Do higher property values increase fire suppression costs?

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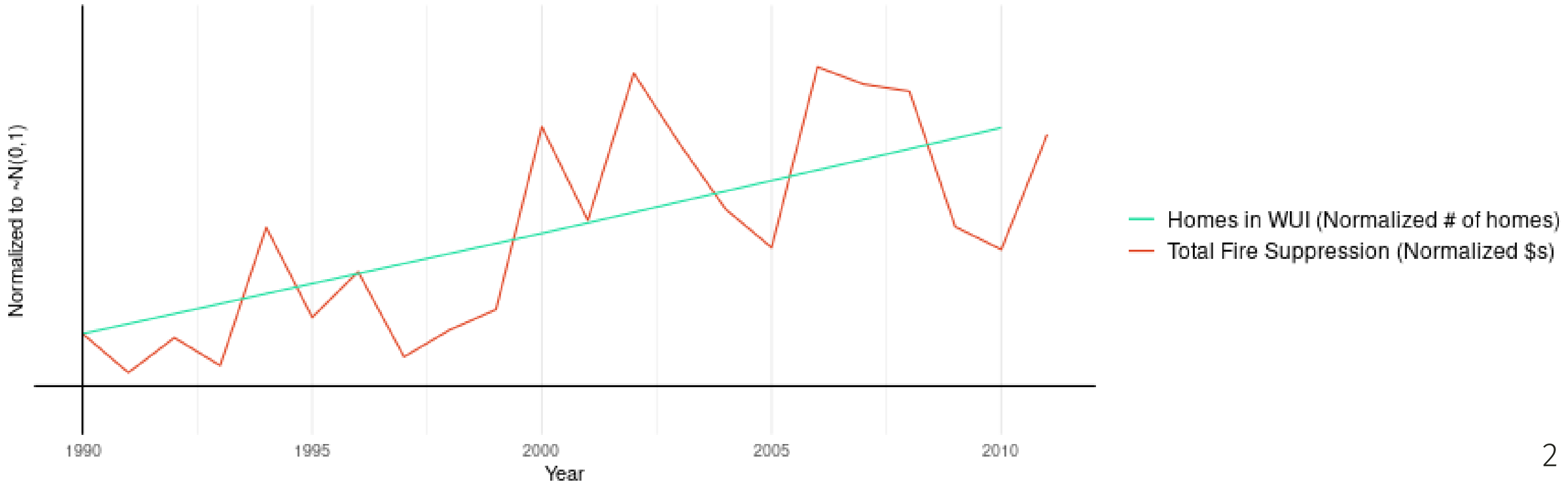
Over the last ten years, the US spent **$21.4** billion on fire suppression

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

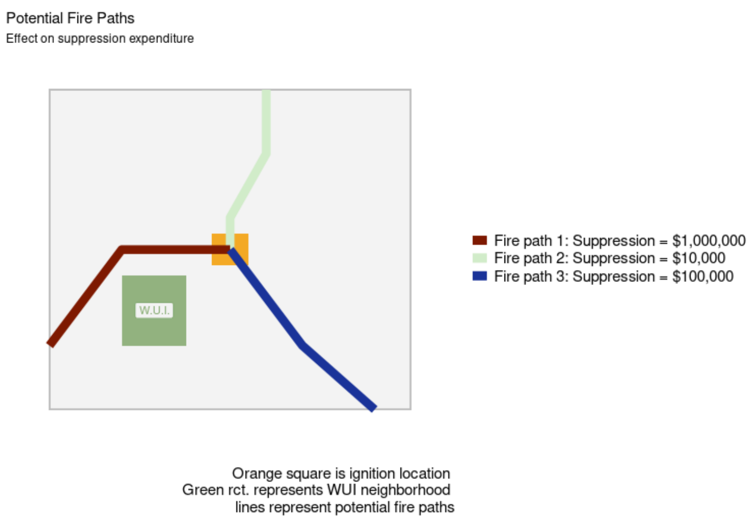


[2] What is **causing** these higher costs?

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) $\rightarrow$ **regressive!**

Is it regressive due to our 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, and expected paths affect suppression decisions, homes at risk and costs. **Simultaneity** problem arises if analyzed ex-post, but disappears if examined ex-ante.

[3] Outline

Research goal: decompose the fire manager's problem to identify -

Q_1 Do fire managers preferentially assign more resources to fires near expensive properties?

Or... is the regressive resource assignment caused by a correlation between fire suppression and property values due to physical attributes common to expensive properties and higher suppression costs.

