How do the economic activities influence the air quality in China?

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Air pollution is one of the biggest environmental health challenges around the world. The fine particulate matters (PM) is particular dangerous to human health, such as brain tissues (Bishop et al., 2018), mortality (Ebenstein et al., 2017), productivity (Chang et al., 2016), human development (Bharadwaj et al., 2017), mental health (Chen et al., 2018) and cognitive ability (Zhang et al., 2018a; Ebenstein et al., 2016). Literature has documented several influencing factors of air pollution including industrialization (Li et al., 2019), urbanization (Luo et al., 2020), transportation (Romero et al., 2020) and energy consumption (Li et al., 2020). Specifically, previous studies also investigated the impact of electricity on air quality, involving electricity demand (Bedi and Toshniwal; Yi et al., 2020), production (Yue et al.) and remote transmission (Wang et al., 2020). However, little was known about the effect of economic activities on air pollution in small communities that are lacking of economic statistics. Our study will investigate how the local air pollution measured by Air Quality Index (AQI) and $PM_{2.5}$ is influenced by the economic activities of small communities in China.

Inspired by Henderson et al. (2012) and Nordhaus and Chen (2015) who estimated the economic activities based on the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) imagery, we draw data from satellite images of urban night lights as a measurement of the economic activities. As the global Visible Infrared Imaging Radiometer Suite (VIIRS) nighttime light data leads to a better performance in estimating GDP and electricity power consumption (Shi et al., 2014), we use VIIRS imagery instead of DMSP-OLS. We are able to identify the nearest 1,498 communities in 322 prefecture cities of 31 provinces in China based on the precise coordinates of ground air quality monitoring stations from Ministry of Ecology and Environment of the People's Republic of China. We make a 5-km buffer with the location of communities and calculate the monthly average intensity of night lights within this buffer from January 2015 to December 2018. We then calculate the corresponding monthly average of nighttime[1] AQI and $PM_{2.5}$ for each community. The final panel dataset includes 71,904 observations at 1,498 communities in 31 provinces of China from January 2015 to December 2018.

There are several reasons why this is an appealing context to reveal the impact of economic activities on air pollution. First and foremost, by observing a large sample of communities over four years, there exists large spatial and temporal variations in night

[1]The nighttime is defined from 18:00 to 6:00.

lights and air pollution. Nighttime light data is more precise than traditional economic statistics. We can identify the impact of economic activities on air pollution at a wider magnitude, which is typically unseen in most developed countries. Secondly, it is difficult to find the monthly economic activities due to data limitation. We build the channel between economic activities and the intensity of night lights. In this way, we are able to examine the influence of night light as a proxy of economic activities on the night air quality. We show that subnational economic statistics are strongly correlated to luminosity data.

Our main empirical model is a linear model with the community fixed effects. We further include the month-by-year, city-by-month, province-by-year and province-by-month-by-year fixed effects to capture the unobservable variables in the time and spatial span. To control for the effect of weather on air quality, we also include the monthly average of nighttime temperature and precipitation for each community based on the nearest weather station.

Our study assumes that under certain pollution levels, people cannot detect air pollution and hence air pollution cannot induce people to stay indoors. Our empirical results indicate that when AQI is at Good level or above, 1% increase in night lights leads to the growth of the AQI by 14.38%, which is statistically significant at the 1% level. Similarly, 1% increase in night lights increases the $PM_{2.5}$ by 7.5%, which is also significant at 1% level. A one standard deviation increase in night lights would increase the nighttime AQI and $PM_{2.5}$ by 2.1% and 2.79%, respectively. These results are consistent with findings from Stark et al. (2011). We also find that the effect of temperature on air pollution is significantly positive while the effect of precipitation on air pollution is significantly negative. When using models only including community fixed-effects and province-by-month-by-year fixed effects, we find that 1% increase in night lights increases the AQI by 7.48% and $PM_{2.5}$ by 7.99% at the 5% significant level. One possible explanation for different results is that provinces in China are typically large and province-by-month-by-year fixed effects includes the variations within provinces.

In the next step, we will estimate a spatial autoregressive model (SAR) to examine the spatial spillover effects of nighttime light on city pollution. Previous research has explored the spatial spillover effects of urbanization (Zhang et al., 2018b), water pollution (Brei et al., 2016), rainfall (Hossain and Ahsan, 2018), and knowledge (Davis and Dingel, 2012) across villages or cities. Specifically, using the same dataset of DMSP/OLS nighttime light, Zhang et al. (2018b) revealed the spillover effect of urbanization on cities nearby and Brei et al. (2016) showed the pollution's spillover effect on the areas near the border. Yet few research has shown the spillover effect of economic activities on air quality.

This paper provides several contributions to the economic literature. We firstly apply the night lights as a measurement of economic activities and investigate the effect of night lights on air pollution in developing country context. This allows us to examine the impact of economic activities on nighttime air quality. This study also contributes to the literature on empirically estimating the satellite imagery night lights on air pollution with a wide range of spatial and temporal variation. From policy and practical perspective, it is beneficial to reduce the night lights for a better air quality. This means that reducing unnecessary night lights in the future will be an efficiency way to improve air quality.

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