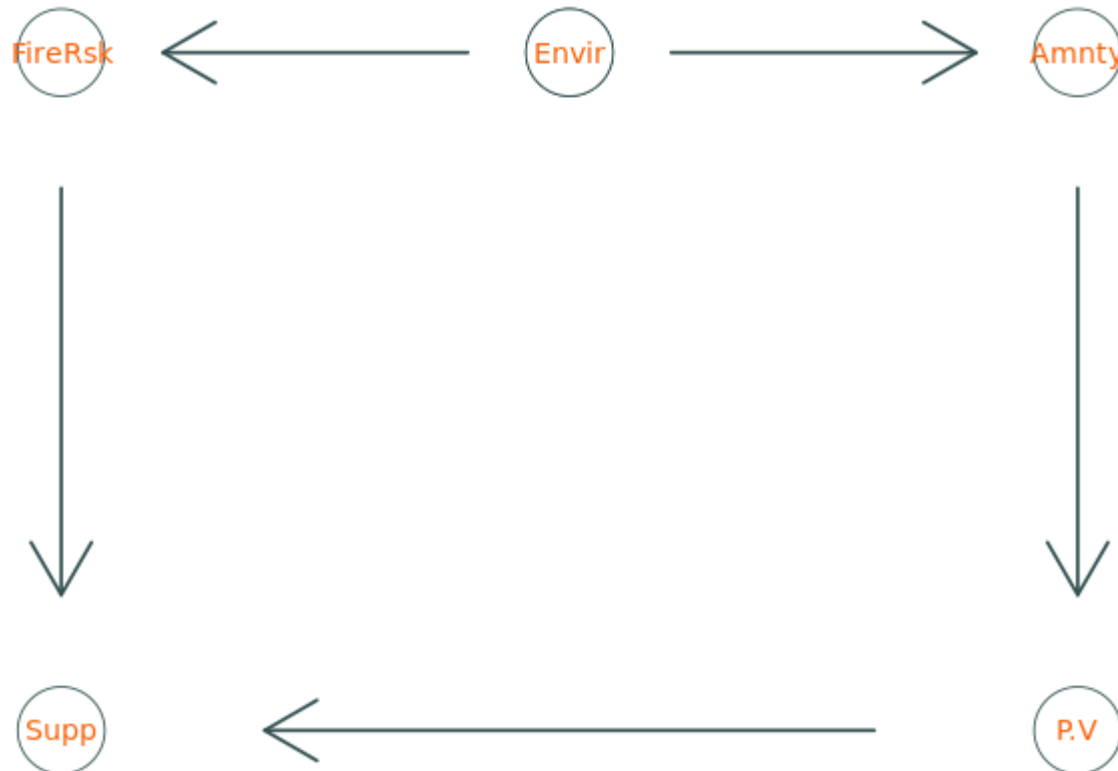
**P.V.**: Property Values | **Supp**: Suppression Costs | **Envir**: Environment | **Amnty**: Amenities |  
**FireRisk** : Fire Risk | **Ex.Supp**: Expected Suppression Costs



# [4] Causal System

## Basic Physics

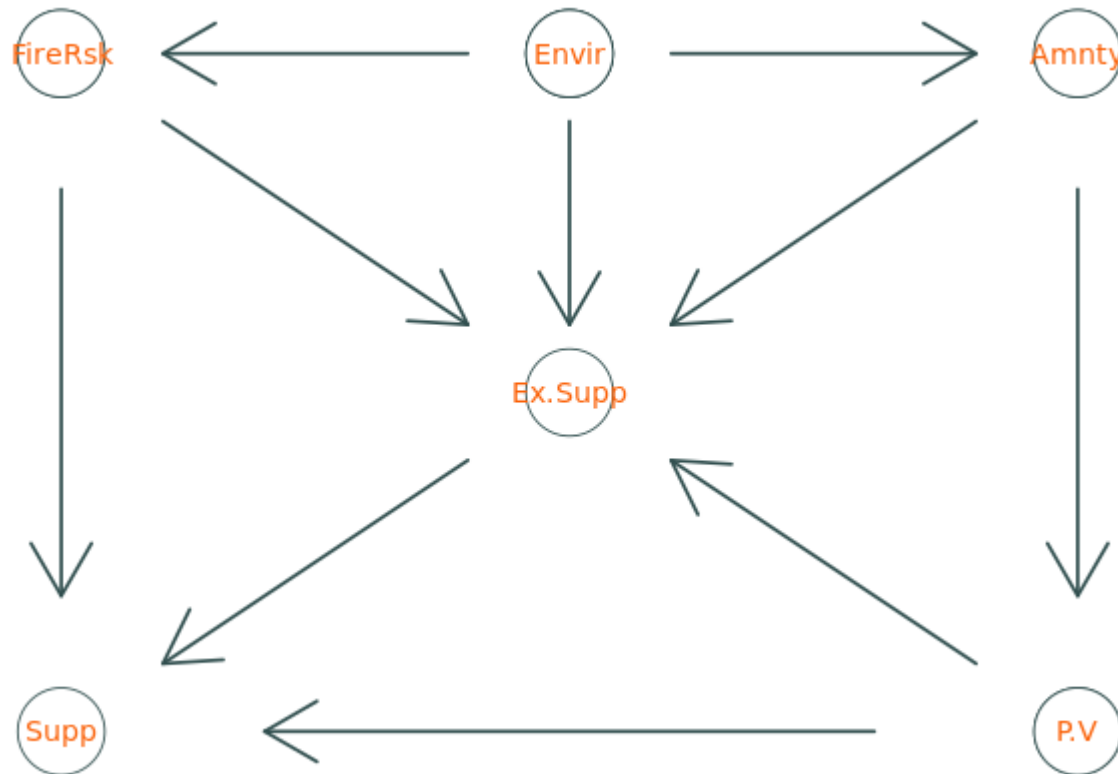
**P.V.**: Property Values | **Supp**: Suppression Costs | **Envir**: Environment | **Amnty**: Amenities |  
**FireRsk** : Fire Risk | **Ex.Supp**: Expected Suppression Costs



# [4] Causal System

## Fire Manager's Expectation/Information

**P.V.**: Property Values | **Supp**: Suppression Costs | **Envir**: Environment | **Amnty**: Amenities |  
**FireRisk** : Fire Risk | **Ex.Supp**: Expected Suppression Costs





✓ **GOAL:** To disentangle physical components of expected fire suppression costs from a tendency to protect expensive property. Use models of fire spread and values at risk to identify control variables - elevation, fuels, water-features, telephone, etc.

**D/DML** uses out-of-sample estimates from **CCT** to estimate the causal effect of property value on suppression, controlling for flexible associations between fire-level per-acre Suppression Expenditure and Environment, Amenities and Fire Risk across two control functions  $f$  &  $g$ . **Assume**  $u, v$  exist & are additively separable from  $g, f$ .

$$\theta \equiv \text{param of interest}, X \equiv \{Rsk, Envr, Amn, Ex. Supp\}$$

$$\log(\text{Suppression Costs}_i) = \theta \log(\text{PropVal}_i) + g(X_i) + u_i \quad (1)$$

$$\log(\text{PropVal}_i) = f(X_i) + v_i \quad (2)$$

Estimating  $\theta$  with functionally rigid modeling tools like OLS can generate bias in this system of equations due to  $f$  in equation (2).

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.

# [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