THE UNIVERSITY OF CHICAGO

The impact of COVID-19 Policies on Mobility

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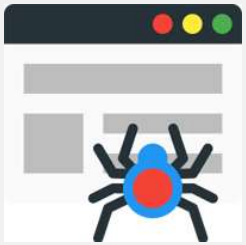

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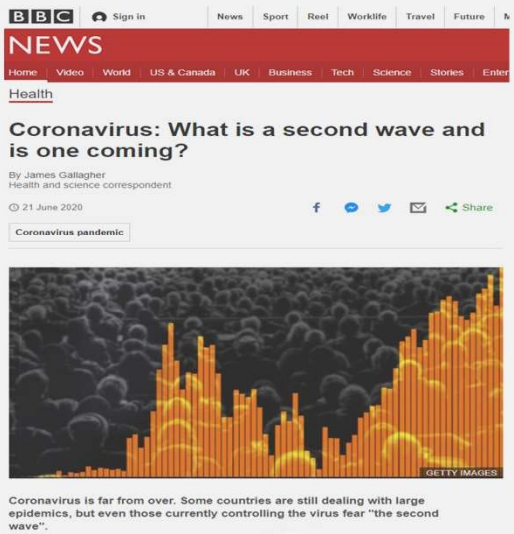
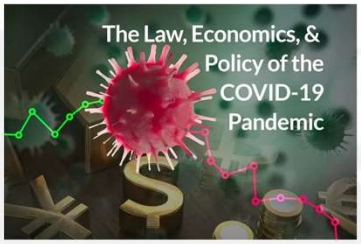
Problem Statement

There is a possibility of a second wave of coronavirus in winter whose severity may be compounded by a flu season.

Then, the states may have to re-implement shutdown policies and social distancing measures. In such scenario, policymakers and businesses may want to know magnitude of effect that each policy has on people's decision to utilize public and private spaces.



Executive Summary



Objective:

Understand the causal effect of various Covid-19 policies and analyze their implications;

Result:

We studied the effect of coronavirus policy on the utilization of retail/recreation, workplace, grocery/pharmercy. We were able to identify the partial effect of policies holding each state's characteristic. We estimate that if states were to re-implement the policies, we project they will have similar effects.

These projected effects can help policy makers to adjust their decision. It also helps business decision makers to measure customer demand and arrange their operations in terms of restaurants, cafes, shopping centers, theme parks, museums, libraries, movie theaters, on-site office service and grocery/medicine supply.

Data Sources

Two Data Sources

Google COVID-19 Community Mobility Reports

date	retail_and_recreati	grocery_and_pharmacy	parks_percent_change
2/15/2020	0	4	5
2/16/2020	1	4	4
2/17/2020	-1	1	5
2/18/2020	-2	1	5
2/19/2020	-2	0	4
2/20/2020	-2	1	6
2/21/2020	-3	2	6
2/22/2020	-2	2	4
2/23/2020	-1	3	3

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STATE	CLSCHOOL	CLDAYCR	CLNURSHM	STAYHOME	END_STHM	CLBSNS	END_BSNS
State	Date closed K-12 schools	Closed day cares	Date banned visitors to nursing homes	Stay at home/ shelter in place	End/relax stay at home/shelter in place	Closed non-essential businesses	Began to reopen businesses
category	school_closure	day_care_closure	nursing_home_vis	shelter	shelter	business_closure	business_closure
type	start	start	start	start	end	start	end
unit	date	date	date	date	date	date	date
Alabama	3/19/2020	3/20/2020	3/19/2020	4/4/2020	4/30/2020	3/28/2020	4/30/2020
Alaska	3/16/2020	0	0	3/28/2020	4/24/2020	3/28/2020	4/24/2020
Arizona	3/16/2020	0	0	3/31/2020	5/16/2020	3/30/2020	5/8/2020
Arkansas	3/17/2020	0	3/13/2020	0	0	0	5/4/2020
California	0	0	0	3/19/2020	0	3/19/2020	5/8/2020