Methods: Double/Debiased Machine Learning

- Uses **C**ompact **C**onvolution **T**ransformer (**CCT**), to model which represent nonlinear confounders in a regression model
- Produces causal estimates of property value on fire suppression costs, controlling for machine learned fire risk attributes

[4] Causal System

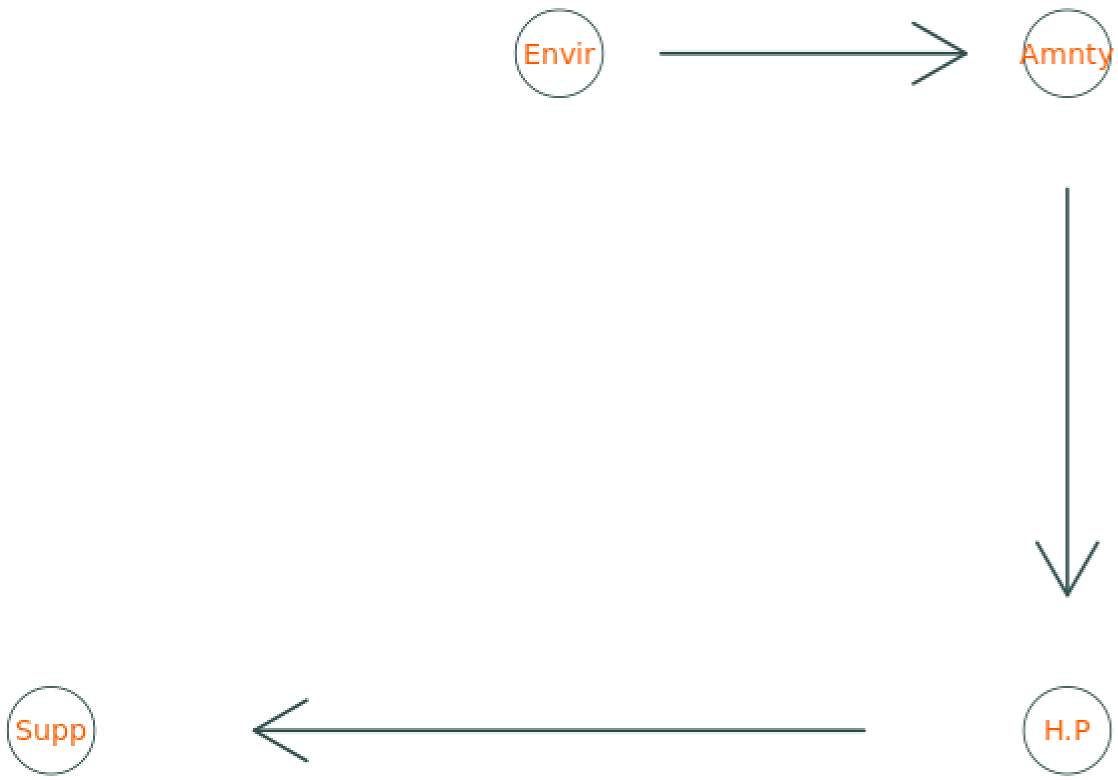
Research Question

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

[4] Causal System

Basic Hedonics

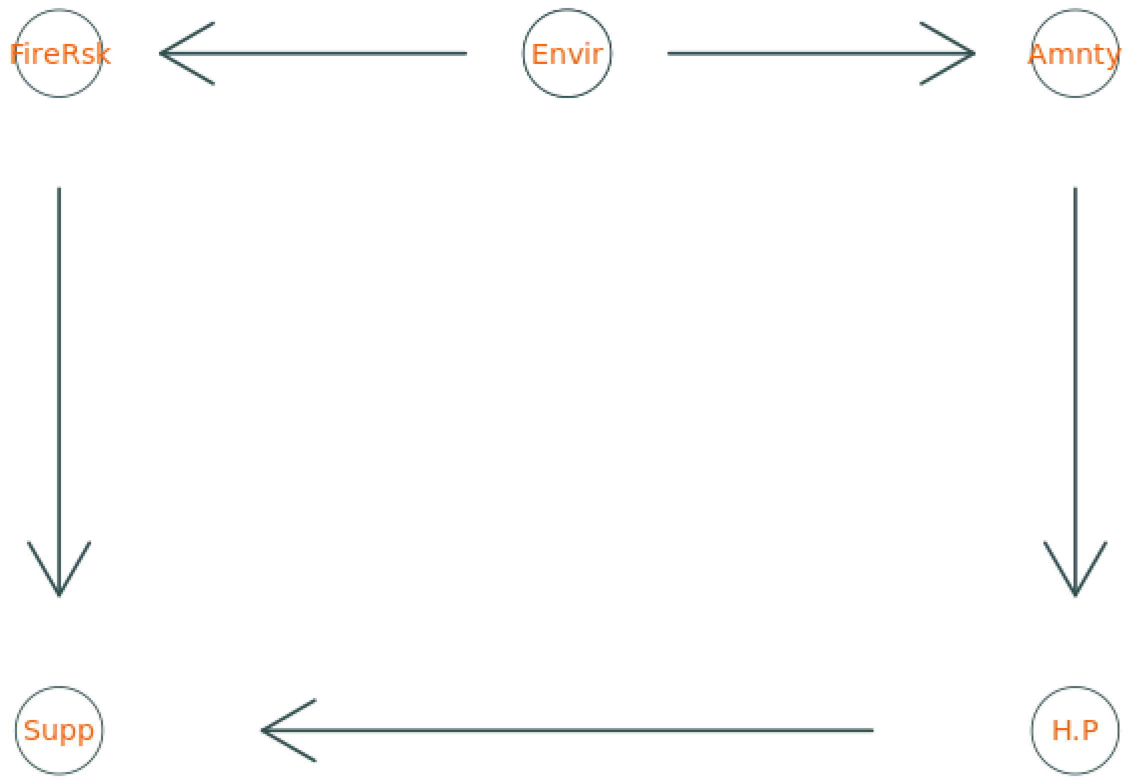
H.P: Property Values| **Supp**: Suppression Costs| **Envir**: Environment| **Amnty**: Amenities| **FireRsk** : Fire Risk|**Ex.Supp**: Expected Suppression Costs



