EMPIRICAL ANALYSES OF FOOD AND ENERGY ECONOMICS AND POLICY IN CHINA

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This dissertation consists of empirical analyses of three important issues related to food and energy economics and policy in China. The first issue – food safety – is a major global public health issue. In **Food Safety and Restaurant Food (Chapter 1)**, we analyze the effects of a media and policy event regarding food safety on the supply and demand for restaurant food. The food safety-related event we examine is a media and policy event regarding the discovery by China's customs of "Zombie meat" – meat that has been frozen for decades and is therefore beyond its expiration date – being smuggled into China in June 2015. We apply a regression discontinuity approach to a unique daily spatially-disaggregated order-level restaurant dataset of 1.6 million dining orders of 1,215 different dishes placed in 58 restaurants across multiple cities in China. Results suggest that customers who ordered meat dishes following the Zombie meat event tended to order more expensive meat dishes, perhaps because they viewed these more expensive dishes as having higher quality and more fresh meat. We supplement our analysis with an empirical model of consumer demand, and similarly find that after the Zombie meat event, consumers in Beijing and Tianjin were more likely to buy more

expensive pork dishes. Our results suggest that a possible means by which restaurants can weather food safety crises is to offer high quality dishes and to establish and maintain a reputation for quality.

The second important issue is the effect of environmental policies on productivity and profits. Critics of environmental policies often claim that such policies decrease productivity and profits. The effects of environmental policies on productivity, GDP, output, and profits is in part an empirical question, however, and may vary by firm, industry, sector, and type of policy. **The Effects of Environmental Policies in China on GDP, Output, and Profits (Chapter 2)** examines the effects of environmental policies in China on GDP, industrial output, and new energy sector profits using province-level panel data over the period 2002 to 2013. Our econometric method employs instruments to address the potential endogeneity of the policies. We find that policies involving financial incentives or monetary awards have the potential of increasing the output and/or profits in some energy-related industries or sectors, but potentially at the cost of GDP in non-energy industries or sectors. In contrast, command and control policies and non-monetary awards appear to decrease GDP, output, and/or profits.

The third important issue is the effect of energy-related policies on energy consumption. **The effects of energy-related policies on energy consumption in**

China (Chapter 3) examines the effects of different types of energy-related policies on different types of energy consumption in China. We collect and construct a novel, comprehensive, and detailed data set on province-level energy-related policies that includes specific types of energy-related command and control policies; financial incentives; awards; intellectual property rights; and education and information policies. Our econometric method employs instruments to address the potential endogeneity of the policies. According to our results, some types of energy-related policies have been effective in reducing energy consumption. However, many other policies have the possibly unintended or even perverse consequence of increasing rather than decreasing energy consumption. Our results on the mixed effectiveness of energy-related policies in China in reducing energy consumption have important implications for the design of energy-related policies in China and elsewhere.

BIOGRAPHICAL SCETCH

Shuyang Si is an agricultural and applied economist whose research focuses on energy and environmental economics, and food and agricultural economics, especially as they pertain to China. Prior to his Ph.D. studies, he received Bachelor's degrees from Purdue University and China Agricultural University; and a Master of Science degree in Agricultural and Resource Economics from the University of California at Davis. His Masters thesis was entitled "The effects of China's biofuel policies on agricultural and ethanol markets".

Shuyang pursued his doctoral study at the Charles H. Dyson School of Applied Economics and Management at Cornell University. He was awarded a Master of Science degree in Applied Economics and Management from Cornell University in 2020 and will receive his Ph.D. degree in Applied Economics and Management from Cornell University in August 2021.

Shuyang has published two papers in Energy Economics (a top journal in energy economics), one of which was featured in the Cornell Chronicle and the Cornell Daily Sun, and the other of which was featured in the Cornell Chronicle; as well as several working papers and works in progress. He uses economic and econometric analysis to study issues related to food, agriculture, energy, and environmental policy in China. Across his different research projects, Shuyang has used a variety of techniques in empirical and data analysis, including regression discontinuity design; local polynomial regression discontinuity robust bias-corrected confidence intervals and inference procedures; instrumental variables; vector autoregression; and Granger causality. Most of his research projects involve analyzing large, novel, and detailed data sets that he has painstakingly collected, translated, constructed, and compiled by hand.

Shuyang has won several prestigious awards and honors for his research, including the 2021 George F. Warren Award for Outstanding Paper, Second Place; the 2020 Cornell Dyson Graduate Student – Research Excellence Award; a Cornell University Heslop Endowment Summer Fellowship; a Cornell University Aplin Endowment Summer Fellowship; a UC-Davis Fellowship for Excellence in Graduate Research; and the 2017 Exxon-Mobil ITS-Davis Corporate Affiliate Fellowship. In addition, he was a member of a team that was awarded Third place at The Data Open at Cornell Datathon Competition presented by Citadel and Citadel Securities in October 2019. Shuyang was selected to be a Graduate Research Associate at Cornell University Think-tank for Resources, Energy, and the Environment: Science and Policy-related Economic Analysis and Research (TREESPEAR).

Shuyang has presented his research to diverse academic and non-academic audiences, including at the Business of Food Annual Meeting at the Cornell University SC Johnson College of Business; at the Interdisciplinary Ph.D. Workshop in Sustainable

Development (IPWSD) at Columbia University; and at the Northeast Agricultural and Resource Economics Association (NAREA) Annual Meeting. He was also one of the speakers selected by Cornell Undergraduate Research Board (CURB) to present at their lecture on “In Your Own Backyard: Innovative Perspectives on the Environment”, to an audience of Cornell undergraduate students interested in learning about research and his research.

After receiving his Ph.D., Shuyang will be joining the faculty at Xi’an Jiaotong-Liverpool University as an Assistant Professor in the Department of Economics.

Dedicated to my family, especially:

My parents and grandparents,

thank you for supporting me throughout this journey.

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CHAPTER 1
FOOD SAFETY AND RESTAURANT FOOD

1.1 Introduction

The effects of media reports and policy events related to food safety have important implications for the food and restaurant industry. Food safety incidents cause significant economic losses in a multitude of ways, including discomfort, pain, loss in productivity, and death (Pouliot and Wang, 2018). In addition, foodborne illness outbreaks and food safety recalls, along with associated media events, can have devastating financial effects on restaurant operations. In 2015, for example, foodborne illness outbreaks related to E. coli and norovirus at the U.S. restaurant company Chipotle resulted in a 30% decline in same-store sales in December 2015, a nearly 53.3% drop in stock price over a five-month period from August to December 2015 (Samson, 2016), and a plunge in quarterly profits of 44% in the fourth quarter of 2015 (Strom, 2015).

Food safety is a major global public health issue, and is particularly important in heavily populated countries such as China, where rapid industrialization and modernization are having profound effects on food safety (Lam et al., 2013). Recent incidents related to food safety in China that were extensively covered by the media include the melamine milk powder incident in 2008, which harmed thousands of infants

(Gossner et al., 2009), as well as food safety incidents involving illegal additives and/or the contamination of the food supply by toxic industrial waste (Lam et al., 2013). China's connections to global agricultural markets are also having important effects on food safety within the country. The rapidly growing Chinese economy has led to a gradual change in focus in China from food supply to food safety: in a 2011 survey, food safety was ranked first in the top five safety issues that worried the Chinese population, surpassing public safety, traffic safety, health safety, and environmental safety (Lam et al., 2013).

In this chapter, we analyze the effects of a media and policy event regarding food safety on the supply and demand for restaurant food. The food safety-related event we examine is a media and policy event that took place in China regarding "Zombie meat", which is meat that has been frozen for decades and is therefore beyond its expiration date. On June 1, 2015, China's General Administration of Customs discovered Zombie meat that was being smuggled into China, and announced that 15 provinces will jointly pay special attention to the smuggling and sale of Zombie meat. Once Zombie meat was discovered by China's customs on June 1, 2015, it quickly grasped the attention of government officials and news media, and the fear of encountering Zombie meat in restaurants quickly spread all over China. Many news reports followed, including one from XinHua News Agency, the official press agency of the People's Republic of China, reporting that "zombie meat" that was produced in the 1970s was being sold decades later in 2015 (Baidu Baike, 2015). USA Today published an article on June 24, 2015 with the headline "40-year-old 'zombie' meat smuggled into China" (Zoroya, 2015). The topic was the center of media and public attention in China until late July 2015.

We analyze the effects of the Zombie meat media and policy event on daily supply and demand for restaurant food in China. To identify the effects of the Zombie meat media and policy event and address the potential bias caused by time-varying omitted variables, we use a regression discontinuity approach applied to a unique daily spatially-disaggregated order-level restaurant dataset of 1.6 million dining orders of 1,215 different dishes placed in 58 restaurants across multiple cities in China in 2015, all from a major restaurant chain company in China. Within a narrow time window, unobserved factors unrelated to the Zombie meat event that influence daily supply and demand for restaurant food are likely to be similar so that observations prior to the Zombie meat event provide a comparison group for observations after the Zombie meat event. We assume that the Zombie meat media and policy event is exogenous to the particular restaurant chain we analyze. We exploit the daily variation in our detailed daily data set to identify the effects of the Zombie meat event on daily supply and demand for restaurant food in China.

We build on the previous literature on food safety (Adalja and Lichtenberg, 2018; Schmit et al., 2020; Adalja, Lichtenberg and Page, 2021), food demand (Zhu, Lopez and Liu, 2016; Yeh, Gómez and Kaiser, 2019; Adalja, 2021; Adalja et al., 2021); restaurant meat consumption (Kurz, 2018), restaurant food demand (Cawley, Susskind and Willage, 2020; Todd et al., 2021); restaurant hygiene, inspections, and food safety (Jin and Leslie, 2003; Jin and Leslie, 2005; Simon et al., 2005; Jin and Leslie, 2009; National Research Council, 2011; Jin and Lee, 2014; Bederson et al., 2018; Jin and Lee, 2018); and the effects of food pricing (Richards, Hamilton, Gómez, and Rabinovich, 2017; Verteramo Chiu, Liaukonyte, Gómez, and Kaiser, 2017), media (Lopez, Liu and Zhu, 2015), and policy (Liu, Lopez and Zhu, 2014) on food consumption and demand. We innovate on the previous literature by analyzing the effects of a media and policy event regarding food safety on the supply and demand for restaurant food; and by analyzing these issues in a heavily populated developing country.

We find that, as a result of the Zombie meat event, customers tended to order more expensive orders, more expensive dishes, and more desserts. Although the Zombie meat event did not have a statistically significant effect on the total number of dishes ordered that had beef, chicken, or pork, those who ordered dishes that had beef, chicken, or pork after the Zombie meat event tended to order the more expensive beef, chicken, and pork dishes. Since restaurant stores did not significantly increase prices of individuals dishes that had beef, chicken, or pork in response to the Zombie meat event, these results suggest that customers who ordered meat following the Zombie meat event tended to order more expensive meat dishes, perhaps because they viewed these more expensive dishes as having higher quality and more fresh meat. We supplement our analysis with an empirical model of consumer demand, and similarly find that after the Zombie meat event, consumers in Beijing and Tianjin were more likely to buy more expensive pork dishes. Our results suggest that a possible means by which restaurants can weather food safety crises is to offer high quality dishes and to establish and maintain a reputation for quality.

The balance of our chapter proceeds as follows. We describe our data in Section 1.2 and our empirical methods in Section 1.3. Section 1.4 presents our results. Section 1.5 presents our supplementary empirical model of demand. We discuss our results and conclude in Section 1.6.

1.2 Data

We use a unique daily spatially-disaggregated order-level restaurant dataset of 1.6 million dining orders of 1,215 different dishes placed in 58 restaurants across multiple cities in China in 2015, all from a major restaurant chain company in China.[1]

1 We are extremely grateful to this restaurant chain company (which must remain anonymous due to confidentiality restrictions) for providing us with the order-level data.

This restaurant chain company has 58 branches in Beijing, Tianjin, Shanghai, Guangzhou, and Shenzhen.

To augment our unique daily spatially-disaggregated order-level restaurant dataset, we have manually collected information about each of the 1,215 different dishes in the data set in order to construct variables for the characteristics of each dish. In particular, we use the information we have manually collected about each dish to create dummy variables indicating whether a dish is a dessert; and dummy variables for whether the dish contains beef, chicken, pork, duck, tofu, seafood (fish, prawns, shellfish, and/or squid), mushrooms, vegetables other than mushrooms, and rice, respectively. We also create a dummy variable for whether the cooking method for the dish was by boiling; this dummy variable includes hot pot dishes. We also create dummy variables for different flavor types, including spicy, sweet, salty, sour, bitter, and umami. In addition, we create dummy variables for promotions, sales, and commercials for each dish in each restaurant on each day. To augment our data on promotions, we collect Dianping data (Chinese Yelp) on whether some consumers mention they receive a certain special deal in specific period.

From the raw data, we then create a daily restaurant-dish-level panel data set. Each observation in this daily restaurant-dish-level panel data set is a restaurant-dish-day (i.e., a particular dish in a particular restaurant on a particular day). For each restaurant-dish-day, the variables include the price (in Yuan) of the dish in that restaurant that day, and dummy variables for each of the dish characteristics created above.[2]

We then use our daily restaurant-dish-level panel data set to create another panel data set, a daily store-level panel data set. Each observation in this daily store-level panel data set is a store-day. For each store-day, we create variables for: the total number of orders at that restaurant on that day; the total number of people (or customers) at that restaurant on that day (calculated by summing the number of people per dining party over all dining parties at that restaurant on that day); the total price of all orders at that restaurant on that day (calculated as total price of each order summed over all orders at that restaurant on that day); and the average price of all orders at that restaurant on that day (calculated as the total price of all orders at that restaurant on that day, divided by number of orders at that restaurant on that day). We also create, for each restaurant dish characteristic, variables for: the total number of dishes ordered at that restaurant on that day with that characteristic; the total price of all dishes ordered at that restaurant on that day with that characteristic (calculated as price of each dish with that characteristic times the number of orders of that dish at that restaurant on that day); and the average

2 To summarize our daily restaurant-dish-level panel data, Appendix 1.A presents time series plots for the dummy variables in our daily restaurant-dish-level panel data set. It is difficult to ascertain whether the Zombie meat event had a significant effect based on the time series plots of the raw data from our daily restaurant-dish-level panel data set.

price of all dishes ordered at that restaurant on that day with that characteristic (calculated as the total price of all dishes ordered at that restaurant on that day with that characteristic, divided by the total number of dishes ordered at that restaurant on that day with that characteristic). Prices are in Yuan.[3,4]

1.3 Methods

In order to analyze and identify the impact of the Zombie meat event on restaurant food supply and demand and address the potential bias caused by time-varying omitted variables, we use a regression discontinuity design. We assume that the Zombie meat media and policy event is exogenous to the particular restaurant chain we analyze. We exploit the daily variation in our detailed daily data set to identify the effects of the Zombie meat media and policy event on daily supply and demand for restaurant food in China.

A regression discontinuity design can be used when observations can be ordered according to a forcing (or running) variable and the treatment is assigned above a given

3 To summarize our daily store-level panel data, Appendix 1.B presents scatterplots over time for the variables in our daily store-level panel data set. It is difficult to ascertain whether the Zombie meat event had a significant effect based on the scatterplots of the raw data from our daily store-level panel data set.
4 As seen in Figure 1.A-5 in Appendix 1.A and 1.B, and in Figures 1.B-11 and 1.B-12 in Appendix 1.B, few dishes in our data set had duck. Thus, as there were too few dishes with duck, particularly in a window from 5 weeks before to 5 weeks after the Zombie meat event, we do not analyze the effect of the Zombie meat event on the price or quantity of duck dishes ordered.

threshold. In our case, the forcing variable is time and the threshold is the date of the Zombie meat event (Percoco, 2014). Previous studies that have used a regression discontinuity design with time as the forcing variable include Davis (2008), Auffhammer and Kellogg (2011), Chen and Whalley (2012), Bento et al. (2014), Grainger and Costello (2014), Salvo and Wang (2017), Zhang, Lin Lawell and Umanskaya (2017), Fuje (2019), and Kheiravar and Lin Lawell (2021). Hausman and Rapson (2018) provide an excellent review of these studies and a guide for practitioners. In a regression discontinuity design, there is no value of the forcing variable at which we observe both treatment and control observations; instead, we extrapolate across covariate values, at least in a neighborhood of the discontinuity (Angrist and Pischke, 2019; Imbens and Lemieux, 2018).

Gelman and Imbens (2018) recommend using local polynomial regressions instead of high-order global polynomials in regression discontinuity design. We therefore use the local polynomial regression discontinuity robust bias-corrected confidence intervals and inference procedures developed in Calonico, Cattaneo and Titiunik (2014), Calonico, Cattaneo and Farrell (2018), and Calonico et al. (2019). The confidence intervals are constructed using a bias-corrected regression discontinuity estimator together with a novel standard error estimator proposed in Calonico, Cattaneo and Titiunik (2014). In particular, the confidence intervals are constructed using an alternative asymptotic theory for bias-corrected local polynomial estimators in the context of regression discontinuity designs, which leads to a different asymptotic variance in general and thus justifies a new standard error estimator. Bandwidth choices that minimize asymptotic mean squared error (MSE) are derived following Imbens and Kalyanaraman (2012). Calonico, Cattaneo and Titiunik (2014) find that the resulting data-driven confidence intervals performed very well in simulations, suggesting in particular that they provide a robust (to the choice of bandwidths) alternative when compared to the conventional confidence intervals routinely employed in empirical work. Hyytinen et al. (2018) similarly find that bias-corrected regression discontinuity design estimates that apply robust inference are in line with the experimental estimate from an experiment that takes place exactly at the cutoff.

In particular, we run the local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014) of residuals from a first-stage regression of each of the variables in our daily store-level panel data set on weather and seasonality covariates, and restaurant fixed effects. The weather and seasonality covariates are daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies. We run the local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014) of residuals from this first-stage regression to analyze the effects of the Zombie meat event.

Formally, for each daily store-level variable s that we analyze, our first-stage regression is given by:

$$y_{it}^{s} = x_{it}^{'}\beta^{s} + \alpha_{i}^{s} + \varepsilon_{it}^{s}, \tag{1}$$

where the dependent variable y_{it}^{s} is either the total number of orders at restaurant *i* on day *t*, the total number of people at restaurant *i* on day *t*, the total price of all orders at restaurant *i* on day *t*,

the total number of orders at restaurant *i* on day *t* that had at least one dish with a particular characteristic, or the average price of all dishes ordered at restaurant *i* on day *t* with a particular characteristic; x_{it} is a vector of covariates for restaurant *i* on day *t*; and α_{i}^{s} is a restaurant fixed effect for restaurant *i*. The vector of covariates x_{it} includes the following weather and seasonality covariates: daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies.

In the second stage, we take the residuals $\hat{\varepsilon}_{it}^{s}$ from the first-stage daily store-level regression in equation (1) and run local linear regression discontinuity regressions of these residuals $\hat{\varepsilon}_{it}^{s}$ to analyze the effects of the Zombie meat event, using the method for local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014).

For each of our local linear regression discontinuity regressions with robust confidence intervals using our daily store-level panel data set, we bootstrap the standard errors over both stages of the estimation, where the first stage is the first-stage regression in equation (1) of each of the variables in our daily store-level panel data set on weather and seasonality covariates, and restaurant fixed effects from which we derive residuals; and the second stage is the local linear regression of residuals. In particular, restaurant stores are randomly drawn from the data set with replacement to generate multiple independent panels each with the same number of restaurant stores in the original data set. We then run both stages on each of the new panels. The standard errors are then formed by taking the standard deviation of the bias-corrected local-polynomial regression discontinuity estimates from each of the panels.

Similarly, we also run local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014) of residuals from a first-stage regression of dummy variables for each of the dish characteristics and for dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set on weather and seasonality covariates, promotion dummies, and either restaurant fixed effects or restaurant-dish fixed effects. The weather and seasonality covariates are daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies.

We run the local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014) of residuals from this first-stage regression to analyze the effects of the Zombie meat event.

Formally, for each daily restaurant-dish-level variable d that we analyze, our first-stage regression is given by:

$$y_{ijt}^{d} = x_{it}^{'}\beta^{d} + \alpha_{ij}^{d} + \varepsilon_{ijt}^{d}, \tag{2}$$

where the dependent variable y_{ijt}^{d} is either a dummy variable for one of the dish characteristics or the dish price conditional on one of the dish characteristics in our daily restaurant-dish-level panel data set for dish *j* in restaurant *i* on day *t*; x_{it} is a vector of covariates for restaurant *i* on day *t*; and, depending on specification, α_{ij}^{d} is either a restaurant fixed effect for restaurant *i* or restaurant-dish fixed effect for dish *j* in restaurant *i*. The vector of covariates x_{it} includes weather and seasonality covariates, and promotion dummies. The weather and seasonality covariates are daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies.

In the second stage, we take the residuals $\hat{\varepsilon}_{ijt}^{d}$ from the first-stage daily restaurant-dish-level regression in equation (2) and run local linear regression discontinuity regressions of these residuals $\hat{\varepsilon}_{ijt}^{d}$ to analyze the effects of the Zombie meat event, using the method for local linear regression discontinuity regressions with robust confidence intervals proposed in Calonico, Cattaneo and Titiunik (2014).

For each of our local linear regression discontinuity regressions with robust confidence intervals our daily restaurant-dish-level panel data set, we bootstrap the standard errors over both stages of the estimation, where the first stage is the first-stage regression in equation (2) of dummy variables for each of the dish characteristics and for dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set on weather and seasonality covariates, promotion dummies, and either restaurant fixed effects or restaurant-dish fixed effects from which we derive residuals; and the second stage is the local linear regression of residuals $\hat{\varepsilon}_{ijt}^{d}$ to analyze the effects of the Zombie meat event. In particular, restaurant-dishes are randomly drawn from the data set with replacement to generate multiple independent panels each with the same number of restaurant-dishes in the original data set. We then run both stages on each of the new panels. The standard errors are then formed by taking the standard deviation of the bias-corrected local-polynomial regression discontinuity estimates from each of the panels.

Our regression discontinuity design addresses the potential bias caused by time-varying omitted variables. Within a narrow time window, the unobserved factors unrelated to the Zombie meat event that influence daily supply and demand for restaurant food are likely to be similar so that observations prior to the Zombie meat event provide a comparison group for observations after the Zombie meat event.

The restaurant fixed effects control for time-invariant restaurant heterogeneity. In specifications that include restaurant-dish fixed effects instead, the restaurant-dish fixed effects control for time-invariant restaurant-dish heterogeneity. The indicator variables for month of the year control for monthly variation in restaurant food supply and demand and other factors that affect restaurant food supply and demand. Similarly, the indicator variables for day of the week control for intra-week variation in restaurant food supply and demand and other factors that affect restaurant food supply and demand.

We augment our regression discontinuity estimator with covariates entering in an additively separable, linear-in-parameters way; Calonico et al. (2019) shows that the resulting covariate-adjusted regression discontinuity estimator remains consistent for the standard regression discontinuity treatment effect and can achieve substantial efficiency gains relative to the unadjusted regression discontinuity estimator.

Since we analyze the effects of the Zombie meat event on several dish characteristics, we apply the Bonferroni correction to adjust for multiple hypothesis testing (Bland and Altman, 1995; Napierala, 2012).

1.4 Results

1.4.1. Daily Store-Level Analysis

The results of our local linear regression discontinuity regressions with robust confidence intervals of residuals from first-stage regressions of each of the variables in our daily store-level panel data set are presented in Table 1.1.[5] Results show that the Zombie meat event resulted in a significant increase in the total price of all orders; in the total number of orders that were desserts; in the average price of all dishes ordered that were desserts; in the average price of all dishes ordered that had beef, chicken, pork, seafood (fish, prawns, shellfish, and/or squid), tofu, mushrooms, other vegetables, or rice; in the average price of all dishes ordered whose cooking method was boiling, including hot pots; and in the average price of all dishes ordered that were spicy, sweet, salty, sour, or umami. On the other hand, the Zombie meat event did not have a statistically significant effect on the total number of orders; the total number of people (or customers) at the restaurant; the total number of dishes ordered that had beef, chicken, pork, seafood (fish, prawns, shellfish, and/or squid), mushrooms, vegetables other than mushrooms, or rice; the total number of dishes ordered that were spicy, sweet, salty, sour, bitter, or umami; or the average price of all dishes ordered that were bitter.

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5 Appendix 1.C presents residual plots that plot residuals from a first-stage regression of each of the variables in our daily store-level panel data set, using data within a window of 10 weeks before to 10 weeks after the Zombie meat event. The first-stage regressions regress each of the variables in our daily store-level panel data set on weather and seasonality covariates, and restaurant fixed effects. Residual plots for the average price of all dishes ordered at that restaurant on that day with pork, chicken, and beef are also presented in Figure 1.1.

The results of the daily store-level local linear regression discontinuity regressions with robust confidence intervals are robust to whether we use a window of 10 weeks before and after the Zombie meat event, or a window of 5 weeks before and after the Zombie meat event, with the exception that for a window of 5 weeks before and after the Zombie meat event, the Zombie meat event does not have a significant effect on the average price of all dishes ordered that had tofu either after applying the Bonferroni correction. With a window of 5 weeks before and after the Zombie meat event, we did not have sufficient observations of dishes that were bitter in order to analyze the effects of the Zombie meat event on either total number of dishes ordered that were bitter or the average price of all dishes ordered that were bitter.

The results of daily store-level local linear regression discontinuity regressions therefore show that the Zombie meat event increased the average prices but not the number of orders of dishes with meat. The result that the Zombie meat event increased the average prices of dishes with meat is summarized graphically via residual plots for the average price of dishes ordered with pork, chicken, and beef in Figure 1.1.[6]

1.4.2. Daily Restaurant-Dish-Level Analysis

To further analyze the effects of the Zombie meat event on dish prices and

6 Residual plots for each of the variables in our daily store-level panel data set are presented in Appendix 1.C.

whether the price effects are a result of the restaurant raising the price of individual dishes, Table 1.2 presents the results of our local linear regression discontinuity regressions with robust confidence intervals of residuals from first-stage regressions of the dish characteristics and the dish price conditional on each of the dish characteristics using our daily restaurant-dish-level panel data set.[7]

The results of our analysis at the restaurant-dish level show that the Zombie meat event had very little significant effect on prices or characteristics of individual dishes. After applying the Bonferroni correction to adjust for multiple hypothesis testing (Bland and Altman, 1995; Napierala, 2012), the only type of dish characteristic on which the Zombie meat event had a significant effect when using a window of 10 weeks before and after the Zombie meat event was sweet flavor: after the Zombie meat event, more restaurant dishes had a sweet flavor. The Zombie meat event did not have a significant effect on the dish price of dishes of any of the dish characteristics we examined, and had only a marginally significant effects (that are no longer significant after applying the Bonferroni correction) on prices of dishes that were prepared using a boiling cooking method, including hotpots.

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7 Appendix 1.D presents residual plots that plot residuals from a first-stage regression of dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set, using data within a window of 10 weeks before to 10 weeks after the Zombie meat event. The first-stage regressions regress dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set on weather and seasonality covariates, promotion dummies, and restaurant-dish fixed effects.

When using a window of 5 weeks before and after the Zombie meat event, the only type of dish characteristics on which the Zombie meat event had a significant effect were sweet flavor, salty flavor, and umami flavor: after the Zombie meat event, more restaurant dishes had a sweet flavor, and fewer restaurant dishes had a salty flavor or an umami flavor. When using a window of 5 weeks before and after the Zombie meat event, the Zombie meat event did not have a significant effect on the dish price of dishes of any of the dish characteristics we examined.

Thus, the results of our analysis at the restaurant-dish level show that the price effects and characteristic effects of the Zombie meat event were not the result of restaurant stores changing the prices or characteristics of individuals dishes in response to the Zombie meat event. Instead, the effects of the Zombie meat event on prices and characteristics were the result of a compositional change in the types of dishes ordered in the aftermath of the Zombie meat event.

1.4.3. Model Validity

An underlying assumption for regression discontinuity designs is that there are no discontinuous changes in the control variables at the time of the Zombie meat event. To examine if there were any discontinuous changes in the control variables at the time of the Zombie meat event, Table 1.E.1a in Appendix 1.E presents results of daily store-level local linear regression discontinuity analyses of our daily weather variables: daily maximum temperature, daily average temperature, and daily precipitation. Table 1.E.1b in Appendix 1.B presents results of daily restaurant-dish-level local linear regression discontinuity analyses of our daily promotion dummy variable. We find that there are no discontinuous changes at the time of the Zombie meat event that are significant at a 5% level for any of the weather variables when using a window of 5 weeks before and after the Zombie meat event. When using a window of 10 weeks before and after the Zombie meat event, we find that there are no discontinuous changes at the time of the Zombie meat event that are significant at a 5% level for either daily maximum temperature or daily precipitation. The Zombie meat event did not have any significant effect at a 5% level on the daily promotion dummy variable for either the window of 10 weeks or 5 weeks before and after the Zombie meat event. Thus, the underlying assumption that there are no discontinuous changes in the control variables at the time of the Zombie meat event seems reasonably satisfied, particularly for the window of 5 weeks before and after the Zombie meat event.

1.4.4. Analysis by City

We have a total of 58 restaurants in our dataset. Of these 58 restaurants, 37 restaurants are located in Beijing, 12 restaurants are located in Shanghai, 4 restaurants are located in Tianjin, 2 restaurants are located in Guangzhou, 2 restaurants are located in Shenzhen, and 1 restaurant is located in Zhengzhou. To examine whether there is any heterogeneity by city in the effects of the Zombie meat event, we also run our local linear regression discontinuity analysis by city.

In particular, we run our local linear regression discontinuity analysis separately for each of the following cities: Beijing, Shanghai, and Tianjin. We were unable to run separate local linear regression discontinuity analyses for any of the other cities, which each had 2 or fewer restaurants, since they each had too few observations. Moreover, in order to have enough observations in each of the cities with more than 2 restaurants, we use a window from 10 weeks before to 10 weeks after the Zombie meat event. The limited number of observations in each city for the window from 5 weeks before to 5 weeks after the Zombie meat event may make it difficult to detect any effect by city, especially since we are applying the Bonferroni correction to adjust for multiple hypothesis testing.

The results of our local linear regression discontinuity regressions with robust confidence intervals by city for each of the variables in our daily store-level panel data set are presented in Table 1.E.2 in Appendix 1.E. The results for Beijing, which has 37 out of the 58 restaurants, are similar to the results from pooling all cities in Table 1.1, including the result that the Zombie meat event increased the average prices of dishes that had certain characteristics, such as dishes that had meat.

In contrast, in Shanghai, the Zombie meat event did not have a statistically significant effect on the average price of dishes ordered with certain characteristics for any of the characteristics we examined. Instead, the Zombie meat event had a significant negative effect on the total number of orders on a restaurant-day, the total number of people at a restaurant-day, and the total number of dishes ordered that had chicken. In Tianjin, the Zombie meat event similarly did not have a statistically significant effect on the average price of dishes ordered with certain characteristics for any of the characteristics we examined, and instead had a significant negative effect on the average price of all orders on a restaurant-day.

The results of our local linear regression discontinuity regressions with robust confidence intervals for the dish characteristics and the dish price conditional on each of the dish characteristics using our daily restaurant-dish-level panel data set using restaurant fixed effects are presented in Table 1.E.3 in Appendix 1.E. Similar to the results from pooling all cities in Table 1.2, the results by city show that the Zombie meat event did not have a significant effect on the dish price of dishes of any of the dish characteristics we examined.

We find qualitatively similar results by city when using a window from 5 weeks before to 5 weeks after the Zombie meat event, except that the limited number of observations in each city may make it difficult to detect any effect by city after applying the Bonferroni correction to adjust for multiple hypothesis testing.

Thus, our analysis by city show that the results in Beijing are similar to our pooled results, but the daily store-level results in Shanghai and Tianjin are not, and therefore that our pooled results may be driven primarily by Beijing, where 37 out of the 58 restaurants are located.

1.5 Restaurant Food Demand

We supplement our regression discontinuity analysis with an empirical model of consumer demand. The results of our local linear regression discontinuity regressions with robust confidence intervals for the dish characteristics and the dish price conditional on each of the dish characteristics using our daily restaurant-dish-level panel data set show that restaurant stores are not changing the prices or characteristics of individuals dishes in response to the Zombie meat event. Moreover, the prices and characteristics for most restaurant dishes do not vary much over time, if at all, in our daily data set for the year 2015, particularly over the narrow window from 5 weeks before to 5 weeks after the Zombie meat event. Thus, the variation in price in our data set is primarily variation across restaurant dish, not variation over time. For restaurant dishes whose price does not vary over time, price is not endogenous to daily demand.

In addition, for a restaurant dish whose price does not vary over time, we are unable to identify to effects of the price of that restaurant dish on the daily demand for that restaurant dish.

Since prices and characteristics of restaurant dishes do not vary much over time, if at all, over the window from 5 weeks before to 5 weeks after the Zombie meat event, following an approach that dates back at least to Lancaster (1971), we estimate demand regressions that represent consumer preferences over restaurant dishes as a function of the price and characteristics of the restaurant dishes, and allow for the possibility that some of the demand parameters may have changed following the Zombie meat event.

In particular, we use observations from our daily restaurant-dish-level panel data set over the window from 5 weeks before to 5 weeks after the Zombie meat event to estimate the following demand regression:

$$q_{ijt} = \beta_p p_{ijt} + c_{ijt}^{'}\beta_c + p_{ijt}c_{ijt}^{'}\beta_{cp} + \beta_{pZ}Z_t p_{ijt} + Z_t c_{ijt}^{'}\beta_{cZ} + Z_t p_{ijt} c_{ijt}^{'}\beta_{cpZ} + x_{it}^{'}\beta_x + \alpha_i + \varepsilon_{ijt}, \quad (3)$$

where the dependent variable q_{ijt} is the total quantity ordered of dish *j* in restaurant *i* on day *t*; p_{ijt} is the price of dish *j* in restaurant *i* on day *t* ; c_{ijt} is a vector of characteristics of dish *j* in restaurant *i* on day *t*; Z_t is a dummy variable for day *t* being a day on or after the Zombie meat event; x_{it} is a vector of covariates for restaurant *i* on day *t*; and α_i is a restaurant fixed effect for restaurant *i*. The vector of covariates x_{it}

includes weather and seasonality covariates, and, in an alternative specification, also includes a dummy for promotions. The weather and seasonality covariates are daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies. Since prices of restaurant dishes do not vary much over time, if at all, over the window from 5 weeks before to 5 weeks after the Zombie meat event, the cross-price effects of other dishes offered by the restaurant are absorbed by the restaurant fixed effect.

Our coefficients of interest are β_{cZ}, which measures the effect of the Zombie meat event on the demand for dishes with certain characteristics; and β_{cpZ}, which measures the effect of the Zombie meat event on the demand for dishes with certain characteristics and certain price levels. Barwick et al. (2020) show that the OLS coefficient on the interaction between a treatment and an endogenous variable is consistent if the treatment is conditionally exogenous and conditionally independent of the endogenous variable. Thus, even if prices and characteristics (which do not vary much over time, if at all, over the window from 5 weeks before to 5 weeks after the Zombie meat event) were endogenous, our coefficients of interest -- the coefficients β_{cZ} and β_{cpZ} on the interactions between the Zombie meat event with prices and characteristics -- are consistent because the Zombie meat event is exogenous to the restaurant dish demand, price, and characteristics of any single dish in any particular restaurant in China.

The full set of results for the two specifications of the fixed effects demand regression are presented in Tables 1.F.1a and 1.F.1b in Appendix 1.F; the results for Beijing are also summarized in Table 1.3. There is some heterogeneity across cities. The pooled results are similar to the results for Beijing, likely because most of the restaurants (37 out of 58) are located in Beijing. We find that after the Zombie meat event, demand in Beijing and Tianjin shifted downward for dishes that had pork; and shifted upward for dishes that had beef, seafood, and vegetables (not including mushrooms). After the Zombie meat event, consumers in Beijing and Tianjin were more likely to buy more expensive pork dishes.

We also estimate the demand regression in equation (3) using an IV fixed effects model in which we instrument for price and the price interactions using the average price of that dish in that city during the first quarter of 2015 (from January 1 to March 31) and its interactions. We report the Angrist-Pischke first-stage F-statistics and Sanderson-Windmeijer first-stage F-statistics for each of endogenous price and price interaction variables in Table 1.F.2 in Appendix 1.F. The Angrist-Pischke first-stage F-statistics and Sanderson-Windmeijer first-stage F-statistics are tests of weak identification of individual endogenous regressors, and are constructed by "partialling-out" linear projections of the remaining endogenous regressors (Angrist and Pischke, 2009; Sanderson and Windmeijer, 2016). As seen in Table 1.F.2 in Appendix 1.F, the first-stage F-statistics are all greater than 1 million for each of the endogenous variables, far greater than the threshold of 10 used in current practice (Staiger and Stock, 1997; Stock and Yogo, 2005; Andrews, Stock and Sun, 2019), and also far greater than the threshold of 104.7 for a true 5 percent test (Lee et al., 2020). Moreover, as seen in Tables 1.F.3a and 1.F.3b in Appendix 1.F, the coefficient on the instrument for price (the average price for that dish in that city during Quarter 1) in the first-stage regression for price is statistically significant and nearly 1.000 in all specifications, and reclassified as exogenous for Tianjin in the specification in Table 1.F.3b. Thus, our instrument for price is nearly perfectly correlated with price, which provides further evidence that price is essentially exogenous and rarely changes for a restaurant dish.

The full set of results for the two specifications of the IV fixed effects demand regression are presented in Tables 1.F.3a and 1.F.3b in Appendix 1.F; the results for Beijing are also summarized in Table 1.3. There is some heterogeneity across cities. The pooled results are similar to the results for Beijing, likely because most of the restaurants (37 out of 58) are located in Beijing. We find that after the Zombie meat event, demand in Beijing and Tianjin shifted downward for dishes that had pork, and consumers in Beijing and Tianjin were more likely to buy more expensive pork dishes.

We use the results from our fixed effects and IV fixed effects demand regressions to calculate the total average effect of the Zombie Meat Event on the demand for a sample of popular dishes offered by this restaurant chain. In particular, our sample of popular dishes consists of all dishes that were ordered at least once over the year 2015 in at least 21 of the 37 restaurants in Beijing; that were ordered over 45 times in Beijing in the window from 5 weeks before to 5 weeks after the Zombie meat event; that were ordered at least once in Beijing in the 5 weeks before the Zombie meat event; that were ordered at least once in Beijing in the 5 weeks on or after the Zombie meat event; that were ordered at least once in the first 3 months of 2015; and that had pork, chicken, beef, seafood, tofu, mushrooms, and/or vegetables. There are 22 dishes that meet these criteria. For each of these 22 dishes, we calculate the total average effect of the Zombie meat event on demand for that dish using the results from the fixed effects and IV fixed effects demand regressions, and evaluated at the dish characteristics and the mean dish price. Standard errors are calculated using the Delta Method (DeGroot, 1986).

Table 1.4a presents the results of the total average effect of the Zombie meat event on the demand for these 22 dishes in Beijing, as calculated using the results from the fixed effects and IV fixed effects demand regressions for Beijing, and evaluated at the dish characteristics and the mean dish price over all restaurants in Beijing over all days in the window from 5 weeks before to 5 weeks after the Zombie meat event. Table 1.4b presents the results of the total average effect of the Zombie meat event on the demand for these 22 dishes in all cities, as calculated using the results from the fixed effects and IV fixed effects demand regressions for all cities, and evaluated at the dish characteristics and the mean dish price over all restaurants over all days in the window from 5 weeks before to 5 weeks after the Zombie meat event.

Across the multiple specifications for demand, we find the robust result that the Zombie meat event had a significant negative total average effect on the least expensive pork dish, Yunnan style ground pork fried rice (黑三剁炒饭), but did not have any statistically significant total average effect on the demand for any of the other more expensive pork dishes, chicken dishes, or beef dishes.

1.6 Discussion and Conclusion

In this chapter, we analyze the effects of a media and policy event regarding food safety, the Zombie meat announcement, on the supply and demand for restaurant food. Our results show that the Zombie meat event increased the total price of all orders; the total number of orders that were desserts; the average price of all dishes ordered that were desserts; and the average price of all dishes ordered that had meat.

Our analyses also show that these price effects and characteristic effects of the Zombie meat event were not the result of restaurant stores changing the prices or characteristics of individuals dishes in response to the Zombie meat event. Instead, the effects of the Zombie meat event on prices and characteristics were the result of a compositional change in the types of dishes ordered in the aftermath of the Zombie meat event.

In particular, as a result of the Zombie meat event, customers tended to order more expensive orders, more expensive dishes, and more desserts. Although the Zombie meat event did not have a statistically significant effect on the total number of dishes ordered that had beef, chicken, or pork, those who ordered dishes that had beef, chicken, or pork after the Zombie meat event tended to order the more expensive beef, chicken, and pork dishes. Since restaurant stores did not significantly increase prices of individuals dishes that had beef, chicken, or pork in response to the Zombie meat event, these results suggest that customers who ordered meat following the Zombie meat event tended to order more expensive meat dishes, perhaps because they viewed these more expensive dishes as having higher quality and more fresh meat.

We find some evidence of heterogeneity by city. Our regression discontinuity analysis by city suggests that our main results may be driven primarily by Beijing, where 37 out of the 58 restaurants are located. Results of our supplementary empirical model of consumer demand show that after the Zombie meat event, consumers in Beijing and Tianjin were more likely to buy more expensive pork dishes. Among 22 popular dishes that were ordered in at least 21 of the 37 restaurants in Beijing, the Zombie meat event had a significant negative total average effect on the least expensive pork dish, Yunnan style ground pork fried rice, but did not have any statistically significant total average effect on the demand for any of the other more expensive pork dishes, chicken dishes, or beef dishes.

Our results are consistent with the anecdotal experience of high-end French restaurants during the mad cow disease epidemic in France. When bovine spongiform encephalopathy (BSE) was assessed as a possible human transmissible disease, a variant of Creutzfeldt-Jakob disease (vCJD), in 1996, French people entered into a long period of fear and avoidance of beef and bovine byproducts, which produced an unprecedented collapse in the beef market at least until the early 2000s (Setbon, 2005). Nevertheless, anecdotal evidence suggests that beef demand at gourmet butcheries and high-end restaurants in France did not decrease and may have even increased as a result of the mad cow disease epidemic, perhaps because they were more trusted by customers to provide high quality beef (Rosenblum, 2000).

The restaurants in the Chinese restaurant chain we analyze are considered mid-range restaurants which are neither high-end fine dining restaurants nor casual fast food restaurants. Our results suggest that the restaurants we analyze were in a good position at the onset of the Zombie meat crisis because they had more expensive (and possibly higher quality) meat dishes to which customers could shift. It is possible, for example, that lower-end restaurants that did not have more expensive meat dishes may have experienced a decline in the demand for all their meat dishes, rather than a shift in demand towards more expensive dishes. Furthermore, the affiliation itself with a mid-range Chinese restaurant chain with high quality dishes may also have been beneficial to the restaurants we analyzed in their ability to withstand the Zombie meat event; in their analysis of restaurant hygiene inspections in Los Angeles, for example, Jin and Leslie (2009) find that chain affiliation provides reputational incentives for good hygiene. Reputation concerns may be stronger for chain-affiliation restaurants, or restaurants that rely relatively more on repeat business (Bar-Isaac and Tadelis, 2008).

Our result that customers who ordered meat following the Zombie meat event tended to order more expensive meat dishes, perhaps because they viewed these more expensive dishes as having higher quality and more fresh meat, suggests that a possible means by which restaurants can weather food safety crises is to offer high quality dishes and to establish and maintain a reputation for quality. In addition, as our results suggest that customers care about the quality of restaurant dishes during food safety crises, restaurants and policymakers may wish to consider adopting quality assurance mechanisms to help provide information about product quality to customers. While branding, experience, word-of-mouth, and warranties are common forms of quality assurance mechanisms, quality disclosure – which is an effort by a certification agency to systematically measure and report product quality for a nontrivial percentage of products in a market – may be an important tool for facilitating consumer purchases when other forms of quality assurance are inadequate (Dranove and Jin, 2010). For example, Jin and Leslie (2003) find that a regulation in Los Angeles County that requires restaurants to publicly display hygiene grade cards resulting from Department of Health Services hygiene inspections creates economic incentives for restaurants to improve hygiene, leading to a significant improvement in public health outcomes (Jin and Leslie, 2005). It is possible that a similar policy requiring food safety inspections and the public display of food safety inspection results may similarly enhance restaurant dish quality and help restaurants withstand food safety crises. Voluntary disclosure, government mandates, and third-party certifiers do not necessarily improve social welfare, however, and it is important to design quality-rating systems carefully, evaluate their effectiveness ex post, and improve system design based on theory and evidence (Dranove and Jin, 2010).

Our research has important implications for the food industry and food policy, including for policymakers who wish to assess the benefits of implementing preventive food safety and sanitation policies, and restaurant firms that wish make more informed decisions about voluntarily implementing stricter food safety systems in their operations. Our results contribute to a better understanding on the part of policymakers as well as industry stakeholders of the impact of food safety events on the restaurant industry.

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Table 1.1. The Effects of Zombie Meat Event on Daily Store-Level Variables

# weeks before and after event	10	5
Restaurant fixed effects	Y	Y
Dependent variable is residualized daily restaurant store-level variable for:		
Total number of orders at that restaurant on that day	-4.497	-80.808
	(23.66)	(49.781)
Total number of people at that restaurant on that day	-72.062	-373.86
	(102.54)	(161.81)
Total price of all orders at that restaurant on that day	169.04*	218.17*
	(41.62)	(58.13)
Average price of all orders at that restaurant on that day	-0.309	-0.560
	(0.217)	(0.325)
Average price of dishes ordered at that restaurant on that day with characteristic:		
Dessert	168.256*	211.217*
	(40.723)	(55.979)
Beef	172.362*	219.560*
	(40.725)	(56.335)
Chicken	169.436*	213.670*
	(40.328)	(56.168)
Pork	169.633*	215.270*
	(39.550)	(56.576)
Seafood	170.164*	213.546*
	(40.700)	(56.002)
Tofu	212.032*	273.730
	(40.419)	(83.286)
Mushroom	172.449*	224.537*
	(40.785)	(56.847)
Vegetable Excluding Mushroom	173.067*	222.154*
	(39.806)	(58.104)

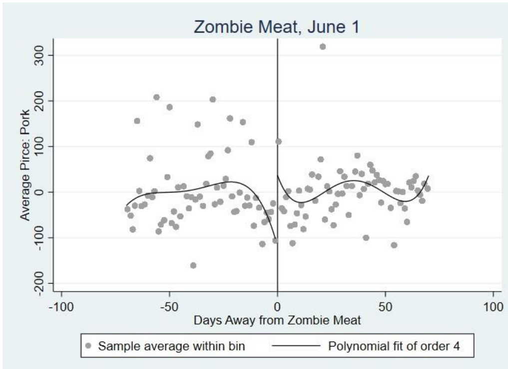
Rice	175.632*	222.994*
	(40.255)	(55.483)
Boiling, including Hotpot	172.121*	219.397*
	(40.314)	(58.081)
Spicy	170.087*	214.715*
	(39.956)	(56.221)
Sweet	164.916*	210.188*
	(40.314)	(56.217)
Salty	174.439*	224.120*
	(39.893)	(58.284)
Sour	169.893*	213.758*
	(40.314)	(56.121)
Umami	173.431*	220.489*
	(40.504)	(57.735)
Total number of dishes ordered at that restaurant on that day with characteristic:		
Dessert	22.294*	20.695*
	(4.051)	(5.039)
Beef	-2.243	-2.361
	(1.826)	(3.548)
Chicken	0.027	-9.347
	(3.595)	(6.618)
Pork	-0.930	-15.654
	(2.751)	(6.641)
Seafood	0.115	-12.672
	(3.392)	(7.163)
Tofu	-32.237*	-45.433*
	(6.404)	(8.556)
Mushroom	-2.681	7.139
	(4.020)	(4.010)
Vegetable Excluding Mushroom	6.744	-6.374
	(5.388)	(11.495)
Rice	1.742	-8.608
	(3.969)	(5.912)
Boiling, including Hotpot	-25.926*	-35.657*
	(7.185)	(9.711)

Spicy	10.341	-15.292
	(7.231)	(17.784)
Sweet	5.061	-7.390
	(7.977)	(14.124)
Salty	-0.538	-53.799
	(15.872)	(33.783)
Sour	3.185	-23.370
	(7.877)	(15.790)
Umami	-7.134	-52.419
	(14.041)	(27.483)

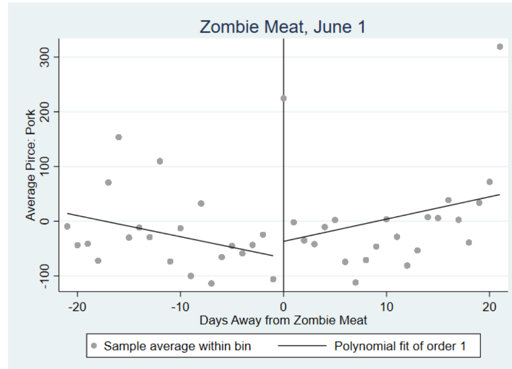
Notes: Each of the cells in this table reports estimates from separate daily store-level local linear regression discontinuity regressions. Each of the 38 rows presents results from using a separate dependent variable. For each of the 38 dependent variables, we run separate daily store-level local linear regression discontinuity regressions using 2 different windows of the residual from a first-stage regression of the variable in that row on weather and seasonality covariates, and restaurant fixed effects. The unit of observation in each daily store-level local linear regression discontinuity regression is a restaurant store-day. Prices are in Yuan. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level after applying the Bonferroni correction to adjust for multiple hypothesis testing.

