Teaching Note: The Economic and Health Effects of the Chemical Spill in the Elk River

Selected Case Study prepared for presentation at the Agricultural & Applied Economics Association Annual Meeting, Chicago, IL, July 30 – August 1, 2017.

Case Review

The primary aim of this teaching case study is to discuss important aspects of the 2014 chemical spill in the Elk River that affect public policy as well as demonstrate statistical analysis of comparative case studies called synthetic controls. The spill was a significant environmental disaster for the Southern West Virginia region and caused exposure to a toxic chemical, 4-methylcyclohexylmethanol, closures of businesses, and a loss of access to clean water. While many developing countries have communities that continuously lack access to clean water, only a few water quality disasters like this spill have occurred. The rarity and nature of this type of disaster make the use of synthetic control methods ideal to analyze its impacts.

The response to the chemical spill produced a robust reaction by multiple levels of government agencies. The department of health and local hospitals coordinated the treatment of individuals that reported illnesses from water exposure at the outbreak of the crisis. The Governor of West Virginia and President Obama declared a state of emergency and deployed National Guard troops to test water samples, provide bottled water to citizens, and support local authorities in reopening schools. Additionally, some experts suggested that the safe limit for 4-methylcyclohexylmethanol was not well understood since it had not been studied sufficiently and that the governments call for resumed use of water might be premature. These factors generated a public perception of poor water quality that persisted well after the stated emergency was over.

In this teaching note to the case study, we highlight the methods of analysis as well as the aspects of policies and responses that are relevant to a water crisis. First, we want to broaden the awareness of synthetic controls as a tool. There are many policies and events of interest that can be analyzed but lack properties amenable for traditional regression techniques. Second, there have been no causal analyses of water contamination events that we are aware. Yet there are growing concerns over risks to water security and contamination of drinking water supplies from a handful of recent water disasters, such as the Elk River spill and the contamination of the water supply in Flint, Michigan. This research allows us to discuss the expected outcomes for a large water quality disaster and potential long term effects. We mean long term effects as the costs that are not apparent or easily accounted for from the outset of the chemical spill which accumulate through costs to health, averting expenditures, or impacts on economic growth. Though there should be caution used in applying the lessons and results here to other regions with different environmental policies and standards.

Target Group

Advanced Undergraduate or Graduate students in economic or applied economic programs.

Learning Objectives

In this study, we concentrate our efforts on a handful of important aspects of the Elk River spill. The first is very general, the statistical analysis of a case study.

1) Synthetic Control Methods

When identifying causal impacts of events one must be careful in attributing changes in outcome variables, such as health or economic variables, to the event of interest. For instance, it may be possible for other drivers of change to confound the analysis. In a controlled environment, such as a laboratory, it would be common to randomize a treatment effect (exposure to a policy change) on one group and use another group as a control (no policy change). Applying this framework to a lot of subjects in the control and treatment groups can then identify an average treatment effect and changes in outcome variables can be attributed to the assignment of treatment. In most environmental disaster contexts this is implausible as no rational researcher would propose randomly exposing communities to dangerous chemicals to measure the causal effects. Therefore, when an event such as a chemical spill occurs we look to make a control group that best matches the treated group (or community). Running an OLS regression would rely on the treated group being a good representation of the averages across the control groups. Using non-laboratory empirical data, when many treated groups are observed a popular method for constructing a valid control are matching methods (Imbens and Rubin, 2015). When there is one treated group the method of synthetic controls is more appropriate. In this teaching note the exposition of synthetic controls actual estimates recovered is secondary to understanding the method. The method itself and the exploration of the choices made in execution of the analysis are therefore the focus of the teaching note.

2) Cause and response to Elk River water crisis

The second learning objective is to understand the cause of the spill and response to the spill. Any discussion of policy changes to address gaps in regulations needs to analyze the costs and benefits of such policies. To identify the costs of avoiding future spills the causes must be understood. Another important aspect of costs and benefits are the responses of the government and agencies tasked with mitigating the effects of the chemical spill. This also can provide a useful opportunity for class discussion on potential challenges to mitigation of environmental disasters as well as response policies.

Case Analysis and Teaching Plan

We organize the Teaching Plan around the two concepts laid out in the Learning Objectives. We provide a guide for one extended class period to cover the main topics but recognize the benefits of extending the case over multiple classes if time permits. We suggest that the students read the paper and replicate the results of the paper before the class discussion. Annotated code to reproduce the results of the paper can be used if desired for replication and as a tool to extend the analysis further through a homework assignment.

Part One: Causal Inference (50 minutes)