[4] Causal System

Basic Physics

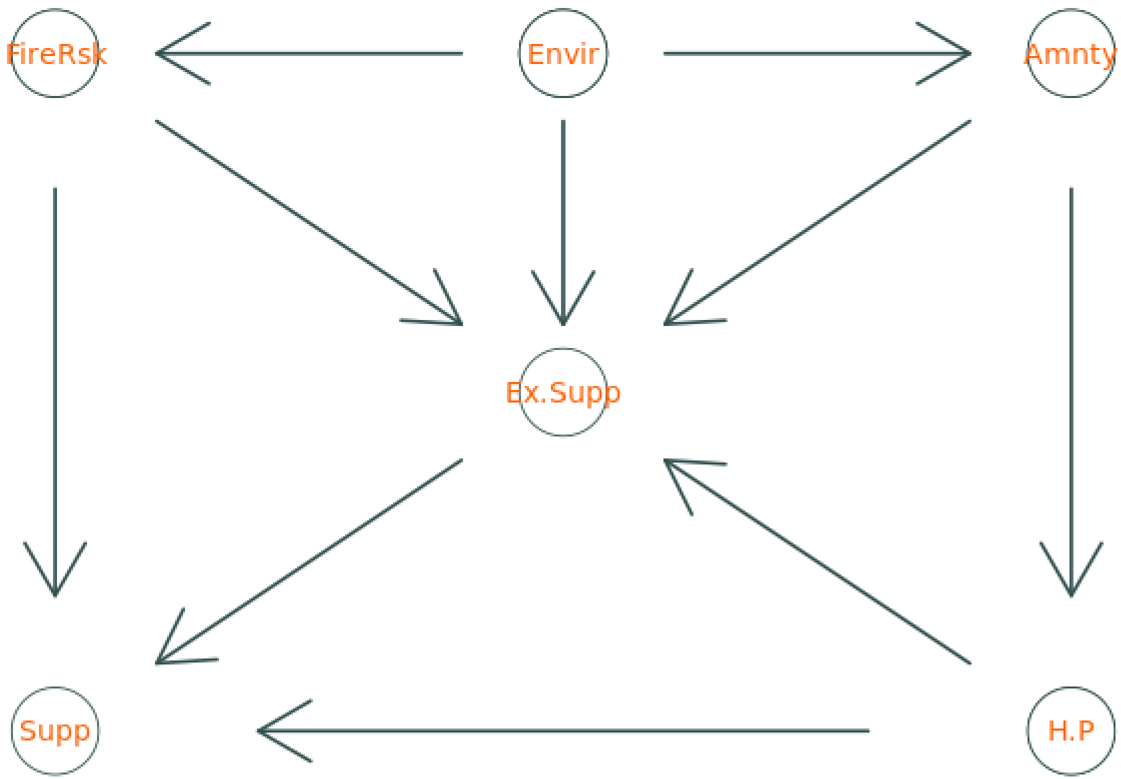
H.P: Property Values| **Supp**: Suppression Costs| **Envir**: Environment| **Amnty**: Amenities| **FireRsk** : Fire Risk|**Ex.Supp**: Expected Suppression Costs



[4] Causal System

Fire Manager's Expectation/Information

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



☑ **GOAL:** Disentangle the physical components of expected fire suppression costs from the human/bias-driven tendency to protect expensive property. Use models of fire spread and values at risk to embed expected suppression into pathways.

We'd need an algorithm that can simultaneously combine short and long-distance dependencies of amenities on... elevation, fuels, water-features, telephone, etc. **Enter Vision Transformer CCT**

D/DML uses out of sample estimates from a ML algorithm to estimate the causal effect of property value on suppression, controlling for $\eta = \{f(x), g(x)\}$. **Assume** errors exist & are additively separable in log-log form

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

$$Supp = \theta PropVal + g(X) + \varepsilon_1,\ PropVal = f(X) + \varepsilon_2$$

Turns out: estimates based on **fire ignition point data** (the current ex-ante approach) fails to capture some important variation in fuels, elevation and amenities that may bias estimates of θ.

Prelim results: Estimate for θ = **.03817**, 95% - CI = **[-.02577, .1021]** vs. Gebert et. al, 2007 OLS estimate of **.1131**, (CI unknown). Repeating Gebert et al. procedure on fire expenditures data from 2020-2021 - [estimate = **.1606**, CI = **[0.0973, 0.223908]**]

[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