Figure 1.1. Residual Plots for Average Price of Meat Dishes Ordered

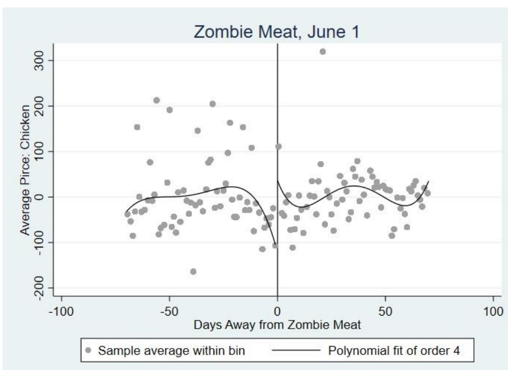
Pork(a)



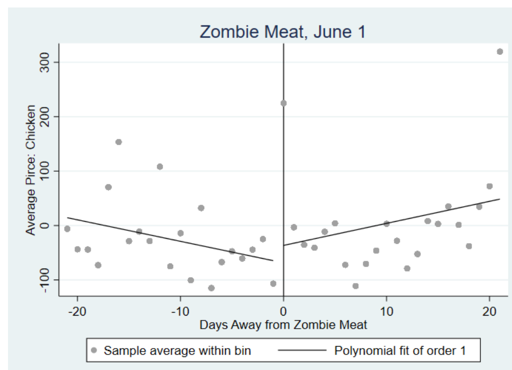
Pork(b)



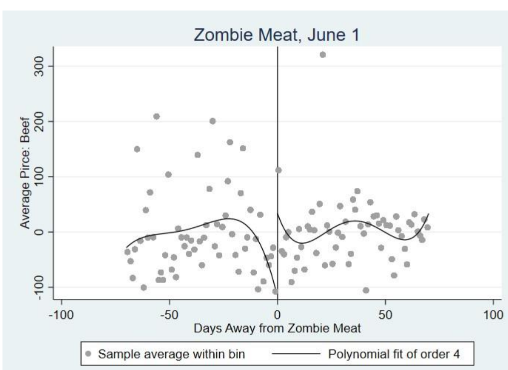
Chicken(a)



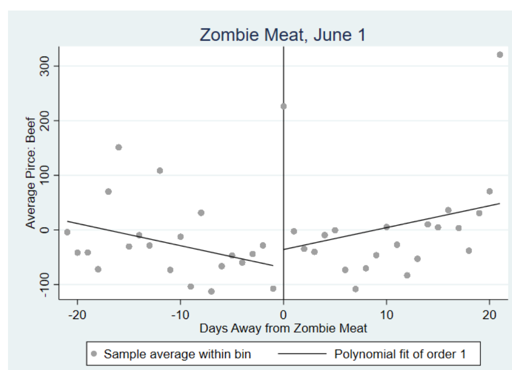
Chicken(b)



Beef(a)



Beef(b)



Notes: Figure presents residual plots of the average price of all dishes ordered at that restaurant on that day with pork, chicken, and beef, respectively, using data within a window of (a) 10 weeks before to 10 weeks after and (b) 3 weeks before to 3 weeks after the Zombie meat event. The residual plots plot residuals from a first-stage regression of the average price of all dishes ordered at that restaurant on that day with pork, chicken, and beef from our daily store-level panel data set on weather and seasonality covariates, and restaurant fixed effects. The results of our local linear regression discontinuity regressions with robust confidence intervals of residuals from first-stage regressions of each of the variables in our daily store-level panel data set are presented in Table 1.1. The full set of residual plots for each of the variables in our daily store-level panel data set for within a window of 10 weeks before to 10 weeks after the Zombie meat event is in Appendix 1.C.

Table 1.2. The Effects of Zombie Meat Event on Daily Restaurant-Dish-Level Variables

# weeks before and after event	10	10	5	5
Restaurant dish fixed effects	Y	N	Y	N
Restaurant fixed effects	N	Y	N	Y
Dependent variable is residualized daily restaurant-dish-level variable for:				
Dummy variable for dish in that restaurant that day having the characteristic:				
Dessert	0.000	0.003	0.000	0.002
	(0.000)	(0.002)	(0.000)	(0.003)
Beef	0.000	-0.001	0.000	-0.003
	(0.000)	(0.001)	(0.000)	(0.001)
Chicken	0.000	-0.002	0.000	-0.003
	(0.000)	(0.001)	(0.000)	(0.002)
Pork	0.000	-0.005		-0.002
	(0.000)	(0.002)		(0.002)
Seafood	0.000	-0.001	0.000	-0.003
	(0.000)	(0.001)	(0.000)	(0.002)
Tofu	0.000	-0.002	0.000	-0.002
	(0.000)	(0.001)	(0.000)	(0.001)
Mushroom	0.000	0.001	0.000	0.002
	(0.000)	(0.002)	(0.000)	(0.002)
Vegetable Excluding Mushroom	0.000	-0.004		-0.004
	(0.000)	(0.002)		(0.003)
Rice	0.000	-0.001	0.000	-0.002
	(0.000)	(0.001)	(0.000)	(0.001)
Boiling, including Hotpot	0.000	-0.005*		-0.008
	(0.000)	(0.001)		(0.002)
Spicy	0.000	-0.004	0.000	-0.007
	(0.000)	(0.002)	(0.000)	(0.003)
Sweet	0.000	0.019*	0.000	0.025*
	(0.000)	(0.004)	(0.000)	(0.005)
Salty	0.000	-0.017*	0.000	-0.023*

	(0.000)	(0.004)	(0.000)	(0.005)
Sour	0.000	-0.002		0.004
	(0.000)	(0.003)		(0.003)
Umami	0.000	-0.013*	0.000	-0.017*
	(0.000)	(0.003)	(0.000)	(0.004)
Promotions – Any	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.004)
Price of dish in that restaurant that day with characteristic:				
Dessert	0.541	0.227	0.445	0.253
	(0.410)	(0.495)	(0.457)	(0.547)
Beef	0.523	0.308	0.353	-0.154
	(0.418)	(0.578)	(0.484)	(0.626)
Chicken	0.560	0.300	0.535	0.178
	(0.407)	(0.475)	(0.483)	(0.533)
Pork	-0.080	-0.700	0.018	-0.774
	(0.395)	(0.465)	(0.486)	(0.500)
Seafood	0.494	-0.548	0.494	-0.748
	(0.416)	(0.565)	(0.492)	(0.622)
Tofu	0.327	0.254	0.164	0.125
	(0.402)	(0.475)	(0.462)	(0.531)
Mushroom	0.261	-1.228	0.061	-1.416
	(0.410)	(0.641)	(0.436)	(0.644)
Vegetable Excluding Mushroom	0.476	0.406	0.356	0.238
	(0.393)	(0.398)	(0.455)	(0.458)
Rice	0.641	0.657	0.596	0.750
	(0.416)	(0.510)	(0.476)	(0.558)
Boiling, including Hotpot	0.740	1.434	0.668	0.916
	(0.411)	(0.541)	(0.454)	(0.536)
Spicy	-0.039	-0.626	-0.087	-0.782
	(0.381)	(0.412)	(0.464)	(0.475)
Sweet	-0.247	-1.092	-0.088	-1.104
	(0.369)	(0.518)	(0.449)	(0.614)
Salty	-0.145	-0.168	-0.144	-0.311
	(0.401)	(0.408)	(0.479)	(0.465)
Sour	-0.013	-1.091	0.071	-1.635
	(0.410)	(0.479)	(0.445)	(0.527)

Umami	-0.019	-0.261	-0.070	-0.396
	(0.381)	(0.412)	(0.466)	(0.463)
Promotions – Any	0.976	-0.228	0.821	0.241
	(1.273)	(0.725)	(0.447)	(1.449)

Notes: Each of the cells in this table reports estimates from separate daily restaurant-dish-level local linear regression discontinuity regressions. Each of the 36 rows presents results from using a separate dependent variable. For each of the 36 dependent variables, we run separate daily restaurant-dish-level local linear regression discontinuity regressions using 2 different windows of the residual from a first-stage regression of the variable in that row on weather and seasonality covariates, promotion dummies, and either restaurant fixed effects or restaurant-dish fixed effects. The unit of observation in each daily restaurant-dish-level local linear regression discontinuity regression is a restaurant store-day. Prices are in Yuan. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level after applying the Bonferroni correction to adjust for multiple hypothesis testing.

Table 1.3 Daily Restaurant Dish Demand in Beijing

Dependent variable is Total Number of Orders of a Dish a Restaurant on a Day	Fixed effects (Table F1a)	Fixed Effects (Table F1b)	IV Fixed Effects (Table F3a)	IV Fixed Effects (Table F3b)
Post Zombie Meat Event * Price	-0.0026	-0.0057*	0.0209***	0.0112**
	(0.0023)	(0.0023)	(0.0036)	(0.0037)
Post Zombie Meat Event * Vegetable Excluding Mushroom	1.4020**	1.3164**	0.7203	1.4222**
	(0.5065)	(0.5074)	(0.5399)	(0.5393)
Post Zombie Meat Event * Mushroom	-0.0827	-0.1275	0.6957	0.4940
	(0.6051)	(0.6048)	(0.6311)	(0.6308)
Post Zombie Meat Event * Tofu	-2.2853**	-2.1011*	-3.8931***	-3.9554***
	(0.8161)	(0.8241)	(1.1278)	(1.1261)
Post Zombie Meat Event * Seafood	5.3536***	5.1406***	7.2645***	6.7021***
	(0.9905)	(0.9903)	(1.0470)	(1.0464)
Post Zombie Meat Event * Pork	-5.9312***	-6.0779***	-4.2652***	-6.8714***
	(0.7474)	(0.7482)	(0.8009)	(0.7932)
Post Zombie Meat Event * Chicken	0.2483	0.0802	1.3975	1.0783
	(0.9644)	(0.9644)	(1.0543)	(1.0538)
Post Zombie Meat Event * Beef	2.0322*	2.0688*	0.6337	0.4429
	(0.8199)	(0.8194)	(0.8633)	(0.8627)
Post Zombie Meat Event * Any Type of Promotion		-0.8080*		-1.0167**
		(0.3138)		(0.3375)
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	-0.0457**	-0.0447**	-0.0398*	-0.0655***
	(0.0146)	(0.0146)	(0.0157)	(0.0156)
Post Zombie Meat Event * Price * Mushroom	-0.0092	-0.0076	-0.0312**	-0.0225
	(0.0108)	(0.0108)	(0.0116)	(0.0116)
Post Zombie Meat Event * Price * Tofu	0.0653*	0.0579*	0.0986**	0.0978**
	(0.0287)	(0.0290)	(0.0375)	(0.0374)
Post Zombie Meat Event * Price * Seafood	-0.0845***	-0.0805***	-0.1365***	-0.1233***
	(0.0157)	(0.0157)	(0.0167)	(0.0166)
Post Zombie Meat Event * Price * Pork	0.1299***	0.1333***	0.0742***	0.1442***
	(0.0187)	(0.0187)	(0.0204)	(0.0201)
Post Zombie Meat Event * Price * Chicken	-0.0249	-0.0214	-0.0795**	-0.0694**
	(0.0240)	(0.0240)	(0.0262)	(0.0262)

Post Zombie Meat Event * Price * Beef	-0.0318	-0.0316	-0.0346*	-0.0262
	(0.0166)	(0.0166)	(0.0175)	(0.0175)
IV for Price and Price Interactions	N	N	Y	Y
Promotion and Promotion Interactions	N	Y	N	Y
Price, Characteristics, and Price*Characteristics Interactions	Y	Y	Y	Y
Post Zombie Meat Event Dummy	Y	Y	Y	Y
Weather and Seasonality Controls	Y	Y	Y	Y
Restaurant Fixed Effect	Y	Y	Y	Y
# Observations	154,693	154,693	144,662	144,662
p-value (Pr > F)	0.0000	0.0000	0.0000	0.0000

Notes: We use observations from the 5 weeks before to 5 weeks after the Zombie meat event. We control for dish price, dish characteristics, and dish price interacted with dish characteristics. Price is in Yuan. The weather and seasonality covariates are daily maximum temperature, daily average temperature, daily precipitation, month-of-year dummies, and day-of-week dummies. For the IV fixed effects regressions, we instrument for price and the price interactions using the average Quarter 1 price of that dish in that city and its interactions. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level. Full regression results are presented in Tables 1.F.1a, 1.F.1b, 1.F.3a, and 1.F.3b in Appendix 1.F.

Table 1.4a. Total Average Effect of Zombie Meat Event in Beijing

Dish Name in English	Dish Name in Chinese	Avg. Price (Yuan)	Total Average Effect in Beijing using results from daily restaurant dish demand for Beijing			
			Fixed effects (Table F1a)	Fixed effects (Table F1b)	IV fixed effects (Table F3a)	IV fixed effects (Table F3b)
Pork dishes						
Yunnan style ground pork fried rice	黑三剁炒饭	29	-2.7326** (0.955)	-2.7269** (0.9566)	-1.5073 (1.0012)	-2.3187* (1.0221)
Yunnan bamboo shoots sauté bacon	云南腊肉炒香笋	38	-2.2103 (1.3067)	-1.9607 (1.3017)	-1.4435 (1.3815)	-1.9869 (1.3924)
Olive oil Nuodeng ham stew with wheat melon	橄榄油诺邓火腿焖小麦瓜	39	-2.1363 (1.3237)	-1.8778 (1.3184)	-1.3882 (1.4002)	-1.897 (1.4105)
Yunnan spicy trotters	老滇香辣猪蹄	40	-1.3323 (1.0869)	-1.3233 (1.0884)	-0.4612 (1.1524)	-0.6093 (1.1669)
Dai flavor roast pork	傣味烤五花肉	43	-0.8948 (1.1328)	-0.8847 (1.1342)	-0.1343 (1.2046)	-0.0752 (1.2171)
Matsuzaka meat with pickles (pork neck)	腌菜松板肉（黄金6两）	79	0.8556 (2.1282)	1.4739 (2.1115)	0.8476 (2.2794)	1.7378 (2.2705)
Chicken dishes						
Lemongrass grilled wings (two pairs)	香茅草烤翅中（两对）	29	-1.0423 (1.214)	-1.0551 (1.2148)	-0.3019 (1.3037)	-0.5634 (1.328)
Cold chicken noodle	鸡丝凉米线	40	-1.3469 (1.3851)	-1.3553 (1.3858)	-0.951 (1.4949)	-1.208 (1.5163)
Yongping potato chicken stew	永平洋芋焖鸡	42	-1.3998 (1.4178)	-1.4074 (1.4185)	-1.0637 (1.5314)	-1.32 (1.5523)
Thai style chicken lemon geranium	泰式柠檬香叶鸡	49	-1.5923 (1.5429)	-1.5971 (1.5435)	-1.4739 (1.6706)	-1.7274 (1.6899)
Beef dishes						
Yi shredded pepper and	彝族手撕美	32	0.1347	0.4118	-0.358	-0.6648

beef tendon	人椒拌牛筋		(1.2254)	(1.2213)	(1.2712)	(1.2946)
Beef stew with fresh mint	鲜薄荷配卤牛肉	37	0.276 (1.0515)	0.3498 (1.052)	0.1307 (1.0843)	-0.0618 (1.1134)
Simmering eight hours Kunming old style crispy beef	文火慢炖8小时老昆明大酥牛肉	87	-1.4441 (1.685)	-1.5153 (1.6853)	-0.5544 (1.7737)	-0.8118 (1.7929)
Seafood dishes						
Dai flavor lemongrass grilled tilapia	傣味香茅草烤罗非鱼	58	-0.2049 (1.3738)	-0.2218 (1.3744)	0.5417 (1.4434)	0.229 (1.462)
Fish in sour soup with Banna wild berries	版纳野果酸汤鱼	67	-0.9818 (1.4727)	-0.9908 (1.4732)	-0.4895 (1.5522)	-0.7711 (1.5686)
Yunnan Yang Lin fish in sour soup	云南杨林酸菜鱼	87	-2.6926 (1.7115)	-2.6839 (1.712)	-2.7601 (1.8141)	-2.9729 (1.826)
Tofu dishes						
Shiping style panfried tofu	香煎石屏豆腐	29	-0.9328 (1.1996)	-0.914 (1.2121)	-0.3756 (1.5816)	-0.7009 (1.5988)
Mushroom dishes						
Dai flavor roasted mushroom	傣味香烤菌菇	36	-1.0006 (0.7609)	-0.9557 (0.7619)	0.3249 (0.7678)	0.1333 (0.8088)
Wild porcini mushrooms cooked in banana leaf	包烧野生牛肝菌	88	-1.6142 (1.1684)	-1.6473 (1.1691)	-0.2107 (1.2412)	-0.4543 (1.2689)
Vegetable dishes						
Grandma potato with scallion	老奶洋芋(葱香)	9	0.4045 (0.5745)	0.5122 (0.5762)	0.5498 (0.5591)	0.9783 (0.6131)
Zhe Ergen crispy potato	折耳根咔嚓洋芋	22	-0.3209 (0.6502)	-0.1418 (0.648)	0.3045 (0.6458)	0.2737 (0.6924)
Dai flavor pineapple rice	傣味菠萝饭	43	-1.5191 (0.8636)	-1.2221 (0.8522)	-0.1006 (0.8837)	-0.8902 (0.9165)

Notes: Table presents the results of the total average effect of the Zombie meat event on the demand for 22 dishes in Beijing, as calculated using the results from the fixed effects and IV fixed effects demand regressions for Beijing, and evaluated at the dish characteristics and the mean dish price over all restaurants in Beijing over all days in the window from 5 weeks before to 5 weeks after the Zombie meat event. The fixed effects and IV fixed effects demand regressions for Beijing are reported in Tables 1.F.1a, 1.F.1b, 1.F.3a, and 1.F.3b in Appendix 1.F and summarized in Table 1.3. Average price in Beijing is average price of dish in all restaurants in Beijing in all days within 5 weeks of Zombie meat event. Some of the meat dishes also had vegetables. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

Table 1.4b. Total Average Effect of Zombie Meat Event in All Cities

Dish Name in English	Dish Name in Chinese	Avg. Price (Yuan)	Total Average Effect using results from daily restaurant dish demand for all cities			
			Fixed effects (Table F1a)	Fixed effects (Table F1b)	IV fixed effects (Table F3a)	IV fixed effects (Table F3b)
Pork dishes						
Yunnan style ground pork fried rice	黑三剁炒饭	29	-2.8935***	-2.8826***	-1.7176	-2.4326**
			(0.8706)	(0.8724)	(0.9172)	(0.9377)
Yunnan bamboo shoots sauté bacon	云南腊肉炒香笋	38	-2.1755	-2.2318	-1.6884	-2.1305
			(1.1881)	(1.1897)	(1.2664)	(1.2776)
Olive oil Nuodeng ham stew with wheat melon	橄榄油诺邓火腿焖小麦瓜	39	-2.0864	-2.1411	-1.6269	-2.0325
			(1.2034)	(1.205)	(1.2836)	(1.2943)
Yunnan spicy trotters	老滇香辣猪蹄	40	-1.3051	-1.2898	-0.5164	-0.5263
			(0.9917)	(0.9933)	(1.0561)	(1.0714)
Dai flavor roast pork	傣味烤五花肉	44	-0.7718	-0.755	-0.1131	0.1138
			(1.037)	(1.0385)	(1.1077)	(1.1212)
Matsuzaka meat with pickles (pork neck)	腌菜松板肉（黄金6两）	80	1.5404	1.5509	0.8765	1.9566
			(1.937)	(1.938)	(2.0964)	(2.0911)
Chicken dishes						
Lemongrass grilled wings (two pairs)	香茅草烤翅中（两对）	29	-0.8924	-0.9054	-0.0242	-0.1747
			(1.0706)	(1.0717)	(1.1728)	(1.196)
Cold chicken noodle	鸡丝凉米线	40	-1.1989	-1.2085	-1.2444	-1.3859
			(1.2251)	(1.226)	(1.3488)	(1.369)
Yongping potato chicken stew	永平洋芋焖鸡	42	-1.246	-1.2551	-1.4321	-1.5722
			(1.2512)	(1.2521)	(1.3785)	(1.3983)
Thai style chicken lemon geranium	泰式柠檬香叶鸡	49	-1.4364	-1.4434	-2.1902	-2.3247
			(1.3619)	(1.3628)	(1.5041)	(1.5223)
Beef dishes						
Yi shredded pepper and beef tendon	彝族手撕美人椒拌牛筋	32	0.5046	0.532	-0.4802	-0.6908
			(1.1263)	(1.1272)	(1.181)	(1.2021)
Beef stew with fresh mint	鲜薄荷配卤牛	37	0.5746	0.6616	0.114	0.0341

	肉		(0.9749)	(0.9755)	(1.0147)	(1.0411)
Simmering eight hours Kunming old style crispy beef	文火慢炖8小时老昆明大酥牛肉	87	-1.2805 (1.5643)	-1.3835 (1.5647)	-0.641 (1.6566)	-0.801 (1.6729)
Seafood dishes						
Dai flavor lemongrass grilled tilapia	傣味香茅草烤罗非鱼	59	-0.0845 (1.2333)	-0.0987 (1.234)	0.4333 (1.3191)	0.2375 (1.3396)
Fish in sour soup with Banna wild berries	版纳野果酸汤鱼	67	-0.7575 (1.3208)	-0.7682 (1.3215)	-0.5355 (1.4165)	-0.6947 (1.4356)
Yunnan Yang Lin fish in sour soup	云南杨林酸菜鱼	87	-2.2671 (1.5359)	-2.27 (1.5365)	-2.7089 (1.6548)	-2.7858 (1.6712)
Tofu dishes						
Shiping style panfried tofu	香煎石屏豆腐	30	-1.0392 (1.1468)	-1.0205 (1.156)	-0.4203 (1.5169)	-0.6413 (1.5341)
Mushroom dishes						
Dai flavor roasted mushroom	傣味香烤菌菇	36	-0.7086 (0.7067)	-0.6604 (0.7079)	0.4167 (0.7162)	0.3346 (0.7537)
Wild porcini mushrooms cooked in banana leaf	包烧野生牛肝菌	88	-1.1246 (1.0902)	-1.1648 (1.0909)	-0.1969 (1.1574)	-0.331 (1.181)
Vegetable dishes						
Grandma potato with scallion	老奶洋芋(葱香)	9	0.588 (0.5258)	0.6331 (0.5281)	0.6156 (0.5134)	1.1793* (0.5634)
Zhe Ergen crispy potato	折耳根咔嚓洋芋	22	-0.1637 (0.5918)	-0.1469 (0.5939)	0.2738 (0.5926)	0.3698 (0.6355)
Dai flavor pineapple rice	傣味菠萝饭	44	-1.4325 (0.783)	-1.4635 (0.7845)	-0.3031 (0.8143)	-0.9967 (0.8436)

Notes: Table presents the results of the total average effect of the Zombie meat event on the demand for 22 dishes in all cities, as calculated using the results from the fixed effects and IV fixed effects demand regressions for all cities, and evaluated at the dish characteristics and the mean dish price over all restaurants over all days in the window from 5 weeks before to 5 weeks after the Zombie meat event. The fixed effects and IV fixed effects demand regressions for all cities are reported in Tables 1.F.1a, 1.F.1b, 1.F.3a, and 1.F.3b in Appendix 1.F. Average price is average price of dish in all restaurants in all days within 5 weeks of Zombie meat event. Some of the meat dishes also had vegetables. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

APPENDIX 1.A.

Number of Restaurant-Dish-Days With and Without Each Dish Characteristic

Figure A-1. Dessert

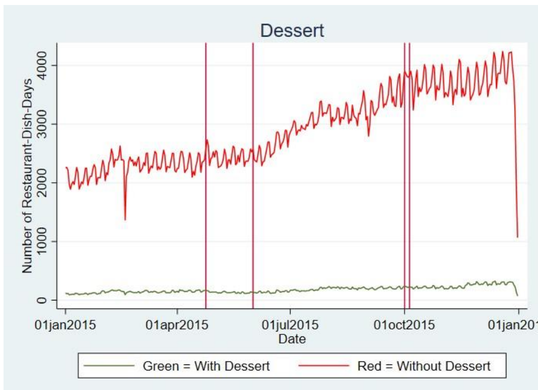


Figure A-2. Beef

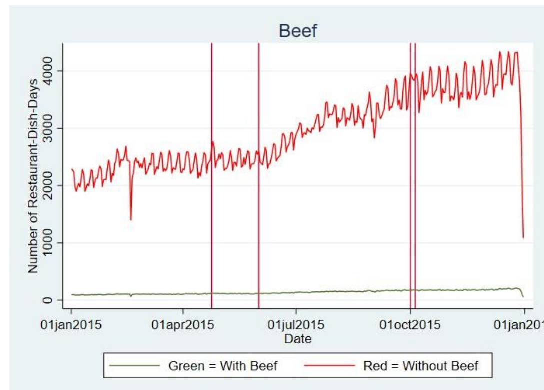


Figure A-3. Chicken

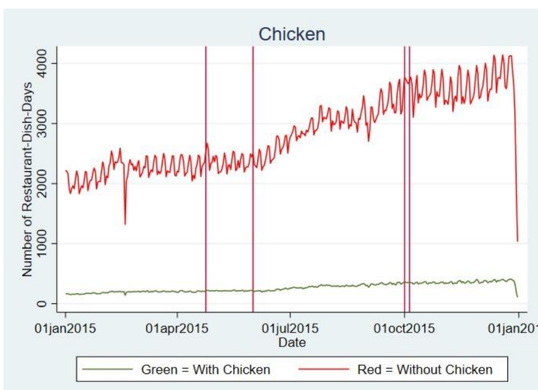


Figure A-4. Pork

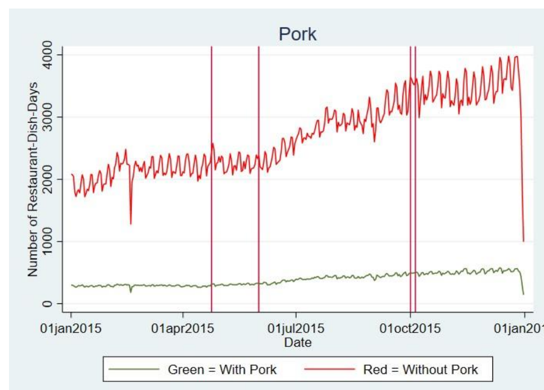


Figure A-5. Duck

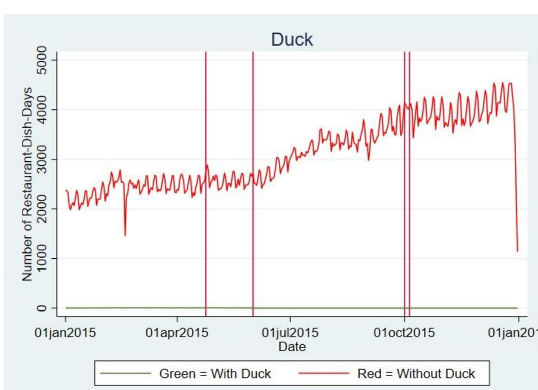


Figure A-6. Tofu

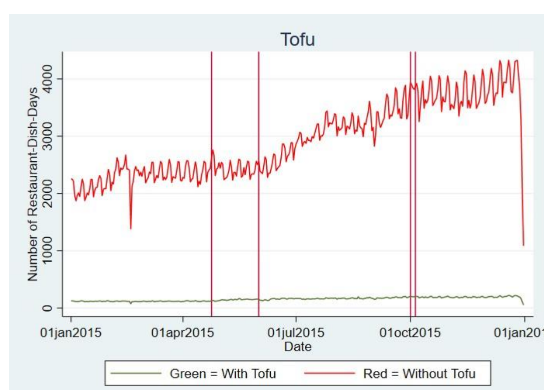


Figure A-7. Seafood

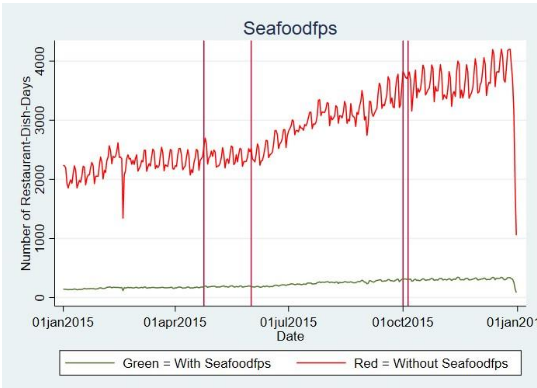


Figure A-8. Mushroom

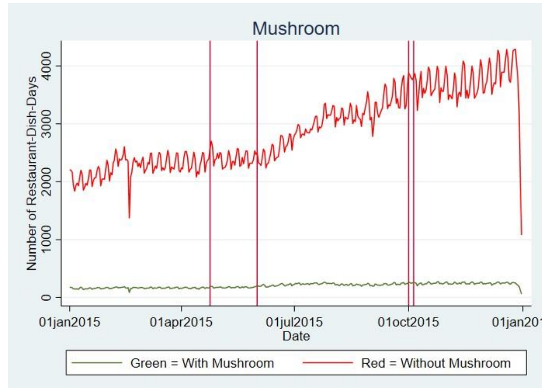


Figure A-9. Vegetable, excluding Mushroom

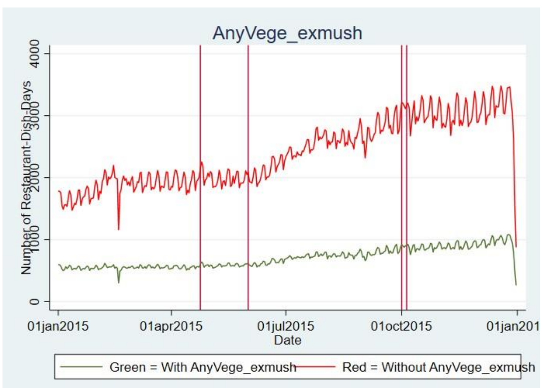


Figure A-10. Rice

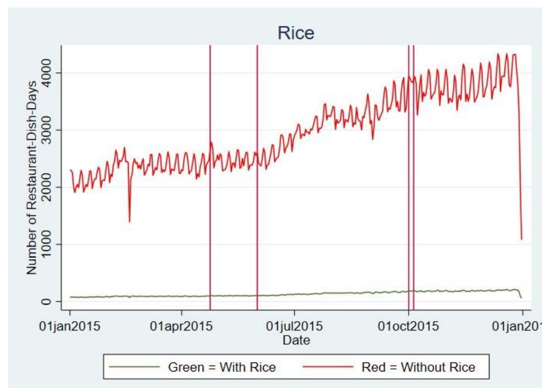


Figure A-11. Boiling, including Hot Pot

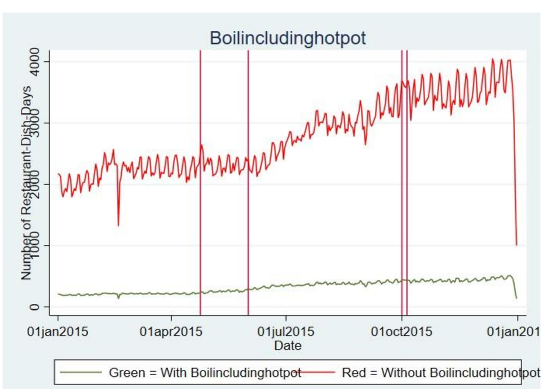


Figure A-12. Spicy

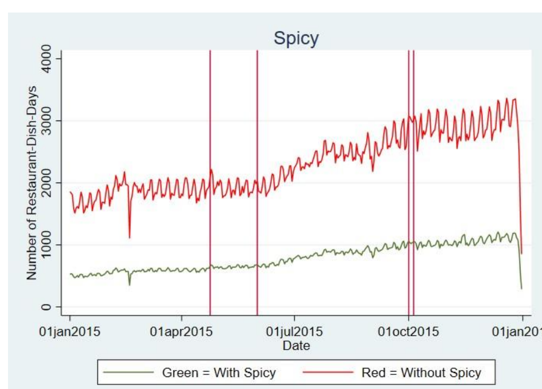


Figure A-13. Sweet

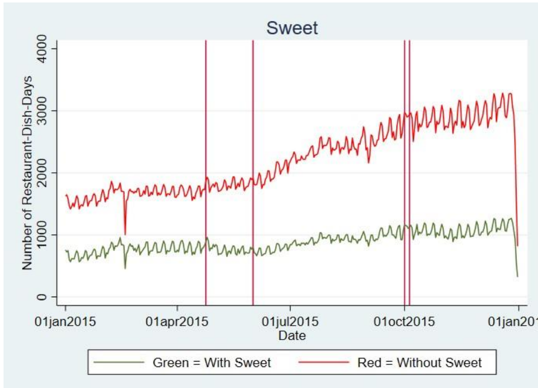


Figure A-14. Salty

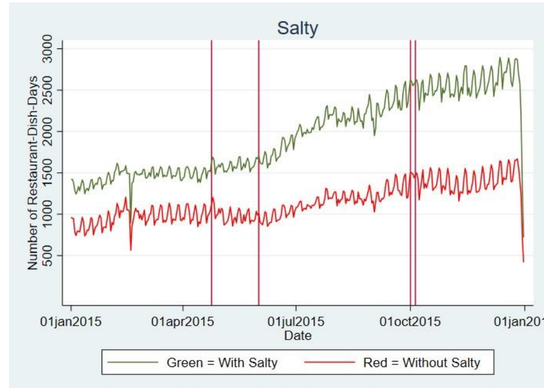


Figure A-15. Sour

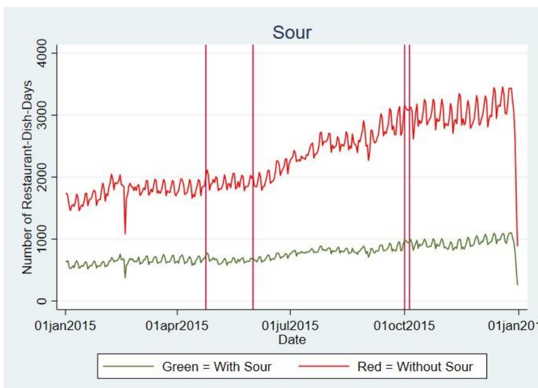
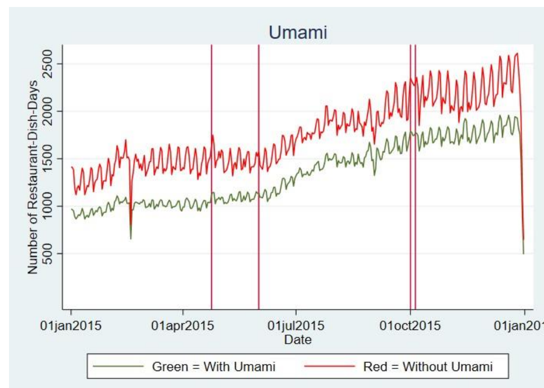


Figure A-16. Umami



Notes: To summarize our daily restaurant-dish-level panel data, Appendix 1.A presents time series plots for the dummy variables in our daily restaurant-dish-level panel data set. For each of the dummy variables in our daily restaurant-dish-level panel data set, we plot (1) the number of restaurant dishes each day that have that dish characteristic (i.e., the number of restaurant dishes each day for which the dummy variable for that dish characteristic is equal to 1) as a green line; and (2) the number of restaurant dishes each day that do not have that dish characteristic (i.e., the number of restaurant dishes each day for which the dummy variable for that dish characteristic is equal to 1) as a red line, both on the same graph, with day on the x-axis. The vertical lines indicate the dates of each of the four major food safety and food price-related media and policy event in China in 2015: the China National Food Safety Law announcement on April 24, 2015; China National Food Safety Law implementation on October 1, 2015 (Guo, 2015); the Zombie meat discovery and announcement on June 1, 2015; and the expensive prawn announcement on October 5, 2015 (Li, 2015). We focus our analysis on the Zombie meat discovery and announcement on June 1, 2015. It is difficult to ascertain whether the Zombie meat event had a significant effect based on the time series plots of the raw data from our daily restaurant-dish-level panel data set.

APPENDIX 1.B.

Scatterplots Over Time for Variables in Daily Store-Level Panel Data Set

Figure B-1. Total number of orders at that restaurant on that day

Figure B-2. Total number of people at that restaurant on that day

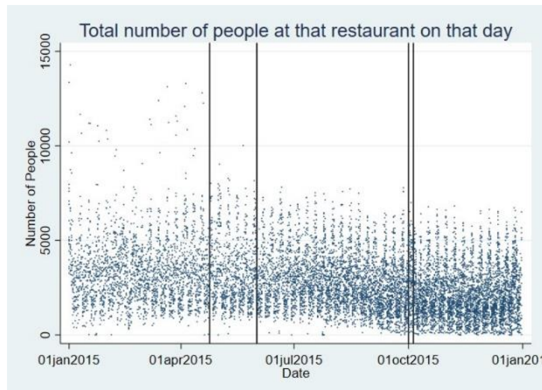


Figure B-3. Total price of all orders at that restaurant on that day

Figure B-4. Average price of all orders at that restaurant on that day

Figure B-5. Average price of all dishes ordered at that restaurant on that day with characteristic: Dessert

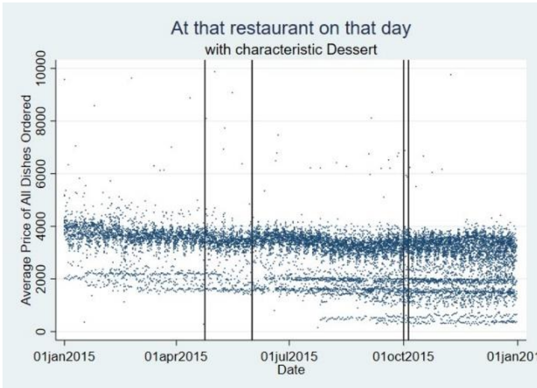


Figure B-6. Total number of dishes ordered at that restaurant on that day with characteristic: Dessert

Figure B-7. Average price of all dishes ordered at that restaurant on that day with characteristic: Beef

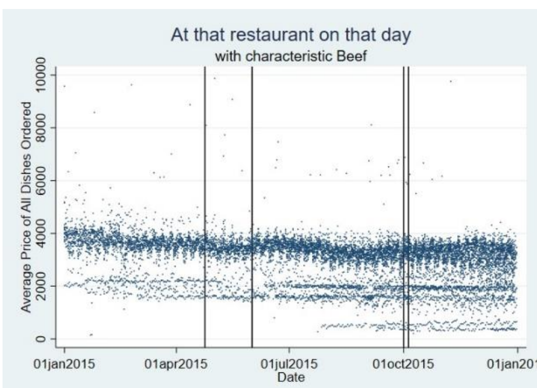


Figure B-8. Total number of dishes ordered at that restaurant on that day with characteristic: Beef

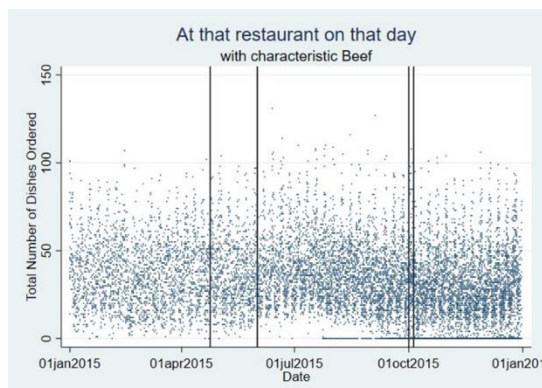


Figure B-9. Average price of all dishes ordered at that restaurant on that day with characteristic: Chicken

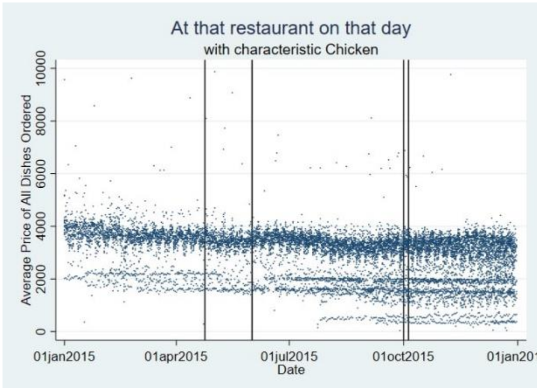


Figure B-10. Total number of dishes ordered at that restaurant on that day with characteristic: Chicken

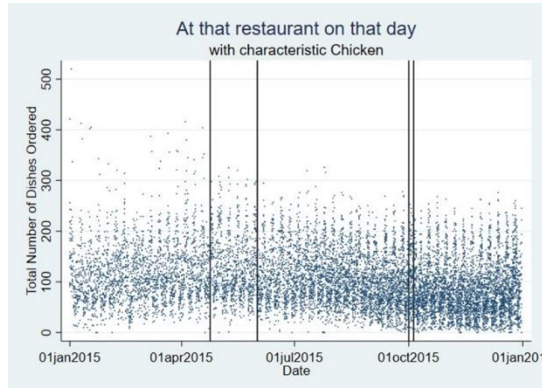


Figure B-11. Average price of all dishes ordered at that restaurant on that day with characteristic: Duck

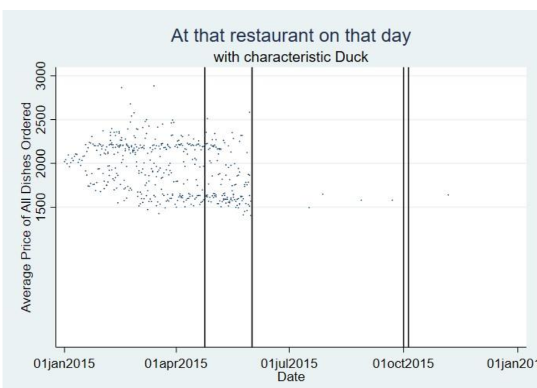


Figure B-12. Total number of dishes ordered at that restaurant on that day with characteristic: Duck

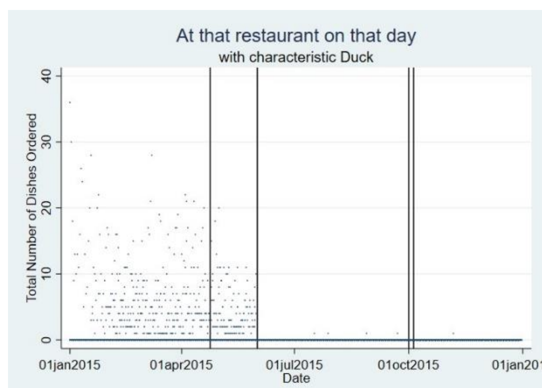


Figure B-13. Average price of all dishes ordered at that restaurant on that day with characteristic: Pork

Figure B-14. Total number of dishes ordered at that restaurant on that day with characteristic: Pork

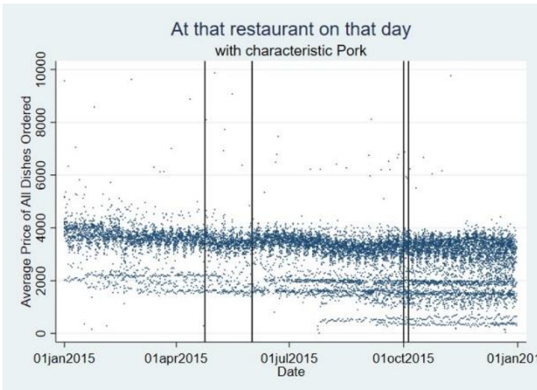
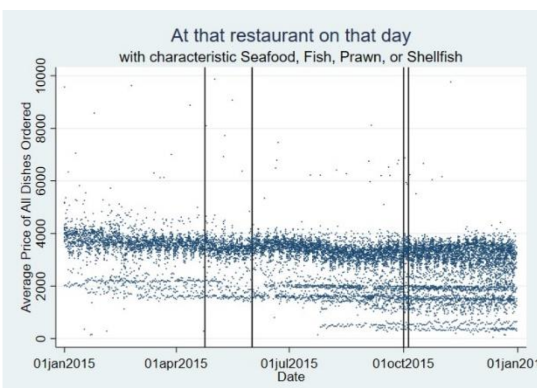


Figure B-15. Average price of all dishes ordered at that restaurant on that day with characteristic: Seafood

Figure B-16. Total number of dishes ordered at that restaurant on that day with characteristic: Seafood



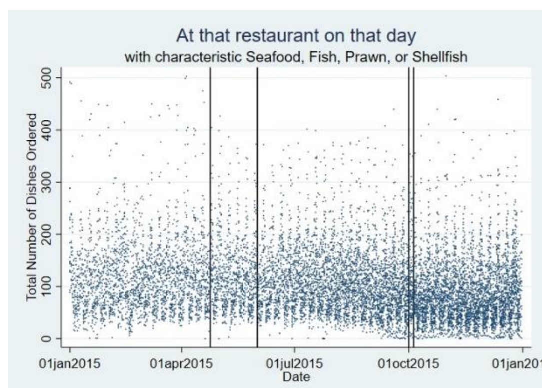


Figure B-17. Average price of all dishes ordered at that restaurant on that day with characteristic: Tofu

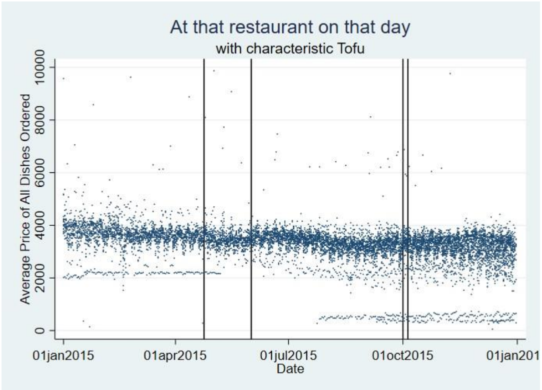


Figure B-18. Total number of dishes ordered at that restaurant on that day with characteristic: Tofu