Preparing Data and Variables

Panel Data

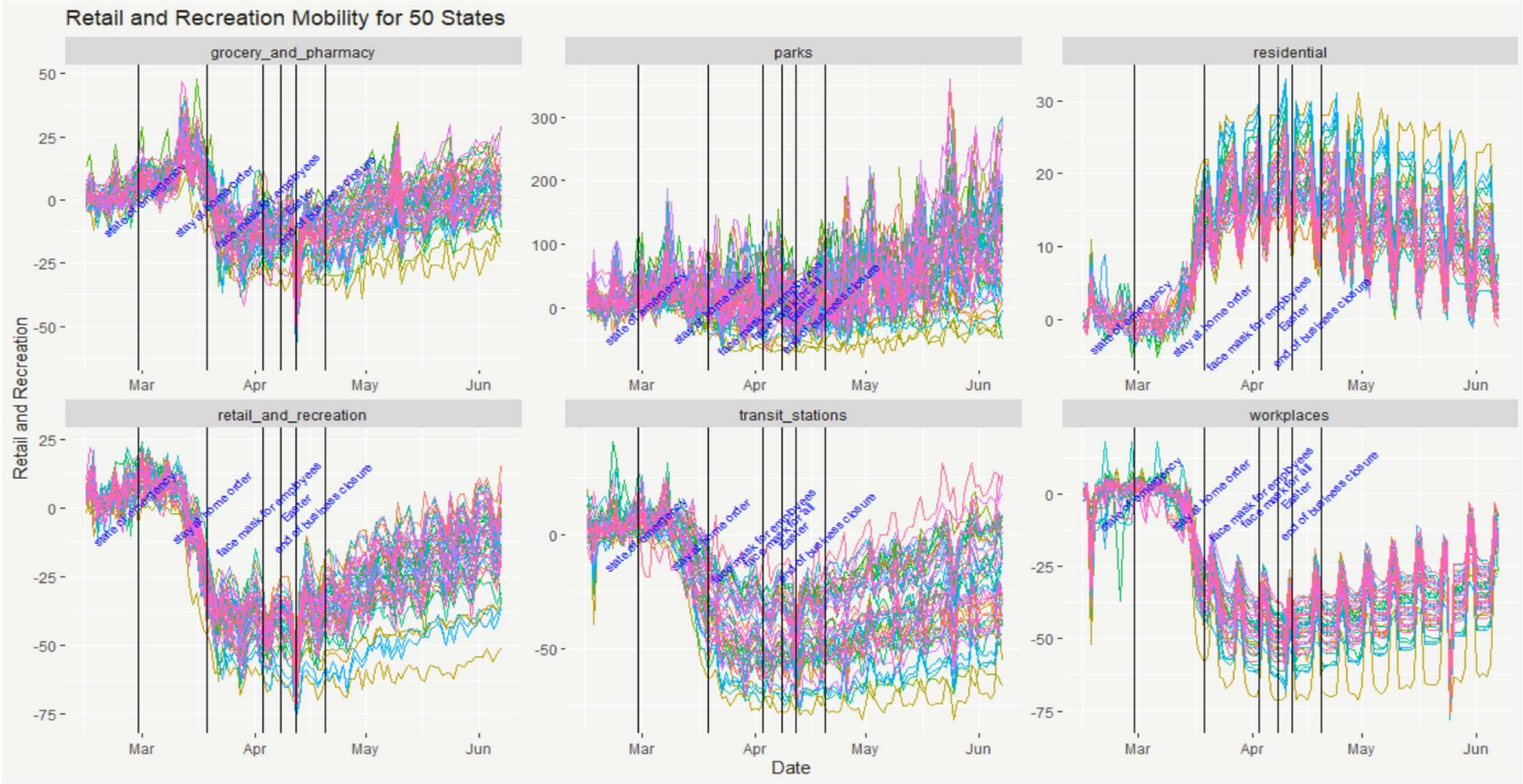
Convert datetime columns to binary variable where 1 indicates a policy is implemented as of current date and combine columns of the same policy.

STEMERG
State of emergency
emergency
start
date
3/13/2020
3/11/2020
3/11/2020
3/11/2020
3/4/2020