Class discussion on casual inference in case studies can be helpful to set the table of the significance of using synthetic controls. Teachers can start by presenting difficulties in casual inference generally, then for case studies specifically. Causal inference is meant to identify the effect of a specific change, and implicitly exclude changes from other sources. Perhaps the crucial question to evaluating a change in policy or the effect of a catastrophe is the causal effect of the event. It is a mistake to take pre-event data and compare it to post-event data because there can be other drivers of change. Ideally, we would like to have a randomized control trial where some units(individuals) are exposed to a treatment and others are not. If properly run, an experiment would tell us the average treatment effect of exposure to a disaster. This of course is not possible for most catastrophes as no one would suggest causing environmental disasters to learn the causal effects on people or economies. So when a unique disaster, or policy change, occurs it may be difficult to analyze the effects of a disaster on outcome variables since there may be few observations of affected areas. For instance, it may be tempting to take the trend of the outcome variable pre-treatment and suppose that an untreated unit would continue along this path. Or it may be tempting to choose a control unit based on its similarity. These are problematic propositions; even a very simple model would require that no changes in other control variables occur during the post-treatment and finding another unit that is an exact match for the treated unit is highly unlikely to occur naturally. Then there is a question of how to weight the comparison of the treated unit to the control units in the statistical framework. Synthetic controls provide the statistical framework to find the optimal weights of control units to construct a better 'synthetic' control unit. Then post-treatment outcomes can be compared to the constructed synthetic control to determine the causal effects of exposure to treatment. Some conditions need to be satisfied to conclude that the synthetic control is in fact a good control unit: The pre-treatment data should match the treated unit, characteristics that would predict the outcome variable should be similar between the control and treated unit (in matching this is referred to as having a good balance), and pre-treatment trends should be predictable in the synthetic control.

In our context, the treatment is exposure to a chemical spill which we hypothesize has effects on economic growth and health outcomes. Teachers can prompt students to discuss why these outcome variables might be of interest and what other variables could be important if available. Comparisons of pre-treatment trends in outcome variables are used to validate the idea of good synthetic control match. When researchers are unable to match pre-treatment trends it suggests that the control units do a poor job of predicting post-treatment outcomes of the hypothetical untreated unit of interest. The balance between control variables is another key topic because there is some random chance that pre-treatment trends could be correlated with other units by chance, but that does not mean that we expect that correlation to continue or be predictive. Therefore, the balance between other variables that we think are important to the outcome variable is important to claim we have a good synthetic control. Lastly, being able to predict pre-treatment trends is another way to validate the ability of a synthetic control's ability to match the treated unit.

The class could also discuss statistical significance of any effect found using this method. A discussion of placebo effects and why that is an appropriate framework to construct a counterfactual is useful to validate whether any change we find is statistically significant. It may be beneficial to discuss what to expect if we ran the analysis on 2012 as a falsification test for any significant effect found. Why would a test like this produce falsification of any effect found in 2014? Can other robustness checks be done to make the analysis more convincing?

Analysis of data with annotated code:

We propose have students analyze the data themselves with the use of annotated code provided[1] to understand the synthetic control method better and experience challenges in executing the analysis.

Potential Questions:

When are synthetic controls appropriate? Can the selection of pretreatment control variables over-fit the data using synthetic controls? Is there a good balance in controls in this application and why is this important? Can the pretreatment path be predicted from 2009-2013 using pre-2009 data? (Why not?) How is statistical significance determined for post-treatment effects? Why might you exclude some control units from the placebo analysis? (West Virginia counties that had water quality warnings after the spill could attenuate the effects in Kanawha County).

Part Two: Regulations and risks of chemical spills (25 minutes)

We propose that Teachers tie the statistical analysis back to regulations and the risks of contamination. While changes in GDP per capita or infant health indicate some costs of the water contamination disaster, along with more direct costs (bottled water, water testing, emergency response, immediate sickness), there are opposing costs to changing regulations or enforcement of the regulations to avoid a spill. We can use a cost benefit framework to analyze a change in policy, where the costs of increased enforcement are weighed against the benefits of the reduction of risk of a chemical spill. On the face of it, this seems like a trivial question. Of course avoiding the chemical spill is worth instituting and enforcing regulations of above ground chemical storage facilities. We recommend discussing this aspect through the risks of the spill, the real trade-off is

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[1] www.toddguilfoos.com/Research

the benefit of a marginal reduction in risk by adopting more stringent enforcement vs. the cost of that enforcement.

In this case, the Elk River spill, the federal and state regulations did not require inspections of the facilities and aboveground storage tanks (ASTs) which were inadequately regulated in West Virginia. Through lack of care on the part of Freedom Industries the containers were corroded which led to the leaking of MCHM and PPH into the Elk River and subsequently into the public water supply. Since ASTs are largely unregulated for these dangerous chemicals there would likely be a large reduction in marginal risk for the establishment of some regulations and enforcement mechanisms.

Other relevant topics that can be included in the discussion is the legal liabilities of the businesses that contaminate water or provide municipal water. Freedom Industries was liable for damages but went bankrupt shortly after the chemical spill. Lawsuits have also been filed against the West Virginia American Water Company and chemical manufacturer, Eastman Chemical. One notable settlement of $151 million, paid by W. Virginia Water and Eastman Chemical, was recently reached to be distributed to businesses or affected residents (Raby, 2016). It is unclear whether legal liabilities alone would significantly reduce risks of future spills from ASTs that are unregulated.

Potential Questions:

To what extent should changes take place to guard against the risks of another contamination event? What determines the cost of the regulations? What determines the value of benefit in risk reduction? What were the regulations for storage of chemicals at Freedom Industries? Would enforcement likely reduce the probability of a spill? Who was liable for the chemical spill? Were communities compensated for exposure to the chemicals (how)? How did perceptions affect the community affected by the chemical spill? How could the local government have responded differently increase public confidence in water quality?

References:

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Imbens, Guido W., and Donald B. Rubin. *Causal inference in statistics, social, and biomedical sciences*. Cambridge University Press, (2015).

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