Figure B-19. Average price of all dishes ordered at that restaurant on that day with characteristic: Mushroom

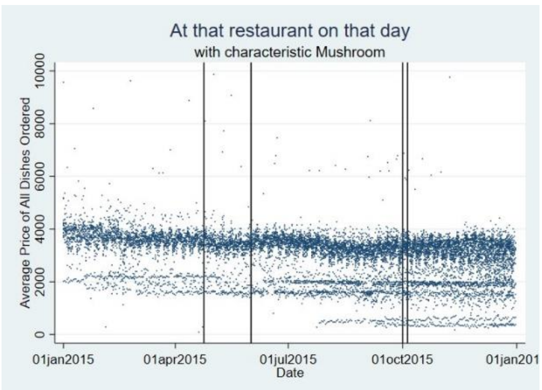


Figure B-20. Total number of dishes ordered at that restaurant on that day with characteristic: Mushroom

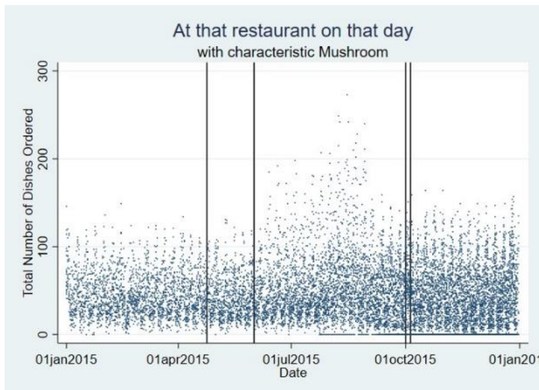


Figure B-21. Average price of all dishes ordered at that restaurant on that day with characteristic: Vegetable Excluding Mushroom

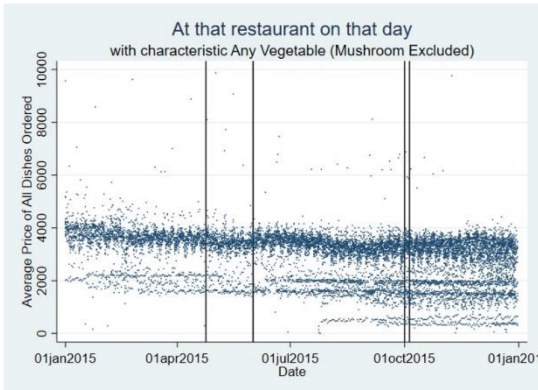


Figure B-22. Total number of dishes ordered at that restaurant on that day with characteristic: Vegetable Excluding Mushroom

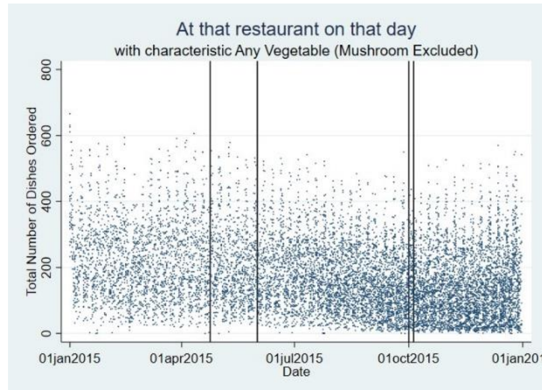


Figure B-23. Average price of all dishes ordered at that restaurant on that day with characteristic: Rice

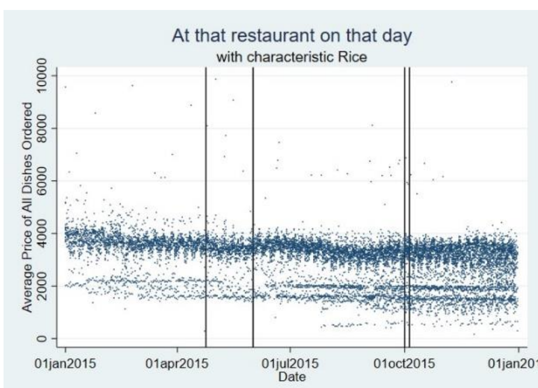


Figure B-24. Total number of dishes ordered at that restaurant on that day with characteristic: Rice

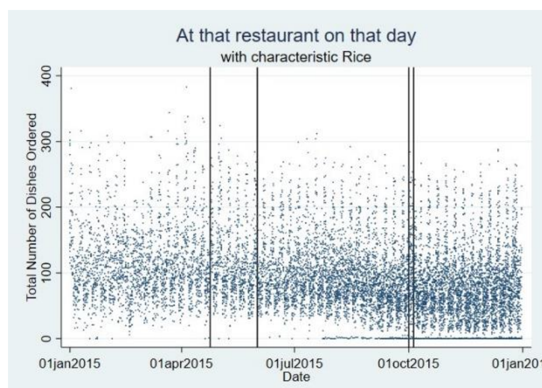


Figure B-25. Average price of all dishes ordered at that restaurant on that day with characteristic: Boiling, including Hotpot

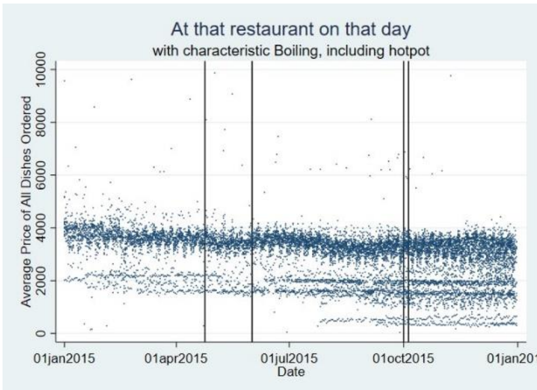


Figure B-26. Total number of dishes ordered at that restaurant on that day with characteristic: Boiling, including Hotpot

Figure B-27. Average price of all dishes ordered at that restaurant on that day with characteristic: Salty

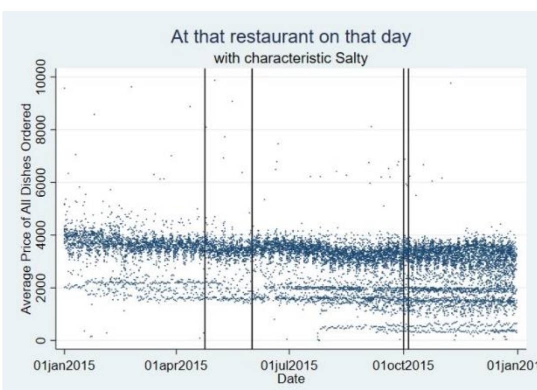


Figure B-28. Total number of dishes ordered at that restaurant on that day with characteristic: Salty

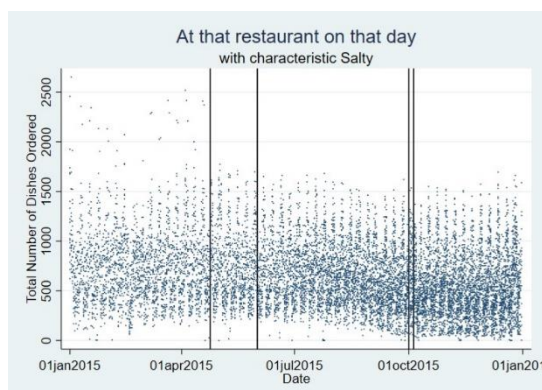


Figure B-29. Average price of all dishes ordered at that restaurant on that day with characteristic: Sour

Figure B-30. Total number of dishes ordered at that restaurant on that day with characteristic: Sour

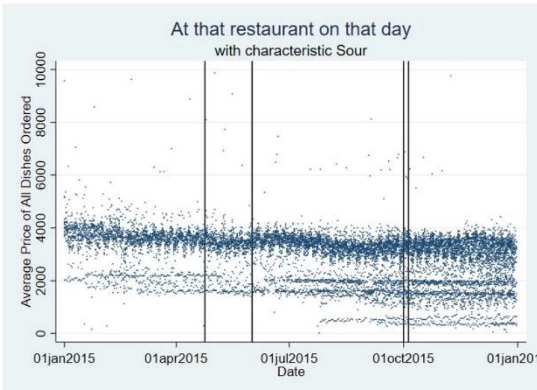
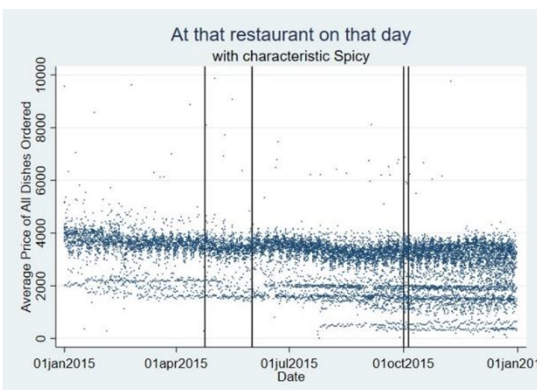


Figure B-31. Average price of all dishes ordered at that restaurant on that day with characteristic: Spicy

Figure B-32. Total number of dishes ordered at that restaurant on that day with characteristic: Spicy



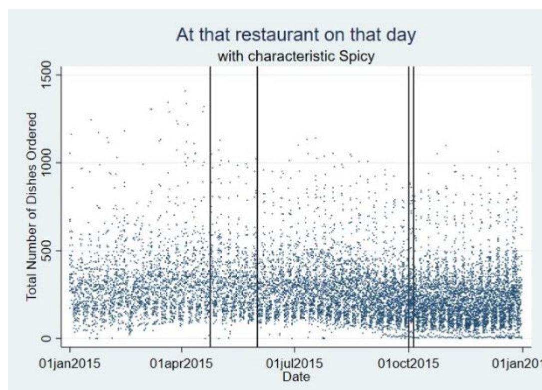


Figure B-33. Average price of all dishes ordered at that restaurant on that day with characteristic: Sweet

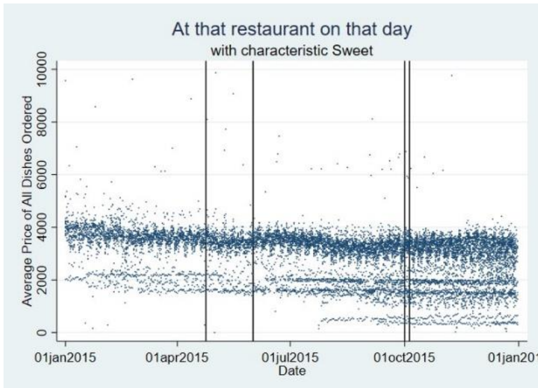


Figure B-34. Total number of dishes ordered at that restaurant on that day with characteristic: Sweet

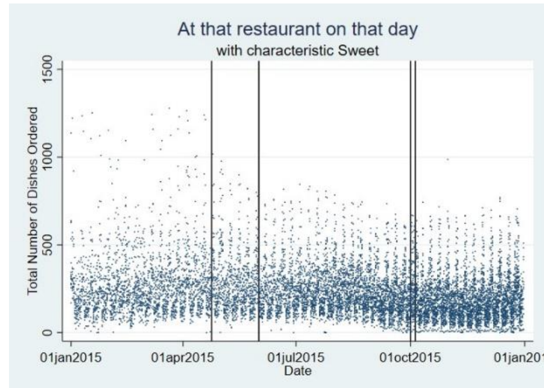


Figure B-35. Average price of all dishes ordered at that restaurant on that day with characteristic: Umami

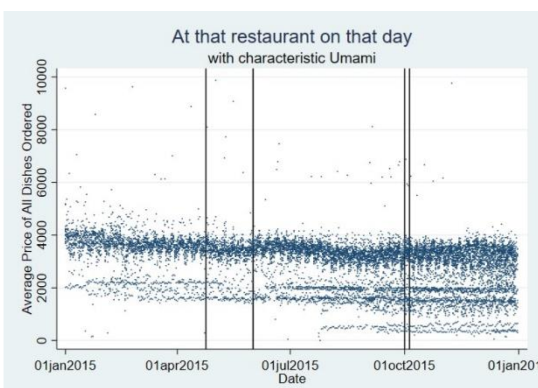
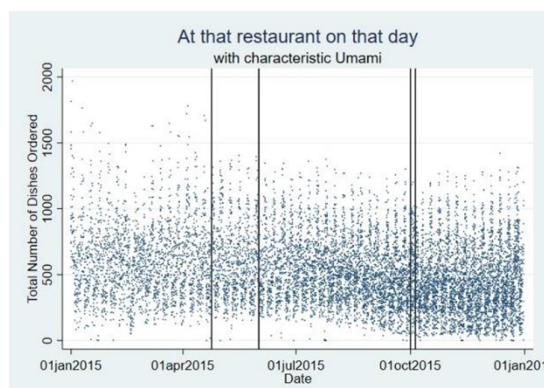


Figure B-36. Total number of dishes ordered at that restaurant on that day with characteristic: Umami



Notes: To summarize our daily store-level panel data, Appendix 1.B presents scatterplots over time for the variables in our daily store-level panel data set. For each variable in our daily store-level panel data set, we make a scatterplot with day on the x-axis on the value of the variable on the y-axis. Each data point on the scatterplot is a store-day. The vertical lines indicate the dates of each of the four major food safety and food price-related media and policy event in China in 2015: the China National Food Safety Law announcement on April 24, 2015; China National Food Safety Law implementation on

October 1, 2015 (Guo, 2015); the Zombie meat discovery and announcement on June 1, 2015; and the expensive prawn announcement on October 5, 2015 (Li, 2015). We focus our analysis on the Zombie meat discovery and announcement on June 1, 2015. It is difficult to ascertain whether the Zombie meat event had a significant effect based on the scatterplots of the raw data from our daily store-level panel data set.

APPENDIX 1.C.

Residual Plots for Daily Store-Level Variables

Figure C-1. Total number of orders at that restaurant on that day

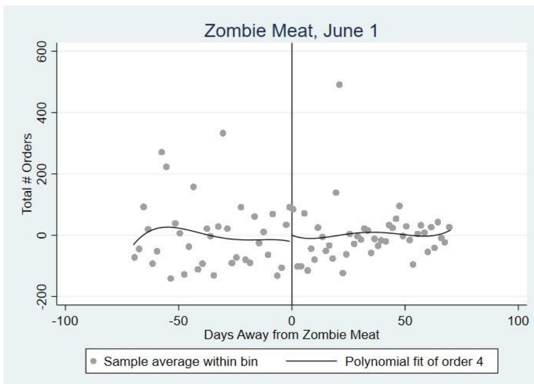


Figure C-2. Total number of people at that restaurant on that day

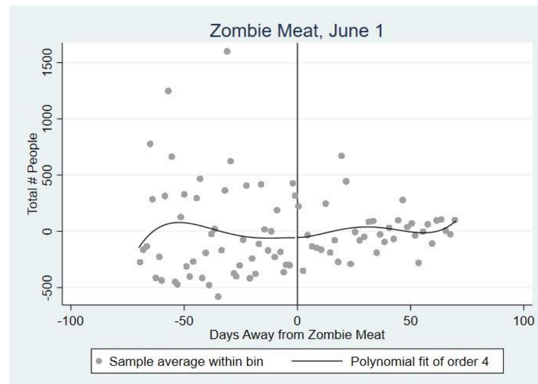


Figure C-3. Total price of all orders at that restaurant on that day

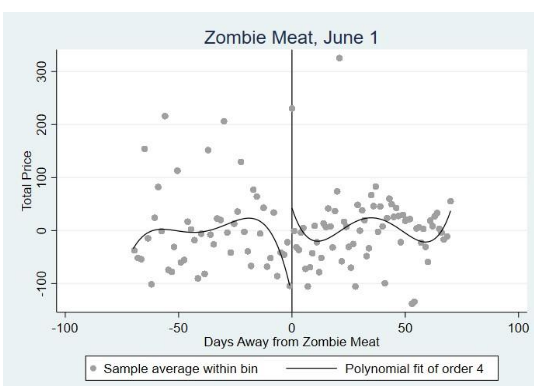


Figure C-4. Average price of all orders at that restaurant on that day

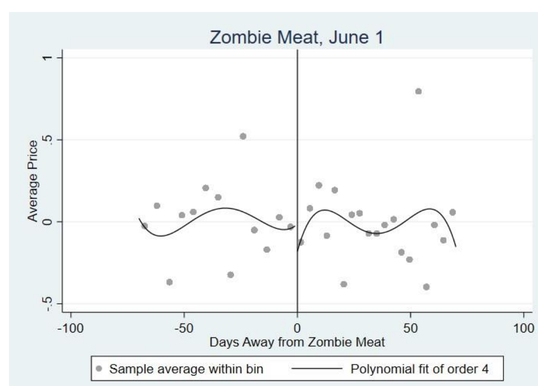


Figure C-5. Average price of all dishes ordered at that restaurant on that day with characteristic: Dessert

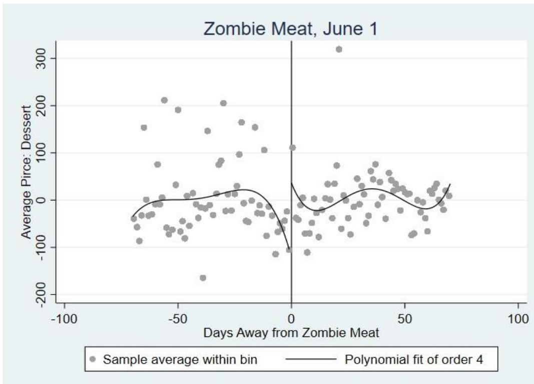


Figure C-6. Total number of dishes ordered at that restaurant on that day with characteristic: Dessert

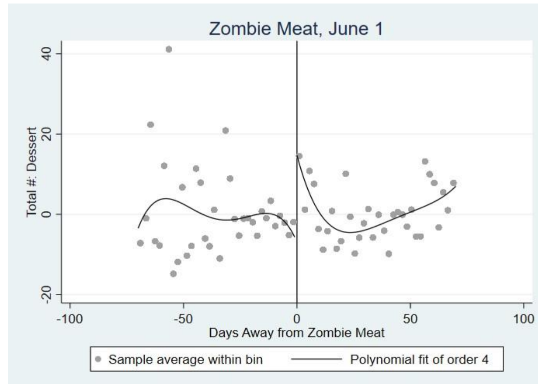


Figure C-7. Average price of all dishes ordered at that restaurant on that day with characteristic: Beef

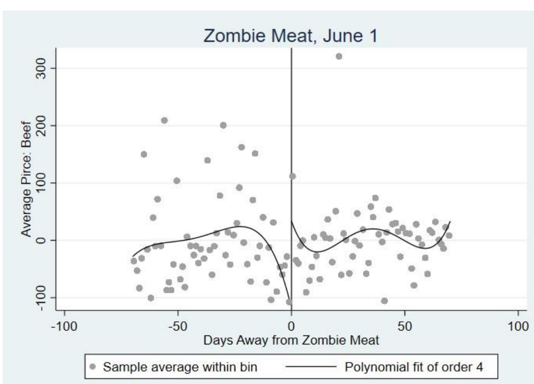


Figure C-8. Total number of dishes ordered at that restaurant on that day with characteristic: Beef

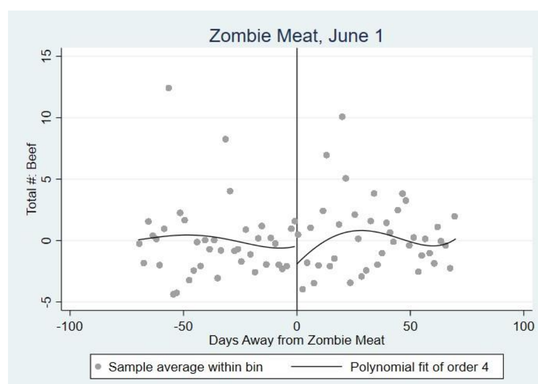


Figure C-9. Average price of all dishes ordered at that restaurant on that day with characteristic: Chicken

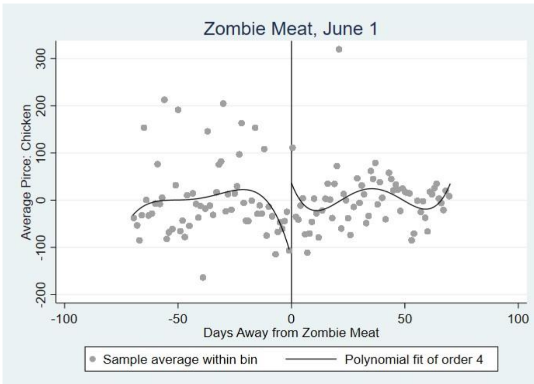


Figure C-10. Total number of dishes ordered at that restaurant on that day with characteristic: Chicken

Figure C-11. Average price of all dishes ordered at that restaurant on that day with characteristic: Pork

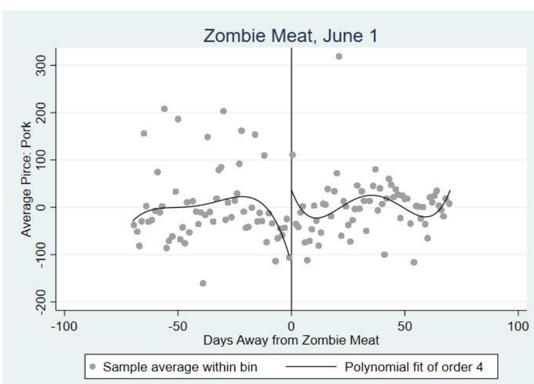


Figure C-12. Total number of dishes ordered at that restaurant on that day with characteristic: Pork

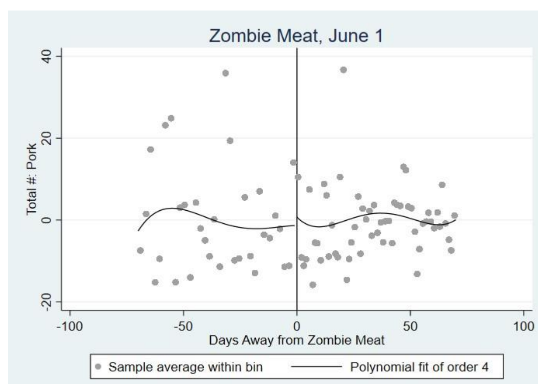


Figure C-13. Average price of all dishes ordered at that restaurant on that day with characteristic: Vegetable Excluding Mushroom

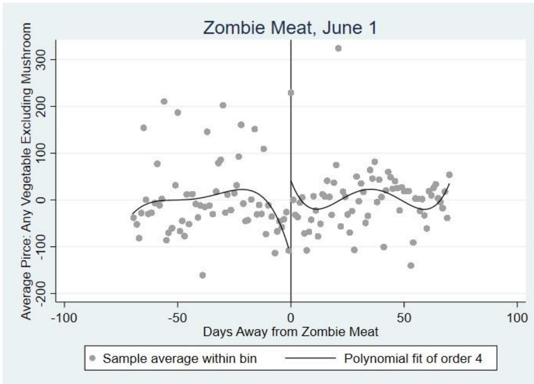


Figure C-14. Total number of dishes ordered at that restaurant on that day with characteristic: Vegetable Excluding Mushroom

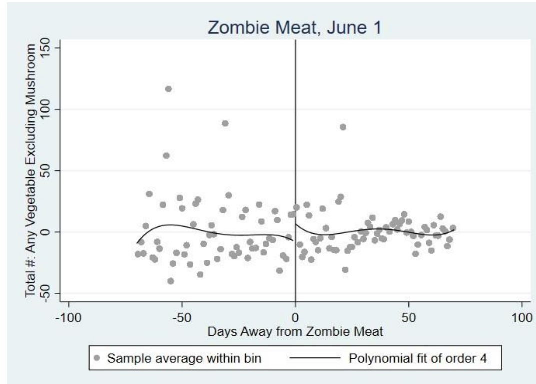


Figure C-15. Average price of all dishes ordered at that restaurant on that day with characteristic: Seafood

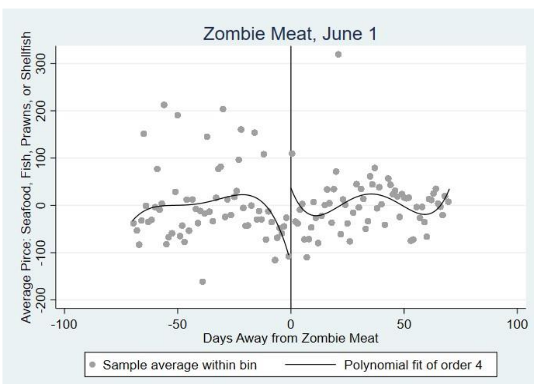


Figure C-16. Total number of dishes ordered at that restaurant on that day with characteristic: Seafood

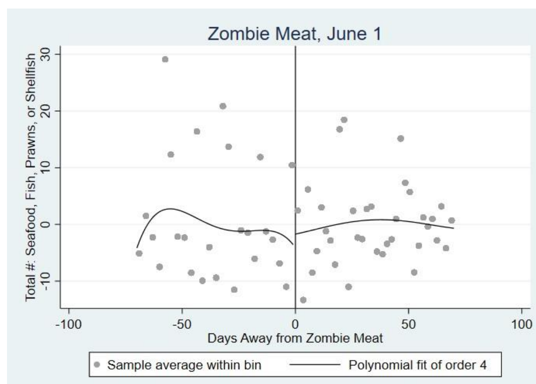


Figure C-17. Average price of all dishes ordered at that restaurant on that day with characteristic: Tofu

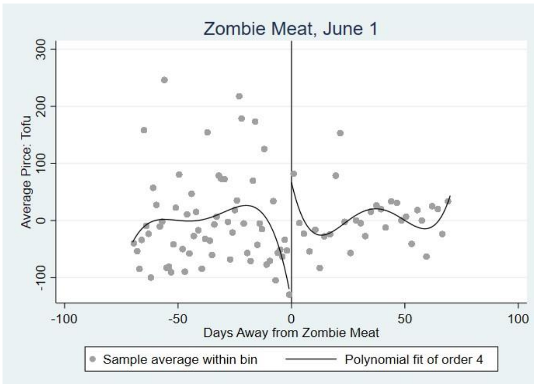


Figure C-18. Total number of dishes ordered at that restaurant on that day with characteristic: Tofu

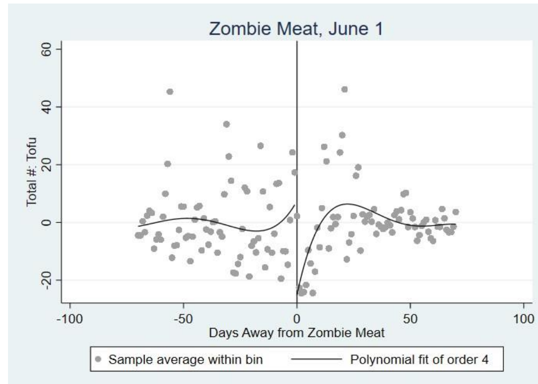


Figure C-19. Average price of all dishes ordered at that restaurant on that day with characteristic: Mushroom

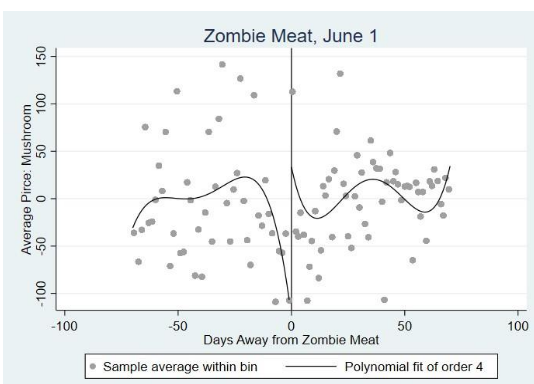


Figure C-20. Total number of dishes ordered at that restaurant on that day with characteristic: Mushroom

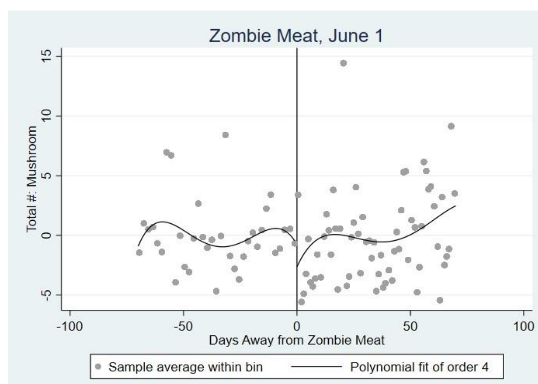


Figure C-21. Average price of all dishes ordered at that restaurant on that day with characteristic: Rice

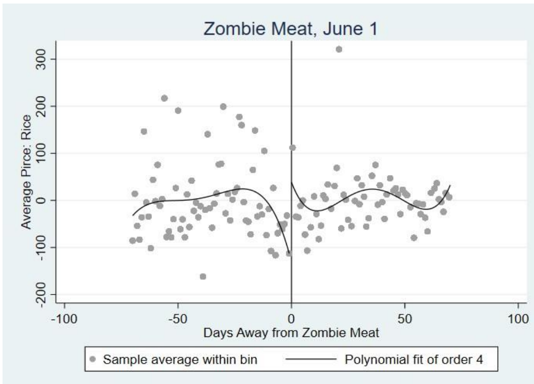


Figure C-22. Total number of dishes ordered at that restaurant on that day with characteristic: Rice

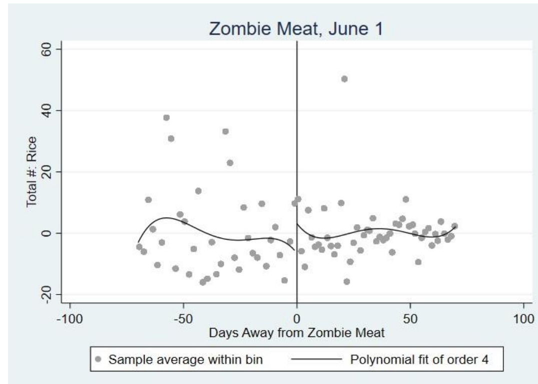


Figure C-23. Average price of all dishes ordered at that restaurant on that day with characteristic: Boiling, including Hotpot

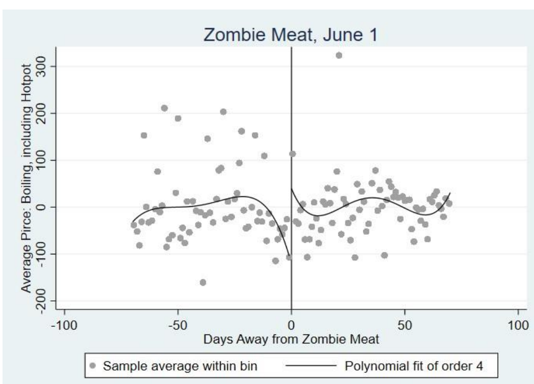


Figure C-24. Total number of dishes ordered at that restaurant on that day with characteristic: Boiling, including Hotpot

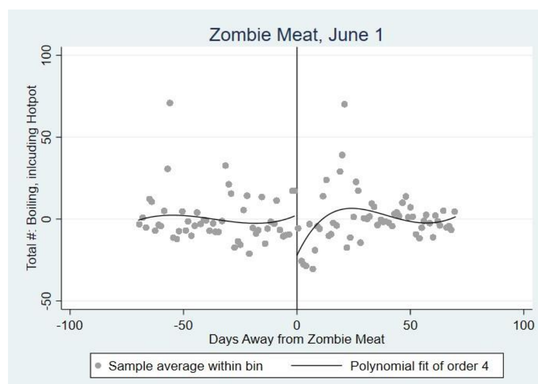


Figure C-25. Average price of all dishes ordered at that restaurant on that day with characteristic: Salty

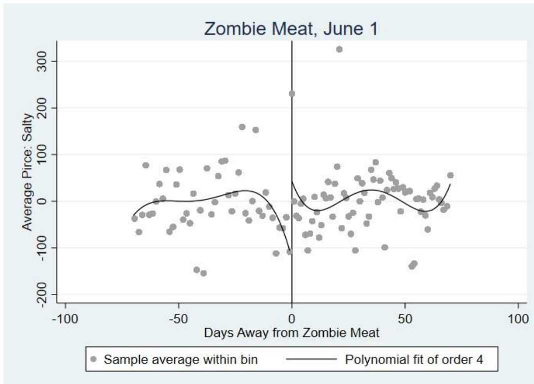


Figure C-26. Total number of dishes ordered at that restaurant on that day with characteristic: Salty

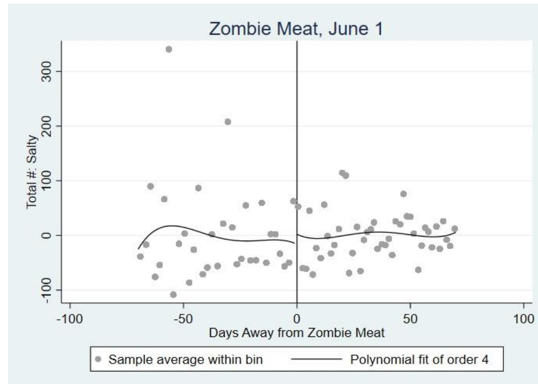


Figure C-27. Average price of all dishes ordered at that restaurant on that day with characteristic: Sour

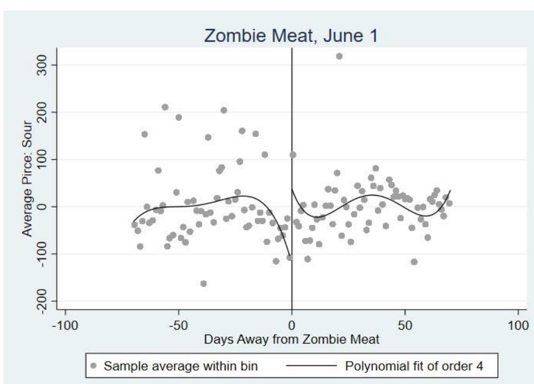


Figure C-28. Total number of dishes ordered at that restaurant on that day with characteristic: Sour

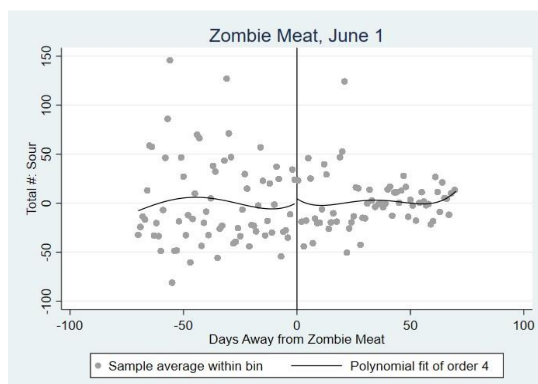


Figure C-29. Average price of all dishes ordered at that restaurant on that day with characteristic: Spicy

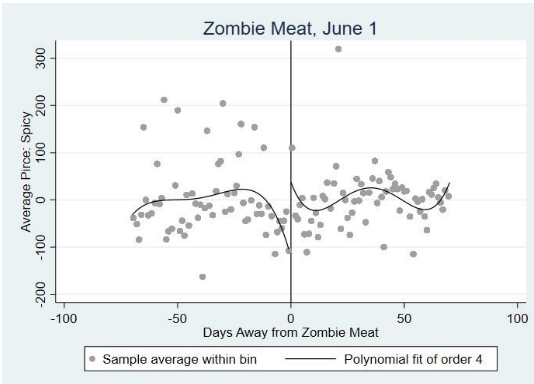


Figure C-30. Total number of dishes ordered at that restaurant on that day with characteristic: Spicy

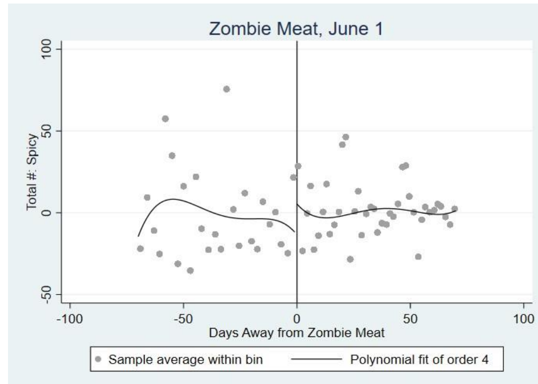


Figure C-31. Average price of all dishes ordered at that restaurant on that day with characteristic: Sweet

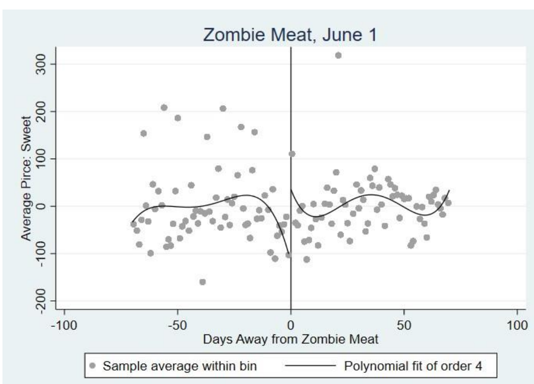


Figure C-32. Total number of dishes ordered at that restaurant on that day with characteristic: Sweet

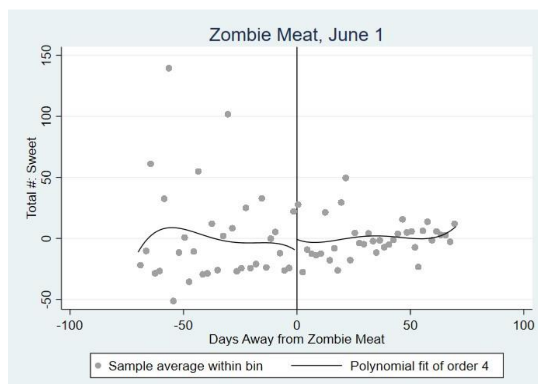
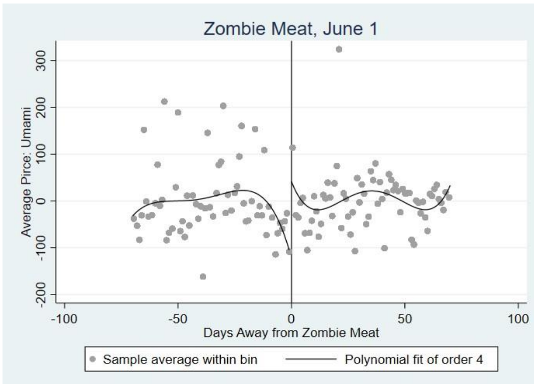


Figure C-33. Average price of all dishes ordered at that restaurant on that day with characteristic: Umami

Figure C-34. Total number of dishes ordered at that restaurant on that day with characteristic: Umami



Notes: Appendix 1.C presents residual plots that plot residuals from a first-stage regression of each of the variables in our daily store-level panel data set, using data within a window of 10 weeks before to 10 weeks after the Zombie meat event. The first-stage regressions are regressions of each of the variables in our daily store-level panel data set on weather and seasonality covariates, and restaurant fixed effects. The results of our local linear regression discontinuity regressions with robust confidence intervals of residuals from first-stage regressions of each of the variables in our daily store-level panel data set are presented in Table 1.1. Residual plots for the average price of all dishes ordered at that restaurant on that day with pork, chicken, and beef are also presented in Figure 1.

APPENDIX 1.D.

Residual Plots for Price Conditional on Dish Characteristics with Restaurant Dish Fixed Effects

Figure D-1. Dish Price: Dessert

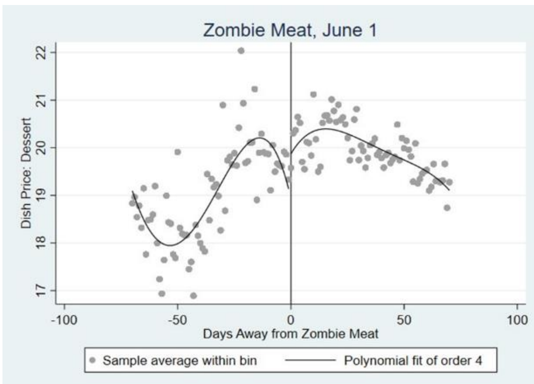


Figure D-2. Dish Price: Beef

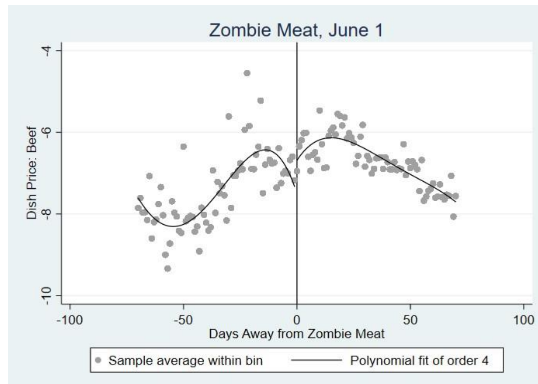


Figure D-3. Dish Price: Chicken

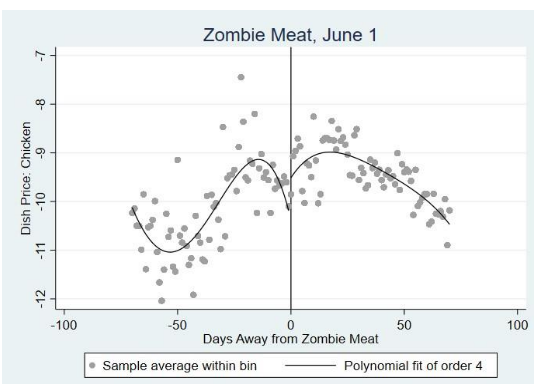


Figure D-4. Dish Price: Pork

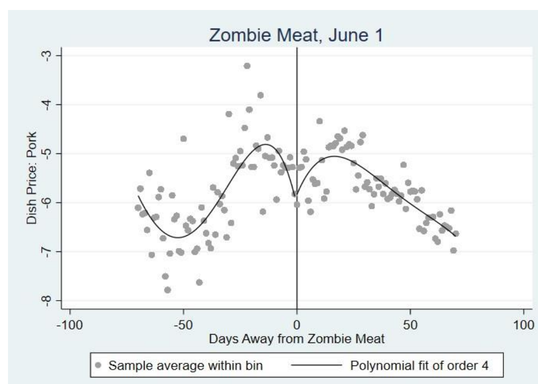


Figure D-5. Dish Price: Tofu

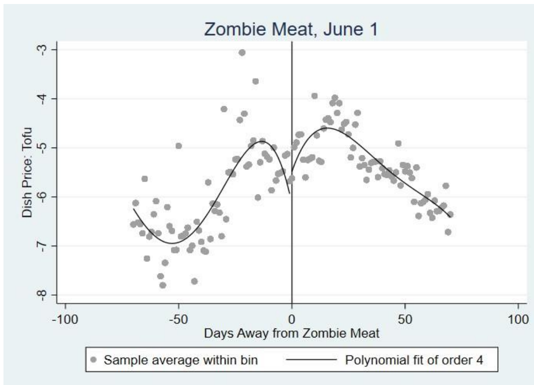


Figure D-6. Dish Price: Seafood

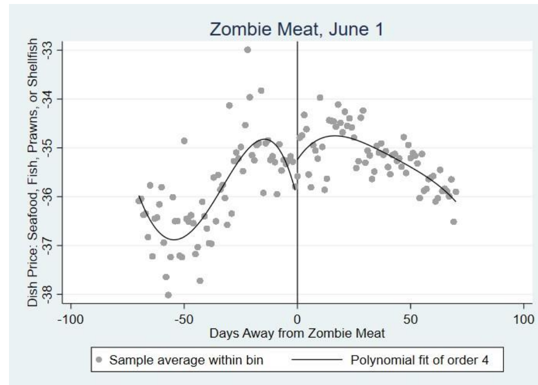


Figure D-7. Dish Price: Mushroom

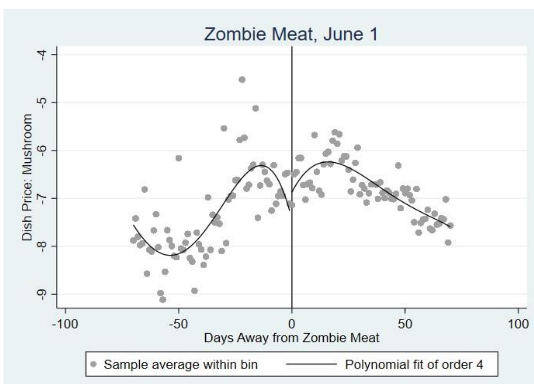


Figure D-8. Dish Price: Vegetable Excluding Mushroom

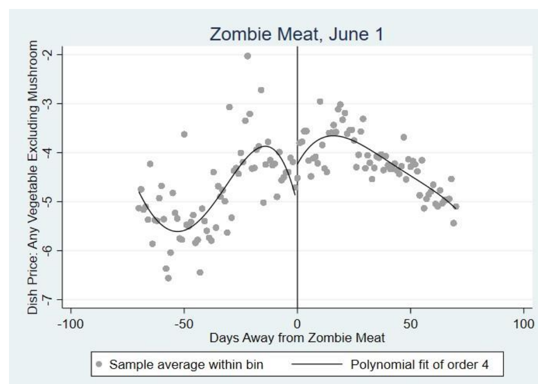


Figure D-9. Dish Price: Rice

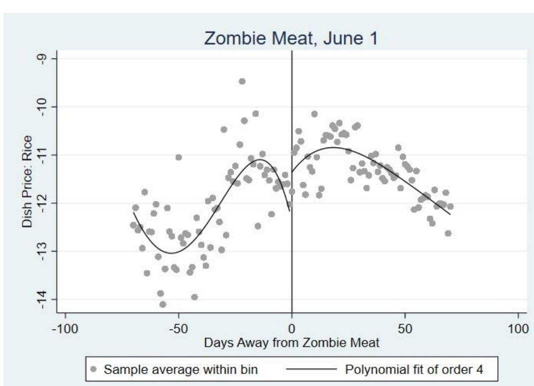


Figure D-10. Dish Price: Boiling, including Hotpot

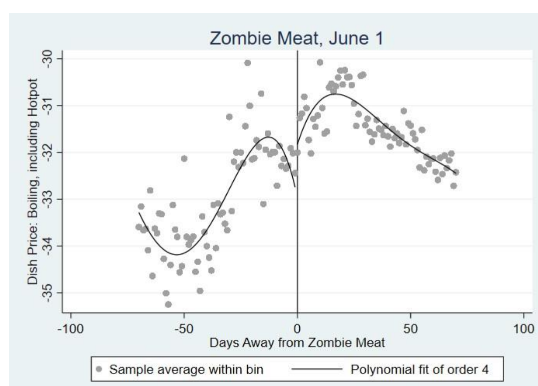


Figure D-11. Dish Price: Spicy

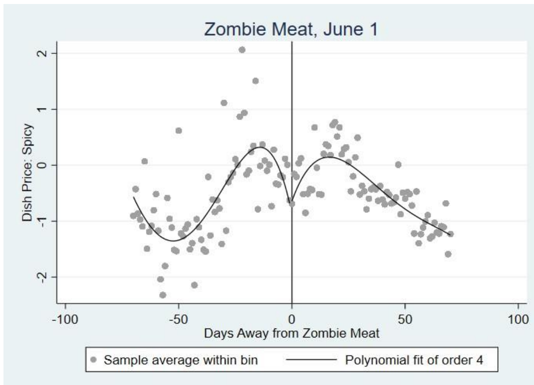


Figure D-12. Dish Price: Sweet

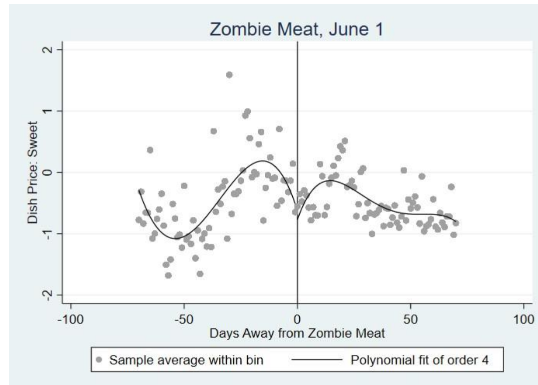


Figure D-13. Dish Price: Salty

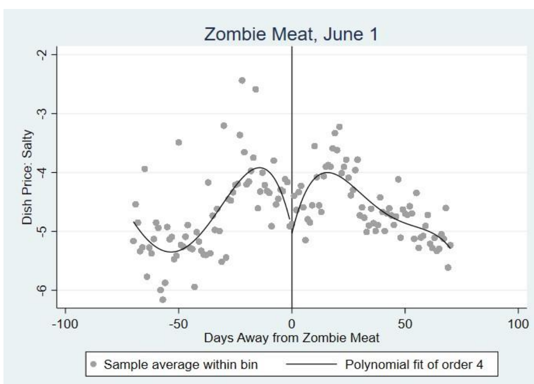


Figure D-14. Dish Price: Sour

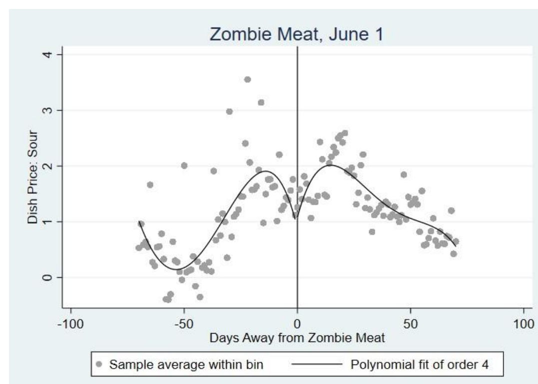


Figure D-15. Dish Price: Umami

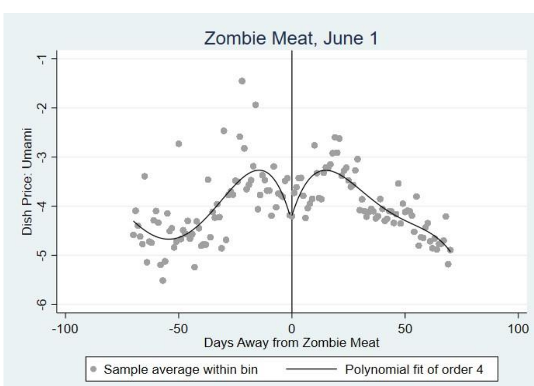
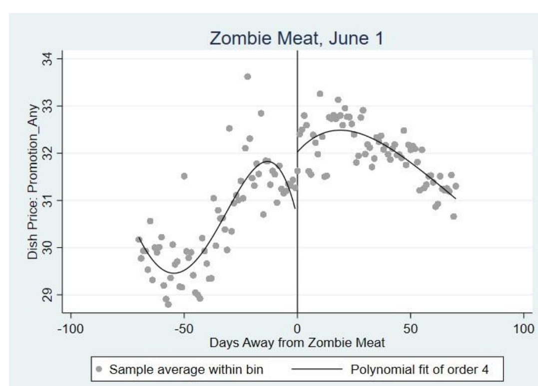


Figure D-16. Dish Price: Promotion–Any



Notes: To further analyze the effects of the Zombie meat event on dish prices and whether the price effects are a result of the restaurant raising the price of individual dishes, Appendix 1.D presents residual plots that plot residuals from a first-stage regression of dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set, using data within a window of 10 weeks before to 10 weeks after the Zombie meat event. The first-stage regressions are regressions of dish price conditional on each of the dish characteristics in our daily restaurant-dish-level panel data set on weather and seasonality covariates, promotion dummies, and restaurant-dish fixed effects. The results of our local linear regression discontinuity regressions with robust confidence intervals of residuals from first-stage regressions of the dish characteristics and the dish price conditional on each of the dish characteristics using our daily restaurant-dish-level panel data set are presented in Table 1.2.