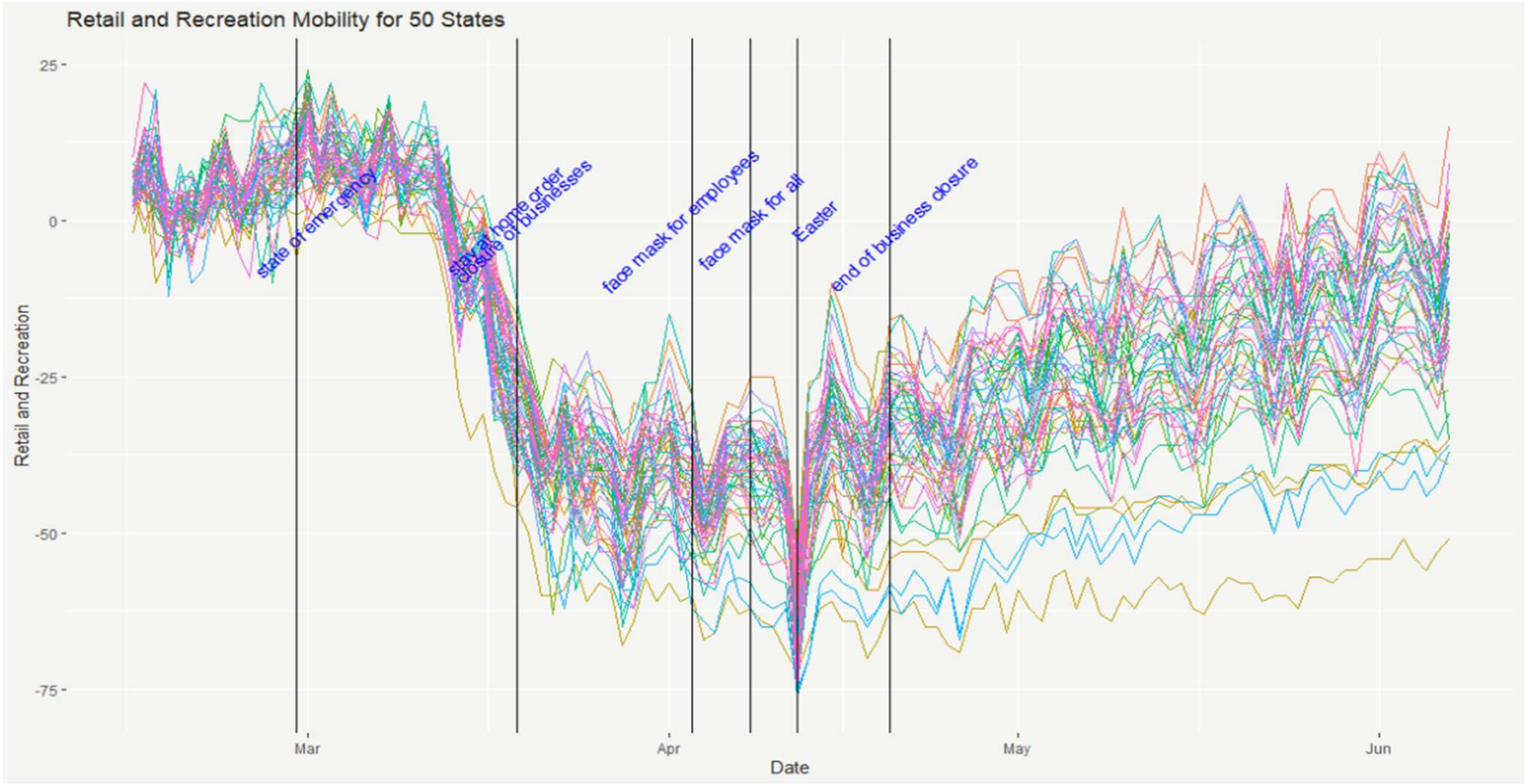
→

STEMERG	CLSCHOOL	CLDAYCR	CLNURSHM	STAYHOME	CLBSNS	RELIGEX	FM_ALL	FM_EMP
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0
1	1	1	0	0	1	0	0	0

EDA -- Overview of All States Mobility

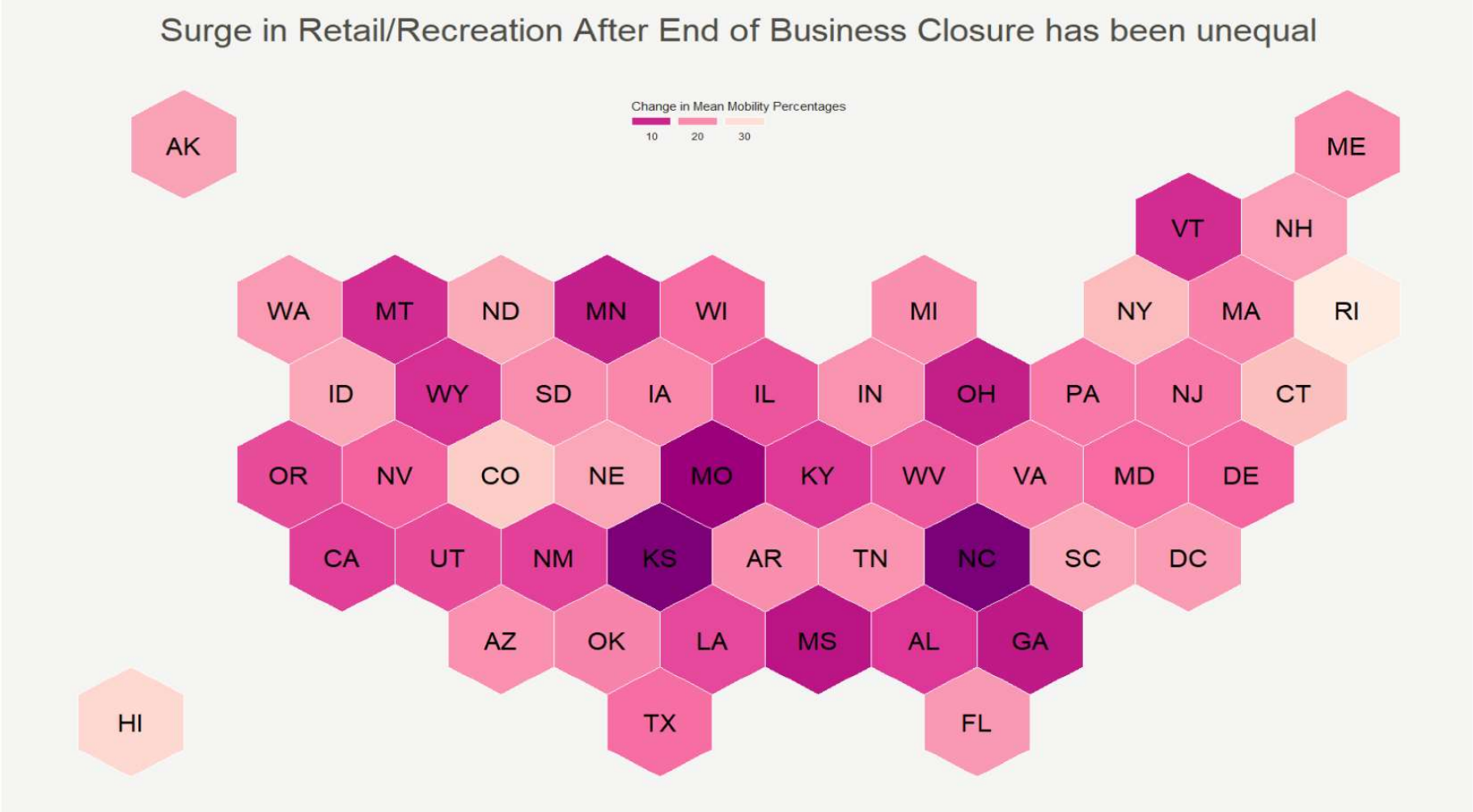


EDA -- Retail Mobility



EDA -- Calendar Heatmap

EDA -- Retail After Business Closure Across States



Panel Data Method: Fixed Effect Model

$$mobility_{state,day} = fixedeffect_{state} + \beta * policy_{state,day} + \epsilon_{state,day}$$
$$state = Alabama, \ldots, Wyoming, day = 2020/02/15, \ldots, 2020/06/10$$

1. Fitted on panel data where we observe the same unit (i.e. state) over time (February through June)
2. Able to model individual heterogeneity and avoid aggregation bias
3. Takes into account individual state differences as different intercepts of the regression lines.
    a. It allows us to variables that change little or not at all over time, such as some individual characteristics
4. Can isolate a causal effect of variable by controlling for individual effects including unobserved heterogeneity