APPENDIX 1.E.

Supplementary Regression Discontinuity Results Tables

Table 1.E.1a. The Effects of Zombie Meat Event on Daily Weather Controls

	Dependent variable is daily weather measurement for:		
	Maximum Temperature	Average Temperature	Precipitation
10 weeks before and after event	-0.631	1.413*	1.490
	(2.176)	(0.475)	(1.093)
5 weeks before and after event	-0.631	1.413	1.490
	(8.374)	(3.641)	(2.250)

Notes: Each cell in this table reports estimates from one of 6 separate daily store-level local linear regression discontinuity regressions. The unit of observation is a restaurant store-day. Maximum temperature and average temperature are in degrees Celsius. Precipitation is in millimeters. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level after applying the Bonferroni correction to adjust for multiple hypothesis testing.

Table 1.E.1b. The Effects of Zombie Meat Event on Daily Promotions Control Variable

	Dependent variable is daily dummy for:
	Promotions, Any
10 weeks before and after event	-0.0042
	(0.0029)
5 weeks before and after event	0.0023
	(0.0040)

Notes: Each cell in this table reports estimates from one of 2 separate daily restaurant-dish-level local linear regression discontinuity regressions. The unit of observation is a restaurant dish-day. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level.

Table 1.E.2. The Effects of Zombie Meat Event on Daily Store-Level Variables by City

Dependent variable is residualized daily restaurant store-level variable for:	Beijing	Shanghai	Tianjin
Total number of orders at that restaurant on that day	-11.685	-190.595*	140.826
	(26.045)	(45.084)	(65.652)
Total number of people at that restaurant on that day	-63.444	-643.617*	551.264
	(108.515)	(148.517)	(236.850)
Total price of all orders at that restaurant on that day	182.665*	-32.148	77.852
	(50.346)	(43.535)	(77.400)
Average price of all orders at that restaurant on that day	-0.098	-0.195	-1.628*
	(0.250)	(0.152)	(0.385)
Average price of dishes ordered at that restaurant on that day with characteristic:			
Dessert	183.002*	-32.549	80.306
	(52.197)	(43.917)	(79.445)
Beef	189.240*	-31.690	76.432
	(53.095)	(49.004)	(78.515)
Chicken	184.689*	-32.148	73.020
	(52.697)	(43.535)	(75.693)
Pork	185.208*	-32.148	80.234
	(52.739)	(43.535)	(78.636)
Seafood	184.551*	-31.842	68.827
	(52.625)	(43.646)	(74.669)
Tofu	223.494*	N/A	71.912
	(67.600)		(85.860)
Mushroom	189.476*	-34.191	73.011
	(53.310)	(48.416)	(76.814)
Vegetable Excluding Mushroom	187.877*	-32.148	77.852
	(53.326)	(43.535)	(77.400)
Rice	188.594*	-19.537	78.677
	(52.585)	(52.853)	(77.386)
Boiling, including Hotpot	186.223*	-32.148	73.126
	(52.613)	(43.535)	(76.575)
Spicy	185.579*	-32.148	78.777
	(52.840)	(43.535)	(77.083)

Sweet	177.539*	-32.148	84.843
	(50.922)	(43.535)	(79.055)
Salty	189.512*	-32.148	77.852
	(52.930)	(43.535)	(77.400)
Sour	184.292*	-31.959	78.777
	(52.682)	(43.624)	(77.083)
Umami	187.195*	-32.148	78.777
	(52.919)	(43.535)	(77.083)
Total number of dishes ordered at that restaurant on that day with characteristic:			
Dessert	25.997*	-8.746	2.035
	(4.218)	(3.629)	(13.994)
Beef	-3.637	-0.213	5.501
	(1.284)	(2.879)	(6.255)
Chicken	-1.603	-22.958*	15.200
	(3.593)	(4.593)	(9.621)
Pork	0.717	-16.378	20.066
	(3.423)	(5.436)	(6.919)
Seafood	-1.499	-19.372	23.732
	(3.215)	(6.258)	(8.991)
Tofu	-37.960*	5.791	-7.023
	(6.863)	(5.392)	(13.387)
Mushroom	3.726	-2.725	-37.386*
	(2.193)	(1.611)	(6.663)
Vegetable Excluding Mushroom	7.236	4.310	24.321
	(5.338)	(4.560)	(22.456)
Rice	1.178	-27.404*	20.142
	(3.478)	(6.405)	(8.067)
Boiling, including Hotpot	-31.719*	9.056	-9.724
	(7.373)	(4.135)	(13.078)
Spicy	7.868	-80.800*	59.174
	(6.831)	(22.885)	(28.373)
Sweet	6.233	-32.269	38.176
	(8.518)	(12.574)	(16.350)
Salty	-6.549	-108.381*	81.661
	(17.714)	(25.557)	(41.884)
Sour	2.892	14.705	61.527

	(7.955)	(6.385)	(58.957)
Umami	-10.353	-67.036*	56.483
	(15.155)	(18.547)	(34.981)

Notes: Each of the cells in this table reports estimates from separate daily store-level local linear regression discontinuity regressions using a window of 10 weeks before to 10 weeks after the Zombie meat event. Each of the 38 rows presents results from using a separate dependent variable. For each of the 38 dependent variables, we run separate daily store-level local linear regression discontinuity regressions for each of the 3 cities of the residual from a first-stage regression of the variable in that row on weather and seasonality covariates, and restaurant fixed effects. The unit of observation in each daily store-level local linear regression discontinuity regression is a restaurant store-day. Prices are in Yuan. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level after applying the Bonferroni correction to adjust for multiple hypothesis testing.

Table 1.E.3. The Effects of Zombie Meat Event on Daily Restaurant-Dish-Level Variables by City

Dependent variable is residualized daily restaurant-dish-level variable for:	Beijing	Shanghai	Tianjin
Dummy variable for dish in that restaurant that day having the characteristic:			
Dessert	0.004	-0.009	0.002
	(0.002)	(0.009)	(0.005)
Beef	-0.002	-0.007	0.003
	(0.001)	(0.004)	(0.002)
Chicken	-0.002	-0.011	0.002
	(0.001)	(0.008)	(0.007)
Pork	-0.002	0.000	-0.008
	(0.002)	(0.005)	(0.006)
Seafood	-0.001	-0.010	-0.001
	(0.001)	(0.007)	(0.002)
Tofu	-0.002	-0.001	-0.001
	(0.001)	(0.001)	(0.002)
Mushroom	0.003	0.000	-0.017
	(0.002)	(0.006)	(0.007)
Vegetable Excluding Mushroom	-0.004	-0.002	0.007
	(0.002)	(0.004)	(0.011)
Rice	-0.001	-0.004	0.002
	(0.001)	(0.004)	(0.002)
Boiling, including Hotpot	-0.006	-0.006	-0.018
	(0.002)	(0.010)	(0.008)
Spicy	-0.005	-0.009	0.004
	(0.003)	(0.010)	(0.009)
Sweet	0.021*	0.020	0.004
	(0.004)	(0.019)	(0.011)
Salty	-0.018*	-0.018	-0.003
	(0.004)	(0.018)	(0.014)
Sour	-0.001	-0.011	0.009
	(0.003)	(0.010)	(0.011)
Umami	-0.012*	-0.030	-0.009
	(0.003)	(0.015)	(0.011)

Promotions – Any	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Price of dish in that restaurant that day with characteristic:			
Dessert	0.273	-1.487	0.555
	(0.601)	(1.694)	(0.603)
Beef	0.427	-2.637	-1.427
	(0.622)	(9.487)	(1.746)
Chicken	0.523	-0.260	-0.845
	(0.484)	(1.626)	(1.531)
Pork	-0.786	-5.514	0.185
	(0.453)	(4.563)	(0.686)
Seafood	-0.568	-1.258	0.394
	(0.679)	(2.674)	(0.444)
Tofu	0.327	2.305	0.273
	(0.507)	(1.181)	(0.705)
Mushroom	-1.294	-3.459	-0.918
	(0.745)	(5.922)	(1.782)
Vegetable Excluding Mushroom	0.526	-2.329	-0.218
	(0.463)	(2.638)	(0.572)
Rice	0.847	-0.881	-0.025
	(0.596)	(3.108)	(0.666)
Boiling, including Hotpot	1.337	4.400	1.006
	(0.690)	(3.841)	(0.869)
Spicy	-0.645	-1.889	-0.774
	(0.467)	(1.641)	(0.787)
Sweet	-1.247	-2.028	-0.402
	(0.624)	(1.424)	(0.742)
Salty	-0.136	-1.695	-0.206
	(0.437)	(1.090)	(0.612)
Sour	-1.420	0.201	-0.902
	(0.528)	(1.690)	(0.790)
Umami	-0.200	-2.031	-0.487
	(0.453)	(1.611)	(0.625)
Promotions – Any	-0.116	4.534	-2.707
	(0.701)	(3.640)	(1.937)

Notes: Each of the cells in this table reports estimates from separate daily restaurant-dish-level local linear regression discontinuity regressions using a window of 10 weeks before to 10 weeks after the Zombie meat event. Each of the 38 rows presents results from using a separate dependent variable. Each of the 36 rows presents results from using a separate dependent variable. For each of the 36 dependent variables, we run separate daily restaurant-dish-level local linear regression discontinuity regressions for each of the 3 cities of the residual from a first-stage regression of the variable in that row on weather and seasonality covariates, promotion dummies, and restaurant fixed effects. The unit of observation in each daily restaurant-dish-level local linear regression discontinuity regression is a restaurant store-day. Prices are in Yuan. Bootstrapped standard errors are in parentheses. Significance code: * indicates significant at a 5% level after applying the Bonferroni correction to adjust for multiple hypothesis testing.

APPENDIX 1.F.

Supplementary Restaurant Food Demand Results Tables

Table 1.F.1a. Daily Restaurant Dish Demand (Fixed Effects)

Dependent variable is Total Number of Orders of a Dish a Restaurant on a Day					
	All cities	Beijing	Shanghai	Tianjin	Zhengzhou
Price	-0.0004	-0.0008	0.0290	0.0027	-0.0018
	(0.0014)	(0.0014)	(0.0162)	(0.0184)	(0.0036)
Vegetable Excluding Mushroom	5.1053***	5.0474***	12.3197***	-23.0871***	0.9169
	(0.3368)	(0.3644)	(1.1515)	(3.6167)	(0.7833)
Mushroom	-7.1020***	-6.3114***	-15.0795***	-21.1521***	-2.6736**
	(0.3976)	(0.4246)	(1.7131)	(3.9133)	(0.9335)
Tofu	23.6827***	22.6469***	37.7511***		9.4606***
	(0.5514)	(0.5742)	(2.1383)		(1.7351)
Seafood	0.6427	0.9933	30.4185***	-12.0868***	14.6120***
	(0.6235)	(0.6704)	(4.3175)	(2.5722)	(2.5720)
Pork	-1.5404**	-0.9576	-19.4499***	41.8017***	-2.7707*
	(0.4928)	(0.5325)	(1.8209)	(4.8704)	(1.1745)
Chicken	-16.0197***	-15.8727***	-30.7551***	-8.4494**	-0.8720
	(0.6262)	(0.6917)	(3.0857)	(3.1916)	(1.4586)
Beef	-3.8749***	-3.4770***	-6.1852**	-10.1699*	-1.2344
	(0.5568)	(0.5939)	(2.2664)	(4.5484)	(1.2450)
Price * Vegetable Excluding	-0.1912***	-0.1872***	-0.4444***	0.8282***	-0.0472*
Mushroom	(0.0098)	(0.0106)	(0.0343)	(0.1357)	(0.0231)
Price * Mushroom	0.0787***	0.0592***	0.2513***	0.9543***	0.0015
	(0.0072)	(0.0076)	(0.0326)	(0.2313)	(0.0168)
Price * Tofu	-0.6210***	-0.5947***	-0.9914***		-0.2143***
	(0.0194)	(0.0203)	(0.0740)		(0.0616)
Price * Seafood	0.0844***	0.0696***	-0.2583***	0.4243***	-0.1776***
	(0.0100)	(0.0107)	(0.0648)	(0.0649)	(0.0388)
Price * Pork	0.1090***	0.0932***	0.5564***	-1.2245***	0.0605*
	(0.0126)	(0.0136)	(0.0461)	(0.1939)	(0.0293)
Price * Chicken	0.5355***	0.5287***	0.9527***	0.2534*	0.0924**
	(0.0157)	(0.0173)	(0.0728)	(0.1187)	(0.0336)
Price * Beef	0.0718***	0.0633***	0.1183*	0.1283	0.0236

	(0.0112)	(0.0119)	(0.0460)	(0.1203)	(0.0253)
Post Zombie Meat Event	-0.3965	-0.4931*	-0.8942	1.1521	-0.0011
	(0.2143)	(0.2341)	(0.8541)	(1.5000)	(0.5470)
Post Zombie Meat Event * Price	-0.0032	-0.0026	-0.0190	0.0072	0.0073
	(0.0022)	(0.0023)	(0.0201)	(0.0243)	(0.0052)
Post Zombie Meat Event * Vegetable Excluding Mushroom	1.5198**	1.4020**	-3.1142*	16.1008**	0.9492
	(0.4638)	(0.5065)	(1.5178)	(5.7103)	(1.1295)
Post Zombie Meat Event * Mushroom	-0.0241	-0.0827	2.5632	6.8181	1.1255
	(0.5613)	(0.6051)	(2.2129)	(7.6522)	(1.3693)
Post Zombie Meat Event * Tofu	-3.8766***	-2.2853**	-16.8587***		4.9000*
	(0.7796)	(0.8161)	(3.0739)		(2.3830)
Post Zombie Meat Event * Seafood	4.8252***	5.3536***	-27.3905***	11.1658**	-1.5959
	(0.8816)	(0.9905)	(4.7261)	(3.6266)	(3.5975)
Post Zombie Meat Event * Pork	-6.6846***	-5.9312***	3.7548	-63.4589***	0.1132
	(0.6797)	(0.7474)	(2.3062)	(6.7832)	(1.6457)
Post Zombie Meat Event * Chicken	0.2929	0.2483	10.1537**	8.3621	-1.9640
	(0.8475)	(0.9644)	(3.5315)	(4.3458)	(2.0914)
Post Zombie Meat Event * Beef	2.3381**	2.0322*	4.1164	16.2023**	0.1278
	(0.7589)	(0.8199)	(2.9465)	(6.0415)	(1.7607)
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	-0.0553***	-0.0457**	0.0861	-0.6881***	-0.0370
	(0.0134)	(0.0146)	(0.0449)	(0.1996)	(0.0329)
Post Zombie Meat Event * Price * Mushroom	-0.0048	-0.0092	-0.0325	-0.5278	-0.0181
	(0.0101)	(0.0108)	(0.0418)	(0.3538)	(0.0242)
Post Zombie Meat Event * Price * Tofu	0.1121***	0.0653*	0.4803***		-0.1656*
	(0.0273)	(0.0287)	(0.1042)		(0.0830)
Post Zombie Meat Event * Price * Seafood	-0.0739***	-0.0845***	0.3828***	-0.3157***	0.0067
	(0.0141)	(0.0157)	(0.0725)	(0.0887)	(0.0541)
Post Zombie Meat Event * Price * Pork	0.1476***	0.1299***	-0.1032	2.0893***	0.0016
	(0.0171)	(0.0187)	(0.0584)	(0.2438)	(0.0412)
Post Zombie Meat Event * Price * Chicken	-0.0240	-0.0249	-0.3182***	-0.3527*	0.0416
	(0.0212)	(0.0240)	(0.0839)	(0.1593)	(0.0487)
Post Zombie Meat Event * Price * Beef	-0.0339*	-0.0318	-0.0602	-0.3586*	-0.0239
	(0.0154)	(0.0166)	(0.0595)	(0.1658)	(0.0356)
Average Temperature	-0.0052	0.0100	-0.1814	-0.0473	-0.0232

	(0.0268)	(0.0282)	(0.1300)	(0.1936)	(0.0715)
Maximum Temperature	0.0690***	0.0804***	0.1518	0.2872	0.0766
	(0.0208)	(0.0226)	(0.0987)	(0.1526)	(0.0501)
Precipitation	-0.0029	0.0507***	-0.0186**	0.1573	0.0235*
	(0.0043)	(0.0120)	(0.0064)	(0.0826)	(0.0097)
Tuesday	0.4155**	0.4186**	-0.1555	0.5247	-1.2091***
	(0.1310)	(0.1434)	(0.4946)	(0.9274)	(0.3227)
Wednesday	0.7787***	0.8370***	0.7138	1.4904	-1.3769***
	(0.1313)	(0.1423)	(0.4918)	(0.9177)	(0.3245)
Thursday	2.6835***	2.7675***	2.7993***	5.2891***	-0.5202
	(0.1314)	(0.1428)	(0.4826)	(0.9213)	(0.3252)
Friday	6.8552***	7.0815***	6.2450***	13.7951***	2.0671***
	(0.1310)	(0.1426)	(0.4922)	(0.9331)	(0.3101)
Saturday	5.8344***	5.8832***	5.1294***	11.2872***	1.6314***
	(0.1298)	(0.1419)	(0.5043)	(0.9317)	(0.3112)
Sunday	0.1379	0.2118	-0.3928	1.4748	-0.9929**
	(0.1289)	(0.1395)	(0.4901)	(0.8953)	(0.3132)
Restaurant Fixed Effect	Y	Y	Y	Y	Y
Month Fixed Effect	Y	Y	Y	Y	Y
# Observations	190,278	154,693	20,289	5,402	7,438
p-value (Pr > F)	0.0000	0.0000	0.0000	0.000	0.0000

Notes: We use observations from the 5 weeks before to 5 weeks after the Zombie meat event. Price is in Yuan. Maximum temperature and average temperature are in degrees Celsius. Precipitation is in millimeters. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level. The results for Beijing are also summarized in Table 1.3.

Table 1.F.1b. Daily Restaurant Dish Demand (Fixed Effects)

Dependent variable is Total Number of Orders of a Dish a Restaurant on a Day					
	All cities	Beijing	Shanghai	Tianjin	Zhengzhou
Price	-0.0014	-0.0017	0.0463**	0.0090	-0.0052
	(0.0014)	(0.0014)	(0.0179)	(0.0184)	(0.0037)
Vegetable Excluding Mushroom	4.8972***	4.7684***	12.4629***	-23.7638***	0.4416
	(0.3373)	(0.3652)	(1.1530)	(3.5995)	(0.7825)
Mushroom	-7.2332***	-6.4368***	-14.4475***	-21.6579***	-3.0314**
	(0.3976)	(0.4245)	(1.7351)	(3.8929)	(0.9296)
Tofu	24.4119***	23.5091***	37.1421***		9.0193***
	(0.5570)	(0.5805)	(2.1546)		(1.7259)
Seafood	0.5323	0.8800	31.0558***	-12.5959***	14.1819***
	(0.6233)	(0.6700)	(4.3259)	(2.5603)	(2.5571)
Pork	-1.8216***	-1.2645*	-18.8777***	41.2962***	-3.1089**
	(0.4935)	(0.5329)	(1.8379)	(4.8443)	(1.1686)
Chicken	-16.1832***	-16.0572***	-30.1348***	-8.7533**	-1.2857
	(0.6261)	(0.6914)	(3.0972)	(3.1744)	(1.4512)
Beef	-4.0193***	-3.6367***	-5.5861*	-10.6904*	-1.4980
	(0.5566)	(0.5936)	(2.2812)	(4.5243)	(1.2380)
Price * Vegetable Excluding Mushroom	-0.1906***	-0.1855***	-0.4466***	0.8315***	-0.0408
	(0.0098)	(0.0106)	(0.0343)	(0.1350)	(0.0230)
Price * Mushroom	0.0777***	0.0574***	0.2340***	0.9479***	0.0042
	(0.0072)	(0.0076)	(0.0335)	(0.2300)	(0.0167)
Price * Tofu	-0.6497***	-0.6283***	-0.9706***		-0.2095***
	(0.0197)	(0.0205)	(0.0746)		(0.0613)
Price * Seafood	0.0831***	0.0677***	-0.2756***	0.4180***	-0.1744***
	(0.0100)	(0.0107)	(0.0652)	(0.0645)	(0.0386)
Price * Pork	0.1126***	0.0966***	0.5399***	-1.2250***	0.0633*
	(0.0126)	(0.0136)	(0.0466)	(0.1928)	(0.0291)
Price * Chicken	0.5344***	0.5272***	0.9357***	0.2398*	0.0958**
	(0.0157)	(0.0173)	(0.0732)	(0.1181)	(0.0334)
Price * Beef	0.0713***	0.0625***	0.1014*	0.1223	0.0253
	(0.0112)	(0.0119)	(0.0466)	(0.1196)	(0.0251)
Any Type of Promotion	-1.8685***	-2.1688***	1.8307*	-6.6469***	-4.0846***

	(0.2065)	(0.2205)	(0.8026)	(1.4844)	(0.6791)
Post Zombie Meat Event	-0.2149	-0.3494	0.0973	1.5831	0.1683
	(0.2183)	(0.2382)	(0.9233)	(1.5034)	(0.5544)
Post Zombie Meat Event * Price	-0.0066**	-0.0057*	-0.0448*	-0.0100	0.0057
	(0.0022)	(0.0023)	(0.0221)	(0.0243)	(0.0052)
Post Zombie Meat Event * Vegetable Excluding Mushroom	1.4034**	1.3164**	-3.3683*	15.6313**	0.7411
	(0.4645)	(0.5074)	(1.5203)	(5.6829)	(1.1289)
Post Zombie Meat Event * Mushroom	-0.0963	-0.1275	1.6061	4.1021	0.9031
	(0.5612)	(0.6048)	(2.2383)	(7.6258)	(1.3643)
Post Zombie Meat Event * Tofu	-3.7366***	-2.1011*	-16.2381***		4.5095
	(0.7858)	(0.8241)	(3.0850)		(2.3719)
Post Zombie Meat Event * Seafood	4.6060***	5.1406***	-28.2637***	10.6934**	-1.5789
	(0.8816)	(0.9903)	(4.7358)	(3.6111)	(3.5764)
Post Zombie Meat Event * Pork	-6.8669***	-6.0779***	2.9023	-64.0432***	-0.0122
	(0.6807)	(0.7482)	(2.3255)	(6.7480)	(1.6376)
Post Zombie Meat Event * Chicken	0.0896	0.0802	9.3669**	7.6780	-2.1320
	(0.8478)	(0.9644)	(3.5429)	(4.3244)	(2.0810)
Post Zombie Meat Event * Beef	2.3835**	2.0688*	3.2119	24.5364***	0.0226
	(0.7586)	(0.8194)	(2.9634)	(6.1260)	(1.7510)
Post Zombie Meat Event * Any Type of Promotion	-0.9989***	-0.8080*	-2.9590**	-3.3647	-0.3536
	(0.2881)	(0.3138)	(1.0492)	(2.1312)	(0.8939)
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	-0.0541***	-0.0447**	0.0900*	-0.6718***	-0.0336
	(0.0134)	(0.0146)	(0.0449)	(0.1985)	(0.0328)

Post Zombie Meat Event * Price * Mushroom	-0.0031	-0.0076	-0.0074	-0.2738	-0.0159
	(0.0101)	(0.0108)	(0.0427)	(0.3538)	(0.0241)
Post Zombie Meat Event * Price * Tofu	0.1053***	0.0579*	0.4568***		-0.1564
	(0.0275)	(0.0290)	(0.1046)		(0.0825)
Post Zombie Meat Event * Price * Seafood	-0.0701***	-0.0805***	0.4071***	-0.2985***	0.0055
	(0.0141)	(0.0157)	(0.0730)	(0.0882)	(0.0538)
Post Zombie Meat Event * Price * Pork	0.1514***	0.1333***	-0.0793	2.1070***	0.0024
	(0.0171)	(0.0187)	(0.0590)	(0.2424)	(0.0410)
Post Zombie Meat Event * Price * Chicken	-0.0203	-0.0214	-0.2972***	-0.3280*	0.0427
	(0.0212)	(0.0240)	(0.0842)	(0.1584)	(0.0484)
Post Zombie Meat Event * Price * Beef	-0.0343*	-0.0316	-0.0353	-0.5242**	-0.0233
	(0.0154)	(0.0166)	(0.0602)	(0.1669)	(0.0354)
Average Temperature	-0.0038	0.0113	-0.1824	-0.0346	-0.0144
	(0.0267)	(0.0282)	(0.1300)	(0.1925)	(0.0711)
Maximum Temperature	0.0683**	0.0796***	0.1531	0.2828	0.0730
	(0.0208)	(0.0226)	(0.0987)	(0.1518)	(0.0497)
Precipitation	-0.0033	0.0504***	-0.0187**	0.1559	0.0217*
	(0.0043)	(0.0120)	(0.0064)	(0.0821)	(0.0096)
Tuesday	0.4236**	0.4241**	-0.1485	0.6191	-1.1336***
	(0.1309)	(0.1433)	(0.4946)	(0.9222)	(0.3209)
Wednesday	0.7866***	0.8443***	0.7160	1.5320	-1.3959***
	(0.1312)	(0.1422)	(0.4917)	(0.9126)	(0.3225)
Thursday	2.6951***	2.7787***	2.7964***	5.4032***	-0.5001
	(0.1314)	(0.1426)	(0.4826)	(0.9164)	(0.3232)
Friday	6.8731***	7.0998***	6.2487***	13.9661***	2.0487***
	(0.1309)	(0.1425)	(0.4921)	(0.9282)	(0.3082)
Saturday	5.8478***	5.8971***	5.1351***	11.3919***	1.6220***
	(0.1297)	(0.1418)	(0.5043)	(0.9265)	(0.3093)
Sunday	0.1405	0.2126	-0.3803	1.5782	-0.9913**
	(0.1288)	(0.1394)	(0.4900)	(0.8903)	(0.3112)

Restaurant Fixed Effect	Y	Y	Y	Y	Y
Month Fixed Effect	Y	Y	Y	Y	Y
# Observations	190,278	154,693	20,289	5,402	7,438
p-value (Pr > F)	0.0000	0.0000	0.000	0.0000	0.0000

Notes: We use observations from the 5 weeks before to 5 weeks after the Zombie meat event. Price is in Yuan. Maximum temperature and average temperature are in degrees Celsius. Precipitation is in millimeters. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level. The results for Beijing are also summarized in Table 1.3

Table 1.F.2. First-Stage F-statistics for Price in IV Fixed Effects Daily Restaurant Demand Regression

Endogenous Variable	Angrist-Pischke First-Stage F-statistic	Sanderson-Windmeijer First-Stage F-Statistic
Price	9.7913e+7	1.0990e+9
Price * Vegetable Excluding Mushroom	3.6291e+7	7.4517e+7
Price * Mushroom	1.3660e+11	1.7270e+10
Price * Tofu	1.2189e+7	2.6938e+7
Price * Seafood	2.1662e+7	5.5931e+7
Price * Pork	2.6463e+6	4.2284e+7
Price * Chicken	1.0672e+7	2.3893e+7
Price * Beef	1.2560e+8	2.8190e+8
Post Zombie Meat Event * Price	3.0083e+7	1.6000e+8
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	3.0581e+7	1.2137e+7
Post Zombie Meat Event * Price * Mushroom	1.3340e+11	1.3760e+9
Post Zombie Meat Event * Price * Tofu	1.1513e+7	2.5033e+7
Post Zombie Meat Event * Price * Seafood	1.7060e+7	4.3091e+7
Post Zombie Meat Event * Price * Pork	1.3929e+6	5.2698e+6
Post Zombie Meat Event * Price * Chicken	9.4666e+6	2.1259e+7
Post Zombie Meat Event * Price * Beef	1.1420e+8	2.2690e+8

Notes: Table reports first-stage F-statistics for each of the endogenous price and price interaction variables in the IV fixed effects model of daily restaurant demand for all cities in Table 1.8a. We instrument for price and the price interactions using the average price of that dish in that city during the first quarter of 2015 (from January 1 to March 31) and its interactions

Table 1.F.3a. Daily Restaurant Dish Demand (IV Fixed Effects)

Dependent variable is Total Number of Orders of a Dish a Restaurant on a Day					
	All cities	Beijing	Shanghai	Tianjin	Zhengzhou
Price	0.0015	0.0010	0.0442*	0.0011	-0.0010
	(0.0017)	(0.0017)	(0.0181)	(0.0188)	(0.0038)
Vegetable Excluding Mushroom	5.5271***	5.4545***	12.5377***	-22.0480***	1.3493
	(0.3473)	(0.3771)	(1.1958)	(3.7979)	(0.8219)
Mushroom	-7.1847***	-6.3558***	-15.1001***	-21.4208***	-2.0908*
	(0.4067)	(0.4358)	(1.7829)	(3.9960)	(0.9523)
Tofu	25.4227***	25.6228***	32.1043***		2.3129
	(0.7766)	(0.8111)	(3.2118)		(2.2797)
Seafood	1.4983*	2.1363**	31.9480***	-12.5413***	14.7292***
	(0.6579)	(0.7150)	(4.4938)	(2.6290)	(2.5922)
Pork	-1.6160**	-1.0215	-19.1274***	41.0762***	-2.8732*
	(0.5114)	(0.5565)	(1.8828)	(4.9838)	(1.1967)
Chicken	-17.4320***	-17.5620***	-31.5095***	-8.5808**	-0.7198
	(0.6615)	(0.7399)	(3.2400)	(3.2636)	(1.4709)
Beef	-3.8613***	-3.4159***	-6.2835**	-10.0748*	-1.1640
	(0.5732)	(0.6134)	(2.3861)	(4.6759)	(1.2554)
Price * Vegetable Excluding Mushroom	-0.1980***	-0.1953***	-0.4373***	0.7938***	-0.0577*
	(0.0101)	(0.0110)	(0.0358)	(0.1405)	(0.0242)
Price * Mushroom	0.0782***	0.0583***	0.2376***	0.9566***	-0.0050
	(0.0074)	(0.0078)	(0.0344)	(0.2362)	(0.0173)
Price * Tofu	-0.6873***	-0.6993***	-0.8364***		0.0260
	(0.0258)	(0.0270)	(0.1040)		(0.0840)
Price * Seafood	0.0719***	0.0532***	-0.2922***	0.4343***	-0.1781***
	(0.0105)	(0.0114)	(0.0676)	(0.0664)	(0.0391)
Price * Pork	0.1100***	0.0955***	0.5296***	-1.1961***	0.0656*
	(0.0131)	(0.0142)	(0.0479)	(0.1988)	(0.0300)
Price * Chicken	0.5672***	0.5673***	0.9565***	0.2521*	0.0910**
	(0.0166)	(0.0185)	(0.0766)	(0.1213)	(0.0339)
Price * Beef	0.0690***	0.0599***	0.1050*	0.1247	0.0229
	(0.0115)	(0.0123)	(0.0486)	(0.1232)	(0.0255)
Post Zombie Meat Event * Price	0.0211***	0.0209***	0.0056	0.3807***	0.0081

	(0.0034)	(0.0036)	(0.0250)	(0.0473)	(0.0054)
Post Zombie Meat Event * Vegetable Excluding Mushroom	0.8590	0.7203	-1.1302	16.9818**	0.7689
	(0.4952)	(0.5399)	(1.6342)	(5.9420)	(1.1732)
Post Zombie Meat Event * Mushroom	0.8415	0.6957	1.6219	0.4954	0.6191
	(0.5889)	(0.6311)	(2.3607)	(18.1930)	(1.3988)
Post Zombie Meat Event * Tofu	-3.7849***	-3.8931***	-5.7322		2.6313
	(1.0773)	(1.1278)	(4.2559)		(3.3802)
Post Zombie Meat Event * Seafood	6.9310***	7.2645***	-8.3226	12.5478***	-1.5110
	(0.9533)	(1.0470)	(5.9483)	(3.7944)	(3.6259)
Post Zombie Meat Event * Pork	-4.8844***	-4.2652***	-0.1213	-59.9448***	0.0859
	(0.7331)	(0.8009)	(2.5014)	(6.9858)	(1.6799)
Post Zombie Meat Event * Chicken	3.1165**	1.3975	20.2097***	17.3113***	-1.9222
	(0.9473)	(1.0543)	(4.4897)	(4.8750)	(2.1093)
Post Zombie Meat Event * Beef	0.6704	0.6337	-0.8733		0.1960
	(0.8082)	(0.8633)	(3.1999)		(1.7756)
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	-0.0477***	-0.0398*	0.0131	-0.9382***	-0.0314
	(0.0144)	(0.0157)	(0.0486)	(0.2079)	(0.0342)
Post Zombie Meat Event * Price * Mushroom	-0.0329**	-0.0312**	-0.0408	-0.2043	-0.0095
	(0.0108)	(0.0116)	(0.0462)	(0.7656)	(0.0252)
Post Zombie Meat Event * Price * Tofu	0.0922*	0.0986**	0.1345		-0.0988
	(0.0358)	(0.0375)	(0.1378)		(0.1224)
Post Zombie Meat Event* Price * Seafood	-0.1321***	-0.1365***	0.0885	-0.5851***	0.0056
	(0.0152)	(0.0167)	(0.0899)	(0.1017)	(0.0545)
Post Zombie Meat Event * Price * Pork	0.0881***	0.0742***	-0.0169	1.8415***	0.0007
	(0.0187)	(0.0204)	(0.0639)	(0.2521)	(0.0423)
Post Zombie Meat Event * Price * Chicken	-0.1294***	-0.0795**	-0.6013***	-0.9011***	0.0414
	(0.0236)	(0.0262)	(0.1075)	(0.1774)	(0.0490)

Post Zombie Meat Event * Price * Beef	-0.0362*	-0.0346*	-0.0007	-0.3789***	-0.0244
	(0.0163)	(0.0175)	(0.0648)	(0.0886)	(0.0359)
Average Temperature	-0.0012	0.0191	-0.2260	-0.0928	-0.0326
	(0.0280)	(0.0295)	(0.1394)	(0.2126)	(0.0749)
Maximum Temperature	0.0700**	0.0782***	0.1904	0.3524*	0.0700
	(0.0218)	(0.0236)	(0.1069)	(0.1678)	(0.0526)
Precipitation	-0.0085	0.0483***	-0.0261***	0.1630	0.0238*
	(0.0047)	(0.0125)	(0.0071)	(0.0868)	(0.0100)
Tuesday	0.4072**	0.4022**	-0.2774	0.7508	-1.1649***
	(0.1383)	(0.1500)	(0.5520)	(1.0066)	(0.3367)
Wednesday	0.7705***	0.8425***	0.2207	1.6982	-1.3048***
	(0.1388)	(0.1490)	(0.5496)	(0.9967)	(0.3385)
Thursday	2.7450***	2.8318***	2.2378***	5.8856***	-0.3826
	(0.1391)	(0.1496)	(0.5388)	(1.0027)	(0.3409)
Friday	7.0182***	7.2035***	5.9900***	14.9473***	2.0472***
	(0.1387)	(0.1494)	(0.5534)	(1.0138)	(0.3234)
Saturday	5.9660***	5.9773***	4.8232***	12.2490***	1.6906***
	(0.1373)	(0.1488)	(0.5616)	(1.0193)	(0.3252)
Sunday	0.0494	0.1586	-0.7966	1.4145	-0.9226**
	(0.1364)	(0.1463)	(0.5455)	(0.9750)	(0.3277)
IV for Price and Price Interactions	Y	Y	Y	Y	Y
Post Zombie Meat Event Dummy	Y	Y	Y	Y	Y
Restaurant Fixed Effect	Y	Y	Y	Y	Y
Month Fixed Effect	Y	Y	Y	Y	Y
First-Stage Regression for Price					
Coefficient on Average price for that dish in that city during Quarter 1	1.0002***	1.0002***	1.0001***	1.0000***	1.0000***
	(0.0001)	(0.0001)	(0.0002)	(2.40e-16)	(6.66e-6)

# Observations	173,404	144,662	17,079	4,748	6,915
p-value (Pr > F)	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: We use observations from the 5 weeks before to 5 weeks after the Zombie meat event. We instrument for price and the price interactions using the average Quarter 1 price of that dish in that city and its interactions. Price is in Yuan. Maximum temperature and average temperature are in degrees Celsius. Precipitation is in millimeters. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level. The results for Beijing are also summarized in Table 1.3.

Table 1.F.3b. Daily Restaurant Dish Demand (IV Fixed Effects)

Dependent Variable is Total number of orders of that dish at that restaurant on that day					
	All cities	Beijing	Shanghai	Tianjin	Zhengzhou
Price	-0.0001	-0.0004	0.0523**	0.0081	-0.0046
	(0.0017)	(0.0017)	(0.0202)	(0.0189)	(0.0039)
Vegetable Excluding Mushroom	5.2482***	5.0861***	12.6118***	-22.6331***	0.8471
	(0.3477)	(0.3777)	(1.1982)	(3.7887)	(0.8214)
Mushroom	-7.3819***	-6.5391***	-14.8137***	-21.8496***	-2.4789**
	(0.4064)	(0.4353)	(1.8111)	(3.9848)	(0.9488)
Tofu	24.7593***	24.8998***	32.3758***		2.0407
	(0.7747)	(0.8087)	(3.2210)		(2.2662)
Seafood	0.9374	1.4307*	32.2335***	-12.9727***	14.2765***
	(0.6568)	(0.7134)	(4.5046)	(2.6229)	(2.5774)
Pork	-2.1980***	-1.6599**	-18.8796***	40.6502***	-3.2315**
	(0.5117)	(0.5564)	(1.9033)	(4.9692)	(1.1910)
Chicken	-17.8163***	-17.9832***	-31.2288***	-8.8141**	-1.1551
	(0.6599)	(0.7376)	(3.2548)	(3.2538)	(1.4638)
Beef	-4.1248***	-3.6955***	-6.0073*	-10.5095*	-1.4413
	(0.5726)	(0.6126)	(2.4056)	(4.6624)	(1.2486)
Price * Vegetable Excluding Mushroom	-0.1981***	-0.1940***	-0.4390***	0.7955***	-0.0509*
	(0.0101)	(0.0109)	(0.0358)	(0.1400)	(0.0241)
Price * Mushroom	0.0767***	0.0558***	0.2295***	0.9495***	-0.0020
	(0.0074)	(0.0078)	(0.0356)	(0.2354)	(0.0172)
Price * Tofu	-0.6754***	-0.6865***	-0.8439***		0.0234
	(0.0258)	(0.0269)	(0.1042)		(0.0835)
Price * Seafood	0.0763***	0.0592***	-0.3003***	0.4273***	-0.1747***
	(0.0105)	(0.0113)	(0.0682)	(0.0662)	(0.0389)
Price * Pork	0.1185***	0.1043***	0.5225***	-1.1977***	0.0683*
	(0.0131)	(0.0142)	(0.0486)	(0.1982)	(0.0298)
Price * Chicken	0.5690***	0.5690***	0.9485***	0.2381*	0.0946**
	(0.0165)	(0.0184)	(0.0771)	(0.1210)	(0.0337)
Price * Beef	0.0694***	0.0598***	0.0970*	0.1178	0.0249
	(0.0115)	(0.0123)	(0.0494)	(0.1228)	(0.0253)
Any Type of Promotion	-2.8375***	-3.1321***	0.7946	-6.2850***	-3.9677***

	(0.2185)	(0.2337)	(0.8868)	(1.5635)	(0.6877)
Post Zombie Meat Event	0.1520	0.0461	0.3820	-1.8930	0.2140
	(0.2344)	(0.2533)	(1.0579)	(1.7346)	(0.5793)
Post Zombie Meat Event * Price	0.0123***	0.0112**	-0.0182	0.3483***	0.0067
	(0.0034)	(0.0037)	(0.0282)	(0.0476)	(0.0054)
Post Zombie Meat Event * Vegetable Excluding Mushroom	1.6038**	1.4222**	-1.0370	16.5025**	0.5156
	(0.4943)	(0.5393)	(1.6381)	(5.9319)	(1.1739)
Post Zombie Meat Event * Mushroom	0.6434	0.4940	0.8718	-0.0933	0.3759
	(0.5890)	(0.6308)	(2.4012)	(18.1381)	(1.3946)
Post Zombie Meat Event * Tofu	-3.8580***	-3.9554***	-6.3597		2.2276
	(1.0761)	(1.1261)	(4.2711)		(3.3610)
Post Zombie Meat Event * Seafood	6.3373***	6.7021***	-9.1077	11.9421**	-1.5320
	(0.9530)	(1.0464)	(5.9645)	(3.7942)	(3.6051)
Post Zombie Meat Event * Pork	-7.6103***	-6.8714***	-1.0230	-60.5749***	-0.0768
	(0.7258)	(0.7932)	(2.5299)	(6.9703)	(1.6722)
Post Zombie Meat Event * Chicken	2.7908**	1.0783	19.5180***	16.5042***	-2.1188
	(0.9473)	(1.0538)	(4.5083)	(4.8680)	(2.0995)
Post Zombie Meat Event * Beef	0.4974	0.4429	-1.6220		0.0835
	(0.8078)	(0.8627)	(3.2293)		(1.7661)
Post Zombie Meat Event * Any Type of Promotion	-1.0769***	-1.0167**	-2.0606	-0.8565	-0.3437
	(0.3134)	(0.3375)	(1.2088)	(2.4715)	(0.9082)
Post Zombie Meat Event * Price * Vegetable Excluding Mushroom	-0.0753***	-0.0655***	0.0090	-0.9131***	-0.0276
	(0.0143)	(0.0156)	(0.0487)	(0.2074)	(0.0340)
Post Zombie Meat Event *	-0.0251*	-0.0225	-0.0175	-0.1726	-0.0077

Price * Mushroom					
	(0.0108)	(0.0116)	(0.0480)	(0.7632)	(0.0251)
Post Zombie Meat Event * Price * Tofu	0.0909*	0.0978**	0.1516		-0.0914
	(0.0358)	(0.0374)	(0.1382)		(0.1216)
Post Zombie Meat Event * Price * Seafood	-0.1191***	-0.1233***	0.1123	-0.5527***	0.0042
	(0.0152)	(0.0166)	(0.0908)	(0.1017)	(0.0542)
Post Zombie Meat Event * Price * Pork	0.1610***	0.1442***	0.0106	1.8697***	0.0012
	(0.0185)	(0.0201)	(0.0649)	(0.2514)	(0.0420)
Post Zombie Meat Event * Price * Chicken	-0.1198***	-0.0694**	-0.5797***	-0.8616***	0.0422
	(0.0236)	(0.0262)	(0.1082)	(0.1770)	(0.0488)
Post Zombie Meat Event * Price * Beef	-0.0290	-0.0262	0.0227	-0.3581***	-0.0242
	(0.0163)	(0.0175)	(0.0661)	(0.0885)	(0.0357)
Average Temperature	0.0002	0.0201	-0.2261	-0.0784	-0.0220
	(0.0280)	(0.0294)	(0.1394)	(0.2120)	(0.0745)
Maximum Temperature	0.0695**	0.0778***	0.1910	0.3450*	0.0655
	(0.0218)	(0.0236)	(0.1069)	(0.1673)	(0.0523)
Precipitation	-0.0089	0.0479***	-0.0262***	0.1622	0.0218*
	(0.0047)	(0.0124)	(0.0071)	(0.0866)	(0.0099)
Tuesday	0.4179**	0.4104**	-0.2721	0.8002	-1.0904**
	(0.1381)	(0.1497)	(0.5520)	(1.0034)	(0.3347)
Wednesday	0.7842***	0.8566***	0.2207	1.7435	-1.3275***
	(0.1386)	(0.1487)	(0.5496)	(0.9937)	(0.3364)
Thursday	2.7629***	2.8505***	2.2360***	5.9563***	-0.3626
	(0.1389)	(0.1493)	(0.5387)	(0.9998)	(0.3388)
Friday	7.0445***	7.2331***	5.9938***	15.0423***	2.0237***
	(0.1385)	(0.1492)	(0.5534)	(1.0110)	(0.3214)
Saturday	5.9866***	6.0001***	4.8266***	12.2948***	1.6793***
	(0.1371)	(0.1486)	(0.5616)	(1.0162)	(0.3232)
Sunday	0.0528	0.1621	-0.7910	1.4855	-0.9216**
	(0.1362)	(0.1460)	(0.5454)	(0.9720)	(0.3256)

IV for Price and Price Interactions	Y	Y	Y	Y	Y
Restaurant Fixed Effect	Y	Y	Y	Y	Y
Month Fixed Effect	Y	Y	Y	Y	Y
First-Stage Regression for Price					
Coefficient on Average price for that dish in that city during Quarter 1	1.0001*** (4.34e-5)	1.0001*** (0.0000)	1.0001*** (0.0000)		1.0001*** (0.0000)
# Observations	173,404	144,662	17,079	4,748	6,915
p-value (Pr > F)	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: We use observations from the 5 weeks before to 5 weeks after the Zombie meat event. We instrument for price and the price interactions using the average Quarter 1 price of that dish in that city and its interactions. For the IV fixed effects daily demand regression for Tianjin, price was reclassified by STATA as exogenous. Price is in Yuan. Maximum temperature and average temperature are in degrees Celsius. Precipitation is in millimeters. Standard errors are in parentheses. Significance codes: * 5% level, ** 1% level, and *** 0.1% level. The results for Beijing are also summarized in Table 1.3

CHAPTER 2

THE EFFECTS OF ENVIRONMENTAL POLICIES IN CHINA ON GDP, OUTPUT, AND PROFITS[8]

2.1 Introduction

China has achieved remarkable rates of economic growth over the past quarter century (Bosworth and Collins, 2008). Owing in part to this unprecedented economic growth that began in the 1980s, as well as to a heavy reliance on fossil fuels -- especially coal -- and inadequate environmental regulations, environmental quality has declined throughout China (Greenstone et al., 2020). To improve China's domestic environmental condition and in reaction to pressure to reduce emissions, the Chinese government has enacted a wide range of policies to protect the environment and promote sustainable development (Political Bureau of the Central Committee, 2013). These include environmental policies to increase the use of renewable energy, and policies to reduce pollution.

The effects of environmental policies on GDP, output, and profit is the subject of much debate. The conventional wisdom is that environmental regulations have a negative effect on the productivity of firms. Critics of environmental regulation often cite the temporal coincidence of the U.S economy slowdown in the 1970s with the

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[8] The research in this chapter has been published in the following publication: Si, Shuyang, Mingjie Lyu, C.-Y. Cynthia Lin Lawell, and Song Chen. (2021). The effects of environmental policies in China on GDP, output, and profits. Energy Economics, 94, 105082.

increasing environmental regulations in the same era as a proof of the negative impact of U.S. Environmental Protection Agency (EPA) regulations (Barabera and McConnell, 1990).

There are several ways in which environmental policies could negatively affect productivity. First, because inputs will be diverted to produce an additional output -- environmental quality -- that is not included in the conventional measures of output and productivity, measured productivity will fall. Second, process and management changes induced by environmental policies may be less efficient than the original practices. Third, environmental investments could crowd out other types of firm investment (Jaffe et al., 1995).

There has been some literature challenging the conventional wisdom, asserting instead that environmental policies may stimulate growth and competitiveness. This line of argument is often called the Porter hypothesis, as it was articulated by Porter (1991). There are several levels on which the Porter hypothesis can be interpreted. First, it can be taken to mean that some sectors of private industry, namely the environmental services sector, would benefit directly from environmental regulations on their customers, because these customers would then buy their products (Jaffe et al., 1995).

Second, environmental policies can induce innovations in technology to achieve compliance (Jaffe et al., 1995). Such induced innovation effects are expected to be greater in developing countries relying on low technologies that promote both high emissions and low production performance (Tanaka, Yin and Jefferson, 2014).

Third, the Porter hypothesis can be taken to mean that some regulated firms might benefit competitively under stricter environmental policies at the expense of other regulated firms. If there are asymmetric costs to compliance that decrease competition and therefore raise prices for those firms with lower compliance costs, then these firms might benefit if the raised prices more than offset their compliance costs (Jaffe et al., 1995).

Fourth, it has also been suggested by proponents of the Porter hypothesis that the imposition of environmental policies induces firms to reconsider their production processes, and hence to discover innovative approaches not only to reduce pollution, but also to decrease costs or increase output (Porter and van der Linde, 1995; Jaffe et al., 1995; Dechezleprêtre and Sato, 2017).

Fifth, environmental regulations cause more productive firms to displace less productive ones, leading to increased productivity at the industry level (Tanaka, Yin and Jefferson, 2014). This selection mechanism may be particularly relevant for developing countries (Tanaka, Yin and Jefferson, 2014), which are plagued with productivity dispersion and resource misallocation (Banerjee and Duflo, 2005; Alfaro, Charlton and

Kanczuk, 2009; Hsieh and Klenow, 2009; Banerjee and Moll, 2010; Restuccia and Rogerson, 2013).

It is possible that a negative effect of environmental regulations on productivity is an indication that firms have already become cleaner and more productive. In their analysis of countries in the European Union, for example, Marinaș et al. (2018) find that environmental policies have a negative effect on the GDP growth rate when the economy is moving towards a higher share of renewable energy. Other studies similarly suggest that a negative impact of environmental policies on economic growth might be an indication the economy is moving along the desired path towards an energy portfolio with higher clean energy shares (Dogan, 2015; Bhattacharya et al. 2016; Afonso, Marques and Fuinhas, 2017; Armeanu, Vintila and Gherghina, 2017).

Thus, the effects of environmental policies on productivity, GDP, output, and profits is in part an empirical question and may vary by firm, industry, sector, and type of policy. In this chapter we empirically examine the effects of environmental policies in China on GDP, industrial output in traditional energy industries, and new energy sector profits.

Previous analyses of China's environmental policies have examined their evolutionary progress (Xie, Hu and Zhang, 2005); their efficiency (Cirone and Urpelainen, 2013); their optimal design (Lin and Zeng, 2014); how their costs are affected by market reforms (Fisher-Vanden and Ho, 2007); and their effects on economic activity (see, e.g., Pereira and Pereira, 2010; Bojnec and Papler, 2011), gasoline consumption (Lin and Zeng, 2013), mortality (Tanaka, 2015), exports of renewable technology (Groba and Cao, 2015), welfare (Li, 2018), energy consumption (Si et al., 2018), air quality (Li et al., 2019), household behavior (Barwick et al., 2020), the automobile market (Chen and Lin Lawell, 2020), the economy (Lin and Jiang, 2011; Liu and Li, 2011; Jiang and Lin, 2014; Ouyang and Lin, 2014), factor substitution (Zhang et al., 2020), and agricultural and ethanol markets (Si et al., 2021). A related literature has examined relationships between energy and GDP in different countries (Nordhaus, 1974; Stiglitz, 1974; Jorgenson, 1998; Corderi and Lin, 2011; Zhang and Lin Lawell, 2017; Jorgenson, 2018; Kerestes, Corderi Novoa and Lin Lawell, 2021; Aghaei and Lin Lawell, forthcoming).

There have been several empirical analyses of the impact of environmental regulation on firm productivity, but most have been in the U.S. context (Gray, 1987; Gollop and Roberts, 1983; Gray and Shadbegian, 1993; Berman and Bui, 2001; Gray and Shadbegian, 2002; Rassier and Earnhart, 2010; Ryan, 2012; Greenstone, List and Syverson, 2012; Fowlie, Reguant and Ryan, 2016). There have also been studies testing the Porter hypothesis using data from OECD countries (Lanoie et al., 2011; Albrizio, Kozluk and Zipperer, 2017). Zakerinia and Lin Lawell (2021) examine the effects of country-level climate change policy on GDP. Tanaka, Yin and Jefferson (2014) analyze the effect of China's Two Control Zone (TCZ) environmental regulatory policy on industrial activities for different levels of pollution and energy intensities, and find that the environmental regulations had positive effects on productivity and competitiveness. Shiu, Li and Woo (2016) examine the effects of large investments in energy and transportation infrastructure on economic growth in China. Stavropoulos, Wall and Xu (2018) find evidence for a U-shaped relationship between environmental regulations and industrial competitiveness in China.

This chapter builds upon the existing literature by examining the effects of environmental policies in China on GDP, industrial output in traditional energy industries, and new energy sector profits using province-level panel data over the period 2002 to 2013. Our econometric method employs instruments to address the potential endogeneity of the policies. We find that policies involving financial incentives or monetary awards have the potential of increasing the output and/or profits in some energy-related industries or sectors, but potentially at the cost of GDP in non-energy industries or sectors. In contrast, command and control policies and non-monetary awards appear to decrease GDP, output, and/or profits.

The balance of the chapter proceeds as follows. Section 2.2 describes our data on GDP, industrial output, and new energy sector profits in China. Section 2.3 describes the data we have collected and constructed on environmental policies. Section 2.4 presents our empirical model. Section 2.5 presents our results. We discuss our results in Section 2.6 and conclude in Section 2.7.

2.2. GDP, Industrial Output, and New Energy Sector Profits in China

To analyze the effects of environmental policies in China on GDP, industrial output in traditional energy industries, and the profits of firms in the new energy sector, we use panel data on GDP, industrial output values of several traditional energy industries, and profits of firms in the new energy sector for 30 provinces from 2002 to 2013. Tibet, Taiwan, Hong Kong, and Macao are excluded from the analysis. We begin our period of study in 2002 owing to missing data prior to 2002. We end our period of study in 2013, the last year before a substantial structural change that took place in China in 2014. In 2014, the Chinese government declared war on pollution and undertook unprecedented regulatory changes on multiple fronts to combat environmental challenges, shifting away from its long-standing strategy of prioritizing economic growth over environmental concerns (Greenstone et al., 2020). We therefore focus our analysis on the period prior to this substantial structural change.

The data we use on GDP and industrial output values of different industries come from the Chinese Statistical Yearbooks and the China Industry Economy Statistical Yearbooks. Our panel data set includes province-level data on total GDP and on the GDP for the primary, secondary, and tertiary sectors. The primary sector consists of the agriculture, forestry, animal husbandry, and fishery industries. The secondary sector consists of the mining and quarrying, manufacturing, electricity, water and gas, and construction industries. The tertiary sector consists of the all other economic activities not included in the primary or secondary sectors, including transport and other services. Our panel data set also includes province-level data on the industrial output value of the following traditional energy industries: the coal mining, smelting, and dressing industry; the petroleum and nuclear fuel processing industry;[9] and the oil and gas exploration industry.

We also collect data on the profits of firms in the new energy sector over the period 2002 to 2013 from Hexun.com ("Hexun.com", 2019). Hexun.com is a specialized business and finance information and news provider focusing on the mainland China financial market. Each of the new energy sector firms that we consider is publicly traded on the Chinese stock market; publicly publishes their annual financial reports, including their annual income statement; and is listed under the new energy

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9 Our data for the industrial output value of the petroleum and nuclear fuel processing industry includes the industrial output value the petroleum processing and coking industry (without nuclear fuel processing) for 2002-2007 and the industrial output value for the petroleum processing and coking industry and nuclear fuel processing industry for 2008-2015.

sector by Hexun.com. There are a total of 280 firms in the new energy sector, which comprises the combustible ice industry[10] (17 companies), low carbon industry11 (85 companies), nuclear power industry (65 companies), shale gas industry (37 companies), and solar energy industry (116 companies). Some firms are involved in multiple industries in the new energy sector.

For each of the 280 firms in the new energy sector, we collect data on their total profit and net profit for each of for each year over 2002 to 2013 from their publicly published annual income statement. Since each one of these new energy companies are publicly traded, we assume that their annual financial reports meet the accounting standards in mainland China, and that the definition of total profit and net profit they use in their annual income statement follows the accounting standards in mainland China. Table 2.A1 in Appendix 2.A illustrates how total profit and net profit are calculated under the accounting standards in mainland China. We focus our analysis on total profit, which is calculated by adding up operating profit and non-business income,

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10 A firm is listed in the combustible ice industry if it is involved in the business related to combustible ice, including technology development, exploration, and processing. Combustible ice, also known as methane hydrate, is a frozen mixture of water and concentrated natural gas which can be lit on fire in its frozen state and is believed to comprise one of the world's most abundant fossil fuels (Brown, 2017).

11 A firm is listed in the low carbon industry if it satisfies the definition of low carbon economy used by the China Council for International Cooperation on Environment and Development (CCICED): a new economic, technological and social system of production and consumption to conserve energy and reduce greenhouse gas emissions compared with the traditional economic system (CCICED, 2019). The low carbon industry includes firms involved in hydroelectric power, wind energy, and energy conservation.

and then subtracting out non-business expenditure. Net profit is total profit minus income tax expense.

To create the province-level total profit observations, we sum up the total profit values across all the firms in each specific new energy industry for each specific province and for each specific year. The province-level total profit for the entire new energy sector is calculated by summing up the total profit values across all the firms in the new energy sector for each specific province and for each specific year.

Table 2.1 presents the summary statistics for the GDP, industrial output value, and new energy sector profit variables in our annual province-level data set, which covers 30 provinces over the period 2002 to 2013. Table 2.A.2 in Appendix 2.A presents the within and between variation for the GDP, industrial output value, and new energy sector profit variables.[12] Table 2.A.3 in Appendix 2.A presents the number of firms in the new energy sector in each province for the entire new energy sector and for each of the 5 new energy industries in the new energy sector (combustible ice industry, low carbon industry, nuclear power industry, shale gas industry, and solar power industry).

We use the Chinese Statistical Yearbooks and the China Industry Economy

12 "Within" variation is the variation in the GDP, output, or profit variable across years for a given province. "Between" variation is the variation in the GDP, output, or profit variable across provinces for a given year.

Statistical Yearbooks to obtain data on energy prices. We use producer price indices for manufactured goods for the coal industry, the power industry, and the petroleum industry over the years 2002 to 2013. We also use the #90 gasoline retail price over the years 2002 to 2013. Table 2.A.4 in Appendix 2.A presents the summary statistics for the energy price variables in the data set.

2.3. Environmental Policies in China

For our environmental policy variables, we collect and construct a novel and comprehensive data set on environmental policies at the provincial level in China by collecting data from online databases of laws and regulations from the websites of each of the provincial governments as well as from Lawtime, a website which collects laws and regulations in China ("Lawtime", 2017).

Our policy variables are constructed from the 2,656 environmental laws and regulations that are in place for at least one year over the period 2002 to 2013. These province-level laws and regulations include national laws and regulations implemented in each province, some of which may be differentiated by province. Some of the laws were implemented during the 2002-2013 time period of our data set; others were already in place. Some laws continued even after the end of our 2002-2013 time period; others expired before the end of the time period. Each of the 2,656 province-level laws and regulations has multiple clauses, and may include multiple provisions.

For each of the 2,656 province-level laws and regulations over the years 2002 to 2013, we categorize their provisions and features into the specific types of command and control policies; financial incentives; and awards policies, as described below. Because each province-level law and regulation has multiple clauses, provisions, and features, each law and regulation may include more than one of the following types of policies.

Our first category of environmental policies are command and control policies. We categorize the 2,656 province-level laws and regulations into whether their features or provisions include policies for the following separate types of command and control policies: (a) an ambient air quality standard for a maximum amount of pollution in air; (b) an ambient water quality standard for a maximum amount of pollution in water; (c) an emissions standard for water pollution for maximum amount of water pollution emissions; (d) a fuel mandate which mandates that a certain share of fuel be renewable, or that the carbon intensity of fuels not exceed a certain amount; and (e) a renewable electricity mandate which mandates that a certain share of electricity be renewable, or that the emissions rate from electricity not exceed a certain amount.

A second category of environmental policies are financial incentives. We consider several types of financial incentives: (a) favorable tax treatments for reducing pollution; (b) environmental taxes for water pollution emissions; (c) funding or subsidies for research and development to reduce pollution; (d) funding or subsidies for reducing pollution; (e) funding or subsidies for energy conservation; (f) loans to households for increasing energy efficiency; (g) loans to households for increasing renewable energy consumption; and (h) loans to firms for increasing renewable energy consumption.

A third category of environmental policies are awards that are given after something has been accomplished. We consider several types of awards: (a) monetary awards for having reduced pollution; (b) monetary awards for having increased energy efficiency; (c) monetary awards for having developed technology to reduce pollution; (d) monetary awards for having developed technology to reduce fossil fuel consumption; and (e) non-monetary awards for having reduced pollution.

For each type of policy, we construct a dummy variable for whether there is a policy of that particular type in province *i* at time *t*. It is difficult to quantify the policies along other dimensions, as dimensions such as the stringency of the policy or the extent of the policy are either not observable or difficult to quantify objectively in a single measure, particularly one that aggregates across the 2,656 province-level laws and regulations. Moreover, as the focus of this chapter is on the marginal effects of different types of environmental policies when considering and controlling for a full and comprehensive set of all environmental policies in place, we have opted to use simple measures of each type of policy in favor of being able to include a comprehensive set of many policies. In future work we hope to develop measures to quantify the magnitude and/or stringency of the policies, particularly for policies whose effects on GDP, output, and/or profits we wish to further examine.

We streamline the set of policies we consider by eliminating those policies that have very little variation in our data set, since for these policies we do not have enough variation to identify their effects. First, we drop all policies that were in place in over 90% of the province-years of our data set, since these essentially province-invariant policies are implemented nearly nation-wide and are therefore absorbed in the year effects. This eliminates the policy variable for funding or subsidies for research and development to reduce pollution, which was in place for 97% of the province-years of our data set.

Second, we drop any policy variable that is constant (i.e., always 0 for all years or always 1 for all years) for 28 or more out of the 30 provinces, since these time-invariant policy variables are absorbed by the province fixed effects. This eliminates a number of policy variables, including the policy variable for funding or subsidies for research and development to reduce pollution also excluded because of the first criterion above.

The policy variables that are eliminated because they are always constant for 28 or more out of the 30 provinces include the policy variables for ambient air quality standards; ambient water quality standards; emissions standards for water pollution; fuel mandates; favorable tax treatment for reducing pollution; taxes on water pollution emissions; funding or subsidies for research and development to reduce pollution; funding or subsidies for reducing pollution; funding or subsidies for energy conservation; loans to households for increasing energy efficiency; loans to households for increasing renewable energy consumption; monetary awards for having increased energy efficiency; monetary awards for having developed technology to reduce pollution; and monetary awards for having developed technology to reduce fossil fuel consumption.

Tables 2.A.5-2.A.9 in Appendix 2.A list, for each of the policy variables we dropped, which provinces always had this type of policy and which provinces never had this type of policy over the 2002-2013 period of our data set.

The policy variables that remain are the following. The command and control policy variable that remains is the policy variable for renewable electricity mandates. The loans policy variable that remains is the policy variable for loans to firms for increasing renewable energy consumption. The monetary awards policy variable that remains is the policy variable for monetary awards for having reduced pollution. The non-monetary awards policy variable that remains is the policy variable for non-monetary awards for having reduced pollution.

Table 2.2 presents the summary statistics for our policy variables. Table 2.3 lists the years in which each type of policy was in place for each province.

2.4. Econometric Model

To analyze the effects of environmental policies in China on GDP, industrial output for traditional energy industries, and profits of firms in the new energy sector, we estimate the following regression for each GDP, output, or profit of type *j*:

$$ln\, y_{ijt} = policies_{it}'\beta_{1j} + \left(\sum_{\tilde{\imath}\neq i} y_{\tilde{\imath},t-1}\right)'\beta_{2j} + ln\, energyprices_{it}'\,\beta_{3j} + \alpha_{ij} + \tau_{tj} + \varepsilon_{ijt},$$

where the dependent variable y_{ijt} is GDP, output, or profit of type *j* for province *i* in year *t*; $policies_{it}$ is a vector of environmental policies; $\sum_{\tilde{\imath}\neq i} y_{\tilde{\imath},t-1}$ is a vector of time lagged spatial lagged GDP, output, and profit in province *i*, each component $\tilde{\jmath}$ of which is the sum of the GDP, output, or profit of type $\tilde{\jmath}$ of all the other provinces except province *i* at time *t-1*; $energyprices_{it}$ is a vector of energy prices; α_{ij} is the province effect (which is either a fixed effect or a random effect, and which varies for each type *j* of GDP, output, or profit y_{ijt} we use as a dependent variable); τ_{tj} is the year effect (which varies for each type *j* of GDP, output, or profit y_{ijt} we use as a dependent variable); and ε_{ijt} is an error term.

The types j of GDP, output, or profit y_{ijt} we analyze as dependent variables include total GDP; the GDP for the primary, secondary, and tertiary sectors; industrial output of the coal mining, smelting, and dressing industry; industrial output of the petroleum and nuclear fuel petroleum and nuclear fuel processing industry; industrial output of the oil and gas exploration industry; profits of firms in the new energy sector; profits of firms in the combustible ice industry in the new energy sector; profits of firms in the low carbon industry in the new energy sector; profits of firms in the nuclear power industry in the new energy sector; profits of firms in the shale gas industry in the new energy sector; and profits of firms in the solar energy industry in the new energy sector.

As explained above, after streamlining the set of policies we consider by eliminating those policies that have very little variation in our data set, since for these policies we do not have enough variation to identify their effects, the vector $policies_{it}$ of environmental policy variables that remain include renewable electricity mandates, loans to firms for increasing renewable energy consumption, monetary awards for having reduced pollution, and non-monetary awards for having reduced pollution. For each type of policy, the policy variable for that policy type for province *i* in time *t* is a dummy variable for whether there is a policy of that particular type in province *i* at time t.

We control for the time lagged spatial lag of all the GDP, output, and profit variables -- which, for each GDP, output, or profit of type $\tilde{j}$, we define as the sum of the GDP, output, or profit of type $\tilde{j}$ of all the other provinces except province *i* at time *t-1* -- since the GDP, output, or profit in one province may be affected by the lagged GDP, output, and profit in other provinces due to spillovers.

The vector $energyprice_{it}$ of energy prices includes gasoline price, coal price, power price, petroleum price. Broadstock et al. (2016) find that around 90 percent of Chinese firms are affected by both oil price and gasoline price.

In analyzing the effects of environmental policies on GDP, output, and new energy sector profits, one may worry that the policies are endogenous (Rehme, 2011). To address any potential endogeneity of the policies, we estimate an instrumental variables (IV) model. For each policy variable, we instrument for that policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. This instrument is therefore the number of other provinces except province *i* that had that policy type at time *t-1*.

We assume that, conditional on our covariates -- which include time lagged spatial lagged GDP, output, and profit -- the time lagged spatial lag of policies in other provinces has no effect on a province's GDP, output, or new energy sector profit except through its effect on the province's current policies. This assumption makes sense since policies of other provinces implemented in the previous year should not influence the GDP, output, or new energy sector profit in that province, except through their effect on the province's current policies.[13] Thus, the instruments are correlated with policies in province *i* at time *t* and do not affect the GDP, output, or new energy sector profit in province *i* at time *t* except through their effect on the policies in province *i* at time *t*.

We report the first-stage F-statistics for each of the endogenous policy variables in Table 2.4. The Angrist-Pischke first-stage F-statistics and Sanderson-Windmeijer first-stage F-statistics are tests of weak identification of individual endogenous regressors. They are constructed by "partialling-out" linear projections of the remaining endogenous regressors. The Sanderson-Windmeijer first-stage F-statistic (Sanderson and Windmeijer, 2016) is a modification and improvement of the Angrist-Pischke first-stage F-statistic (Angrist and Pischke, 2009). As seen in Table 2.4, the Angrist-Pischke

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13 There may be a concern that policies in other provinces might affect GDP in a province if policies in other provinces cause firms shift their production to provinces with less stringent environmental policy, away from provinces with more stringent environmental policy, a phenomenon called the pollution haven effect (Levinson and Taylor, 2008; Dechezleprêtre and Sato, 2017). If this is the case, then the time lagged spatial lag policies might not be a good instrument. Even if there is a pollution haven effect, however, it is likely that the pollution haven effect operates through GDP. That is, the reason firms may move their production as a result of a policy is that that policy may have an adverse effect on GDP. Thus, if we control for the time lagged spatial lag of GDP (which we do), then, conditional on the time lagged spatial lag of GDP, the time lagged spatial lag of a policy plausibly does not affect GDP except through its effect on the policy, and therefore serves as a good instrument for the policy.

first-stage F-statistics are all greater than 10 for each of the endogenous variables, and the Sanderson-Windmeijer first-stage F-statistics are all greater than 9 for each of the endogenous variables. Moreover, as seen in the results from the first-stage regressions for each of the endogenous policy variables in Tables 2.B.1-2.B.4 in Appendix 2.B, for each endogenous policy variable, there is at least one instrument that has a significant effect on that endogenous policy variable: the time lagged spatial lag of that respective policy variable. Thus, the instruments are correlated with the endogenous variables, even when controlling for all the other instruments and for the control variables.

For each type j of GDP, output, or profit y_{ijt} we analyze as dependent variables, the province effect α_{ij} is either a province fixed effect or province random effect depending on whether random effects or fixed effects are more appropriate for the IV regression of that dependent variable type j, as determined by a Hausman test.

2.5. Results

The results of our IV regressions are presented in Tables 2.5-2.7. In particular, Table 2.5 presents the results of the IV regressions of province-level GDP and province-level GDP in the primary, secondary, and tertiary sectors. Table 2.6 presents the results of the IV regressions of the industrial output value in the following traditional energy industries: the coal mining, smelting, and dressing industry; the petroleum and nuclear fuel processing industry; and the oil and gas exploration industry. Tables 2.7a and 2.7b present the IV results for total profits for firms in the new energy sector and total profits for firms in each industry in the new energy sector (combustible ice industry, low carbon industry, nuclear power industry, shale gas industry, and solar power industry).

For each type j of GDP, output, or profit y_{ijt} we analyze as dependent variables, we conduct a Hausman test to determine whether random effects or fixed effects are more appropriate for the province effect α_{ij} for the IV regression of that dependent variable type j. The results of the Hausman tests for each IV regression are reported in Tables 2.5-2.7. We find that, for each of our IV regressions of GDP and output,[14] as well as for our IV regression of total profits in the new energy sector, we reject the null hypothesis that the random effects and regressors are uncorrelated; as a consequence, for these IV regressions, fixed effects is the more appropriate specification since the random effects estimator is biased and inconsistent (Hausman, 1978). In contrast, for all our new energy profit variables except the total profits in the new energy sector, we do not reject the null hypothesis that the random effects and regressors are uncorrelated; thus, for these IV regressions, both the fixed effects estimator and the random effects

14 We are unable to conduct a Hausman test for our IV regression of the industrial output of the coal mining, smelting, and dressing industry, as the model fitted on the data fails to meet the asymptotic assumptions of the Hausman test. Since a fixed effects estimator is consistent even if there are time-invariant province unobservables that are correlated with the regressors (Hausman, 1978), we use a fixed effects specification for our IV regression of the industrial output of the coal mining, smelting, and dressing industry.

estimator are consistent, but a random effects specification is preferred since the random effects estimator is asymptotically efficient while the fixed effects estimator is not efficient (Hausman, 1978). We therefore report the results of IV fixed effects regressions for GDP, output, and total profits in the new energy sector in Tables 2.5, 2.6, and 2.7a; and the results of IV random effects regressions for all our new energy profit variables except the total profits in the new energy sector in Tables 2.7a and 2.7b.

According to our GDP results (Table 2.5), renewable electricity mandates, which are a command and control policy, significantly decrease GDP by 0.22%; while monetary awards for having reduced pollution significantly decrease GDP by 0.23%. Providing loans to firms for increasing renewable energy consumption significantly reduces the GDP of the primary sector by 0.12%, while providing non-monetary awards for having reduced pollution significantly decreases the GDP of the primary sector by 0.27%. Renewable electricity mandates decrease the GDP of the secondary sector by 0.71%.

In terms of output (Table 2.6), we find that renewable electricity mandates significantly decrease the industrial output value of the petroleum and nuclear fuel processing industry by 0.81%, while providing loans to firms for increasing renewable energy consumption significantly increases the industrial output value of the petroleum and nuclear fuel processing industry by 0.27%.

As for new energy sector profits (Tables 2.7a and 2.7b), results show that providing monetary awards for having reduced pollution significantly increases the total profits of firms in the new energy sector by 3.36% and the total profits of firms in the combustible ice industry in the new energy sector by 5.24%. In contrast, providing non-monetary awards for having reduced pollution significantly decreases the total profits of firms in the new energy sector by 3.25%; the total profits of firms in the combustible ice industry in the new energy sector by 2.43%, the total profits of firms in the low carbon economy industry in the new energy sector by 4.69%; and the total profits of firms in the shale gas industry in the new energy sector by 1.07%.

We run several alternative specifications for robustness in Appendix 2.C. First, since a fixed effects estimator is consistent whether or not time-invariant province unobservables are correlated with the regressors (Hausman, 1978), for the first robustness check we also estimate the regressions for which random effects are preferred (but fixed effects are still consistent) using fixed effects instead. In particular, since the random effects estimator is preferred and therefore used for the IV regressions of all our new energy profit variables except the total profits in the new energy sector in Tables 2.7a and 2.7b, we report the results of IV regressions that use fixed effects instead of random effects for all the new energy sector profits variables in Tables 2.C.1a and

2.C.1b in Appendix 2.C.[15] As expected, for those new energy sector profit variables for which random effects are preferred (but fixed effects are still consistent), a few of the coefficients that are statistically significant when we use the random effects estimator are no longer statistically significant when we use the fixed effects estimator, since the fixed effects estimator is not efficient when random effects and regressors are uncorrelated (Hausman, 1978). Nevertheless, our results that monetary awards for having reduced pollution increase profits in the new energy sector while non-monetary awards for having reduced pollution decrease profits in the new energy sector are robust to whether we use random effects or fixed effects.

For the second robustness check, we run the IV regressions for new energy sector profit using net profit instead of total profit; the results are presented in Tables 2.C.2a and 2.C.2b in Appendix 2.C. As explained in Table 2.A.1 in Appendix 2.A, net profit is total profit minus income tax expense. Our results that monetary awards for having reduced pollution increase profits in the new energy sector while non-monetary awards for having reduced pollution decrease profits in the new energy sector are robust to whether we use total profits or net profits.

In our base-case specification, in addition to instrumenting for each endogenous

15 Since the random effects estimator is biased and inconsistent for total profits in the new energy sector, we report the same IV fixed effects regression results for the total profits in the new energy sector in both Table 2.7a and Table 2.C.1a.

policy variable using the time lagged spatial lag of that policy variable, we also instrument for each energy price using the time lag of that energy price. For the third robustness check, we instrument for the endogenous policy variables but no longer instrument for energy price; the results are presented in Tables 2.C.3, 2.C.4, 2.C.5a, and 2.C.5b in Appendix 2.C. Our results are robust to whether we instrument for energy prices in addition to the endogenous policy variables.

2.6. Discussion

Our results show that renewable electricity mandates, which are a command and control policy, have significant negative effects on GDP, the GDP of the primary sector (which consists of the agriculture, forestry, animal husbandry, and fishery industries), and the industrial output value of the petroleum and nuclear fuel processing industry. Similarly, non-monetary awards for having reduced pollution have significant negative effects on the GDP of the primary sector, the total profits of firms in the new energy sector, the total profits in the combustible ice industry in the new energy sector, the total profits of firms in the low carbon industry in the new energy sector, and the total profits of firms in the shale gas industry in the new energy sector.

In contrast, policies involving financial incentives or monetary awards have mixed effects on GDP, output, or profits; with positive effects on output or profits in some energy-related industries or sectors. Loans to firms for increasing renewable energy consumption have mixed effects on GDP, industrial output, and profits, with a significant negative effect on the GDP of the primary sector, and a significant positive effect on the industrial output value of the petroleum and nuclear fuel processing industry. One possible explanation for the significant positive effect of loans to firms for increasing renewable energy consumption on the industrial output value of the petroleum and nuclear fuel processing industry is that the nuclear industry is primarily an electricity producing sector. Promoting consumption of the renewable electricity and renewable energy leads to increased sales in the nuclear industry, which in turn increases the industrial output value of the petroleum and nuclear fuel processing industry.

Similarly, monetary awards for having reduced pollution have mixed effects on GDP, industrial output, and profits, with a significant negative effect on GDP, but significant positive effects on the total profits of firms in the new energy sector and on the total profits of firms in the combustible ice industry in the new energy sector.

Thus, we find that, contrary to conventional wisdom, environmental policies do not necessarily lead to a decrease in output or profits. Consistent with the Porter hypothesis, we find that loans to firms for increasing renewable energy consumption have a significant positive effect on the industrial output values of the petroleum and nuclear fuel processing industry; and monetary awards for having reduced pollution have significant positive effects on total profits of firms in the new energy sector and on and the total profits of firms in the combustible ice industry in the new energy sector. These environment policies may be increasing productivity by inducing innovations in compliance technology; by benefiting firms with lower compliance costs; by inducing firms to reconsider their production processes, and hence to discover innovative approaches not only to reduce pollution, but also to decrease costs or increase output; and/or by more productive firms to displace less productive ones, leading to increased productivity at the industry level.

In addition to benefiting the regulated industries, environmental regulation may benefit the whole economy by benefiting the environmental services sector and by inducing innovations in compliance technology. Our results show that, on the contrary, environmental policies can decrease the GDP of some non-energy industries and sectors. Providing loans to firms for increasing renewable energy consumption and providing non-monetary awards for having reduced pollution significantly reduces the GDP of the primary sector, which consists of the agriculture, forestry, animal husbandry, and fishery industries.

One possible reason environmental policies may have a negative effect on productivity, GDP, output, and profits is that firms have already become cleaner and more productive, and that the economy is moving along the desired path towards an energy portfolio with higher clean energy shares (Dogan, 2015; Bhattacharya et al. 2016; Afonso, Marques and Fuinhas, 2017; Armeanu, Vintila and Gherghina, 2017; Marinaș et al., 2018). Since our period of analysis is prior to China's war on pollution, however, it is unlikely that firms during this period have already become cleaner and more productive.

Economists tend to favor incentive- or market-based instruments over command and control policies, including quantity-based mandates, for efficiency reasons (Auffhammer et al., 2016). Whenever unpriced emissions are the sole market failure, incentive-based instruments are more likely to achieve the social optimum and maximize social net benefits (Pigou, 1920; Coase, 1960). Our results provide an additional reason for policy-makers to use incentive- or market-based instruments as opposed to command and control policies: while command and control policies and non-monetary awards appear to decrease GDP, output, and/or profits; environmental policies involving financial incentives or monetary awards have the potential of increasing the output and/or profits in some energy-related industries or sectors, albeit potentially at the cost of GDP in other sectors.

2.7. Conclusion

Critics of environmental policies often claim that such policies decrease productivity and profits. The effects of environmental policies on productivity, GDP, output, and profits is in part an empirical question, however, and may vary by firm, industry, sector, and type of policy.

This chapter examines the effects of environmental policies in China on GDP, industrial output, and new energy sector profits using province-level data over the period 2002 to 2013. Our econometric method employs instruments to address the potential endogeneity of the policies.

Our results suggest that policies involving financial incentives or monetary awards have the potential of increasing the output and/or profits in some energy-related industries or sectors, but potentially at the cost of total GDP and GDP in the primary sector (which consists of the agriculture, forestry, animal husbandry, and fishery industries). In contrast, command and control policies and non-monetary awards appear to decrease GDP, output, and/or profits.

Economists tend to favor incentive- or market-based instruments over command and control policies (including quantity-based mandates) because incentive- or market-based instruments are more likely to maximize social net benefits (Pigou, 1920; Coase, 1960; Auffhammer et al., 2016). Our results on the possible beneficial impact of financial incentives and monetary awards on the output and/or profits in some energy-related industries or sectors may potentially provide an additional reason for policymakers to use incentive- or market-based instruments as opposed to command and control policies.

This chapter points to several potential avenues for future research. First, we hope in future work to quantify the stringency and extent of various environmental policies in order to further examine the relationships between environmental policies and GDP, industrial output, and new energy sector profits in China. Second, we hope in future work to further analyze and tease out the mechanisms through which various environmental policies affect GDP, industrial output, and new energy sector profits in China. Third, we hope in future work to collect and construct data to enable us to examine the relationships between environmental policies and GDP, industrial output, and new energy sector profits in China after the unprecedented environmental regulatory changes that took place when China declared war on pollution in 2014 (Greenstone et al., 2020).

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Table 2.1. Summary statistics for province-level GDP, industrial output, and profit variables, 2002-2013

	Obs	Mean	Std. Dev.	Min	Max
Total GDP (10^8 yuan)	360	9,326.25	8,758.71	340.65	50,143.63
GDP of primary sector (10^8 yuan)	360	923.41	725.21	44.90	3,788.68
GDP of secondary sector (10^8 yuan)	360	4,373.80	4,405.57	125.33	23,619.15
GDP of tertiary sector (10^8 yuan)	360	3,486.83	3,661.25	125.28	23,829.02
Industrial output value of coal mining, smelting, and dressing industry (10^8 yuan)	331	368.29	594.70	0.04	3,727.28
Industrial output value of petroleum processing and nuclear industry (10^8 yuan)	360	534.99	615.39	0.06	3,331.78
Industrial output value of oil and gas exploration industry (10^8 yuan)	263	297.14	360.62	0.07	1,742.65
Total profits of firms in new energy sector (10^8 yuan)	360	31.52	56.37	-49.63	500.48
Total profits of firms in combustible ice industry (10^8 yuan)	360	1.84	9.14	-14.36	108.71
Total profits of firms in low carbon industry (10^8 yuan)	360	18.36	43.47	-58.23	369.86
Total profits of firms in nuclear power industry (10^8 yuan)	360	7.89	19.85	-58.23	152.22
Total profits of firms in shale gas industry (10^8 yuan)	360	3.08	9.74	-12.31	92.76
Total profits of firms in solar energy industry (10^8 yuan)	360	5.23	12.17	-49.63	69.45

Note: The data consists of annual province-level data over the period 2002 to 2013.

Table 2.2. Summary statistics for province-level policy variables, 2002-2013

	Obs	Mean	Std. Dev.	Min	Mas
Command and Control					
Renewable electricity mandate	360	0.619	0.486	0	1
Financial Incentives					
Loans to firms for increasing renewable energy consumption	360	0.289	0.454	0	1
Monetary Awards					
Monetary awards for having reduced pollution	360	0.411	0.493	0	1
Non-Monetary Awards					
Non-monetary awards for having reduced pollution	360	0.475	0.500	0	1

Note: The data consists of annual province-level data over the period 2002 to 2013.

Table 2.3. Environmental policies in China by province, 2002-2013

Province	*Renewable electricity mandate*	*Loans to firms for increasing renewable energy consumption*	*Monetary awards for having reduced pollution*	*Non-monetary awards for having reduced pollution*
Anhui	2002 - 2013	NONE	NONE	2002 – 2013
Beijing	2005 - 2013	NONE	NONE	2005 - 2013
Chongqing	2002 - 2013	NONE	2003 - 2013	NONE
Fujian	2002 - 2013	NONE	2002 - 2013	2002 - 2013
Gansu	NONE	2004 - 2013	NONE	NONE
Guangdong	2002 - 2013	2002 - 2013	2002 - 2013	2002 - 2013
Guangxi	2002 - 2013	2002 - 2013	NONE	2011 - 2013
Guizhou	NONE	NONE	NONE	NONE
Hainan	2002 - 2013	NONE	NONE	2005 - 2013
Hebei	2004 - 2013	2011 - 2013	2002 - 2013	2002 - 2013
Heilongjiang	2010 - 2013	NONE	2006 - 2013	2009 - 2013
Henan	2002 - 2013	2002 - 2013	2004 - 2013	2002 - 2013
Hubei	2002 - 2013	NONE	NONE	NONE
Hunan	2002 - 2013	NONE	NONE	NONE
Inner Mongolia	NONE	NONE	NONE	NONE
Jiangsu	2002 - 2013	NONE	NONE	2002 - 2013
Jiangxi	NONE	NONE	NONE	2002 - 2013
Jilin	2002 - 2013	NONE	2009 - 2013	2009 - 2013
Liaoning	2010 - 2013	2002 - 2013	2004 - 2013	2002 - 2013
Ningxia	NONE	NONE	NONE	NONE
Qinghai	NONE	NONE	NONE	NONE
Shaanxi	NONE	NONE	NONE	NONE
Shandong	2002 - 2013	2002 - 2013	2002 - 2013	2002 - 2013
Shanghai	2004 - 2013	NONE	2002 - 2013	NONE
Shanxi	2006 - 2013	2004 - 2013	2006 - 2013	2006 - 2013
Sichuan	2003 - 2013	2002 - 2013	2002 - 2013	2002 - 2013
Tianjin	2002 - 2013	2002 - 2013	2002 - 2013	2002 - 2013
Xinjiang	NONE	NONE	NONE	NONE
Yunnan	NONE	NONE	NONE	NONE

Zhejiang	2003 - 2013	NONE	2002 - 2013	NONE

Notes: This table lists the years in which each type of policy was in place in each province. If a province did not have that type of policy in place for any year over 2002-2013, this is indicated with “NONE”.

Table 2.4. Angrist-Pischke and Sanderson-Windmeijer First-Stage F-statistics

	Angrist-Pischke First-Stage F-Statistic	Sanderson-Windmeijer First-Stage F-statistic
Command and Control		
Renewable electricity mandate	22.20	11.11
Financial Incentives		
Loans to firms for increasing renewable energy consumption	241.64	48.58
Monetary Awards		
Monetary awards for having reduced pollution	29.37	10.67
Non-Monetary Awards		
Non-monetary awards for having reduced pollution	51.25	9.20

Note: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*.

Table 2.5. Results for total GDP and GDP of the primary, secondary, and tertiary sectors

	Dependent variable is:			
	Log GDP	*Log GDP of the primary sector*	*Log GDP of the secondary sector*	*Log GDP of the tertiary sector*
	(1)	(2)	(3)	(4)
Policy Variables				
Command and Control				
Renewable electricity mandate	-0.2206**	0.1614	-0.7069**	-0.1437
	(0.0836)	(0.0968)	(0.2455)	(0.0995)
Financial Incentives				
Loans to firms for increasing renewable energy consumption	0.0377	-0.1181**	0.1053	0.0136
	(0.0491)	(0.043)	(0.115)	(0.0838)
Monetary Awards				
Monetary awards for having reduced pollution	-0.2323*	0.2463	-0.5155	-0.2127
	(0.1173)	(0.1361)	(0.3234)	(0.1549)
Non-Monetary Awards				
Non-monetary awards for having reduced pollution	0.1979	-0.2742*	0.6349	0.2228
	(0.1197)	(0.1358)	(0.3543)	(0.1409)
Energy Prices				
Log gasoline price	-0.0391	-0.0521	-0.3548	-0.0769
	(0.1713)	(0.1664)	(0.4744)	(0.2211)
Log power price	-0.2802	-0.0617	-1.286	-0.4625
	(0.3336)	(0.5077)	(0.8701)	(0.6338)
Log coal price	0.5795***	-0.3718	1.3510**	0.058
	(0.1662)	(0.2477)	(0.4323)	(0.2983)
Log petroleum price	0.1547	-0.0726	-0.0546	-0.15
	(0.129)	(0.1553)	(0.3306)	(0.2087)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y	Y

Province fixed effects	Y	Y	Y	Y
Province random effects	N	N	N	N
Year effects	Y	Y	Y	Y
IVs for policy variables	Y	Y	Y	Y
IVs for energy prices	Y	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)				
chi2	3,102.29	707.56	102.38	159.51
	[0.0000]*	[0.0000]*	[0.0000]*	[0.0000]*
p-value (Pr>chi2)	***	***	***	***
Observations	161	161	161	161
R-squared	0.9834	0.9552	0.889	0.9593

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.6. Results for industrial output value of traditional energy industries

	Dependent variable is log industry output value of:		
	Coal mining, smelting, and dressing industry	*Petroleum and nuclear fuel processing industry*	*Oil and gas exploration industry*
	(5)	(6)	(7)
Policy Variables			
Command and Control			
Renewable electricity mandate	-0.7	-0.8098*	-0.3628
	(0.3774)	(0.3349)	(0.4484)
Financial Incentives			
Loans for firms for increasing renewable energy consumption	0.2323	0.2732*	-0.4533
	(0.1705)	(0.1267)	(0.3118)
Monetary Awards			
Monetary awards for having reduced pollution	-0.9187	-0.245	-1.399
	(0.5195)	(0.3861)	(0.8037)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	0.8349	0.524	0.9954
	(0.5186)	(0.4782)	(0.7357)
Energy Prices			
Log gasoline price	-0.0327	0.4688	-0.8021
	(0.6243)	(0.6134)	(0.9103)
Log power price	2.2355	-1.8991	0.1371
	(1.9503)	(1.2524)	(2.5416)
Log coal price	-0.469	0.8186	-0.071
	(1.0436)	(0.7487)	(1.6079)
Log petroleum price	-0.8907	-2.6487***	0.6774
	(0.6872)	(0.625)	(1.0624)
Time lagged spatial lag of GDP, output, and	Y	Y	Y

profit			
Province fixed effects	Y	Y	Y
Province random effects	N	N	N
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)			
chi2	N/A	543.22	137.53
p-value (Pr>chi2)	N/A	[0.0000]****	[0.0000]****
Observations	160	161	159
R-squared	0.9234	0.8951	0.5259

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. We are unable to conduct a Hausman test for our IV regression of the industrial output of the coal mining, smelting, and dressing industry, as the model fitted on the data fails to meet the asymptotic assumptions of the Hausman test. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.7a. Results for total profits of firms in new energy sector

	Dependent variable is log total profits of firms in:		
	New energy sector	*Combustible ice industry in new energy sector*	*Low carbon industry in new energy sector*
	(8)	(9)	(10)
Policy Variables			
Command and Control			
Renewable electricity mandate	2.0072	-0.9332	3.2403
	(1.134)	(2.4975)	(1.7193)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.6057	0.3564	-1.0840
	(0.7067)	(1.4744)	(1.326)
Monetary Awards			
Monetary awards for having reduced pollution	3.3587*	5.2411**	1.7309
	(1.4558)	(1.6251)	(1.7796)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-3.2496*	-2.4324*	-4.6880*
	(1.4541)	(1.1434)	(1.8311)
Energy Prices			
Log gasoline price	1.4721	-4.0243	2.2063
	(1.398)	(5.3296)	(2.831)
Log power price	-0.1359	4.7141	2.0636
	(4.4001)	(11.4612)	(6.2423)
Log coal price	-4.5934**	13.0159	-7.0391
	(1.7502)	(10.8656)	(3.7349)
Log petroleum price	-2.0164	4.3465	1.6444
	(1.6066)	(5.1297)	(2.2132)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y
Province fixed effects	Y	N	N

Province random effects	N	Y	Y
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)			
chi2	125.81	14.00	0.00
p-value (Pr>chi2)	[0.0000]****	[0.8697]	[1.0000]
Observations	148	72	148
R-squared	0.569	0.9075	0.0198

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.7b. Results for total profits of firms in new energy sector

	Dependent variable is log total profit of firms in:		
	Nuclear power industry in new energy sector	*Shale gas industry in new energy sector*	*Solar energy industry in new energy sector*
	(11)	(12)	(13)
Policy Variables			
Command and Control			
Renewable electricity mandate	-1.446	-0.5038	-0.9963
	(0.8425)	(0.6978)	(2.2487)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.1603	-0.2581	1.9746
	(0.9193)	(0.6787)	(569.4897)
Monetary Awards			
Monetary awards for having reduced pollution	0.1048	0.8952	-1.4965
	(0.6944)	(0.5094)	(1.7039)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	0.9203	-1.0705*	0.3223
	(0.6878)	(0.4917)	(2.3176)
Energy Prices			
Log gasoline price	11.276	-1.6105	-2.0886
	(11.6543)	(4.3862)	(2.7689)
Log power price	10.3726	2.6588	2.535
	(6.9872)	(4.0933)	(6.1946)
Log coal price	-0.7865	1.2537	3.1196
	(2.2015)	(1.1884)	(4.8198)
Log petroleum price	0.0712	1.1945	-2.5979
	(1.7232)	(0.9024)	(2.498)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y
Province fixed effects	N	N	N

Province random effects	Y	Y	Y
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)			
chi2	37.28	23.80	0.00
p-value (Pr>chi2)	[0.0543]	[0.4151]	[1.0000]
Observations	118	99	118
R-squared	0.4660	0.7386	0.0316

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

APPENDIX 2.A.