Modeling Selection

1. Method Selection
   a. Try Four Panel Data Methods: *Pooled OLS* vs *Fixed Effect* vs *Random Effect* vs *First Difference*
   b. Breusch-Pagan Lagrange Multiplier Test to compare Pooled OLS vs Fixed Effect: The null hypothesis in the BPLM test is that variances across entities is zero. This is, no significant difference across units. The null hypothesis was rejected, so we control for individual fixed effect.
   c. Hausman Test to compare Fixed Effect vs Random Effect: The null hypothesis of zero variance in individual-specific errors is rejected; therefore, heterogeneity among individuals may be significant.
   d. Fixed Effect Model is the most preferred choice of method.
2. Variable Selection
   a. In-Sample Evaluation with penalty term: we use corrected Akaike Information Criterion (AICc) and adjusted R-squared to compare different subsets of variable
3. Model Assumption Diagnostics of Fixed Effect Model
   a. Unit Root Test: check whether a dependent variable is stationarity - Passes
   b. Serial Correlation Test: check whether error terms are autocorrelated per state - Fails
   c. Breusch-Pagan Heteroskedasticity test: check whether error terms are homoskedastic - Fails
4. Correct standard errors by autocorrelation and heteroskedasticity correction method (HC0)

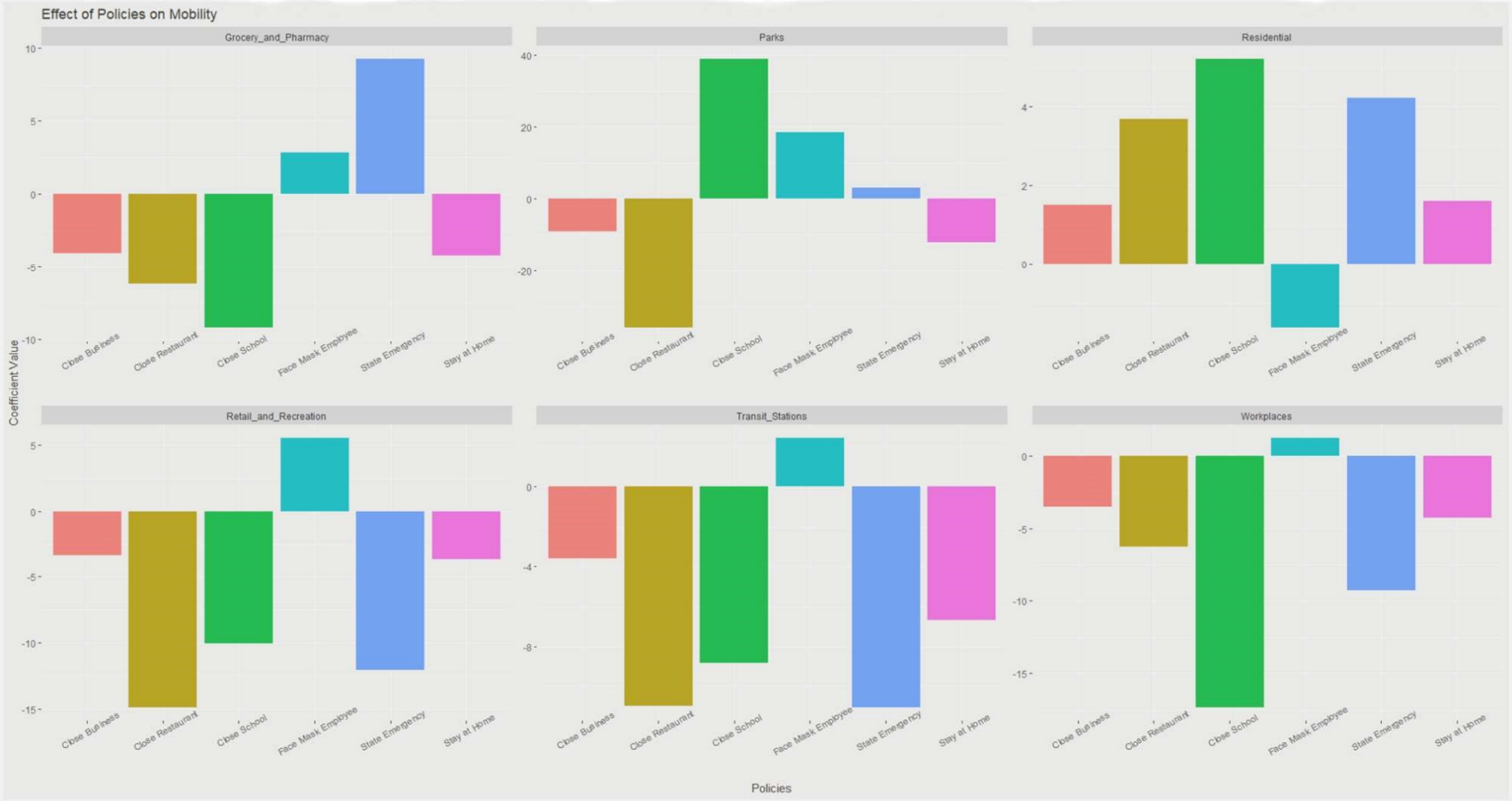
Panel Data Method: Fixed Effect Model

Fixed Effect Models of Google Mobility Measures

	Retail and Recreation	Grocery and Pharmacy	Workplaces	Parks	Residential	Transit