Supplementary Tables Describing Data

Table 2.A1. Definition of Profit According to China's Accounting Rules

Operating Profit	
	Gross Revenue
less	Operating Cost
less	Business Tax and Surcharges
less	Marketing Cost
less	Management Cost
less	Financing Cost
adjust	Change in Fair Value
adjust	Investment Income
Total Profit	
	Operating Profit
plus	Non-Business Profit
less	Non-Business Cost
Net Profit	
	Total Profit
less	Income Tax Expenditure

Note: Table illustrates how total profit and net profit are calculated under the accounting standards in mainland China.

Table 2.A2. Within and between variation of GDP, output, and profit variables

		Mean	Std. Dev.	Min	Max	Obs.
Total GDP	overall	9326.25	8758.71	340.65	50143.63	360
	between		7324.85	795.98	30376.25	30
	within		4970.46	-7547.59	30088.05	12
GDP of primary sector	overall	923.41	725.21	44.90	3788.68	360
	between		641.96	81.97	2433.58	30
	within		355.58	-120.18	2278.50	12
GDP of secondary sector	overall	4373.80	4405.57	125.33	23619.15	360
	between		3686.72	335.76	14235.53	30
	within		2496.72	-3926.09	14113.49	12
GDP of tertiary sector	overall	3486.83	3661.25	125.28	23829.02	360
	between		2853.19	260.90	12153.26	30
	within		2348.08	-3865.12	15162.59	12
Industrial output value of coal mining, smelting, and dressing industry	overall	472.73	876.27	0.04	6805.46	332
	between		601.80	0.04	2725.72	30
	within		635.64	-1975.59	4552.47	11.0667
Industrial output values of petroleum processing and nuclear industry combined	overall	659.40	877.42	0.06	6847.55	360
	between		660.95	13.32	2810.74	30
	within		588.55	-1708.26	4696.20	12
Industrial output value of oil and gas exploration industry	overall	341.52	444.16	0.07	2174.51	264
	between		384.22	0.13	1413.23	24
	within		226.42	-338.01	1344.73	11
Total profits of firms in new energy sector	overall	31.52	56.37	-49.63	500.48	360

	between		46.36	-3.00	232.36	30
	within		33.07	-133.18	299.65	12
Total profits of firms in combustible ice industry in new energy sector	overall	1.84	9.14	-14.36	108.71	360
	between		7.24	0.00	39.27	30
	within		5.72	-35.90	71.28	12
Total profits of firms in low carbon industry in new energy sector	overall	18.36	43.47	-58.23	369.86	360
	between		37.64	-3.14	189.74	30
	within		22.73	-113.42	198.48	12
Total profits of firms in nuclear power industry in new energy sector	overall	7.89	19.85	-58.23	152.22	360
	between		15.01	-3.14	59.44	30
	within		13.26	-47.20	107.30	12
Total profits of firms in shale gas industry in new energy sector	overall	3.08	9.74	-12.31	92.76	360
	between		7.36	-1.35	39.14	30
	within		6.51	-36.06	56.70	12
Total profits of firms in solar energy industry in new energy sector	overall	5.23	12.17	-49.63	69.45	360
	between		8.81	-3.00	30.86	30
	within		8.54	-41.40	46.16	12

Note: Table presents the within and between variation for the GDP, industrial output value, and new energy sector profit variables. "Within" variation is the variation in the GDP/output/profit variable across years for a given province. "Between" variation is the variation in the GDP/output/profit variable across provinces for a given year.

Table 2.A3. Number of firms in new energy sector by province, 2002-2013

Province	New Energy Sector (All Industries)	Combustible Ice Industry	Low Carbon Industry	Nuclear Power Industry	Shale Gas Industry	Solar Energy Industry
Anhui	3-6	0-1	2	0-1	0	1-2
Beijing	8-21	1-4	6-8	1-5	0-4	1-5
Chongqing	4-6	0	1-2	1-2	2	2
Fujian	3-7	0	1	2	0-1	0-3
Gansu	3-7	0-1	1-2	2-4	0-2	0
Guangdong	14-35	0	6-9	0-5	0	10-24
Guangxi	2	0	2	0	0	0
Guizhou	2	0	1	0	1	0
Hainan	0	0	0	0	0	0
Hebei	4	0	1	1	0	4
Heilongjiang	3-5	0	1	2-4	0	1
Henan	3-10	0	1-2	0	1-2	1-6
Hubei	6	1	1	1	2	3
Hunan	4-6	0	2	1	2	0-2
Inner Mongolia	4	0	2	1	0	1
Jiangsu	9-34	0-1	4-6	2-7	1-4	3-19
Jiangxi	3-4	0	1	2	0	0-1
Jilin	3	0	1	0	2	0
Liaoning	3-6	0	1-2	1	1	0-2
Ningxia	3	0	1	0	0	3
Qinghai	0-1	0-1	0	0	0	0
Shaanxi	2-8	0	1-2	0-3	0-1	1-2
Shandong	8-16	1-2	5-7	0-2	0-3	3-6
Shanghai	9-15	0-1	5-6	3-6	0-1	3-5
Shanxi	8	0	5	1	2	0
Sichuan	8-11	1	4	2-4	1	3-4
Tianjin	2-5	1-3	1	0	0	0-1
Xinjiang	5-7	0-1	3-4	1	2	3
Yunnan	2	0	2	0	0	0
Zhejiang	17-35	0	6-7	3-11	3-4	6-16

Notes: This table lists the number of firms that claim they are operating in a specific province in their annual financial report in any year over the period 2002-2013. If the number of firms in the new energy sector never changes for that province over 2002-2013, then only one number is reported, which is the number of firms in the new energy sector in that province each year over 2002-2013. If the number of firms in the new energy sector changes for that province over 2002-2013, then the table presents the range between the number of firms in the new energy sector in the year that had the lowest number of firms in the new energy sector, and the number of firms in the new energy sector in the year that had the highest number of firms in the new energy sector for that province over 2002-2013.

Table 2.A4. Summary statistics for province-level energy prices, 2002-2013

	Obs	Mean	Std. Dev.	Min	Max
Gasoline price (yuan) (2002 constant price)	295	5594.86	1312.19	2412.20	8023.27
Power price index (2002 constant price)	360	112.43	7.49	100.00	120.15
Coal price index (2002 constant price)	360	170.42	47.34	100.00	221.44
Petroleum price index (2002 constant price)	360	170.39	44.07	100.00	215.43

Note: The data consists of annual province-level data over the period 2002 to 2013.

Table 2.A5. Command and control policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Command and control			
	Ambient air quality standard	Ambient water quality standard	Emissions standard for water pollution	Fuel mandate
Anhui	1	1	1	1
Beijing	1	1	1	
Chongqing	1	1		
Fujian	1	1	1	1
Gansu	0	0	1	1
Guangdong	1	1	1	1
Guangxi	1	1	1	1
Guizhou	0	0	1	1
Hainan	1	1	1	1
Hebei	1	1	1	0
Heilongjiang		0	0	0
Henan	1	1	1	1
Hubei	1	1	1	1
Hunan	1	1	1	1
Inner Mongolia	0	0	0	0
Jiangsu	1	1	1	1
Jiangxi	1	1	1	0
Jilin	0	0	1	0
Liaoning	1	1	1	0
Ningxia	0	0	0	1
Qinghai	0	0	0	1
Shaanxi	0	0	1	1
Shandong	1	1	1	1
Shanghai	1	1	1	1
Shanxi				0
Sichuan	1	1	1	1
Tianjin	1	1	1	1
Xinjiang	0	0	1	1

Yunnan	0	0	0	1
Zhejiang	1	1	1	1

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 2.A6. Tax variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Taxes	
	Favorable tax treatment for reducing pollution	Tax on water pollution emissions
Anhui	0	0
Beijing	0	0
Chongqing	0	0
Fujian	0	0
Gansu	0	1
Guangdong	1	1
Guangxi	1	0
Guizhou	0	1
Hainan	1	0
Hebei	0	0
Heilongjiang	0	0
Henan	1	1
Hubei	1	0
Hunan	0	0
Inner Mongolia	0	0
Jiangsu	0	0
Jiangxi	1	0
Jilin	0	0
Liaoning	1	0
Ningxia	0	1
Qinghai	0	1
Shaanxi	0	1
Shandong	1	1
Shanghai	1	0
Shanxi	0	0
Sichuan	1	0
Tianjin	1	
Xinjiang	0	1
Yunnan		1
Zhejiang	1	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with "1"; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with "0"; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 2.A7. Funding or subsidies policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Funding or subsidies		
	Funding or subsidies for research and development to reduce pollution	Funding or subsidies for reducing pollution	Funding or subsidies for energy conservation
Anhui	1	1	1
Beijing	1	1	1
Chongqing	1	0	1
Fujian	1	1	1
Gansu	1	0	0
Guangdong	1	1	1
Guangxi	1	1	1
Guizhou	1	1	0
Hainan	1	1	1
Hebei	1		0
Heilongjiang	1	0	0
Henan	1	1	1
Hubei	1	0	0
Hunan	1	0	0
Inner Mongolia	0	0	0
Jiangsu	1	1	1
Jiangxi	1	0	0
Jilin	1	0	0
Liaoning	1	0	0
Ningxia	1	0	0
Qinghai	1	0	0
Shaanxi	1	0	0
Shandong	1	1	1
Shanghai	1		
Shanxi	1	0	
Sichuan	1		1
Tianjin	1	1	1
Xinjiang	1	0	0
Yunnan	1	0	0

Zhejiang	1	0	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 2.A8. Loans to households policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Loans to households	
	Loans to households for increasing energy efficiency	Loans to households for increasing renewable energy consumption
Anhui	0	0
Beijing		0
Chongqing	0	0
Fujian	0	0
Gansu	1	0
Guangdong	1	1
Guangxi	1	1
Guizhou	1	0
Hainan		
Hebei	0	0
Heilongjiang	0	0
Henan	1	1
Hubei	0	0
Hunan	0	1
Inner Mongolia	0	0
Jiangsu	0	0
Jiangxi	0	0
Jilin	0	0
Liaoning	0	1
Ningxia	0	0
Qinghai	0	0
Shaanxi	0	0
Shandong	1	1
Shanghai	0	0
Shanxi	0	0
Sichuan	0	1
Tianjin	0	0
Xinjiang	0	0
Yunnan	1	0

Zhejiang	0	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 2.A9. Monetary awards policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Monetary awards		
	Monetary awards for having increased energy efficiency	Monetary awards for having developed technology to reduce pollution	Monetary awards for having developed technology to reduce fossil fuel consumption
Anhui	0	0	0
Beijing	0	0	0
Chongqing	0	1	0
Fujian	1	0	
Gansu	0	0	0
Guangdong	1	1	1
Guangxi		0	0
Guizhou	0	0	0
Hainan		0	0
Hebei	0	0	0
Heilongjiang	0	0	0
Henan	1	0	0
Hubei	0	0	0
Hunan	1	0	0
Inner Mongolia	0	0	0
Jiangsu	0	0	0
Jiangxi	0		0
Jilin	0	0	0
Liaoning	0	0	0
Ningxia	0	0	0
Qinghai	0	0	0
Shaanxi	0	0	0
Shandong	1	1	1
Shanghai	1	1	0
Shanxi	1	0	0
Sichuan	1	1	1
Tianjin	1		
Xinjiang	0	0	0

Yunnan	0	0	0
Zhejiang	1	1	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with "1"; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with "0"; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

APPENDIX 2.B.

First-Stage Regressions

Table 2.B1. First-stage regressions for command and control policy variable

	Dependent variable is: Renewable electricity mandate
Instruments	
Time lagged spatial lag of:	
Command and Control	
Renewable electricity mandate	-0.5253**
	(0.1636)
Financial Incentives	
Loans to firms for increasing renewable energy consumption	0.0638
	(0.0694)
Monetary Awards	
Monetary awards for having reduced pollution	-0.0310
	(0.0645)
Non-Monetary Awards	
Non-monetary awards for having reduced pollution	-0.2499
	(0.1984)
Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	161

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Economic variables include energy prices and the time lagged spatial lag of GDP, output, and profit. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 2.B2. First-stage regressions for financial incentive policy variable

	Dependent variable is: Loans to firms for increasing renewable energy consumption
Instruments	
Time lagged spatial lag of:	
Command and Control	
Renewable electricity mandate	0.0145
	(0.0444)
Financial Incentives	
Loans to firms for increasing renewable energy consumption	-0.8352***
	(0.1169)
Monetary Awards	
Monetary awards for having reduced pollution	-0.0117
	(0.0318)
Non-Monetary Awards	
Non-monetary awards for having reduced pollution	0.0124
	(0.0430)
Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	161

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Economic variables include energy prices and the time lagged spatial lag of GDP, output, and profit. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 2.B3. First-stage regressions for monetary awards policy variable

	Dependent variable is: Monetary awards for having reduced pollution
Instruments	
Time lagged spatial lag of:	
Command and Control	
Renewable electricity mandate	0.1162
	(0.0704)
Financial Incentives	
Loans to firms for increasing renewable energy consumption	-0.0277
	(0.0310)
Monetary Awards	
Monetary awards for having reduced pollution	-0.4537*
	(0.1762)
Non-Monetary awards	
Non-Monetary awards for having reduced pollution	-0.1958
	(0.1112)
Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	161

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Economic variables include energy prices and the time lagged spatial lag of GDP, output, and profit. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 2.B4. First-stage regressions for non-monetary awards policy variable

	Dependent variable is: Non-monetary awards for having reduced pollution
Instruments	
Time lagged spatial lag of:	
Command and Control	
Renewable electricity mandate	0.0169
	(0.0477)
Financial Incentives	
Loans to firms for increasing renewable energy consumption	0.0304
	(0.0500)
Monetary Awards	
Monetary awards for having reduced pollution	-0.1288
	(0.0892)
Non-Monetary Awards	
Non-monetary awards for having reduced pollution	-0.7080***
	(0.1606)
Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	161

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Economic variables include energy prices and the time lagged spatial lag of GDP, output, and profit. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

APPENDIX 2.C.

Robustness Checks

Table 2.C.1a. Robustness 1: Results for total profits of firms in new energy sector using fixed effects

	Dependent variable is log total profits of firms in:		
	New energy sector	*Combustible ice industry in new energy sector*	*Low carbon industry in new energy sector*
	(8)	(9')	(10')
Policy Variables			
Command and Control			
Renewable electricity mandate	2.0072	-3.2473	3.2404
	(1.134)	(2.7609)	(1.8289)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.6057	1.9969	-1.084
	(0.7067)	(2.6008)	(1.0535)
Monetary Awards			
Monetary awards for having reduced pollution	3.3587*	(omitted)	1.731
	(1.4558)	N/A	(1.7463)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-3.2496*	(omitted)	-4.6882*
	(1.4541)	N/A	(1.9593)
Energy Prices			
Log gasoline price	1.4721	-0.4869	2.2064
	(1.398)	(2.8904)	(1.9568)
Log power price	-0.1359	6.6353	2.0635
	(4.4001)	(15.3581)	(5.2265)
Log coal price	-4.5934**	4.9948	-7.0393
	(1.7502)	(6.6342)	(3.1028)
Log petroleum price	-2.0164	8.1808*	1.6444

	(1.6066)	(3.5552)	(1.9074)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y
Province fixed effects	Y	Y	Y
Province random effects	N	N	N
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)			
chi2	125.81	14.00	0.00
p-value (Pr>chi2)	[0.0000]****	[0.8697]	[1.0000]
Observations	148	71	147
R-squared	0.569	0.8449	0.1938

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Since the random effects estimator is biased and inconsistent for total profits in the new energy sector, the IV fixed effects regression results for the total profits in the new energy sector are also reported in Table 2.7a in the chapter. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C.1b. Robustness 1: Results for total profits of firms in new energy sector using fixed effects

	Dependent variable is log total profit of firms in:		
	Nuclear power industry in new energy sector	*Shale gas industry in new energy sector*	*Solar energy industry in new energy sector*
	(11')	(12')	(13')
Policy Variables			
Command and Control			
Renewable electricity mandate	4.0512	-3.4396	-0.9934
	(4.012)	(6.2454)	(1.5008)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.9611	0.8907	(omitted)
	(1.6107)	(3.2558)	N/A
Monetary Awards			
Monetary awards for having reduced pollution	4.8359	-3.9309	-1.4934
	(2.5657)	(13.5796)	(1.2508)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-5.7345	-1.8688	0.3177
	(4.7526)	(6.2373)	(1.7182)
Energy Prices			
Log gasoline price	3.0822	-3.6427	-2.0857
	(3.0175)	(10.7771)	(2.6328)
Log power price	10.7439	-5.8059	2.5339
	(10.4821)	(8.1733)	(4.7103)
Log coal price	-12.9145	4.7774	3.1134
	(8.3126)	(7.0403)	(3.0001)
Log petroleum price	-4.8635	5.6475	-2.5974
	(4.4496)	(13.5553)	(2.3655)
Time lagged spatial lag of GDP, output,	Y	Y	Y

and profit			
Province fixed effects	Y	Y	Y
Province random effects	N	N	N
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Hausman test (H0: random effects and regressors are uncorrelated)			
chi2	37.28	23.80	0.00
p-value (Pr>chi2)	[0.0543]	[0.4151]	[1.0000]
Observations	116	99	117
R-squared	0.4944	0.4916	0.6384

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C2a. Robustness 2: Results for net profits of firms in new energy sector

	Dependent variable is log net profit of firms in:		
	New energy sector	*Combustible ice industry in new energy sector*	*Low carbon industry in new energy sector*
	(14)	(15)	(16)
Policy Variables			
Command and Control			
Renewable electricity mandate	1.392	-5.1367*	3.363
	(1.5067)	(2.3389)	(1.7773)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.7042	3.7127	-1.6344
	(0.986)	(2.4284)	(1.1176)
Monetary Awards			
Monetary awards for having reduced pollution	4.072	(omitted)	1.7924
	(1.8102)	N/A	(1.7167)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-2.7581	(omitted)	-4.3157*
	(1.6863)	N/A	(1.9221)
Energy Prices			
Log gasoline price	2.1333	-0.7678	2.0997
	(1.9364)	(3.5657)	(1.8401)
Log power price	-0.1508	12.5634	4.1044
	(5.3971)	(16.526)	(5.1903)
Log coal price	-4.1368	8.0238	-6.4598*
	(2.0887)	(6.6201)	(3.0076)
Log petroleum price	-2.6117	10.1844**	1.2514
	(2.1432)	(3.2131)	(1.8677)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y

Province fixed effects	Y	Y	Y
Province random effects	N	N	N
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Observations	148	70	147
R-squared	0.529	0.8201	0.2183

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C.2b. Robustness 2: Results for net profits of firms in new energy sector

	Dependent variable is log net profit of firms in:		
	Nuclear power industry in new energy sector	*Shale gas industry in new energy sector*	*Solar energy industry in new energy sector*
	(17)	(18)	(19)
<u>Policy Variables</u>			
Command and Control			
Renewable electricity mandate	5.3661	-4.1188	-1.7659
	(4.78)	(6.8791)	(3.0097)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-2.1585	1.2435	(omitted)
	(2.0724)	(3.5948)	N/A
Monetary Awards			
Monetary awards for having reduced pollution	6.5742*	-4.421	-3.2722
	(3.2687)	(15.1079)	(2.6839)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-6.7331	-2.0953	1.8297
	(5.4717)	(6.9468)	(3.3045)
<u>Energy Prices</u>			
Log gasoline price	5.1142	-4.0701	-7.283
	(3.9823)	(11.9096)	(5.5072)
Log power price	8.7013	-6.4942	4.3774
	(12.0645)	(9.0866)	(7.6351)
Log coal price	-12.9776	5.721	3.6072
	(9.4223)	(7.7611)	(5.3809)
Log petroleum price	-6.5231	6.9395	-1.6791
	(5.3317)	(15.0787)	(3.6805)
Time lagged spatial lag of GDP, output, and profit	Y	Y	Y

Province fixed effects	Y	Y	Y
Province random effects	N	N	N
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	Y	Y	Y
Observations	115	99	116
R-squared	0.3681	0.4027	0.2032

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. For each energy price, we instrument for that energy price using the time lag of that energy price. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C.3. Robustness 3: Results for total GDP and GDP of the primary, secondary, and tertiary sectors

	Dependent variable is:			
	Log GDP	*Log GDP of the primary sector*	*Log GDP of the secondary sector*	*Log GDP of the tertiary sector*
	(1")	(2")	(3")	(4")
Policy Variables				
Command and Control				
Renewable electricity mandate	-0.1437*	0.088	-0.5167*	-0.1515
	(0.0731)	(0.0894)	(0.2016)	(0.0918)
Financial Incentives				
Loans to firms for increasing renewable energy consumption	-0.0003	-0.1049**	0.0318	0.0111
	(0.045)	(0.0401)	(0.0964)	(0.0727)
Monetary Awards				
Monetary awards for having reduced pollution	-0.1348	0.1738	-0.2772	-0.2269
	(0.0893)	(0.1186)	(0.2392)	(0.1265)
Non-Monetary Awards				
Non-monetary awards for having reduced pollution	0.1094	-0.2008	0.405	0.2616*
	(0.09)	(0.1079)	(0.2677)	(0.1212)
Energy Prices				
Log gasoline price	0.0493	-0.1375*	-0.0105	-0.1077
	(0.0579)	(0.0638)	(0.1173)	(0.0675)
Log power price	0.1581	-0.1621	-0.1661	-0.2077
	(0.2031)	(0.3139)	(0.5012)	(0.3515)
Log coal price	0.2341**	-0.1853	0.6995**	0.1038
	(0.089)	(0.1461)	(0.2454)	(0.1349)
Log petroleum price	0.0369	-0.0874	-0.1645	-0.1615
	(0.0906)	(0.1045)	(0.2127)	(0.1509)
Time lagged spatial lag of GDP, output,	Y	Y	Y	Y

and profit				
Province fixed effects	Y	Y	Y	Y
Year effects	Y	Y	Y	Y
IVs for policy variables	Y	Y	Y	Y
IVs for energy prices	N	N	N	N
Observations	176	176	176	176
R-squared	0.9892	0.9581	0.9209	0.9588

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C4. Robustness 3: Results for industrial output value of traditional energy industries

	Dependent variable is log industry output value of:		
	Coal mining, smelting, and dressing industry	*Petroleum and nuclear fuel processing industry*	*Oil and gas exploration industry*
	(5")	(6")	(7")
Policy Variables			
Command and Control			
Renewable electricity mandate	-0.7986*	-0.6167*	-0.2836
	(0.3927)	(0.2895)	(0.4997)
Financial Incentives			
Loans for firms for increasing renewable energy consumption	0.2987*	0.2154*	-0.4224
	(0.1475)	(0.1068)	(0.238)
Monetary Awards			
Monetary awards for having reduced pollution	-0.8679	-0.2977	-1.2633
	(0.5489)	(0.3446)	(0.7133)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	0.7897	0.2851	0.7262
	(0.5302)	(0.379)	(0.6765)
Energy Prices			
Log gasoline price	0.4422	-0.0561	0.4343
	(0.3313)	(0.1815)	(0.3692)
Log power price	1.1819	-1.6932*	-0.1155
	(1.2732)	(0.8463)	(1.9737)
Log coal price	0.2765	0.3983	0.7189
	(0.5313)	(0.4123)	(0.8164)
Log petroleum price	-0.8203	-1.6092***	1.1886
	(0.6484)	(0.4577)	(0.7445)
Time lagged spatial lag of GDP, output,	Y	Y	Y

and profit			
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	N	N	N
Observations	175	176	174
R-squared	0.9284	0.9116	0.5548

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C.5a. Robustness 3: Results for total profits of firms in new energy sector

	Dependent variable is log total profits of firms in:		
	New energy sector	*Combustible ice industry in new energy sector*	*Low carbon industry in new energy sector*
	(8”)	(9”)	(10”)
Policy Variables			
Command and Control			
Renewable electricity mandate	1.8567	-1.5589	2.2159
	(0.9496)	(1.7019)	(1.2416)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	-0.6244	1.8282	-1.1602
	(0.6566)	(2.1055)	(1.0231)
Monetary Awards			
Monetary awards for having reduced pollution	2.7162*	(omitted)	0.4466
	(1.3615)	N/A	(1.3058)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-2.7734*	(omitted)	-2.9966*
	(1.2271)	N/A	(1.1642)
Economic Variables			
Log gasoline price	0.5523	0.8027	0.1094
	(0.5027)	(0.9128)	(0.5652)
Log power price	1.1267	3.6378	-2.9685
	(2.6392)	(4.9696)	(3.2818)
Log coal price	-4.1825***	3.195	-3.4089*
	(1.1064)	(2.8909)	(1.4905)
Log petroleum price	-1.5632	4.2108	2.1393
	(1.3344)	(2.7742)	(1.6482)
Time lagged spatial lag of GDP, output,	Y	Y	Y

and profit			
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	N	N	N
Observations	163	76	159
R-squared	0.5870	0.8098	0.3739

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. Significance codes: *5% level, **1% level, and ***0.1% level.

Table 2.C.5b. Robustness 3: Results for total profits of firms in new energy sector

	Dependent variable is log total profits of firms in:		
	Nuclear power industry in new energy sector	*Shale gas industry in new energy sector*	*Solar energy industry in new energy sector*
	(11")	(12")	(13")
Policy Variables			
Command and Control			
Renewable electricity mandate	0.427	-3.8115	0.8718
	(2.2103)	(4.2795)	(0.897)
Financial Incentives			
Loans to firms for increasing renewable energy consumption	1.0214	1.8562	(omitted)
	(1.384)	(2.7948)	N/A
Monetary Awards			
Monetary awards for having reduced pollution	2.0922	-4.8713	-0.7462
	(1.6223)	(8.5302)	(0.9675)
Non-Monetary Awards			
Non-monetary awards for having reduced pollution	-1.7407	-3.5544	-1.5447
	(2.5583)	(3.6167)	(0.964)
Economic Variables			
Log gasoline price	-1.0635	-1.053	-0.5027
	(0.6277)	(1.5611)	(0.7521)
Log power price	11.6875**	-0.2244	1.9304
	(3.713)	(5.7324)	(2.5337)
Log coal price	-3.3752	3.4883	-0.5248
	(2.5362)	(5.1009)	(0.9842)
Log petroleum price	-0.1428	6.1039	-2.481
	(2.4907)	(8.9816)	(1.428)
Time lagged spatial lag of GDP, output,	Y	Y	Y

and profit			
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
IVs for policy variables	Y	Y	Y
IVs for energy prices	N	N	N
Observations	126	105	126
R-squared	0.7460	0.2259	0.7324

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. We define the time lagged spatial lag of the dependent variable in province *i* as the sum of the values of the dependent variable of all the other provinces except province *i* at time *t-1*. Significance codes: *5% level, **1% level, and ***0.1% level.

CHAPTER 3.

THE EFFECTS OF ENERGY-RELATED POLICIES ON ENERGY CONSUMPTION IN CHINA[16]

3.1. Introduction

Energy-related issues are pervasive throughout the world. In many developing countries such as China, energy consumption has been increasing rapidly, resulting in energy-related problems such as power shortages and environmental pollution. These problems have severely threatened the sustainable development of these countries and have caused great concern at all levels of society, from the general public to national governments to international agencies.

Due to the severity of energy-related problems, the governments of many developing countries have begun to introduce energy policies and regulations to combat these problems. The intention with most energy-related policies is to influence processes in such a way that leads to more efficient or more careful use of resources and to more environmentally sustainable behavior. In this chapter, we examine the effects of different types of energy-related policies on different types of energy consumption in China.

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[16] The research in this chapter has been published in the following publication: Si, Shuyang, Mingjie Lyu, C.-Y. Cynthia Lin Lawell, and Song Chen. (2018). The effects of energy-related policies on energy consumption in China. Energy Economics, 76, 202-227

There is a large previous literature on the effects of different types of energy policies, particularly in the context of the United States (see e.g., Auffhammer et al., 2016; Barker, Ekins and Foxon, 2007; Beaudoin et al., 2021; Fell and Linn, 2013; Gillingham, Newell and Palmer, 2006; Lade, Lin Lawell and Smith, 2018; Parry et al., 2014; Popp, 2002; Reguant, 2019; Scott et al., 2008; Weyant and Olavson, 1999; Williams, 2017). Blackman, Li and Liu (2018) review emerging experimental and quasi-experimental evidence on the efficacy of command-and-control and market-based environmental policies in developing countries.

There is also a growing strand of literature on the rebound effect, which may cause energy policies to be ineffective in reducing energy consumption. A "rebound" effect arises when some of the gains from improving the efficiency of energy use is lost because of behavioral responses. For example, a decrease in energy consumption due to efficiency improvement also leads to a reduction in the real cost of energy services per unit, and thus brings about an increase in the demand for energy services. Therefore, the potential energy savings and emissions reduction from efficiency improvement might be offset by responses to the cost reduction (Gillingham et al., 2013; Lin, Yang and Liu, 2013; Zhang and Lin Lawell, 2017). Similarly, an increase in energy efficiency can spur economic growth, either through a reallocation of growth through sectoral reallocation or overall growth through an increase in total factor productivity, and the economic growth requires additional energy consumption (Gillingham, Rapson and Wagner, 2016; Zhang and Lin Lawell, 2017).

While there are many studies on different types of energy policies, there are fewer empirical papers on the relationship between China's energy policies and their consequences, and some of these papers are written in Chinese. In its 1999 World Energy Outlook, the International Energy Agency (IEA, 1999) quantifies the size of China's fossil fuel and electricity subsidies, and assesses the potential impact that a removal of the subsidy would have on energy consumption. Lin, Jiang and Lin (2009) argue that China's subsidy mechanism was both inefficient and unfair, and suggest that it would have been essential to adopt a more targeted subsidy policy. Lin and Jiang (2011) analyze China's energy subsidies and use a computable general equilibrium (CGE) model to analyze the economic impacts of energy subsidy reforms. Liu and Li (2011) analyze the fossil energy subsidies of China and use a CGE model to simulate the effects of fossil energy subsidy reform under different scenarios. Jiang and Lin (2014) examine China's fossil fuel subsidies and use a CGE model to analyze the effects of removing them. Ouyang and Lin (2014) evaluate the impacts of increasing renewable energy subsidies and phasing out fossil fuel subsidies on the macro-economy and energy system in China. Li and Lin (2015) analyze the effects of China's fossil fuel subsidies on energy rebound effects. Lin and Zeng (2014) calculate the optimal gasoline tax for

China. Si, Chalfant, Lin Lawell, and Yi (2021) analyze the effects of China's biofuel policies on agricultural and ethanol markets. Liu and Lin (2018) analyze the natural gas subsidy in China.

There is also a literature on energy consumption in China. Fisher-Vanden et al. (2016) find that energy costs are a significant contributor to the decline in energy intensity in four Chinese industries: pulp and paper, cement, iron and steel, and aluminum. Lin and Zeng (2013) estimate the elasticity of demand for gasoline in China. Cao, Ho and Liang (2016) estimate the income and price elasticities of household energy demand for various energy types using Chinese urban household micro-data collected by the National Bureau of Statistics.

This chapter builds upon the existing literature by examining the effects of multiple different energy-related policies in China on energy consumption using province-level data over the period 2002 to 2013. In particular, we collect and construct a novel and comprehensive data set on energy-related policies at the provincial level in China from the 2656 energy-related province-level laws and regulations that are in place for at least one year over the years 2002 to 2013. We construct detailed policy variables for specific types of command and control policies; financial incentives; awards; intellectual property rights; and education and information policies. We analyze the marginal effects of each specific type of energy-related policy on energy consumption, including various forms of fossil fuel consumption and various forms of biomass energy consumption, while controlling for all other specific types of energy-related policy. Our econometric method employs instruments to address the potential endogeneity of the policies.

According to our results, some types of policies have been effective in reducing energy consumption, including loans to firms for reducing pollution; funding or subsidies for research and development to increase energy efficiency; funding or subsidies for reducing fossil fuel consumption; non-monetary awards for having developed technology to reduce fossil fuel consumption; and providing education and information for energy conservation.

However, many other policies have the possibly unintended or even perverse consequence of increasing rather than decreasing energy consumption. These include loans to either firms or households for reducing fossil fuel consumption; monetary awards for having reduced fossil fuel consumption; emissions standards for air pollution; and intellectual property rights for research and development to increase energy efficiency. Providing education and information for increasing energy efficiency has the perverse effect of leading to a significant increase in electricity consumption per capita and in stalks consumption per capita, possibly due to a rebound effect resulting from the adoption of energy efficiency practices and technologies mentioned in the education and information being provided. Monetary awards for having reduced pollution have different effects on different types of energy consumption.

Our results on the mixed effectiveness of energy-related policies in China in reducing energy consumption have important implications for the design of energy-related policies in China and elsewhere.

The balance of the chapter proceeds as follows. Section 3.2 describes the different types of energy-related policies in China. Section 3.3 describes our data. Section 3.4 presents the empirical model. Section 3.5 presents the results. Section 3.6 concludes.

3.2. Energy-Related Policies in China

For our policy variables, we collect and construct a novel and comprehensive data set on energy-related policies at the provincial level in China by collecting data from online databases of laws and regulations from the websites of each of the provincial governments as well as from Lawtime, a website which collects laws and regulations in China (Lawtime, 2017).

Our policy variables are constructed from the 2656 energy-related province-level laws and regulations that are in place for at least one year over the period 2002 to 2013. These province-level laws and regulations include national laws and regulations implemented in each province, some of which may be differentiated by province. Some of the laws were implemented during the 2002-2013 time period of our data set; others were already in place. Some laws continued even after the end of our 2002-2013 time period; others expired before the end of the time period. Each of the 2656 province-level laws and regulations has multiple clauses, and may include multiple provisions.

For each of the 2656 province-level laws and regulations over the years 2002 to 2013, we categorize their provisions and features into the specific types of command and control policies; financial incentives; awards; intellectual property rights; and education and information policies described below. Because each province-level law and regulation has multiple clauses, provisions, and features each law and regulation may include more than one of the following types of policies.

3.2.1. Command and control

Our first category of energy-related policies are command and control policies. We categorize the 2656 province-level laws and regulations into whether their features or provisions include policies for the following 7 separate types of command and control policies: (1) an ambient air quality standard for a maximum amount of pollution in air; (2) an ambient water quality standard for a maximum amount of pollution in water; (3) an emissions standard for air pollution for a maximum amount of air pollution emissions; (4) an emissions standard for water pollution for maximum amount of water pollution emissions; (5) a technology standard which requires polluters to use certain technologies, practices, or techniques, such as a certain pollution control technology; (6) a fuel mandate which mandates that a certain share of fuel be renewable, or that the carbon intensity of fuels not exceed a certain amount; and (7) a renewable electricity mandate which mandates that a certain share of electricity be renewable, or that the emissions rate from electricity not exceed a certain amount.

3.2.2. Financial incentives

Another category of energy-related policies are financial incentives. We consider several types of financial incentives. The first type of financial incentives are favorable tax treatments, which we further delineate into favorable tax treatments for (a) reducing pollution; (b) increasing energy efficiency; or (c) conserving energy.

A second type of financial incentives are environmental taxes, which we further delineate into environmental taxes for (a) water pollution emissions and (b) fossil fuel consumption.

A third type of financial incentives are funding or subsidies, which we further delineate into funding or subsidies for (a) research and development to reduce pollution; (b) research and development to increase energy efficiency; (c) research and development to reduce fossil fuel consumption; (d) research and development to increase renewable energy consumption; (e) reducing pollution; (f) increasing energy efficiency; (g) reducing fossil fuel consumption; and (h) energy conservation.

A third type of financial incentives are loans the government provides to firms, which we further delineate into loans to firms for (a) reducing pollution; (b) increasing energy efficiency; (c) reducing fossil fuel consumption; (d) increasing renewable energy consumption; and (e) energy conservation.

A fourth type of financial incentives are loans provided by the government to households, which we further categorize into loans to households for (a) increasing energy efficiency; (b) reducing fossil fuel consumption; and (c) increasing renewable energy consumption.

3.2.3. Awards

Another category of energy-related policies are awards that are given after something has been accomplished. We separate awards between monetary awards and non-monetary awards.

For monetary awards, we further distinguish between monetary awards for having (a) reduced pollution; (b) increased energy efficiency; (c) reduced fossil fuel consumption; (d) increased renewable energy consumption; (e) developed technology to reduce pollution; (f) developed technology to increase energy efficiency; (g) developed technology to reduce fossil fuel consumption; (h) developed technology to increase renewable energy consumption; and (i) reduced energy consumption, or saved or conserved energy.

For non-monetary awards, we further distinguish between non-monetary awards for having (a) reduced pollution; (b) increased energy efficiency; (c) reduced fossil fuel consumption; (d) developed technology to reduce pollution; (e) developed technology to reduce fossil fuel consumption; (f) developed technology to increase renewable energy consumption; and (g) reduced energy consumption.

3.2.4. Intellectual property rights

Another category of energy-related policies are intellectual property rights, which we further categorize into intellectual property rights for (a) research and development to reduce pollution; (b) research and development to increase energy efficiency; (c) research and development to reduce fossil fuel consumption; (d) research and development to increase renewable energy consumption; and (e) other research and development.

3.2.5. Education and information

Another category of energy-related policies are policies that provide education and information, which we further categorize into policies that provide education and information for (a) reducing pollution; (b) increasing energy efficiency; (c) increasing renewable energy consumption; (d) energy conservation; and (e) managing energy

3.3. Data

To analyze the effects of energy-related policies in China on energy consumption, we use panel data for 30 provinces from 2002 to 2013. Tibet, Hong Kong, Macau, and Taiwan are excluded from the analysis. Because of missing data prior to 2002, and owing to data limitations for more recent data, we limit the period of study to the period 2002 to 2013.

Data on energy consumption come from the China Energy Statistical Yearbooks. We use data on various forms of fossil fuel energy consumption and various forms of biomass energy consumption. For fossil fuel consumption, we obtain data on the consumption three types of fossil fuels – coal, crude oil, and natural gas – as well as the consumption of four types of fossil fuel distillates – coke, fuel oil, kerosene oil, and diesel oil. We also obtain data on the consumption of gasoline and electricity. For biomass energy consumption, we obtain data on noncommercial energy consumption of biogas, stalks, and firewood in rural areas in China.[17]

Table 3.1 presents the summary statistics for the energy consumption variables in our data set, as well as for total energy consumption per capita, which we define as the sum of all the various forms of energy consumption per capita in our data set. We convert the units for each kind of energy consumption into tons coal equivalent (TCE) using conversion factors reported in the China Energy Statistical Yearbook. Table 3.A.1 in Appendix 3.A presents the within and between variation for the energy consumption variables. "Within" variation is the variation in the energy consumption variable across years for a given province. "Between" variation is the variation in the energy consumption variable across provinces for a given year.

17 Coal, natural gas, oil, electricity, and biomass are the primary sources of energy for heating in China (Benazeraf, 2017).

For our policy variables, we collect and construct a novel data set on energy-related policies at the provincial level in China by collecting data from online databases of laws and regulations from the websites of each of the provincial governments as well as from Lawtime, a website which collects laws and regulations in China (Lawtime, 2017).

Our policy variables are constructed from the 2656 energy-related province-level laws and regulations that are in place for at least one year over the period 2002 to 2013. These province-level laws and regulations include national laws and regulations implemented in each province, some of which may be differentiated by province. Some of the laws were implemented during the 2002-2013 time period of our data set; others were already in place. Some laws continued even after the end of our 2002-2013 time period; others expired before the end of the time period. Each of the 2656 province-level laws and regulations has multiple clauses, and may include multiple provisions.

For each of the 2656 province-level laws and regulations over the years 2002 to 2013, we categorize their provisions and features into the types of policies described in Section 3.2. Because each province-level law and regulation has multiple clauses, provisions, and features each law and regulation may include more than one type of policy.

For each type of policy, we construct a dummy variable for whether there is a policy of that particular type in province i at time t. It is difficult to quantify the policies along other dimensions, as dimensions such as the stringency of the policy or the extent of the policy are either not observable or difficult to quantify objectively in a single measure, particularly one that aggregates across the 2656 province-level laws and regulations. Moreover, as the focus of this chapter is on the marginal effects of different types of energy-related policies when considering and controlling for a full and comprehensive set of all energy-related policies in place, we have opted to use simple measures of each type of policy in favor of being able to include a comprehensive set of many policies. In future work we hope to develop measures to quantify the magnitude and/or stringency of the policies, particularly for the subset of policies we have found in this chapter to have significant effects on energy consumption.

We streamline the set of policies we consider by eliminating those policies that have very little variation in our data set, since for these policies we do not have enough variation to identify their effects. First, we drop all policies that were in place in over 90% of the province-years of our data set, since these essentially province-invariant policies are implemented nearly nation-wide and are therefore absorbed in the year effects. This eliminates the policy variable for funding or subsidies for research and development to reduce pollution, which was in place for 97% of the province-years of our data set.

Second, we drop any policy variable that is constant (i.e., always 0 for all years or always 1 for all years) for 28 or more out of the 30 provinces, since these time-invariant policy variables are absorbed by the province fixed effects. This eliminates a number of policy variables, including the policy variable for funding or subsidies for research and development to reduce pollution also excluded because of the first criterion above.

The policy variables that are eliminated because they are always constant for 28 or more out of the 30 provinces include the policy variables for ambient air quality standards; ambient water quality standards; emissions standards for water pollution; fuel mandates; favorable tax treatment for reducing pollution; taxes on water pollution emissions; funding or subsidies for research and development to reduce pollution; funding or subsidies for reducing pollution; funding or subsidies for energy conservation; loans to households for increasing energy efficiency; loans to households for increasing renewable energy consumption; monetary awards for having increased energy efficiency; monetary awards for having developed technology to reduce pollution; monetary awards for having developed technology to reduce fossil fuel consumption; intellectual property rights for research and development to reduce pollution; intellectual property rights for research and development to reduce fossil fuel consumption; intellectual property rights for research and development to increase renewable energy consumption; and intellectual property rights for other research and development.

Tables 3.A.2-3.A.7 in Appendix 3.A list, for each of the policy variables we dropped, which provinces always had this type of policy and which provinces never had this type of policy over the 2002-2013 period of our data set.

The policy variables we use in our empirical analysis are the policy variables described in Section 3.2 that remain after eliminating those policies that have very little variation in our data set as described above. Table 3.2 lists our policy variables along with the summary statistics.

Since energy consumption may be affected by energy prices and income, the economic variables we control for include energy-related prices and income. In particular, we use annual province-level data on three energy-related price indices that may affect energy consumption: the consumer price index for transportation fuels and parts; the consumer price index for residential water, electricity, and fuels; and the retail price index for fuels. As these price indices are neither highly correlated nor collinear,[18]

18 Though correlated, the price indices we use as economic controls are neither highly correlated nor collinear. The correlation coefficient between the consumer price index for transportation fuels and parts; and the consumer price index for residential water, electricity, and fuels, is 0.4690. The correlation

as each controls for a different economic factor that may affect energy consumption, and as our focus is on identifying the effects of energy-related policies rather than on identifying the effects of individual economic variables, we include all three price indices as economic controls in our regressions. In addition, since energy consumption may be affected by income and/or economic growth, we also control for GDP per capita. All of our economic variables are from the China Statistical Yearbook. Table 3.3 presents the summary statistics for the economic variables in our data set.

3.4. Econometric Model

To analyze the effects of energy-related policies in China on energy consumption, we estimate the following instrumental variables (IV) fixed effects model:

$$ln\, c_{ijt} = policies_{it}^{'}\beta_1 + ln\, economic_{it}^{'}\beta_2 + \alpha_i + \tau_t + \varepsilon_{it},$$

where c_{ijt} is per capita energy consumption for energy type *j* for province *i* in year *t*, $policies_{it}$ is a vector of energy-related policy variables, $economic_{it}$ is a vector of economic variables, α_i is a province fixed effect, τ_t is a year effect, and ε_{it} is an error term.

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coefficient between the consumer price index for residential water, electricity, and fuels; and the retail price index for fuels, is 0.7487. The correlation coefficient between the consumer price index for transportation fuels and parts; and the retail price index for fuels, is 0.8299.

The types j of per capita energy consumption c_{ijt} we analyze include total energy consumption, coal consumption, crude oil consumption, natural gas consumption, gasoline consumption, electricity consumption, coke consumption, fuel oil consumption, kerosene consumption, diesel oil consumption, biogas consumption, stalks consumption, and firewood consumption.

The vector $policies_{it}$ of energy-related policy variables includes specific types of command and control policies; financial incentives; awards; intellectual property rights; and education and information policies.

The command and control policy variables include policy variables for emissions standards for air pollution; technology standards; and renewable electricity mandates.

The financial incentives policy variables include policy variables for specific types of taxes; funding or subsidies; loans to firms; and loans to households. The tax policy variables include policy variables for favorable tax treatment for increasing energy efficiency; favorable tax treatment for conserving energy; and taxes on fossil fuel consumption.

The funding or subsidies policy variables include policy variables for funding or subsidies for research and development to increase energy efficiency; for research and development to reduce fossil fuel consumption; for research and development to increase renewable energy consumption; for increasing energy efficiency; and for reducing fossil fuel consumption.

The loans policy variables include policy variables for loans to firms for reducing pollution; for increasing energy efficiency; for reducing fossil fuel consumption; for increasing renewable energy consumption; and for energy conservation; and loans to households for reducing fossil fuel consumption.

The awards policy variables include policy variables for specific types of monetary and non-monetary awards. The monetary awards policy variables include policy variables for monetary awards for having reduced pollution; for having reduced fossil fuel consumption; for having increased renewable energy consumption; for having developed technology to increase energy efficiency; for having developed technology to increase renewable energy consumption; and for having reduced energy consumption, or having saved or conserved energy.

The non-monetary awards policy variables include policy variables for non-monetary awards for having reduced pollution; for having increased energy efficiency; for having reduced fossil fuel consumption; for having developed technology to reduce pollution; for having developed technology to reduce fossil fuel consumption; for having developed technology to increase renewable energy consumption; and for having reduced energy consumption.

The intellectual property rights policy variable is the policy variable for intellectual property rights for research and development to increase energy efficiency.

The education and information policy variables include policy variables for education and information for reducing pollution; for increasing energy efficiency; for increasing renewable energy consumption; for energy conservation; and for managing energy.

For each type of policy, the policy variable for that policy type for province i in time t is a dummy for whether there is a policy of a particular type in province i at time t. It is difficult to quantify the policies along other dimensions, as dimensions such as the stringency of the policy or the extent of the policy are either not observable or difficult to quantify objectively in a single measure, particularly one that aggregates across the 2656 province-level laws and regulations. Moreover, as the focus of this chapter is on the marginal effects of different types of energy-related policies when considering and controlling for a full and comprehensive set of all energy-related policies in place, we have opted to use simple measures of each type of policy in favor of being able to include a comprehensive set of many policies policies. In future work we hope to develop measures to quantify the magnitude and/or stringency of the policies, particularly for the subset of policies we have found in this chapter to have significant effects on energy consumption.

Since energy consumption may be affected by energy prices and income, the vector of economic variables we control for include energy-related prices and income. In particular, we use annual province-level data on three energy-related price indices that may affect energy consumption: the consumer price index for transportation fuels and parts; the consumer price $economic_{it}$ index for residential water, electricity, and fuels; and the retail price index for fuels. As these price indices are neither highly correlated nor collinear,[19] as each controls for a different economic factor that may affect energy consumption, and as our focus is on identifying the effects of energy-related policies rather than on identifying the effects of individual economic variables, we include all three price indices as economic controls in our regressions. In addition, since energy consumption may be affected by income and/or economic growth, we also control for GDP per capita.[20] Additional economic factors that vary by province or over time, such as aspects of industrial development not fully captured by GDP per capita, or aspects of transportation infrastructure not fully captured by the consumer price index

19 Though correlated, the price indices we use as economic controls are neither highly correlated nor collinear. The correlation coefficient between the consumer price index for transportation fuels and parts; and the consumer price index for residential water, electricity, and fuels, is 0.4690. The correlation coefficient between the consumer price index for residential water, electricity, and fuels; and the retail price index for fuels, is 0.7487. The correlation coefficient between the consumer price index for transportation fuels and parts; and the retail price index for fuels, is 0.8299.

20 Si, Lyu, Lin Lawell, and Song (2021) analyze the effects of energy policies in China on GDP, industrial output, and new energy profits.

for transportation fuels and parts, are captured by the province fixed effects and year effects.

Since we control for GDP per capita in our regressions, the coefficients on our energy-related policy variables measure the marginal effects of the energy-related policies holding GDP per capita constant, and can therefore be interpreted as the marginal effects of the energy-related policies on any energy consumption that is not simply explained by purely by economic growth. Thus, even if the primary objective of energy-related policies were to mitigate increases in energy consumption that result from economic growth, rather than to reduce energy consumption *per se*, the coefficients would still measure how effective the individual policies were in mitigating increases in energy consumption.

In analyzing the effects of government energy-related policies on energy consumption, one may worry that the policies are endogenous (Rehme, 2011). One reason for this endogeneity is that the presence of certain energy-related policies in certain provinces may be correlated with unobserved factors that affect energy consumption. For example, provinces that have industries such as manufacturing that generate a lot of pollution may have more need for energy-related pollution regulation, but these industries may also consume a lot of energy.

To address any potential endogeneity of the policies, we estimate an instrumental variables (IV) fixed effects model. For each policy type, we instrument for the policy variable for that policy type using the time lagged spatial lag of that policy type in province *i*, which we define as the sum of the policy variables of that policy type over all the other provinces except province *i* at time *t-1*. This instrument is therefore the number of other provinces except province *i* that had that policy type at time *t-1*.

We assume that, conditional on our controls -- which include the consumer price index for transportation fuels and parts; the consumer price index for residential water, electricity, and fuels; the retail price index for fuels; GDP per capita; province fixed effects; and year effects -- the time lagged spatial lag of policies in other provinces have no effect on a province's energy consumption except through their effect on the province's current policies. This assumption makes sense since unobservable factors that may be correlated across provinces such as infrastructure, transboundary pollution, and trade are absorbed by the year effects, and also controlled for by the consumer price index for transportation fuels and parts; the consumer price index for residential water, electricity, and fuels; the retail price index for fuels; GDP per capita; and province fixed effects. Thus, conditional on economic variables, province fixed effects, and year effects, policies of other provinces implemented in the previous year should not influence the energy consumption in that province, except through their effect on the province's current policies. The instruments are therefore correlated with policies in province *i* at time *t* and do not affect the energy consumption in province *i* at time *t* except through their effect on the policies in province *i* at time *t*.

Table 3.4 presents the Angrist-Pischke first-stage F-statistics. All the Angrist-Pischke first-stage F-statistics are greater than 8; and 35 out of the 37 Angrist-Pischke first-stage F-statistics are greater than 10. The results from the first-stage regressions for each of the endogenous policy variables are in Tables 3.B.1-3.B.10 in Appendix 3.B. For each endogenous policy variable, there is at least one instrument that has a significant effect on that endogenous policy variable. Thus, the instruments are correlated with the endogenous variables, even when controlling for all the other instruments and for the control variables.

We choose to use fixed effects instead of random effects because we believe that time-invariant province unobservables are potentially correlated with the regressors; our choice was confirmed by results of Hausman tests in preliminary analyses which deemed fixed effects to be the more appropriate specification (results not shown).

3.5. Results

Table 3.C.1 in Appendix 3.C presents the IV fixed effects results for total energy consumption. There are fewer observations for our total energy consumption variable

than for our variables for energy consumption for different types of energy since total energy consumption was calculated from summing the variables for all the different types of energy consumption together, and is therefore missing an observation for a particular province-year whenever at least one of the energy consumption variables for that province-year is missing. Because the regression results for total energy consumption are based on fewer observations, we put less weight on our total energy consumption results.

According to the results for total energy consumption in Table 3.C.1 in Appendix 3.C, funding or subsidies for reducing fossil fuel consumption and non-monetary awards for having developed technology to reduce fossil fuel consumption lead to a significant decrease of 7.003% and 1.740%, respectively, in total energy consumption per capita, suggesting that these policies are effective in reducing energy consumption. However, in contrast, monetary awards for having reduced fossil fuel consumption lead to an increase, rather than a decrease, in total energy consumption per capita, of 4.293%, suggesting that this policy has a possible unintended or perverse consequence of increasing rather than decreasing total energy consumption.

To better tease out the channels through which energy-related policies affect energy consumption, we analyze the effects of energy-related policies on consumption of different types of energy. Table 3.5 presents the IV fixed effects results for the consumption of three types of fossil fuels: coal, crude oil, and natural gas. According to the results, emissions standards for air pollution lead to a significant increase of 8.490% in natural gas consumption per capita. Loans to firms for reducing fossil fuel consumption have the perverse effect of leading to a significant increase of 1.186% in crude oil consumption per capita.

Table 3.6 presents the IV fixed effects results for the consumption of four types of fossil fuel distillates: coke, fuel oil, kerosene oil, and diesel oil. According to the results, loans to firms for reducing pollution have a significant negative effect on coke consumption per capita, decreasing coke consumption per capita by 2.650%. Loans to firms for reducing fossil fuel consumption lead to a significant increase of 2.198% in coke consumption per capita. Loans to households for reducing fossil fuel consumption have the perverse consequence of leading to a significant increase of 8.781% in fuel oil consumption per capita. Monetary awards for having reduced pollution lead to a significant decrease of 2.463% in kerosene oil consumption per capita. Providing education and information for energy conservation leads to a significant decrease of 7.593 % in fuel oil consumption per capita. Higher transportation fuels and parts prices lead to a significant decrease in fuel oil consumption per capita. GDP per capita has a significant positive effect on coke consumption per capita and diesel oil consumption per capita.

Table 3.7 presents the IV fixed effects results for gasoline and electricity consumption. As we have fewer observations for electricity consumption, we put less weight on our electricity consumption regression results. According to the results, funding or subsidies for research and development to increase energy efficiency lead to a significant decrease of 5.005% in electricity consumption per capita. Loans to firms for reducing fossil fuel consumption have the perverse effect of leading to a significant increase of 0.475% in electricity consumption per capita. Monetary awards for having reduced pollution also lead to a significant increase of 0.384% in electricity consumption per capita. Providing education and information for increasing energy efficiency has the perverse effect of leading to a significant increase of 0.566% in electricity consumption per capita, possibly due to a rebound effect. GDP per capita has a significant positive effect on gasoline consumption per capita.

Table 3.8 presents the IV fixed effects results for the consumption of three types of biomass energy consumption: biogas, stalks, and firewood. As we have fewer observations for biomass energy consumption, we put less weight on these regression results. According to the results, funding or subsidies for research and development to increase energy efficiency lead to a significant decrease of 5.055% in stalks consumption per capita. Loans to firms for reducing pollution lead to a significant decrease of 2.685% in biogas consumption per capita. Loans to firms for reducing fossil fuel consumption lead to a significant increase of 2.871% in biogas consumption per capita, 0.475% in stalks consumption per capita, and 1.038% in firewood consumption per capita. Monetary awards for having reduced pollution lead to a significant increase of 0.384% in biogas consumption per capita. Intellectual property rights for research and development to increase energy efficiency lead to a significant increase of 1.873% in stalks consumption per capita. Providing education and information for increasing energy efficiency leads to a significant increase of 0.566% in stalks consumption per capita, possibly due to a rebound effect.

3.6. Conclusion

This chapter examines the effects of energy-related policies in China on energy consumption. In particular, we collect and construct a novel and comprehensive data set on energy-related policies at the provincial level in China from the 2656 energy-related province-level laws and regulations that are in place for at least one year over the years 2002 to 2013. We construct detailed policy variables for specific types of energy-related command and control policies; financial incentives; awards; intellectual property rights; and education and information policies.

We analyze the marginal effects of each specific type of policy variable on energy consumption, including various forms of fossil fuel consumption and various forms of biomass energy consumption. We analyze how the different types of energy-related policies affect different types of energy consumption using instruments to address the potential endogeneity of the policies.

According to our results, some types of policies have been effective in reducing energy consumption. Funding or subsidies for reducing fossil fuel consumption, and non-monetary awards for having developed technology to reduce fossil fuel consumption both lead to a significant decrease in total energy consumption per capita. Loans to firms for reducing pollution have a significant negative effect on coke consumption per capita, and on biogas consumption per capita. Funding or subsidies for research and development to increase energy efficiency lead to a significant decrease in electricity consumption per capita and in stalks consumption per capita. Providing education and information for energy conservation leads to a significant decrease in fuel oil consumption per capita.

However, many other policies have the possibly unintended or even perverse consequence of increasing rather than decreasing energy consumption. Monetary awards for having reduced fossil fuel consumption has a possible unintended or perverse consequence of increasing rather than decreasing total energy consumption per capita. Loans to firms for reducing fossil fuel consumption have the possibly perverse effect of leading to a significant increase in crude oil consumption per capita, in coke consumption per capita, in electricity consumption per capita, in biogas consumption per capita, in stalks consumption per capita, and in firewood consumption per capita. Similarly, loans to households for reducing fossil fuel consumption have the perverse consequence of leading to a significant increase in fuel oil consumption per capita. Emissions standards for air pollution have the perverse effect of leading to a significant increase in natural gas consumption per capita. Intellectual property rights for research and development to increase energy efficiency lead to a significant increase in stalks consumption per capita.

Providing education and information for increasing energy efficiency has the perverse effect of leading to a significant increase in electricity consumption per capita and in stalks consumption per capita, possibly due to a rebound effect resulting from the adoption of energy efficiency practices and technologies mentioned in the education and information being provided.

Some policies have different effects on different types of energy consumption. Monetary awards for having reduced pollution lead to a significant decrease in kerosene oil consumption per capita but a significant increase in electricity consumption per capita.

In terms of the effects of the economic variables on energy consumption, higher transportation fuels and parts prices lead to a significant decrease in fuel oil consumption per capita. GDP per capita has a significant positive effect on gasoline consumption per capita, on coke consumption per capita, and on diesel oil consumption per capita.

In general, there are several possible reasons why some energy-related policies in China may be ineffective or even have perverse consequences. One possible reason is the rebound effect. Energy-related policies may encourage firms or households to increase the efficiency with which they use energy. At first blush it may seem intuitive that improving the efficiency of energy use will lead to a reduction in energy consumption. Evidence from history and empirical research shows, however, that the actual savings in energy consumption from an increase in energy efficiency can be less than the expected savings.

A “rebound” effect arises when some of the gains from improving the efficiency of energy use is lost because of behavioral responses. For example, a decrease in energy consumption due to efficiency improvement also leads to a reduction in the real cost of energy services per unit, and thus brings about an increase in the demand for energy services. Therefore, the potential energy savings and emissions reduction from efficiency improvement might be offset by responses to the cost reduction (Gillingham et al., 2013; Lin, Yang and Liu, 2013; Zhang and Lin Lawell, 2017). Similarly, an increase in energy efficiency can spur economic growth, either through a reallocation of growth through sectoral reallocation or overall growth through an increase in total factor productivity, and the economic growth requires additional energy consumption (Gillingham, Rapson and Wagner, 2016; Zhang and Lin Lawell, 2017).

In the previous literature, Li and Lin (2015) conduct a detailed analysis of energy rebound effects in China's economy at the aggregate and sectoral level over 2006-2010, and find that technological advancement has varied impacts on energy conservation and rebound effects at a sectoral level because of varied rates of technological advancement and the complex interdependencies among sectors. Zhang and Lin Lawell (2017) econometrically estimate the macroeconomic energy rebound effect in China, and find that for some years and some provinces, they cannot reject the possibility that improvements in energy efficiency increased rather than decreased energy consumption.

Owing to a rebound effect, energy-related policies that lead to an increase in energy efficiency may be ineffective in reducing energy consumption, or may even have the perverse consequence of increasing rather than decreasing energy consumption.

A rebound effect may at least partially explain our result that – even after controlling for economic variables, province fixed effects, year effects, and other energy-related policies – providing education and information for increasing energy efficiency has the perverse effect of leading to a significant increase in electricity consumption per capita and in stalks consumption per capita; after learning about energy efficiency, firms and households may subsequently adopt energy efficiency practices and technologies, leading to a possible rebound effect. A rebound effect may also partially explain our result that intellectual property rights for research and development to increase energy efficiency lead to a significant increase in stalks consumption per capita.

If some of the gains from improving the efficiency of energy use is lost because of a rebound effect, then, to best benefit from energy efficient technologies, rather than halt the provision of education and information for increasing energy efficiency, and rather than halt intellectual property rights for research and development to increase energy efficiency, policy-makers may wish to consider coupling education about and the development of energy efficient technology with education and information on energy conservation and on cleaner, renewable sources of energy. For example, our results show that providing education and information for energy conservation leads to a significant decrease in fuel oil consumption per capita.

A second possible reason some energy-related policies may be ineffective in reducing energy consumption is that the reduction of energy consumption is not always the primary goal of energy-related policies. For example, the primary objective of energy-related pollution policies may be to reduce pollution rather than to reduce energy consumption *per se*. It is possible that complying with pollution regulations may actually require an increase in energy consumption. For example, our results show that emissions standards for air pollution have the perverse effect of leading to a significant increase in natural gas consumption per capita.

Another possible objective of energy-related policies may be to mitigate increases in energy consumption that result from economic growth, rather than to reduce energy consumption *per se*. Since we control for GDP per capita in our regressions, the coefficients on our energy-related policy variables measure the marginal effects of the energy-related policies holding GDP per capita constant, and can therefore be interpreted as the marginal effects of the energy-related policies on any energy consumption that is not simply explained by purely by economic growth. Thus, even if the primary objective of energy-related policies were to mitigate increases in energy consumption that result from economic growth, rather than to reduce energy consumption *per se*, the coefficients would still measure how effective the individual policies were in mitigating increases in energy consumption. Our results show that some energy-related policies might be ineffective in not only reducing energy consumption but also in mitigating increases in energy consumption that result from economic growth, and that some energy-related policies may have the unintended or even perverse effect of exacerbating rather than mitigating increases in energy consumption that result from economic growth.

A third possible reason some energy-related policies might be ineffective in China is that having multiple energy-related policies in place may diminish the effectiveness of the individual policies, or even lead to perverse impacts. In the context of overlapping policies for reducing pollution, Novan (2017) finds that if one policy places a binding cap on a subset of pollutants, additional policies to reduce emissions through expansions in renewable electricity have the potential unintended consequence of increasing instead of decreasing unregulated pollutants. It is possible that a similar perverse impact may occur with some overlapping energy-related policies in China as well.

A fourth possible reason why some energy-related policies in China may be ineffective or even have perverse consequences is that coordination problems and conflicting objectives among and within different levels of government, different government sectors, and different government agencies may cause energy-related policies to be ineffective. For renewable energy sources such as wind power, solar power, and bioenergy, coordination problems such as the lack of coordination between projects approved by different levels of government, and between renewable power planning and grid planning, have led to a low proportion of grid-connected renewable energy capacity (Zhang et al., 2013). In the meantime, coordination problems among different government sectors may cause inconsistencies in the energy-related policy due to differences in goals. Even within the same government agency, there may be conflicting goals including the desire for importing advanced technology on the one hand, and the desire for protecting the local energy industry in China on the other (Zhang et al., 2009). Lin, (2010), Lin Lawell (2021a), and Lin Lawell (2021b) examine the optimal distribution of regulatory power among different tiers of government.

A fifth possible reason why some energy-related policies in China may be ineffective is that these policies may be poorly enforced and/or have loopholes. Most firms still regard environmental compliance as a burden, leading to conflicts between firms and the government during the enforcement process (Yang and Yao, 2012). Energy-related policies are also poorly enforced on large state-owned power companies, which generate most of the energy power in China (Zhang et al., 2013). Moreover, anecdotally pollution prevention policies in China have loopholes that enable enterprises and some government departments to avoid implementing them (Chen, 2013). Energy-related policies are also plagued by weak monitoring and insufficient legal enforcement resulting from inadequate human and financial resources as well as from bribery (Richerzhagen et al., 2008).

A sixth possible reason for the ineffectiveness of some energy-related policies is that energy prices in China are often partially controlled by the government. For example, before the 2013 reform in the price of coal for electricity production, there were two different prices for coal: (1) the government-controlled contract price for coal for electricity production, and (2) the market price for coal. When the market price for coal was much higher than its contract price, coal enterprises were not willing to sell coal to electricity production enterprises, and electricity production enterprises ended up suffering from low electricity prices and high coal prices. These problems in the coal-electricity price linkage mechanism have caused electricity shortages in China in recent years (Zhang et al., 2013) and may have caused energy-related policies to be ineffective. When energy prices are partially controlled by the government rather than determined by the market, government policies may be ineffective.

Thus, there are several possible reasons why some energy-related policies in China may be ineffective or even have perverse consequences. We hope to explore these possible reasons more fully in future work.

As the focus of this chapter is on the marginal effects of different types of energy-related policies when considering and controlling for a full and comprehensive set of all energy-related policies in place, we have opted to use simple measures of each type of policy in favor of being able to include a comprehensive set of many policies. In future work we hope to develop measures to quantify the magnitude and/or stringency of the policies, particularly for the subset of policies we have found in this chapter to have significant effects on energy consumption.

Our results on the mixed effectiveness of energy-related policies in China in reducing energy consumption have important implications for the design of energy-related policies in China and elsewhere.

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Table 3.1. Summary statistics for energy consumption

	Obs	Mean	Std. Dev.	Min	Max
Total energy consumption per capita (tce)	136	3.312	3.716	1.01	28.392
Coal consumption per capita (tce)	358	2.614	4.031	0.281	55.016
Crude oil consumption per capita (tce)	328	0.530	0.508	0.000005	2.279
Natural gas consumption per capita (tce)	346	0.142	0.170	0.00000003	0.956
Coke consumption per capita (tce)	358	0.225	0.213	0.000002	1.127
Fuel oil consumption per capita (tce)	358	0.050	0.101	0.00001	0.652
Kerosene consumption per capita (tce)	351	0.028	0.061	0.000	0.332
Diesel consumption per capita (tce)	358	0.162	0.092	0.024	0.542
Gasoline consumption per capita (tce)	358	0.095	0.065	0.017	0.324
Electricity consumption per capita (tce)	174	0.121	0.075	0.011	0.536
Biogas consumption per capita (tce)	172	0.003	0.004	0.000003	0.019
Stalks consumption per capita (tce)	174	0.121	0.075	0.011	0.536
Firewood consumption per capita (tce)	170	0.085	0.072	0.0002	0.455

Notes: Data are in tons coal equivalent (tce). The data consists of annual province-level data over the period 2002 to 2013.

Table 3.2. Summary statistics for policy variables

	Obs	Mean	Std. Dev.
Command and control			
Emissions standard for air pollution	360	0.783	0.413
Technology standard	360	0.600	0.491
Renewable electricity mandate	360	0.619	0.486
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	360	0.508	0.501
Favorable tax treatment for conserving energy	360	0.792	0.407
Tax on fossil fuel consumption	360	0.494	0.501
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	360	0.381	0.486
For research and development to reduce fossil fuel consumption	360	0.325	0.469
For research and development to increase renewable energy consumption	360	0.394	0.489
For increasing energy efficiency	360	0.494	0.501
For reducing fossil fuel consumption	360	0.439	0.497
Financial incentives: Loans to firms			
For reducing pollution	360	0.367	0.483
For increasing energy efficiency	360	0.531	0.500
For reducing fossil fuel consumption	360	0.572	0.495
For increasing renewable energy consumption	360	0.289	0.454
For energy conservation	360	0.722	0.449
Financial incentives: Loans to households			
For reducing fossil fuel consumption	360	0.447	0.498
Awards: Monetary awards			
For having reduced pollution	360	0.411	0.493
For having reduced fossil fuel consumption	360	0.358	0.480

For having increased renewable energy consumption	360	0.278	0.449
For having developed technology to increase energy efficiency	360	0.244	0.430
For having developed technology to increase renewable energy consumption	360	0.258	0.438
For having reduced energy consumption, or having saved or conserved energy	360	0.572	0.495
Awards: Non-monetary awards			
For having reduced pollution	360	0.475	0.500
For having increased energy efficiency	360	0.406	0.492
For having reduced fossil fuel consumption	360	0.581	0.494
For having developed technology to reduce pollution	360	0.278	0.449
For having developed technology to reduce fossil fuel consumption	360	0.256	0.437
For having developed technology to increase renewable energy consumption	360	0.400	0.491
For having reduced energy consumption	360	0.536	0.499
Intellectual property rights			
For research and development to increase energy efficiency	360	0.300	0.459
Provide education and information			
For reducing pollution	360	0.492	0.501
For increasing energy efficiency	360	0.383	0.487
For increasing renewable energy consumption	360	0.511	0.501
For energy conservation	360	0.422	0.495
For managing energy	360	0.594	0.492

Note: The data consists of annual province-level data over the period 2002 to 2013.

Table 3.3. Summary statistics for economic variables

	Obs	Mean	Std. Dev.	Min	Max
Transportation fuels and parts consumer price index	360	105.831	6.293	88.188	117.791
Residential water, electricity, and fuels consumer price index	360	104.595	3.641	92.170	117.566
Fuel retail price index	360	107.648	6.842	85.177	125.076
GDP per capita (yuan) (2002 constant price)	360	2.220	1.557	0.324	7.733

Note: The data consists of annual province-level data over the period 2002 to 2013.

Table 3.4. Angrist-Pischke First-Stage F-statistics

	Angrist-Pischke First-Stage F-Statistic
Command and control	
Emissions standard for air pollution	34.79
Technology standard	49.00
Renewable electricity mandate	25.54
Financial incentives: Taxes	
Favorable tax treatment for increasing energy efficiency	23.38
Favorable tax treatment for conserving energy	48.60
Tax on fossil fuel consumption	74.07
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	38.96
For research and development to reduce fossil fuel consumption	49.31
For research and development to increase renewable energy consumption	54.53
For increasing energy efficiency	15.45
For reducing fossil fuel consumption	94.85
Financial incentives: Loans to firms	
For reducing pollution	91.07
For increasing energy efficiency	118.70
For reducing fossil fuel consumption	46.63
For increasing renewable energy consumption	8.16
For energy conservation	9.93
Financial incentives: Loans to households	
For reducing fossil fuel consumption	50.29
Awards: Monetary awards	
For having reduced pollution	18.89
For having reduced fossil fuel consumption	151.82
For having increased renewable energy consumption	22.34
For having developed technology to increase energy efficiency	247.05
For having developed technology to increase renewable energy consumption	20.86

For having reduced energy consumption, or having saved or conserved energy	30.57
Awards: Non-monetary awards	
For having reduced pollution	97.64
For having increased energy efficiency	61.03
For having reduced fossil fuel consumption	32.43
For having developed technology to reduce pollution	247.24
For having developed technology to reduce fossil fuel consumption	21.79
For having developed technology to increase renewable energy consumption	21.03
For having reduced energy consumption	21.26
Intellectual property rights	
For research and development to increase energy efficiency	135.74
Provide education and information	
For reducing pollution	75.13
For increasing energy efficiency	11.47
For increasing renewable energy consumption	24.89
For energy conservation	14.77
For managing energy	35.96

Note: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*.

Table 3.5. Results for fossil fuel consumption

	Dependent variable is:		
	Log coal consumption per capita	*Log crude oil consumption per capita*	*Log natural gas consumption per capita*
	(1)	(2)	(3)
<u>Policy Variables</u>			
Command and control			
Emissions standard for air pollution	-1.147	-1.236	8.490**
	(0.838)	(1.023)	(2.751)
Technology standard	1.975	-0.434	0.932
	(2.288)	(1.304)	(4.686)
Renewable electricity mandate	-0.622	0.457	0.779
	(0.371)	(0.582)	(1.764)
Financial incentives: Taxes			
For increasing energy efficiency	-0.062	-0.635	-2.011
	(0.374)	(1.363)	(1.739)
For conserving energy	-1.732	4.010	-5.260
	(2.337)	(2.368)	(4.720)
Tax on fossil fuel consumption	2.149	0.842	-13.535
	(2.213)	(4.418)	(12.940)
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	0.305	1.639	-0.902
	(1.478)	(4.176)	(5.453)
For research and development to reduce fossil fuel consumption	-0.683	-3.406	-0.948
	(1.376)	(4.252)	(5.534)
For research and development to increase renewable energy consumption	1.272	-0.608	0.345
	(0.863)	(0.646)	(4.205)
For increasing energy efficiency	-1.151	1.011	0.596

	(0.778)	(0.651)	(3.579)
For reducing fossil fuel consumption	-3.974	5.890	-6.700
	(2.376)	(4.247)	(8.987)
Financial incentives: Loans to firms			
For reducing pollution	0.045	-1.008	5.480
	(0.860)	(0.736)	(4.070)
For increasing energy efficiency	-1.350	-0.392	2.705
	(0.781)	(1.604)	(3.693)
For reducing fossil fuel consumption	-0.126	1.186*	-5.100
	(0.778)	(0.599)	(3.559)
For increasing renewable energy consumption	-0.655	-0.425	1.852
	(0.452)	(0.415)	(1.757)
For energy conservation	2.775	-2.652	8.542
	(3.236)	(2.571)	(8.246)
Financial incentives: Loans to households			
For reducing fossil fuel consumption	1.130	0.559	7.350
	(1.081)	(1.076)	(4.601)
Awards: Monetary awards			
For having reduced pollution	-0.185	1.577	1.176
	(0.488)	(0.810)	(1.579)
For having reduced fossil fuel consumption	1.871	5.598	-7.458
	(1.952)	(7.895)	(10.085)
For having increased renewable energy consumption	-0.022	-0.775	0.966
	(0.269)	(0.370)	(1.270)
For having developed technology to increase energy efficiency	1.777	-6.014	0.298
	(1.037)	(8.638)	(5.370)
For having developed technology to increase renewable energy consumption	-1.503	3.021	-7.479
	(1.288)	(4.349)	(7.336)
For having reduced energy consumption, or having saved or conserved energy	-0.616	0.382	-3.642
	(1.520)	(2.159)	(7.041)

Awards: Non-monetary awards			
For having reduced pollution	0.110	-2.001	-0.684
	(0.702)	(1.138)	(2.307)
For having increased energy efficiency	0.324	0.737	-1.114
	(0.294)	(0.509)	(1.233)
For having reduced fossil fuel consumption	-0.354	-0.098	9.660
	(0.930)	(0.845)	(13.338)
For having developed technology to reduce pollution	-1.761	0.556	-2.607
	(1.838)	(1.786)	(10.146)
For having developed technology to reduce fossil fuel consumption	-0.800	-0.220	0.961
	(0.449)	(0.387)	(1.092)
For having developed technology to increase renewable energy consumption	2.109	-1.533	4.742
	(1.439)	(4.689)	(7.450)
For having reduced energy consumption	1.296	-0.843	1.495
	(0.972)	(1.243)	(5.140)
Intellectual property rights			
For research and development to increase energy efficiency	0.953	2.406	2.488
	(2.820)	(2.751)	(14.446)
Provide education and information			
For reducing pollution	-1.332	-1.013	7.427
	(0.770)	(2.803)	(4.609)
For increasing energy efficiency	0.334	-0.313	0.230
	(0.443)	(0.376)	(1.490)
For increasing renewable energy consumption	0.187	-0.224	1.090
	(0.317)	(0.425)	(1.879)
For energy conservation	-0.591	0.401	-2.658
	(0.823)	(0.405)	(3.880)
For managing energy	1.269	0.564	-7.571
	(1.279)	(1.965)	(5.695)

Economic Variables

Log transportation fuels and parts consumer price index	-0.428	-1.704	-36.715
	(4.390)	(6.067)	(28.380)
Log residential water, electricity, and fuels consumer price index	6.563	12.859	-11.537
	(8.481)	(7.827)	(26.961)
Log fuel retail price index	0.624	-2.628	43.339
	(6.108)	(7.172)	(37.318)
Log GDP per capita (yuan) (2002 constant price)	1.070	-0.388	-0.077
	(0.434)	(0.456)	(1.753)
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	303	325
R-squared	0.1915	0.1223	-0.4614

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.6. Results for fossil fuel distillates

	Dependent variable is:			
	Log coke consumption per capita	*Log fuel oil consumption per capita*	*Log kerosene oil consumption per capita*	*Log diesel oil consumption per capita*
	(6)	(7)	(8)	(9)
Policy Variables				
Command and control				
Emissions standard for air pollution	-0.005	-1.541	-1.701	-0.377
	(1.065)	(2.068)	(1.504)	(0.412)
Technology standard	-1.760	1.045	-0.424	0.077
	(2.459)	(3.985)	(1.942)	(0.789)
Renewable electricity mandate	-0.298	1.552	0.961	-0.246
	(0.527)	(1.387)	(0.949)	(0.153)
Financial incentives: Taxes				
Favorable tax treatment for increasing energy efficiency	0.853	0.669	-0.973	0.140
	(0.557)	(1.259)	(0.704)	(0.169)
Favorable tax treatment for conserving energy	1.015	0.022	0.724	0.532
	(2.206)	(3.691)	(1.508)	(0.713)
Tax on fossil fuel consumption	1.924	4.986	-0.361	-0.377
	(2.594)	(6.292)	(4.441)	(0.894)
Financial incentives: Funding or subsidies				
For research and development to increase energy efficiency	-1.593	3.045	-2.051	-0.848
	(1.387)	(4.599)	(3.311)	(0.612)
For research and development to reduce fossil fuel consumption	0.274	-6.645	1.419	1.019
	(1.403)	(4.528)	(2.948)	(0.632)

For research and development to increase renewable energy consumption	0.752	5.968	0.588	0.176
	(0.826)	(3.246)	(1.896)	(0.367)
For increasing energy efficiency	0.844	-3.210	0.343	0.026
	(0.921)	(2.742)	(1.879)	(0.353)
For reducing fossil fuel consumption	-1.474	-10.857	1.006	0.956
	(2.549)	(6.603)	(5.379)	(0.964)
Financial incentives: Loans to firms				
For reducing pollution	-2.650*	5.160	2.919	-0.155
	(1.269)	(3.162)	(2.141)	(0.349)
For increasing energy efficiency	-0.599	-1.372	2.105	-0.156
	(0.748)	(1.984)	(1.323)	(0.355)
For reducing fossil fuel consumption	2.198*	-5.334	-2.079	-0.168
	(1.104)	(3.136)	(2.101)	(0.308)
For increasing renewable energy consumption	0.162	-0.070	-0.131	-0.194
	(0.527)	(0.969)	(0.651)	(0.270)
For energy conservation	-1.536	0.560	0.483	-0.063
	(3.419)	(5.733)	(3.048)	(1.091)
Financial incentives: Loans to households				
For reducing fossil fuel consumption	-0.545	8.781*	1.728	-0.115
	(1.342)	(4.239)	(2.721)	(0.459)
Awards: Monetary awards				
For having reduced pollution	-0.100	0.931	-2.463*	-0.239
	(0.414)	(1.635)	(1.051)	(0.246)
For having reduced fossil fuel consumption	-1.425	8.716	-3.130	-0.886
	(2.026)	(6.402)	(4.912)	(0.863)
For having increased renewable energy consumption	0.229	0.238	0.497	-0.160
	(0.252)	(0.960)	(0.870)	(0.147)
For having developed technology to increase energy efficiency	1.736	7.080	2.868	0.220
	(1.285)	(4.241)	(2.330)	(0.437)
For having developed technology to increase renewable energy consumption	-0.149	-4.411	1.422	0.193
	(1.180)	(4.038)	(2.743)	(0.594)

For having reduced energy consumption, or having saved or conserved energy	0.840	-4.415	2.678	0.646
	(1.253)	(4.079)	(2.849)	(0.623)
Awards: Non-monetary awards				
For having reduced pollution	0.570	-1.416	1.494	0.270
	(0.666)	(2.072)	(1.298)	(0.292)
For having increased energy efficiency	0.392	0.903	-0.022	0.113
	(0.296)	(1.243)	(0.921)	(0.183)
For having reduced fossil fuel consumption	0.099	1.229	-3.355	-0.034
	(1.023)	(2.324)	(2.700)	(0.475)
For having developed technology to reduce pollution	0.424	-10.795	-1.929	0.431
	(1.999)	(6.674)	(4.387)	(0.825)
For having developed technology to reduce fossil fuel consumption	0.535	-0.429	0.515	-0.139
	(0.413)	(0.652)	(0.364)	(0.132)
For having developed technology to increase renewable energy consumption	0.491	6.011	-1.573	-0.392
	(1.306)	(4.542)	(2.883)	(0.594)
For having reduced energy consumption	-0.414	4.750	-2.991	-0.079
	(1.048)	(3.433)	(2.266)	(0.503)
Intellectual property rights				
For research and development to increase energy efficiency	-2.211	11.176	-3.812	-1.407
	(2.854)	(9.170)	(5.769)	(1.088)
Provide education and information				
For reducing pollution	-0.612	-2.121	-1.096	-0.418
	(0.972)	(2.386)	(1.931)	(0.355)
For increasing energy efficiency	-0.681	0.099	0.539	0.206
	(0.558)	(0.705)	(0.434)	(0.177)
For increasing renewable energy consumption	0.330	-0.189	-0.404	-0.051
	(0.378)	(1.146)	(0.877)	(0.153)
For energy conservation	-1.281	-7.593*	-1.969	-0.030
	(0.855)	(3.518)	(1.691)	(0.337)
For managing energy	0.620	1.109	0.671	0.355

	(1.166)	(3.350)	(2.517)	(0.436)
<u>Economic Variables</u>				
Log transportation fuels and parts consumer price index	3.795	-29.193*	6.756	0.547
	(6.569)	(13.757)	(9.694)	(2.467)
Log residential water, electricity, and fuels consumer price index	2.792	-7.978	2.399	0.384
	(8.367)	(16.832)	(11.287)	(3.301)
Log fuel retail price index	-6.283	31.545	-8.339	-1.913
	(7.390)	(17.655)	(14.662)	(3.064)
Log GDP per capita (yuan) (2002 constant price)	1.917*	-0.353	0.049	1.273***
	(0.753)	(1.625)	(0.961)	(0.180)
Province fixed effects	Y	Y	Y	Y
Year effects	Y	Y	Y	Y
Observations	330	330	322	330
R-squared	0.2136	-1.6641	-0.2666	0.7603

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.7. Results for gasoline and electricity consumption

	Dependent variable is:	
	Log gasoline consumption per capita	*Log electricity consumption per capita*
	(4)	(5)
<u>Policy Variables</u>		
Command and control		
Emissions standard for air pollution	-0.284	0.251
	(0.332)	(0.314)
Technology standard	-0.206	-0.046
	(0.574)	(0.281)
Renewable electricity mandate	-0.292	0.378
	(0.210)	(0.283)
Financial incentives: Taxes		
Favorable tax treatment for increasing energy efficiency	0.052	-0.305
	(0.188)	(0.673)
Favorable tax treatment for conserving energy	0.556	1.890
	(0.603)	(1.100)
Tax on fossil fuel consumption	0.609	-3.583
	(1.085)	(1.871)
Financial incentives: Funding or subsidies		
For research and development to increase energy efficiency	0.385	-5.005**
	(0.623)	(1.722)
For research and development to reduce fossil fuel consumption	0.144	4.198
	(0.536)	(1.771)
For research and development to increase renewable energy consumption	-0.198	0.088
	(0.462)	(0.340)

For increasing energy efficiency	-0.056	0.372
	(0.347)	(0.631)
For reducing fossil fuel consumption	0.398	1.107
	(0.772)	(1.561)
Financial incentives: Loans to firms		
For reducing pollution	0.128	-0.261
	(0.461)	(0.328)
For increasing energy efficiency	-0.256	0.630
	(0.362)	(0.620)
For reducing fossil fuel consumption	-0.549	0.475*
	(0.339)	(0.228)
For increasing renewable energy consumption	-0.059	0.144
	(0.230)	(0.133)
For energy conservation	-0.464	-1.791
	(0.962)	(1.218)
Financial incentives: Loans to households		
For reducing fossil fuel consumption	0.061	
	(0.548)	
Awards: Monetary awards		
For having reduced pollution	-0.122	0.384*
	(0.292)	(0.182)
For having reduced fossil fuel consumption	0.812	-1.535
	(1.068)	(1.279)
For having increased renewable energy consumption	-0.149	-0.233
	(0.172)	(0.261)
For having developed technology to increase energy efficiency	0.279	-1.480
	(0.605)	(1.607)
For having developed technology to increase renewable energy consumption	0.570	0.248
	(0.497)	(0.442)
For having reduced energy consumption, or having saved or conserved energy	-0.546	0.137
	(0.727)	(0.500)

Awards: Non-monetary awards		
For having reduced pollution	-0.025	
	(0.272)	
For having increased energy efficiency	-0.390	0.278
	(0.229)	(0.443)
For having reduced fossil fuel consumption	0.019	2.126
	(0.436)	(1.371)
For having developed technology to reduce pollution	-1.047	
	(1.005)	
For having developed technology to reduce fossil fuel consumption	0.107	0.020
	(0.106)	(0.230)
For having developed technology to increase renewable energy consumption	-0.245	
	(0.533)	
For having reduced energy consumption	0.211	0.029
	(0.484)	(0.366)
Intellectual property rights		
For research and development to increase energy efficiency	1.364	1.873
	(1.374)	(0.940)
Provide education and information		
For reducing pollution	-0.173	-0.066
	(0.472)	(0.420)
For increasing energy efficiency	0.044	0.566*
	(0.136)	(0.231)
For increasing renewable energy consumption	0.231	0.139
	(0.191)	(0.175)
For energy conservation	-0.627	-0.025
	(0.503)	(0.206)
For managing energy	0.774	
	(0.659)	

Economic Variables		
Log transportation fuels and parts consumer price index	0.994	4.342
	(2.479)	(5.259)
Log residential water, electricity, and fuels consumer price index	-0.891	1.563
	(2.425)	(4.100)
Log fuel retail price index	-2.689	1.841
	(2.925)	(2.882)
Log GDP per capita (yuan) (2002 constant price)	0.776***	1.150
	(0.235)	(1.014)
Province fixed effects	Y	Y
Year effects	Y	Y
Observations	330	145
R-squared	0.5562	0.2837

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. For the electricity consumption regression, the policy variables for loans to households for reducing pollution; non-monetary awards for having reduced pollution; non-monetary awards for having developed technology to reduce pollution; having developed technology to increase renewable energy consumption; and education and information for managing energy are dropped owing to collinearity in the smaller sample size of data available for electricity consumption. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.8. Results for biomass energy consumption

	Dependent variable is:		
	Log biogas consumption per capita	*Log stalks consumption per capita*	*Log firewood consumption per capita*
	(10)	(11)	(12)
Policy Variables			
Command and control			
Emissions standard for air pollution	-0.500	0.251	-0.592
	(0.465)	(0.314)	(0.485)
Technology standard	-0.620	-0.046	-0.628
	(0.760)	(0.281)	(0.438)
Renewable electricity mandate	-1.443	0.378	0.135
	(1.160)	(0.283)	(0.598)
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	-1.295	-0.305	-0.687
	(0.998)	(0.673)	(0.734)
Favorable tax treatment for conserving energy	2.480	1.890	0.476
	(1.549)	(1.100)	(1.064)
Tax on fossil fuel consumption	0.750	-3.583	0.421
	(2.470)	(1.871)	(1.756)
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	-2.950	-5.005**	-4.714
	(4.350)	(1.722)	(2.571)
For research and development to reduce fossil fuel consumption	-0.402	4.198	3.994
	(4.424)	(1.771)	(2.615)
For research and development to increase renewable energy consumption	1.504	0.088	0.283
	(0.824)	(0.340)	(0.381)
For increasing energy efficiency	2.961	0.372	1.743

	(2.785)	(0.631)	(1.498)
For reducing fossil fuel consumption	1.186	1.107	-2.034
	(1.921)	(1.561)	(1.980)
Financial incentives: Loans to firms			
For reducing pollution	-2.685**	-0.261	-0.895
	(0.934)	(0.328)	(0.517)
For increasing energy efficiency	0.934	0.630	0.103
	(0.789)	(0.620)	(0.532)
For reducing fossil fuel consumption	2.871**	0.475*	1.038*
	(0.921)	(0.228)	(0.446)
For increasing renewable energy consumption	0.019	0.144	0.316
	(0.363)	(0.133)	(0.276)
For energy conservation	-2.216	-1.791	-0.464
	(1.691)	(1.218)	(1.169)
Awards: Monetary awards			
For having reduced pollution	0.186	0.384*	0.300
	(0.497)	(0.182)	(0.321)
For having reduced fossil fuel consumption	2.311	-1.535	0.634
	(3.472)	(1.279)	(2.267)
For having increased renewable energy consumption	0.683	-0.233	-0.955
	(0.736)	(0.261)	(0.527)
For having developed technology to increase energy efficiency	-4.476	-1.480	0.526
	(3.948)	(1.607)	(2.377)
For having developed technology to increase renewable energy consumption	1.515	0.248	-0.855
	(1.640)	(0.442)	(0.944)
For having reduced energy consumption, or having saved or conserved energy	0.344	0.137	-0.057
	(0.971)	(0.500)	(0.601)
Awards: Non-monetary awards			
For having increased energy efficiency	-0.036	0.278	0.355
	(0.561)	(0.443)	(0.604)
For having reduced fossil fuel consumption	0.333	2.126	1.384

	(0.863)	(1.371)	(0.869)
For having developed technology to reduce fossil fuel consumption	-0.476	0.020	-0.905
	(0.409)	(0.230)	(0.666)
For having reduced energy consumption	0.262	0.029	0.590
	(0.693)	(0.366)	(0.467)
Intellectual property rights			
For research and development to increase energy efficiency	1.941	1.873*	0.000
	(1.416)	(0.940)	(0.900)
Provide education and information			
For reducing pollution	-0.464	-0.066	0.298
	(0.948)	(0.420)	(0.621)
For increasing energy efficiency	-0.177	0.566*	-0.221
	(0.382)	(0.231)	(0.370)
For increasing renewable energy consumption	0.575	0.139	0.083
	(0.480)	(0.175)	(0.203)
For energy conservation	-0.705	-0.025	0.190
	(0.679)	(0.206)	(0.246)
Economic Variables			
Log transportation fuels and parts consumer price index	-17.714	4.342	-7.787
	(12.272)	(5.259)	(7.649)
Log residential water, electricity, and fuels consumer price index	-7.781	1.563	-6.868
	(7.200)	(4.100)	(6.547)
Log fuel retail price index	4.500	1.841	1.387
	(4.983)	(2.882)	(3.087)
Log GDP per capita (yuan) (2002 constant price)	2.501	1.150	-1.009
	(3.137)	(1.014)	(2.334)
Province fixed effects	Y	Y	Y

Year effects	Y	Y	Y
Observations	143	145	142
R-squared	0.5607	0.2837	0.1160

Notes: Robust standard errors in parentheses. For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Policy variables for loans to households for reducing pollution; non-monetary awards for having reduced pollution; non-monetary awards for having developed technology to reduce pollution; having developed technology to increase renewable energy consumption; and education and information for managing energy are dropped owing to collinearity in the smaller sample size of data available for biomass energy consumption. Significance codes: * 5% level, ** 1% level, and *** 0.1% level.

APPENDIX 3.A.

Supplementary Tables Describing Data

Table 3.A.1. Within and between variation for energy consumption

		Mean	Std. Dev.	Min	Max	# Obs
Coal consumption per capita (tce)	overall	2.614	4.031	0.281	55.016	358
	between		2.223	0.556	10.590	
	within		3.389	-4.066	47.039	
Crude oil consumption per capita (tce)	overall	0.530	0.508	0.000	2.279	328
	between		0.485	0.000	1.919	
	within		0.177	-0.374	1.105	
Natural gas consumption per capita (tce)	overall	0.142	0.170	0.000	0.956	346
	between		0.153	0.005	0.585	
	within		0.078	-0.160	0.513	
Coke consumption per capita (tce)	overall	0.225	0.213	0.000	1.127	358
	between		0.188	0.009	0.771	
	within		0.105	-0.285	0.581	
Fuel oil consumption per capita (tce)	overall	0.050	0.101	0.000	0.652	358
	between		0.097	0.002	0.515	
	within		0.031	-0.108	0.251	
Kerosene consumption per capita (tce)	overall	0.028	0.061	0.000	0.332	351
	between		0.059	0.001	0.244	
	within		0.018	-0.091	0.116	
Diesel consumption per capita (tce)	overall	0.162	0.092	0.024	0.542	358

	between		0.073	0.071	0.340	
	within		0.057	-0.111	0.371	

Gasoline consumption per capita (tce)	overall	0.095	0.065	0.017	0.324	358
	between		0.057	0.034	0.254	
	within		0.031	-0.004	0.201	

Electricity consumption per capita (tce)	overall	0.121	0.075	0.011	0.536	174
	between		0.063	0.022	0.268	
	within		0.042	0.039	0.462	

Biogas consumption per capita (tce)	overall	0.003	0.004	0.000	0.019	172
	between		0.004	0.000	0.014	
	within		0.002	-0.002	0.010	

Stalks consumption per capita (tce)	overall	0.121	0.075	0.011	0.536	174
	between		0.063	0.022	0.268	
	within		0.042	0.039	0.462	

Firewood consumption per capita (tce)	overall	0.085	0.072	0.000	0.455	170
	between		0.062	0.008	0.268	
	within		0.040	-0.103	0.318	

Notes: “Within” variation is the variation in the energy consumption variable across years for a given province. “Between” variation is the variation in the energy consumption variable across provinces for a given year.