STEMERG	-12.07***	9.24***	-9.29***	3.20	4.23***	-11.03***
	(1.84)	(1.14)	(1.53)	(3.52)	(0.66)	(1.67)
CLSCHOOL	-10.07***	-9.21***	-17.34***	38.87***	5.22***	-8.83***
	(2.66)	(1.75)	(2.17)	(8.37)	(0.93)	(2.54)
CLDAYCR	-1.39	-1.61	-3.05**	5.51	1.07	-0.35
	(1.85)	(1.27)	(1.42)	(7.41)	(0.72)	(3.19)
CLNURSHM	0.45	-0.29	-1.24	-4.18	0.46	-5.20*
	(1.77)	(1.10)	(1.25)	(7.76)	(0.62)	(2.81)
STAYHOME	-3.63***	-4.21***	-4.21***	-12.06***	1.61***	-6.68***
	(1.26)	(0.83)	(0.84)	(3.97)	(0.37)	(1.54)
CLBSNS	-3.32***	-4.05***	-3.46***	-9.10**	1.52***	-3.57***
	(1.06)	(0.83)	(0.66)	(4.60)	(0.32)	(1.23)
FM_ALL	-1.48	-0.43	0.60	9.48	0.02	-3.17
	(2.42)	(1.55)	(1.35)	(9.92)	(0.66)	(2.80)
FM_EMP	5.52***	2.85**	1.23	18.43**	-1.63***	2.41
	(1.79)	(1.30)	(1.14)	(7.17)	(0.51)	(2.09)
CLREST	-14.90***	-6.22***	-6.20***	-36.01***	3.68***	-10.97***
	(1.44)	(1.41)	(1.12)	(4.85)	(0.48)	(1.45)
CLGYM	-1.40	-0.47	-1.49	3.98	0.18	-2.18
	(1.83)	(1.58)	(1.02)	(7.08)	(0.54)	(2.32)
CLMOVIE	-1.52	-2.51*	-2.44***	-0.60	1.03**	-2.21
	(1.66)	(1.38)	(0.91)	(7.98)	(0.48)	(2.19)
Observations	5,763	5,763	5,763	5,748	5,763	5,763
R2	0.82	0.54	0.78	0.23	0.72	0.80
Adjusted R2	0.81	0.53	0.78	0.23	0.72	0.79
F Statistic	2,292.76*** (df = 11; 5701)	606.53*** (df = 11; 5701)	1,859.53*** (df = 11; 5701)	158.78*** (df = 11; 5686)	1,333.31*** (df = 11; 5701)	2,019.66*** (df = 11; 5701)

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*significant at the 10 percent level.

Impacts of Key Policies from Models



Actionable Recommendation

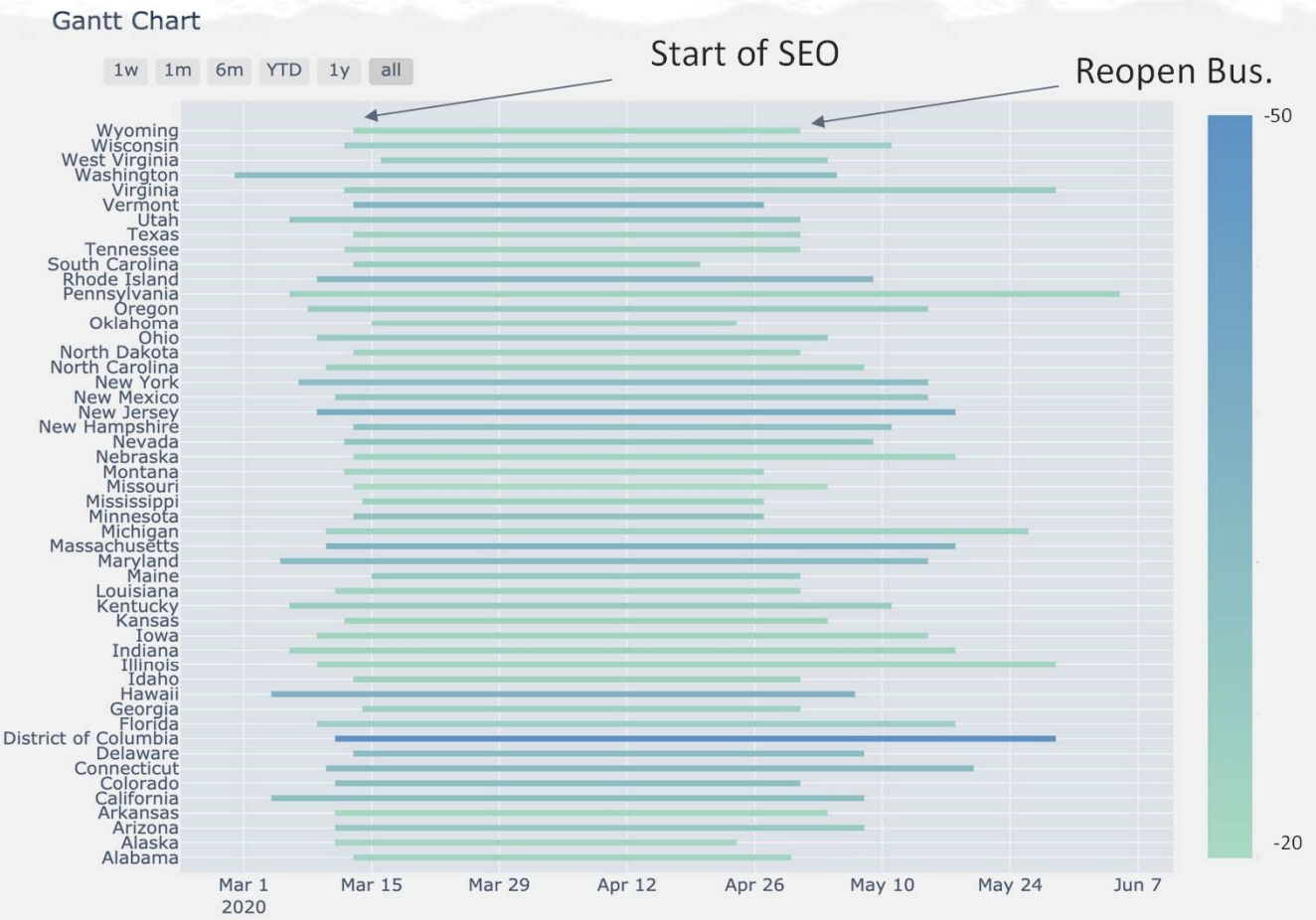
Policy Makers:

1. Among the significant policies from our models, Closing Business seems to have least impact on most forms of mobility while School closures incurs a significant negative impact on all forms of mobility outside the residence and park.
2. People go to park when they can't go anywhere else. If policy makers want to effectively maintain social distance, it is important to increase strictness of the regulations imposed in park areas.

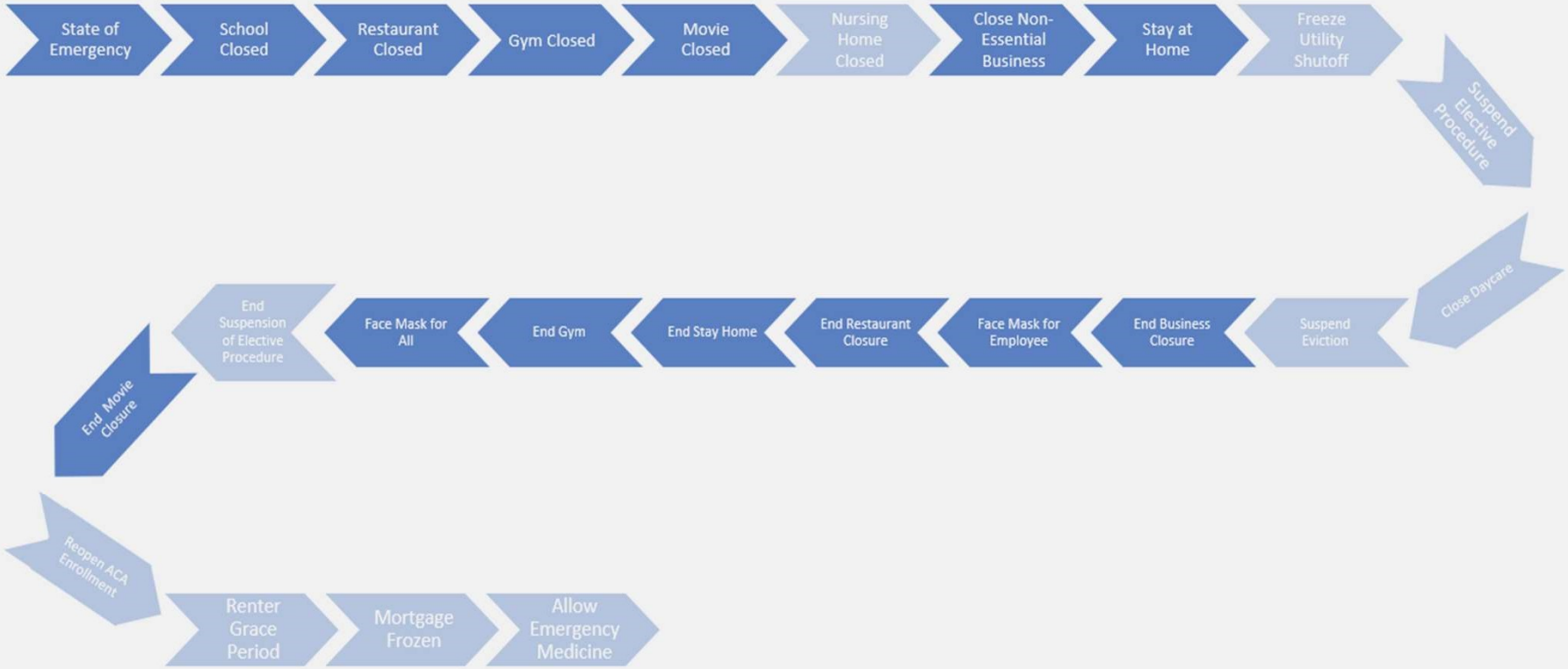
Business Decision Makers:

1. Retail and businesses can make logistic, inventory, and human resources preparations expecting changes in mobility from policies.
2. For work mobility, companies providing office-service should be prepared for a demand roll back in short term for states like DC, MA NJ, since they recently re-open business and currently have high negative work mobility rate. Our inference model helps with the estimation of potential increasing as well.
3. Transportation mobility follow similar trend to work mobility and we have similar conclusion as well.

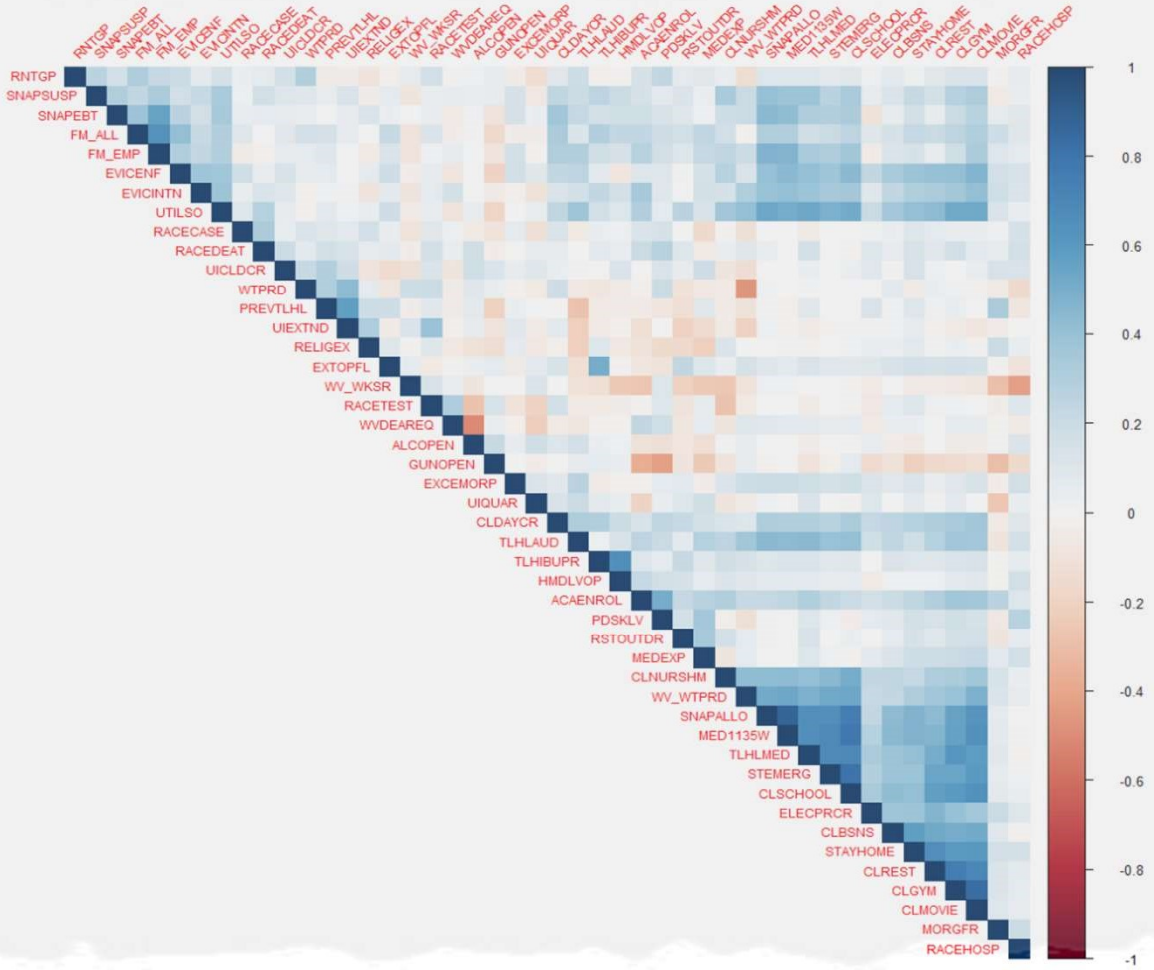
Work Mobility Current Status By States



Concern for Model Validity - Policies Come in Packs

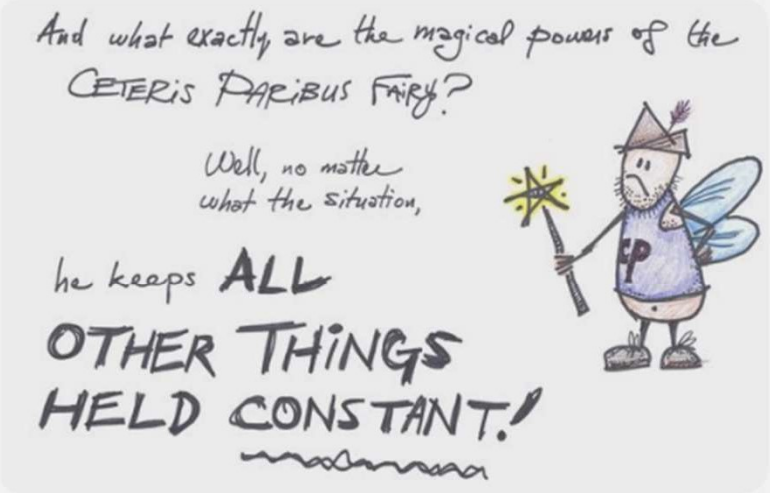


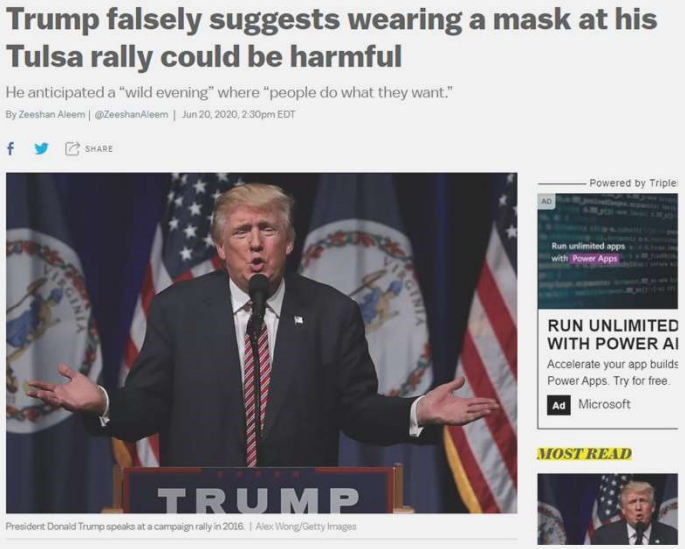
A Moderate Level of Multicollinearity among Significant Policies



Assumptions of the Analysis

1. Estimated effects of policy will be similar in the future and in other states (ceteris paribus).
2. There are no omitted variables that have causal effect on mobility (no omitted variable bias).
3. All policies are implemented perfectly (no measurement error).