Table 3.A.2. Command and control policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Command and control			
	Ambient air quality standard	Ambient water quality standard	Emissions standard for water pollution	Fuel mandate
Anhui	1	1	1	1
Beijing	1	1	1	
Chongqing	1	1		
Fujian	1	1	1	1
Gansu	0	0	1	1
Guangdong	1	1	1	1
Guangxi	1	1	1	1
Guizhou	0	0	1	1
Hainan	1	1	1	1
Hebei	1	1	1	0
Heilongjiang		0	0	0
Henan	1	1	1	1
Hubei	1	1	1	1
Hunan	1	1	1	1
Inner Mongolia	0	0	0	0
Jiangsu	1	1	1	1
Jiangxi	1	1	1	0
Jilin	0	0	1	0
Liaoning	1	1	1	0
Ningxia	0	0	0	1
Qinghai	0	0	0	1
Shaanxi	0	0	1	1
Shandong	1	1	1	1
Shanghai	1	1	1	1
Shanxi				0
Sichuan	1	1	1	1
Tianjin	1	1	1	1
Xinjiang	0	0	1	1
Yunnan	0	0	0	1

Zhejiang	1	1	1	1

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 3.A.3. Tax variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Taxes	
	Favorable tax treatment for reducing pollution	Tax on water pollution emissions
Anhui	0	0
Beijing	0	0
Chongqing	0	0
Fujian	0	0
Gansu	0	1
Guangdong	1	1
Guangxi	1	0
Guizhou	0	1
Hainan	1	0
Hebei	0	0
Heilongjiang	0	0
Henan	1	1
Hubei	1	0
Hunan	0	0
Inner Mongolia	0	0
Jiangsu	0	0
Jiangxi	1	0
Jilin	0	0
Liaoning	1	0
Ningxia	0	1
Qinghai	0	1
Shaanxi	0	1
Shandong	1	1
Shanghai	1	0
Shanxi	0	0
Sichuan	1	0
Tianjin	1	
Xinjiang	0	1
Yunnan		1
Zhejiang	1	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 3.A.4. Funding or subsidies policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Funding or subsidies		
	For research and development to reduce pollution	For reducing pollution	For energy conservation
Anhui	1	1	1
Beijing	1	1	1
Chongqing	1	0	1
Fujian	1	1	1
Gansu	1	0	0
Guangdong	1	1	1
Guangxi	1	1	1
Guizhou	1	1	0
Hainan	1	1	1
Hebei	1		0
Heilongjiang	1	0	0
Henan	1	1	1
Hubei	1	0	0
Hunan	1	0	0
Inner Mongolia	0	0	0
Jiangsu	1	1	1
Jiangxi	1	0	0
Jilin	1	0	0
Liaoning	1	0	0
Ningxia	1	0	0
Qinghai	1	0	0
Shaanxi	1	0	0
Shandong	1	1	1
Shanghai	1		
Shanxi	1	0	
Sichuan	1		1
Tianjin	1	1	1

Xinjiang	1	0	0
Yunnan	1	0	0
Zhejiang	1	0	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with "1"; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with "0"; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 3.A.5. Loans to households policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Financial incentives: Loans to households	
	For increasing energy efficiency	For increasing renewable energy consumption
Anhui	0	0
Beijing		0
Chongqing	0	0
Fujian	0	0
Gansu	1	0
Guangdong	1	1
Guangxi	1	1
Guizhou	1	0
Hainan		
Hebei	0	0
Heilongjiang	0	0
Henan	1	1
Hubei	0	0
Hunan	0	1
Inner Mongolia	0	0
Jiangsu	0	0
Jiangxi	0	0
Jilin	0	0
Liaoning	0	1
Ningxia	0	0
Qinghai	0	0
Shaanxi	0	0
Shandong	1	1
Shanghai	0	0
Shanxi	0	0
Sichuan	0	1
Tianjin	0	0
Xinjiang	0	0
Yunnan	1	0
Zhejiang	0	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with "1"; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with "0"; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 3.A.6. Monetary awards policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Awards: Monetary awards		
	For having increased energy efficiency	For having developed technology to reduce pollution	For having developed technology to reduce fossil fuel consumption
Anhui	0	0	0
Beijing	0	0	0
Chongqing	0	1	0
Fujian	1	0	
Gansu	0	0	0
Guangdong	1	1	1
Guangxi		0	0
Guizhou	0	0	0
Hainan		0	0
Hebei	0	0	0
Heilongjiang	0	0	0
Henan	1	0	0
Hubei	0	0	0
Hunan	1	0	0
Inner Mongolia	0	0	0
Jiangsu	0	0	0
Jiangxi	0		0
Jilin	0	0	0
Liaoning	0	0	0
Ningxia	0	0	0
Qinghai	0	0	0
Shaanxi	0	0	0
Shandong	1	1	1
Shanghai	1	1	0
Shanxi	1	0	0
Sichuan	1	1	1

Tianjin	1		
Xinjiang	0	0	0
Yunnan	0	0	0
Zhejiang	1	1	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

Table 3.A.7. Intellectual property rights policy variables that we dropped from the empirical analysis because they constant for at least 28 out of the 30 provinces

	Intellectual property rights for research and development to:			
	Reduce pollution	Reduce fossil fuel consumption	Increase renewable energy consumption	Other
Anhui	1	1	1	1
Beijing	1	1	1	1
Chongqing	1	0	0	1
Fujian	1	1	1	1
Gansu	0	1	0	1
Guangdong	1	1	1	0
Guangxi	1	1	0	0
Guizhou	0	1	0	0
Hainan		1	1	0
Hebei	0	0	0	0
Heilongjiang	0	0	0	1
Henan	1	1	1	1
Hubei	0	0	0	0
Hunan	0	0	0	0
Inner Mongolia	1	0	0	0
Jiangsu		1	1	1
Jiangxi	0	0	1	
Jilin	0	0		1
Liaoning	0	0	0	1
Ningxia	0	1	0	0
Qinghai	0	1	0	
Shaanxi	1	1	0	1
Shandong		1	1	1
Shanghai	0	1	0	0
Shanxi	1	0	0	1
Sichuan	0	0	1	1
Tianjin	1			1
Xinjiang	0	1	0	1
Yunnan	0	1	0	1

Zhejiang	0	1	0	0

Notes: For each type of policy, provinces that have that type of policy for every year during the 2002-2013 period are indicated with “1”; provinces that never have that type of policy for any year during the 2002-2013 period are indicated with “0”; and provinces that have that type of policy for some years but not others during the 2002-2013 period are indicated with a blank cell.

APPENDIX 3.B.

First-Stage Regressions

Table 3.B.1. First-stage regressions for Command and Control policy variables

	Dependent variable is:		
	Emissions standard for air pollution	*Technology standard*	*Renewable electricity mandate*
Instruments			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	-0.626**	-0.100	-0.180
Technology standard	-0.036	-0.461*	0.054
Renewable electricity mandate	-0.005	-0.007	-0.313**
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	0.047	-0.018	-0.081
Favorable tax treatment for conserving energy	0.058	0.086	0.082
Tax on fossil fuel consumption	0.037	0.027	-0.052
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	0.051	0.207	-0.204
For research and development to reduce fossil fuel consumption	0.137	0.006	0.122
For research and development to increase renewable energy consumption	-0.206*	0.121	0.117
For increasing energy efficiency	0.042	-0.270*	-0.108
For reducing fossil fuel consumption	0.142	-0.245	0.030
Financial incentives: Loans to firms			
For reducing pollution	-0.105	0.161	-0.036
For increasing energy efficiency	-0.182*	0.106	0.047

For reducing fossil fuel consumption	0.057	-0.203	-0.047
For increasing renewable energy consumption	0.147	0.008	-0.018
For energy conservation	-0.136	-0.061	0.084
Financial incentives: Loans to households			
For reducing fossil fuel consumption	-0.214	-0.041	0.177
Awards: Monetary awards			
For having reduced pollution	0.005	-0.024	0.133
For having reduced fossil fuel consumption	0.237*	0.086	-0.136
For having increased renewable energy consumption	0.013	0.005	0.026
For having developed technology to increase energy efficiency	-0.074	-0.100	0.053
For having developed technology to increase renewable energy consumption	0.089	-0.474**	-0.279
For having reduced energy consumption, or having saved or conserved energy	-0.100	-0.109*	-0.140
Awards: Non-monetary awards			
For having reduced pollution	0.025	-0.035	-0.138
For having increased energy efficiency	-0.015	-0.011	-0.041
For having reduced fossil fuel consumption	0.064	0.012	0.105
For having developed technology to reduce pollution	0.074	-0.060	0.070
For having developed technology to reduce fossil fuel consumption	-0.012	0.041	-0.038
For having developed technology to increase renewable energy consumption	-0.076	0.480**	-0.016
For having reduced energy consumption	0.017	0.204*	-0.088
Intellectual property rights			
For research and development to increase energy efficiency	0.095	0.152	-0.304
Provide education and information			
For reducing pollution	-0.041	0.098	0.006
For increasing energy efficiency	0.045	0.033	-0.001

For increasing renewable energy consumption	0.006	0.005	0.056
For energy conservation	0.077	0.009	-0.073
For managing energy	0.158	-0.163*	-0.263
Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.2. First-stage regressions for Financial incentives: Taxes policy variables

	Dependent variable is:		
	Favorable tax treatment for:		*Tax on:*
	Increasing energy efficiency	*Conserving energy*	*Fossil fuel consumption*
Instruments			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	0.083	-0.433*	-0.137
Technology standard	0.001	-0.286	0.087
Renewable electricity mandate	-0.007	-0.047	0.035
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	-0.607***	-0.012	0.006
Favorable tax treatment for conserving energy	-0.136	-0.444*	-0.118
Tax on fossil fuel consumption	0.032	0.180	-0.333
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	0.070	0.065	-0.020
For research and development to reduce fossil fuel consumption	-0.112	-0.084	0.118
For research and development to increase renewable energy consumption	0.099	-0.031	0.110
For increasing energy efficiency	-0.022	0.051	-0.239*
For reducing fossil fuel consumption	-0.140	0.199	-0.093
Financial incentives: Loans to firms			
For reducing pollution	-0.026	0.107	-0.041
For increasing energy efficiency	0.170	0.117	0.047
For reducing fossil fuel consumption	-0.009	-0.049	0.025
For increasing renewable energy consumption	0.019	-0.004	0.025
For energy conservation	-0.060	-0.088	-0.091

Financial incentives: Loans to households			
For reducing fossil fuel consumption	0.086	0.105	-0.135
Awards: Monetary awards			
For having reduced pollution	0.054	-0.016	0.032
For having reduced fossil fuel consumption	-0.101	-0.078	0.056
For having increased renewable energy consumption	-0.003	-0.033	-0.018
For having developed technology to increase energy efficiency	0.112	0.061	0.146
For having developed technology to increase renewable energy consumption	0.031	0.048	-0.073
For having reduced energy consumption, or having saved or conserved energy	-0.026	0.031	-0.021
Awards: Non-monetary awards			
For having reduced pollution	-0.087	0.028	-0.007
For having increased energy efficiency	-0.083*	0.028	0.015
For having reduced fossil fuel consumption	0.039	0.126	-0.044
For having developed technology to reduce pollution	-0.157	-0.413**	-0.108
For having developed technology to reduce fossil fuel consumption	-0.032	0.052	-0.053
For having developed technology to increase renewable energy consumption	0.047	-0.031	0.086
For having reduced energy consumption	0.081	-0.070	0.053
Intellectual property rights			
For research and development to increase energy efficiency	0.095	0.262*	0.104
Provide education and information			
For reducing pollution	0.104	-0.066	-0.143
For increasing energy efficiency	0.000	0.007	-0.001
For increasing renewable energy consumption	0.048	-0.029	-0.072
For energy conservation	-0.154	0.030	0.025
For managing energy	-0.223*	0.152	0.115

Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.3. First-stage regressions for Financial incentives: Research and development funding or subsidies policy variables

	Dependent variable is funding or subsidies for research and development to:		
	Increase energy efficiency	*Reduce fossil fuel consumption*	*Increase renewable energy consumption*
<u>Instruments</u>			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	0.059	-0.023	0.104
Technology standard	-0.049	-0.019	-0.029
Renewable electricity mandate	-0.033	-0.034	-0.004
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	0.006	0.010	0.001
Favorable tax treatment for conserving energy	0.074	-0.019	0.066
Tax on fossil fuel consumption	-0.066	-0.379	0.005
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	-0.821***	-0.357	-0.209
For research and development to reduce fossil fuel consumption	0.095	-0.294	0.221
For research and development to increase renewable energy consumption	0.125*	0.115	-0.648***
For increasing energy efficiency	-0.210*	-0.260*	-0.153
For reducing fossil fuel consumption	0.210	0.442*	0.306
Financial incentives: Loans to firms			
For reducing pollution	-0.164	-0.100	0.055
For increasing energy efficiency	-0.027	-0.052	0.038
For reducing fossil fuel consumption	0.088	0.025	-0.017
For increasing renewable energy consumption	0.034	0.023	-0.073

For energy conservation	-0.106	-0.104	-0.101
Financial incentives: Loans to households			
For reducing fossil fuel consumption	0.194	0.161	0.023
Awards: Monetary awards			
For having reduced pollution	0.021	0.023	0.017
For having reduced fossil fuel consumption	-0.314**	-0.399	-0.204
For having increased renewable energy consumption	-0.013	0.040	-0.008
For having developed technology to increase energy efficiency	0.057	0.118	0.085
For having developed technology to increase renewable energy consumption	0.039	0.247	0.089
For having reduced energy consumption, or having saved or conserved energy	0.030	0.068	0.081
Awards: Non-monetary awards			
For having reduced pollution	-0.026	-0.041	-0.004
For having increased energy efficiency	0.001	-0.031	0.036
For having reduced fossil fuel consumption	-0.104	-0.134	-0.100
For having developed technology to reduce pollution	0.147	0.210	0.106
For having developed technology to reduce fossil fuel consumption	0.213	0.255*	-0.013
For having developed technology to increase renewable energy consumption	-0.082	-0.264	-0.177
For having reduced energy consumption	0.052	0.015	-0.011
Intellectual property rights			
For research and development to increase energy efficiency	-0.427**	-0.467**	-0.410*
Provide education and information			
For reducing pollution	0.005	-0.121	0.000
For increasing energy efficiency	-0.052	-0.047	-0.004
For increasing renewable energy consumption	-0.062	-0.140	-0.111
For energy conservation	-0.022	0.023	-0.024

For managing energy	-0.071	-0.009	-0.029
Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.4. First-stage regressions for Financial incentives: Funding or subsidies policy variables

	Dependent variable is funding or subsidies for:	
	Increasing energy efficiency	*Reducing fossil fuel consumption*
Instruments Time lagged spatial lag of:		
Command and control		
Emissions standard for air pollution	0.065	0.071
Technology standard	-0.430	-0.543**
Renewable electricity mandate	-0.032	0.023
Financial incentives: Taxes		
Favorable tax treatment for increasing energy efficiency	0.069	-0.027
Favorable tax treatment for conserving energy	0.136	0.194
Tax on fossil fuel consumption	0.039	0.016
Financial incentives: Funding or subsidies		
For research and development to increase energy efficiency	0.012	-0.209
For research and development to reduce fossil fuel consumption	-0.206	0.131
For research and development to increase renewable energy consumption	-0.094	-0.021
For increasing energy efficiency	-0.565***	0.062
For reducing fossil fuel consumption	0.398	-0.123
Financial incentives: Loans to firms		
For reducing pollution	0.104	0.088
For increasing energy efficiency	0.029	0.076
For reducing fossil fuel consumption	-0.064	-0.069
For increasing renewable energy consumption	0.089	-0.001
For energy conservation	-0.179	-0.223

Financial incentives: Loans to households		
For reducing fossil fuel consumption	0.263	0.163
Awards: Monetary awards		
For having reduced pollution	0.011	0.027
For having reduced fossil fuel consumption	-0.119	-0.269*
For having increased renewable energy consumption	-0.021	-0.018
For having developed technology to increase energy efficiency	-0.051	0.076
For having developed technology to increase renewable energy consumption	0.259	0.338**
For having reduced energy consumption, or having saved or conserved energy	0.062	0.080
Awards: Non-monetary awards		
For having reduced pollution	0.024	-0.019
For having increased energy efficiency	0.035	0.020
For having reduced fossil fuel consumption	0.094	-0.052
For having developed technology to reduce pollution	-0.001	0.070
For having developed technology to reduce fossil fuel consumption	0.037	-0.004
For having developed technology to increase renewable energy consumption	-0.221	-0.389
For having reduced energy consumption	-0.118	-0.041
Intellectual property rights		
For research and development to increase energy efficiency	-0.110	-0.469***
Provide education and information		
For reducing pollution	-0.027	-0.023
For increasing energy efficiency	0.006	-0.005
For increasing renewable energy consumption	0.032	-0.010
For energy conservation	0.093	0.034
For managing energy	0.080	-0.030

Economic variables	Y	Y
Province fixed effects	Y	Y
Year effects	Y	Y
Observations	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province *i*, which we define as the sum of the values of that policy variable over all the other provinces except province *i* at time *t-1*. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.5a. First-stage regressions for Financial incentives: Loans to firms policy variables

	Dependent variable is loans to firms for:	
	Reducing pollution	*Increasing energy efficiency*
Instruments		
Time lagged spatial lag of:		
Command and control		
Emissions standard for air pollution	0.051	0.270*
Technology standard	0.114	-0.034
Renewable electricity mandate	0.069**	0.035
Financial incentives: Taxes		
Favorable tax treatment for increasing energy efficiency	-0.022	-0.063
Favorable tax treatment for conserving energy	0.046	0.016
Tax on fossil fuel consumption	0.020	0.081
Financial incentives: Funding or subsidies		
For research and development to increase energy efficiency	0.256**	0.236
For research and development to reduce fossil fuel consumption	-0.213**	-0.257
For research and development to increase renewable energy consumption	0.051	0.120
For increasing energy efficiency	-0.128	-0.126
For reducing fossil fuel consumption	-0.442**	-0.206
Financial incentives: Loans to firms		
For reducing pollution	-0.403*	-0.012
For increasing energy efficiency	0.042	-0.225
For reducing fossil fuel consumption	-0.096	0.040
For increasing renewable energy consumption	0.029	0.014
For energy conservation	-0.056	-0.403*
Financial incentives: Loans to households		

For reducing fossil fuel consumption	0.116	0.011
Awards: Monetary awards		
For having reduced pollution	0.070*	0.090
For having reduced fossil fuel consumption	0.326	-0.105
For having increased renewable energy consumption	0.007	0.098
For having developed technology to increase energy efficiency	0.138	0.181
For having developed technology to increase renewable energy consumption	-0.322**	-0.200
For having reduced energy consumption, or having saved or conserved energy	0.022	0.096
Awards: Non-monetary awards		
For having reduced pollution	-0.067	-0.097
For having increased energy efficiency	-0.013	-0.087
For having reduced fossil fuel consumption	0.014	-0.097
For having developed technology to reduce pollution	-0.119	-0.048
For having developed technology to reduce fossil fuel consumption	-0.039	0.009
For having developed technology to increase renewable energy consumption	0.331**	0.148
For having reduced energy consumption	0.061	0.029
Intellectual property rights		
For research and development to increase energy efficiency	0.252**	-0.026
Provide education and information		
For reducing pollution	-0.111	0.027
For increasing energy efficiency	0.050	0.023
For increasing renewable energy consumption	-0.011	0.042
For energy conservation	0.015	-0.006
For managing energy	-0.024	-0.274*

Economic variables	Y	Y
Province fixed effects	Y	Y
Year effects	Y	Y
Observations	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.5b. First-stage regressions for Financial incentives: Loans to firms policy variables

	Dependent variable is loans to firms for:		
	Reducing fossil fuel consumption	*Increasing renewable energy consumption*	*Energy conservation*
Instruments			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	0.094	0.015	-0.404*
Technology standard	0.010	0.070	0.037
Renewable electricity mandate	0.064	0.010	-0.019
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	-0.012	-0.052	-0.011
Favorable tax treatment for conserving energy	0.061	0.001	-0.129
Tax on fossil fuel consumption	0.054	0.064	0.122
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	0.088	-0.009	0.007
For research and development to reduce fossil fuel consumption	-0.195*	-0.114	-0.023
For research and development to increase renewable energy consumption	0.110	0.244*	-0.066
For increasing energy efficiency	-0.094	-0.156	0.071
For reducing fossil fuel consumption	-0.206	0.000	0.100
Financial incentives: Loans to firms			
For reducing pollution	-0.189	0.052	0.072
For increasing energy efficiency	-0.202	-0.031	0.032
For reducing fossil fuel consumption	-0.409	-0.026	-0.059
For increasing renewable energy consumption	0.076	-0.709***	-0.012
For energy conservation	-0.101	-0.061	-0.316

Financial incentives: Loans to households			
For reducing fossil fuel consumption	0.121	0.181	0.106
Awards: Monetary awards			
For having reduced pollution	0.065	-0.005	0.046
For having reduced fossil fuel consumption	0.122	0.020	0.147
For having increased renewable energy consumption	0.063	-0.008	-0.018
For having developed technology to increase energy efficiency	0.231	-0.002	0.097
For having developed technology to increase renewable energy consumption	-0.115	-0.096	0.237
For having reduced energy consumption, or having saved or conserved energy	0.112	-0.015	0.072
Awards: Non-monetary awards			
For having reduced pollution	-0.046	-0.003	-0.030
For having increased energy efficiency	-0.026	-0.005	0.006
For having reduced fossil fuel consumption	-0.163	0.005	0.057
For having developed technology to reduce pollution	0.160	-0.082	-0.451**
For having developed technology to reduce fossil fuel consumption	0.231*	0.003	0.005
For having developed technology to increase renewable energy consumption	-0.023	0.096	-0.231
For having reduced energy consumption	0.001	0.070	-0.129
Intellectual property rights			
For research and development to increase energy efficiency	-0.259	0.033	0.150
Provide education and information			
For reducing pollution	-0.148	-0.017	-0.106
For increasing energy efficiency	-0.023	-0.116	0.010
For increasing renewable energy consumption	-0.013	-0.008	-0.025
For energy conservation	-0.022	0.050	0.102
For managing energy	-0.012	-0.054	0.179

Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.6. First-stage regressions for Financial incentives: Loans to households policy variables

	Dependent variable is: Loans to households for reducing fossil fuel consumption
Instruments	
Time lagged spatial lag of:	
Command and control	
Emissions standard for air pollution	-0.042
Technology standard	-0.070
Renewable electricity mandate	-0.017
Financial incentives: Taxes	
Favorable tax treatment for increasing energy efficiency	-0.039
Favorable tax treatment for conserving energy	0.012
Tax on fossil fuel consumption	-0.370
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	-0.311
For research and development to reduce fossil fuel consumption	0.323
For research and development to increase renewable energy consumption	0.152*
For increasing energy efficiency	-0.217
For reducing fossil fuel consumption	0.334*
Financial incentives: Loans to firms	
For reducing pollution	-0.104
For increasing energy efficiency	-0.017
For reducing fossil fuel consumption	0.026
For increasing renewable energy consumption	0.015
For energy conservation	-0.155
Financial incentives: Loans to households	

For reducing fossil fuel consumption	-0.494**
Awards: Monetary awards	
For having reduced pollution	0.009
For having reduced fossil fuel consumption	-0.437*
For having increased renewable energy consumption	0.036
For having developed technology to increase energy efficiency	0.153
For having developed technology to increase renewable energy consumption	0.170
For having reduced energy consumption, or having saved or conserved energy	0.049
Awards: Non-monetary awards	
For having reduced pollution	-0.020
For having increased energy efficiency	-0.024
For having reduced fossil fuel consumption	-0.162
For having developed technology to reduce pollution	0.193
For having developed technology to reduce fossil fuel consumption	0.256*
For having developed technology to increase renewable energy consumption	-0.221
For having reduced energy consumption	0.041
Intellectual property rights	
For research and development to increase energy efficiency	-0.471*
Provide education and information	
For reducing pollution	-0.130
For increasing energy efficiency	-0.051
For increasing renewable energy consumption	-0.026
For energy conservation	-0.039
For managing energy	-0.007

Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.7a. First-stage regressions for Awards: Monetary awards policy variables

	Dependent variable is monetary awards for having:		
	Reduced pollution	*Reduced fossil fuel consumption*	*Increased renewable energy consumption*
Instruments Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	-0.142*	0.106	-0.034
Technology standard	0.004	-0.032	0.038
Renewable electricity mandate	0.171**	0.017	0.120*
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	0.065*	-0.023	0.089
Favorable tax treatment for conserving energy	0.132	0.098	-0.069
Tax on fossil fuel consumption	-0.033	0.052	-0.206
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	0.239*	0.195*	0.022
For research and development to reduce fossil fuel consumption	-0.180	-0.303**	0.094
For research and development to increase renewable energy consumption	-0.257***	0.015	-0.011
For increasing energy efficiency	0.206***	0.076*	0.002
For reducing fossil fuel consumption	0.361**	-0.188	0.403
Financial incentives: Loans to firms			
For reducing pollution	-0.039	0.042	-0.016
For increasing energy efficiency	0.035	-0.006	0.107
For reducing fossil fuel consumption	0.012	-0.020	0.073
For increasing renewable energy consumption	-0.020	0.010	0.047

For energy conservation	0.026	-0.235*	-0.059
Financial incentives: Loans to households			
For reducing fossil fuel consumption	-0.053	0.146	-0.221
Awards: Monetary awards			
For having reduced pollution	-0.386**	0.025	0.059
For having reduced fossil fuel consumption	0.330	-0.396	0.077
For having increased renewable energy consumption	-0.057	0.089*	-0.707***
For having developed technology to increase energy efficiency	-0.297**	0.164*	-0.517
For having developed technology to increase renewable energy consumption	0.372**	-0.080	-0.071
For having reduced energy consumption, or having saved or conserved energy	0.270*	0.109*	-0.036
Awards: Non-monetary awards			
For having reduced pollution	-0.368**	-0.005	-0.025
For having increased energy efficiency	0.067	-0.061	-0.197
For having reduced fossil fuel consumption	-0.032	-0.176	0.171
For having developed technology to reduce pollution	0.071	0.199	0.122
For having developed technology to reduce fossil fuel consumption	-0.016	0.015	-0.013
For having developed technology to increase renewable energy consumption	-0.274*	-0.036	0.043
For having reduced energy consumption	-0.310**	-0.090*	-0.031
Intellectual property rights			
For research and development to increase energy efficiency	-0.039	-0.274	0.161
Provide education and information			
For reducing pollution	0.081	-0.085	0.113
For increasing energy efficiency	0.046	0.004	0.008
For increasing renewable energy consumption	-0.056	0.015	-0.050
For energy conservation	0.168*	-0.017	0.039

For managing energy	-0.329*	0.020	-0.136
Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.7b. First-stage regressions for Awards: Monetary awards policy variables

	Dependent variable is monetary awards for having developed technology to:	
	Increase energy efficiency	*Increase renewable energy consumption*
<u>Instruments</u>		
Time lagged spatial lag of:		
Command and control		
Emissions standard for air pollution	0.121	-0.197
Technology standard	-0.582**	0.055
Renewable electricity mandate	0.056	0.087*
Financial incentives: Taxes		
Favorable tax treatment for increasing energy efficiency	-0.040	0.036
Favorable tax treatment for conserving energy	0.123	0.107
Tax on fossil fuel consumption	0.243	0.018
Financial incentives: Funding or subsidies		
For research and development to increase energy efficiency	0.098	-0.105
For research and development to reduce fossil fuel consumption	-0.276*	0.288
For research and development to increase renewable energy consumption	-0.075	-0.036
For increasing energy efficiency	0.177**	-0.151
For reducing fossil fuel consumption	0.037	0.159
Financial incentives: Loans to firms		
For reducing pollution	0.059	-0.052
For increasing energy efficiency	0.059	-0.069
For reducing fossil fuel consumption	-0.058	0.034
For increasing renewable energy consumption	-0.018	-0.002
For energy conservation	-0.286	0.043

Financial incentives: Loans to households		
For reducing fossil fuel consumption	0.319**	-0.221*
Awards: Monetary awards		
For having reduced pollution	0.073	0.007
For having reduced fossil fuel consumption	0.307	-0.039
For having increased renewable energy consumption	-0.002	-0.059
For having developed technology to increase energy efficiency	-0.443**	0.005
For having developed technology to increase renewable energy consumption	0.092	-0.565**
For having reduced energy consumption, or having saved or conserved energy	0.213**	-0.006
Awards: Non-monetary awards		
For having reduced pollution	-0.024	-0.035
For having increased energy efficiency	0.028	0.021
For having reduced fossil fuel consumption	-0.058	0.029
For having developed technology to reduce pollution	0.064	0.039
For having developed technology to reduce fossil fuel consumption	-0.010	-0.027
For having developed technology to increase renewable energy consumption	-0.138	-0.111
For having reduced energy consumption	-0.105*	0.000
Intellectual property rights		
For research and development to increase energy efficiency	-0.268	0.052
Provide education and information		
For reducing pollution	-0.373**	-0.034
For increasing energy efficiency	0.010	0.004
For increasing renewable energy consumption	0.053	-0.113
For energy conservation	0.045	0.070
For managing energy	0.155	-0.179

Economic variables	Y	Y
Province fixed effects	Y	Y
Year effects	Y	Y
Observations	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.7c. First-stage regressions for Awards: Monetary awards policy variables

	Dependent variable is monetary awards for: Having reduced energy consumption, or having saved or conserved energy
Instruments Time lagged spatial lag of:	
Command and control	
Emissions standard for air pollution	-0.052
Technology standard	-0.015
Renewable electricity mandate	0.057
Financial incentives: Taxes	
Favorable tax treatment for increasing energy efficiency	0.061
Favorable tax treatment for conserving energy	0.037
Tax on fossil fuel consumption	-0.372
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	-0.100
For research and development to reduce fossil fuel consumption	0.233
For research and development to increase renewable energy consumption	-0.132
For increasing energy efficiency	0.051
For reducing fossil fuel consumption	0.366*
Financial incentives: Loans to firms	
For reducing pollution	-0.021
For increasing energy efficiency	0.054
For reducing fossil fuel consumption	0.005
For increasing renewable energy consumption	0.001
For energy conservation	0.023
Financial incentives: Loans to households	

For reducing fossil fuel consumption	-0.155
Awards: Monetary awards	
For having reduced pollution	-0.106
For having reduced fossil fuel consumption	0.048
For having increased renewable energy consumption	-0.008
For having developed technology to increase energy efficiency	-0.030
For having developed technology to increase renewable energy consumption	0.332*
For having reduced energy consumption, or having saved or conserved energy	-0.196
Awards: Non-monetary awards	
For having reduced pollution	0.018
For having increased energy efficiency	0.021
For having reduced fossil fuel consumption	-0.027
For having developed technology to reduce pollution	0.108
For having developed technology to reduce fossil fuel consumption	-0.004
For having developed technology to increase renewable energy consumption	-0.330**
For having reduced energy consumption	-0.136
Intellectual property rights	
For research and development to increase energy efficiency	-0.228
Provide education and information	
For reducing pollution	-0.238
For increasing energy efficiency	0.004
For increasing renewable energy consumption	-0.033
For energy conservation	0.125
For managing energy	-0.218

Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.8a. First-stage regressions for Awards: Non-monetary awards policy variables

	Dependent variable is non-monetary award for having:		
	Reduced pollution	*Increased energy efficiency*	*Reduced fossil fuel consumption*
<u>Instruments</u>			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	-0.134	0.053	0.073
Technology standard	-0.002	-0.101	0.114
Renewable electricity mandate	0.122*	-0.008	0.028
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	-0.016	0.022	-0.038
Favorable tax treatment for conserving energy	0.137	0.071	0.022
Tax on fossil fuel consumption	-0.029	0.027	0.023
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	-0.262	-0.072	0.248***
For research and development to reduce fossil fuel consumption	0.269	-0.017	-0.303***
For research and development to increase renewable energy consumption	0.026	0.066	0.098
For increasing energy efficiency	-0.069	0.025	-0.121
For reducing fossil fuel consumption	0.523**	0.259	-0.550***
Financial incentives: Loans to firms			
For reducing pollution	-0.001	0.011	-0.007
For increasing energy efficiency	-0.075	-0.067	0.022
For reducing fossil fuel consumption	0.020	-0.003	0.014
For increasing renewable energy consumption	-0.002	0.004	0.016

For energy conservation	-0.125	-0.155	-0.040
Financial incentives: Loans to households			
For reducing fossil fuel consumption	-0.023	0.113	0.093
Awards: Monetary awards			
For having reduced pollution	-0.015	-0.100	0.058*
For having reduced fossil fuel consumption	-0.321	-0.049	0.175
For having increased renewable energy consumption	0.099	0.078	-0.018
For having developed technology to increase energy efficiency	0.038	0.072	0.123*
For having developed technology to increase renewable energy consumption	-0.025	0.087	-0.393***
For having reduced energy consumption, or having saved or conserved energy	-0.006	0.115	0.016
Awards: Non-monetary awards			
For having reduced pollution	-0.623***	0.081	-0.002
For having increased energy efficiency	-0.061	-0.786***	0.017
For having reduced fossil fuel consumption	-0.056	-0.168	-0.441
For having developed technology to reduce pollution	0.185	0.135	0.061
For having developed technology to reduce fossil fuel consumption	0.025	0.018	-0.024
For having developed technology to increase renewable energy consumption	-0.524**	-0.238*	0.413***
For having reduced energy consumption	-0.126	-0.051	0.014
Intellectual property rights			
For research and development to increase energy efficiency	-0.531***	-0.491**	0.102
Provide education and information			
For reducing pollution	0.064	-0.003	-0.062
For increasing energy efficiency	0.038	0.026	0.017
For increasing renewable energy consumption	-0.024	0.029	0.022
For energy conservation	0.011	-0.051	-0.023

For managing energy	-0.074	0.009	0.001
Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.8b. First-stage regressions for Awards: Non-monetary awards policy variables

	Dependent variable is non-monetary awards for having developed technology to:		
	Reduce pollution	*Reduce fossil fuel consumption*	*Increase renewable energy consumption*
Instruments			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	0.010	0.084	0.059
Technology standard	0.018	0.126	-0.448**
Renewable electricity mandate	0.025	0.037	0.020
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	-0.051	-0.032	-0.048
Favorable tax treatment for conserving energy	0.024	0.043	0.103
Tax on fossil fuel consumption	-0.320	0.035	0.069
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	-0.174	0.185*	-0.164
For research and development to reduce fossil fuel consumption	0.159	-0.218**	0.057
For research and development to increase renewable energy consumption	0.105	0.043	0.040
For increasing energy efficiency	-0.153	-0.080	0.020
For reducing fossil fuel consumption	-0.205	-0.393***	0.200
Financial incentives: Loans to firms			
For reducing pollution	0.042	0.136	0.079
For increasing energy efficiency	0.044	0.096	0.042
For reducing fossil fuel consumption	-0.025	-0.041	-0.061
For increasing renewable energy consumption	0.018	-0.007	-0.002
For energy conservation	-0.232	-0.123	-0.010

Financial incentives: Loans to households			
For reducing fossil fuel consumption	0.070	-0.197	0.177
Awards: Monetary awards			
For having reduced pollution	0.045	0.030	-0.026
For having reduced fossil fuel consumption	-0.066	0.206	-0.325*
For having increased renewable energy consumption	-0.041	-0.034	-0.078
For having developed technology to increase energy efficiency	0.213	0.027	0.152
For having developed technology to increase renewable energy consumption	-0.088	-0.354**	0.106
For having reduced energy consumption, or having saved or conserved energy	-0.063	0.000	-0.001
Awards: Non-monetary awards			
For having reduced pollution	-0.032	0.050	0.043
For having increased energy efficiency	0.002	0.062	0.088
For having reduced fossil fuel consumption	-0.084	0.049	0.126
For having developed technology to reduce pollution	-0.293	0.109	0.030
For having developed technology to reduce fossil fuel consumption	-0.017	-0.638***	0.008
For having developed technology to increase renewable energy consumption	0.079	0.313**	-0.764***
For having reduced energy consumption	0.089	0.040	-0.053
Intellectual property rights			
For research and development to increase energy efficiency	-0.242	0.329***	-0.310
Provide education and information			
For reducing pollution	-0.145	-0.017	-0.083
For increasing energy efficiency	-0.017	-0.029	0.019
For increasing renewable energy consumption	-0.019	0.005	0.050
For energy conservation	-0.019	0.026	-0.001
For managing energy	0.051	-0.028	0.039

Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.8c. First-stage regressions for Awards: Non-monetary awards policy variables

	Dependent variable is non-monetary awards for having reduced energy consumption
Instruments	
Time lagged spatial lag of:	
Command and control	
Emissions standard for air pollution	0.082
Technology standard	0.037
Renewable electricity mandate	0.047
Financial incentives: Taxes	
Favorable tax treatment for increasing energy efficiency	0.143*
Favorable tax treatment for conserving energy	0.144
Tax on fossil fuel consumption	0.008
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	-0.051
For research and development to reduce fossil fuel consumption	0.328**
For research and development to increase renewable energy consumption	0.021
For increasing energy efficiency	-0.309*
For reducing fossil fuel consumption	0.048
Financial incentives: Loans to firms	
For reducing pollution	-0.091
For increasing energy efficiency	-0.057
For reducing fossil fuel consumption	0.031
For increasing renewable energy consumption	0.015
For energy conservation	-0.174
Financial incentives: Loans to households	
For reducing fossil fuel consumption	-0.256*

Awards: Monetary awards	
For having reduced pollution	0.026
For having reduced fossil fuel consumption	0.180
For having increased renewable energy consumption	0.058
For having developed technology to increase energy efficiency	-0.021
For having developed technology to increase renewable energy consumption	-0.059
For having reduced energy consumption, or having saved or conserved energy	-0.336*
Awards: Non-monetary awards	
For having reduced pollution	-0.010
For having increased energy efficiency	-0.096*
For having reduced fossil fuel consumption	-0.007
For having developed technology to reduce pollution	-0.062
For having developed technology to reduce fossil fuel consumption	-0.065
For having developed technology to increase renewable energy consumption	0.177
For having reduced energy consumption	-0.251
Intellectual property rights	
For research and development to increase energy efficiency	0.404**
Provide education and information	
For reducing pollution	-0.159
For increasing energy efficiency	-0.010
For increasing renewable energy consumption	-0.037
For energy conservation	0.115
For managing energy	-0.209
Economic variables	Y

Province fixed effects	Y
Year effects	Y
Observations	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.9. First-stage regressions for Awards: Intellectual property rights policy variables

	Dependent variable is intellectual property rights for research and development to increase energy efficiency
Instruments	
Time lagged spatial lag of:	
Command and control	
Emissions standard for air pollution	-0.118*
Technology standard	-0.003
Renewable electricity mandate	0.006
Financial incentives: Taxes	
Favorable tax treatment for increasing energy efficiency	0.018
Favorable tax treatment for conserving energy	-0.045
Tax on fossil fuel consumption	-0.304
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	-0.134
For research and development to reduce fossil fuel consumption	0.234
For research and development to increase renewable energy consumption	-0.063
For increasing energy efficiency	-0.014
For reducing fossil fuel consumption	0.243**
Financial incentives: Loans to firms	
For reducing pollution	0.034
For increasing energy efficiency	0.019
For reducing fossil fuel consumption	-0.029
For increasing renewable energy consumption	-0.013
For energy conservation	-0.056

Financial incentives: Loans to households	
For reducing fossil fuel consumption	-0.087
Awards: Monetary awards	
For having reduced pollution	0.001
For having reduced fossil fuel consumption	0.025
For having increased renewable energy consumption	-0.032
For having developed technology to increase energy efficiency	0.013
For having developed technology to increase renewable energy consumption	0.269**
For having reduced energy consumption, or having saved or conserved energy	0.026
Awards: Non-monetary awards	
For having reduced pollution	-0.042
For having increased energy efficiency	0.006
For having reduced fossil fuel consumption	-0.038
For having developed technology to reduce pollution	-0.031
For having developed technology to reduce fossil fuel consumption	0.022
For having developed technology to increase renewable energy consumption	-0.225
For having reduced energy consumption	0.029
Intellectual property rights	
For research and development to increase energy efficiency	-0.409*
Provide education and information	
For reducing pollution	-0.148
For increasing energy efficiency	-0.014
For increasing renewable energy consumption	-0.045*
For energy conservation	0.054
For managing energy	0.056

Economic variables	Y
Province fixed effects	Y
Year effects	Y
Observations	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.10a. First-stage regressions for Provide education and information policy variables

	Dependent variable is provide education and information for:		
	Reducing pollution	*Increasing energy efficiency*	*Increasing renewable energy consumption*
Instruments			
Time lagged spatial lag of:			
Command and control			
Emissions standard for air pollution	0.030	0.044	-0.288*
Technology standard	-0.090	-0.131	0.053
Renewable electricity mandate	0.065	0.001	-0.207*
Financial incentives: Taxes			
Favorable tax treatment for increasing energy efficiency	0.078	0.046	-0.070
Favorable tax treatment for conserving energy	-0.296	0.096	0.027
Tax on fossil fuel consumption	-0.091	0.082	-0.252
Financial incentives: Funding or subsidies			
For research and development to increase energy efficiency	-0.117	-0.219	-0.090
For research and development to reduce fossil fuel consumption	0.198	0.206	0.084
For research and development to increase renewable energy consumption	-0.063	0.044	0.261
For increasing energy efficiency	0.036	0.028	-0.060
For reducing fossil fuel consumption	0.312	0.055	-0.207
Financial incentives: Loans to firms			
For reducing pollution	-0.001	-0.264	-0.014
For increasing energy efficiency	0.088	-0.341	0.050
For reducing fossil fuel consumption	0.002	0.236	-0.014
For increasing renewable energy consumption	0.026	0.098	-0.013

For energy conservation	-0.053	-0.108	-0.071
Financial incentives: Loans to households			
For reducing fossil fuel consumption	-0.105	-0.133	0.013
Awards: Monetary awards			
For having reduced pollution	-0.039	-0.063	-0.042
For having reduced fossil fuel consumption	-0.274	0.124	-0.196
For having increased renewable energy consumption	0.114	0.006	-0.026
For having developed technology to increase energy efficiency	0.038	0.139	0.004
For having developed technology to increase renewable energy consumption	0.141	0.148	-0.137
For having reduced energy consumption, or having saved or conserved energy	0.116	0.108	-0.086
Awards: Non-monetary awards			
For having reduced pollution	0.046	0.028	-0.027
For having increased energy efficiency	-0.061	0.031	0.018
For having reduced fossil fuel consumption	-0.229	-0.100	0.111
For having developed technology to reduce pollution	0.293	0.157	0.206
For having developed technology to reduce fossil fuel consumption	-0.007	-0.023	0.027
For having developed technology to increase renewable energy consumption	-0.309*	-0.207	0.320
For having reduced energy consumption	-0.155	-0.019	0.165*
Intellectual property rights			
For research and development to increase energy efficiency	-0.490*	-0.438*	-0.140
Provide education and information			
For reducing pollution	-0.604***	-0.108	0.009
For increasing energy efficiency	0.006	-0.502***	0.035
For increasing renewable energy consumption	-0.101	0.033	-0.469***
For energy conservation	0.064	-0.017	-0.189

For managing energy	-0.194	0.095	-0.022
Economic variables	Y	Y	Y
Province fixed effects	Y	Y	Y
Year effects	Y	Y	Y
Observations	330	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

Table 3.B.10b. First-stage regressions for Provide education and information policy variables

	Dependent variable is provide education and information for:	
	For energy conservation	*For managing energy*
Instruments		
Time lagged spatial lag of:		
Command and control		
Emissions standard for air pollution	0.076	0.056
Technology standard	-0.155	-0.096
Renewable electricity mandate	0.030	-0.051
Financial incentives: Taxes		
Favorable tax treatment for increasing energy efficiency	-0.071	0.072*
Favorable tax treatment for conserving energy	0.060	0.174
Tax on fossil fuel consumption	0.242	0.164
Financial incentives: Funding or subsidies		
For research and development to increase energy efficiency	0.166	0.108
For research and development to reduce fossil fuel consumption	0.023	0.046
For research and development to increase renewable energy consumption	-0.156	-0.160*
For increasing energy efficiency	-0.005	0.074
For reducing fossil fuel consumption	0.287	0.266*
Financial incentives: Loans to firms		
For reducing pollution	0.018	-0.039
For increasing energy efficiency	0.115	-0.067
For reducing fossil fuel consumption	0.006	-0.010
For increasing renewable energy consumption	-0.126	-0.027
For energy conservation	-0.208	-0.166*

Financial incentives: Loans to households		
For reducing fossil fuel consumption	-0.142	-0.116
Awards: Monetary awards		
For having reduced pollution	0.032	-0.054
For having reduced fossil fuel consumption	0.337	0.319*
For having increased renewable energy consumption	0.035	0.029
For having developed technology to increase energy efficiency	-0.217	-0.090
For having developed technology to increase renewable energy consumption	-0.088	0.183
For having reduced energy consumption, or having saved or conserved energy	0.143	-0.054
Awards: Non-monetary awards		
For having reduced pollution	-0.014	0.048
For having increased energy efficiency	0.041	-0.015
For having reduced fossil fuel consumption	0.012	0.152*
For having developed technology to reduce pollution	-0.107	-0.324*
For having developed technology to reduce fossil fuel consumption	-0.009	0.016
For having developed technology to increase renewable energy consumption	0.105	-0.102
For having reduced energy consumption	-0.059	-0.068
Intellectual property rights		
For research and development to increase energy efficiency	0.217	0.321**
Provide education and information		
For reducing pollution	-0.350*	-0.138
For increasing energy efficiency	0.006	0.046*
For increasing renewable energy consumption	0.012	-0.005
For energy conservation	-0.376*	0.158*
For managing energy	0.209*	-0.422*

Economic variables	Y	Y
Province fixed effects	Y	Y
Year effects	Y	Y
Observations	330	330

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.

APPENDIX 3.C.

Table 3.C.1. Results for total energy consumption

	Dependent variable is: *Log total energy consumption per capita*
<u>Policy Variables</u>	
Command and control	
Emissions standard for air pollution	0.302
Technology standard	-0.696
Renewable electricity mandate	1.018
Financial incentives: Taxes	
For increasing energy efficiency	-0.108
For conserving energy	0.180
Tax on fossil fuel consumption	3.792
Financial incentives: Funding or subsidies	
For research and development to increase energy efficiency	0.474
For research and development to reduce fossil fuel consumption	0.000
For research and development to increase renewable energy consumption	-0.058
For increasing energy efficiency	1.841
For reducing fossil fuel consumption	-7.003*
Financial incentives: Loans to firms	
For reducing pollution	-1.516
For increasing energy efficiency	-1.354
For reducing fossil fuel consumption	0.739
For increasing renewable energy consumption	-0.106
For energy conservation	2.046
Financial incentives: Loans to households	
For reducing fossil fuel consumption	0.000

Awards: Monetary awards	
For having reduced pollution	-0.399
For having reduced fossil fuel consumption	4.293***
For having increased renewable energy consumption	0.412
For having developed technology to increase energy efficiency	0.000
For having developed technology to increase renewable energy consumption	0.000
For having reduced energy consumption, or having saved or conserved energy	0.549
Awards: Non-monetary awards	
For having reduced pollution	0.000
For having increased energy efficiency	1.182
For having reduced fossil fuel consumption	0.000
For having developed technology to reduce pollution	0.000
For having developed technology to reduce fossil fuel consumption	-1.740***
For having developed technology to increase renewable energy consumption	0.000
For having reduced energy consumption	-1.653
Intellectual property rights	
For research and development to increase energy efficiency	0.000
Provide education and information	
For reducing pollution	0.625
For increasing energy efficiency	-0.530
For increasing renewable energy consumption	0.164
For energy conservation	0.050
For managing energy	0.000

<u>Economic Variables</u>

Log transportation fuels and parts consumer price index	4.285
Log residential water, electricity, and fuels consumer price index	8.672
Log fuel retail price index	8.767*
Log GDP per capita (yuan) (2002 constant price)	1.897
	4.285
Province fixed effects	Y
Year effects	Y
Observations	120
R-squared	0.0507

Notes: For each policy variable, we instrument for the policy variable using the time lagged spatial lag of that policy variable in province i, which we define as the sum of the values of that policy variable over all the other provinces except province i at time t-1. Significance codes based on robust standard errors: * 5% level, ** 1% level, and *** 0.1% level.