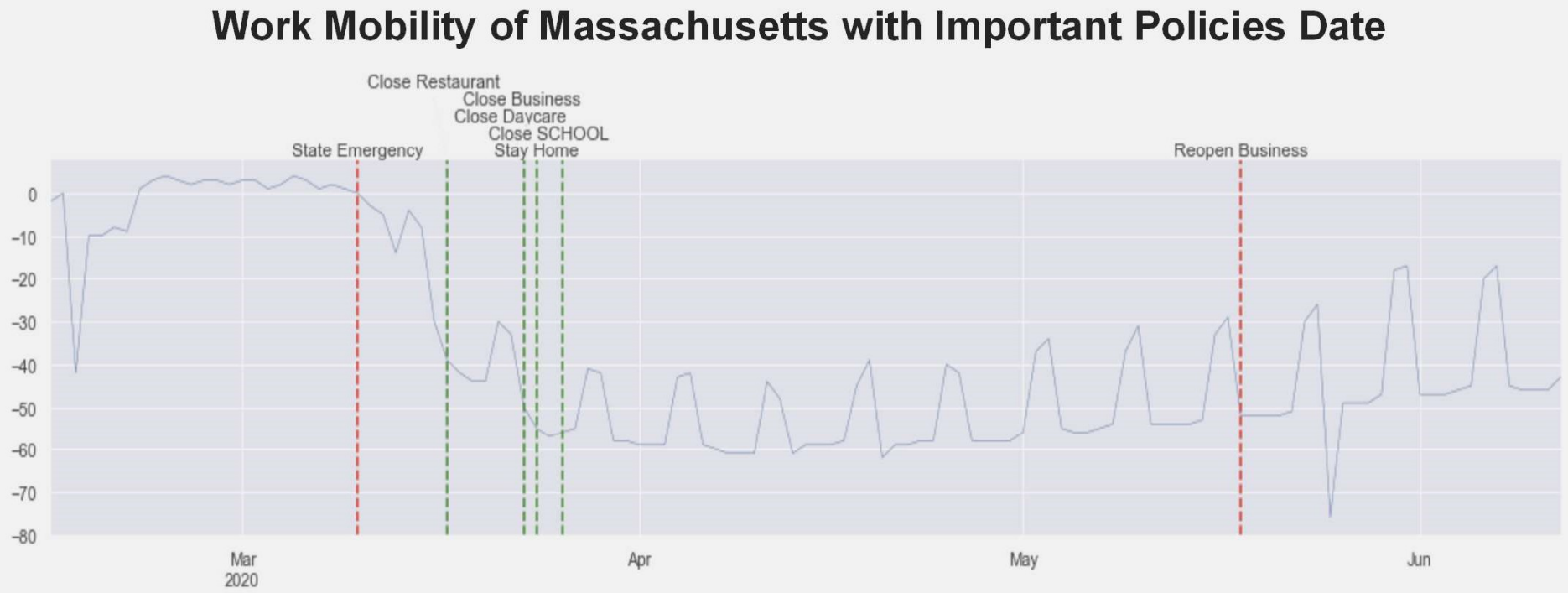


Future Extensions

1. Control voluntary social distancing behaviors by collecting more variables
    a. State unemployment rate
    b. Amount of protest
    c. Measure of risk perception (lagged covid19 case?)
        i. Spike in coronavirus cases -> Perception of increased risk -> Decreased mobility
    d. People's trust in public health expert
        i. Maryland (more people wear mask) vs Indiana (no trust in public health)
        ii. SARS paper (public health) on the role of public's trust in public health expertise
2. Isolate effects of simultaneous policies (collinearity problem)
3. Analyze effects of demographic, political and cultural factors - something that fixed effect model bypasses
4. Measure how policies are actually enforced
    a. Measurement error is likely smaller for top/down state government and greater for bottom/up state government

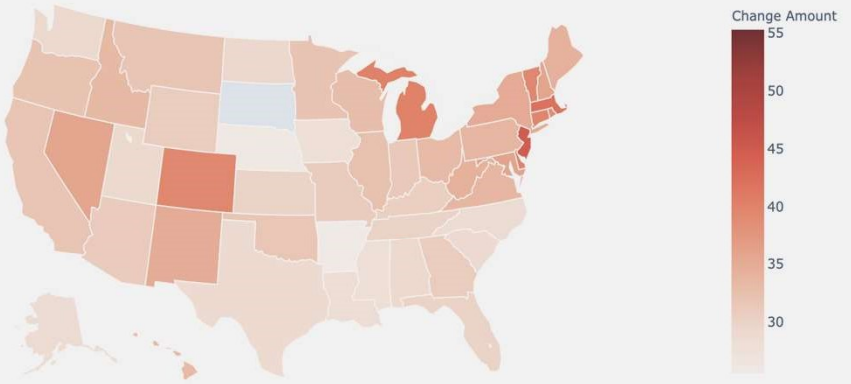
Thank You!

EDA -- Work Mobility in MA with Important Policies



EDA -- Work Mobility Across States

Decrease Rate Of Work Mobility After Emergency Order



Increase Rate Of Work Mobility After Reopening Business