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Changing Population Exposure to Pollution in China's Special Economic Zones†

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There are over 5,000 special economic zones (SEZ) in 147 countries around the world; the number is growing (United Nations Conference on Trade and Development 2019). SEZs are areas within a country that are subject to unique economic regulations. These may include favorable tax treatments, export promotion, or infrastructure investments that are designed to attract domestic and foreign investment to the zones and foster economic growth. In the case of China, Wang (2013); Zheng et al. (2017); and Lu, Wang, and Zhu (2019) have documented that SEZs have driven investments in foreign direct investment, output growth, and positive spillovers from colocation of producers of intermediate and final goods.

In Martin and Zhang (2020), we show that the increase in manufacturing output in China's SEZs between 1990 and 2010 significantly increased air pollution in host counties. In this complementary paper, we document how migration into these industrial clusters changed overall population exposure to pollution. We first show that population grew disproportionately in these zones: although only 12 percent of counties hosted zones, over half of the population growth between 2000–2010 took place in existing or newly established zones. We then use satellite air pollution data to show that on average, SEZs suffer from worse air quality than other counties, with larger differentials the longer the zones have been around. But these SEZ-heavy migration patterns do not increase population exposure to pollution; if anything, they slightly reduce overall exposure. We show that there is large heterogeneity across SEZs in pollution levels and that most movement into SEZs targeted relatively cleaner zones, supporting recent literature that documents a willingness to make location decisions based on environmental quality (Chen, Oliva, and Zhang 2017; Khanna et al. 2020).

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I. Data

Our SEZ data come from the China Association of Development Zones (CADZ). The CADZ provides the Chinese and English name for each zone along with its geocoordinates. For the years of establishment, we turn to the online Appendix of Wang (2013), manually supplemented and cross validated by data collected from official government and industry websites.

We measure air quality using fine particulate matter ($PM_{2.5}$), particles with a diameter of 2.5 microns or less, commonly measured in micrograms per cubic meters of air ($\mu g/m^3$). Chronic exposure to $PM_{2.5}$ increases the risk of developing cardiovascular and respiratory diseases, including lung cancer. The literature in economics has documented a strong effect of suspended particulates on infant mortality (Chay and Greenstone 2003, Currie and Neidell 2005), mortality among the elderly (Deryugina et al. 2019), and overall long-run mortality (Chen et al. 2013, Ebenstein et al. 2017).

Our $PM_{2.5}$ estimates come from van Donkelaar et al. (2016), who combine aerosol optical depth (AOD) retrievals from the National Aeronautics and Space Administration's Moderate Resolution Imaging Spectroradiometer, Multi-angle Imaging SpectroRadiometer, and Sea-Viewing Wide Field-of-View Sensor satellite instruments with the Goddard Earth Observing System chemical transport model. We use data

Table 1—Disproportionate Population Growth in Newly Established Zones

	Percent counties	Population 2000	Percent total	Increase 2000–2010	Growth rate
Never SEZ	59	569,800,000	46%	26,900,000	4.7%
SEZ before 2000	23	351,100,000	28%	16,300,000	4.6%
SEZ 2000–2010	19	319,400,000	26%	49,900,000	15.6%

Note: SEZ designation and number of counties based on 2010 county borders.

gridded at a $0.01° \times 0.01°$ spatial resolution, which we intersect with county-level administrative maps. In 2010, there were 2,864 administrative units at the county level in China.

We obtain population from the 1990, 2000, and 2010 population censuses. We developed a geographic-information-system-based concordance from year to year to adjust for changes in county boundaries and administrative divisions over that period, using the assumption that population is uniformly spatially distributed within each county. This paper focuses on 2000–2010, the period that overlaps with high-resolution satellite air pollution data.

II. Did Migration Worsen Population Exposure to Pollution?

As shown in Martin and Zhang (2020), the first SEZs were established in 1984, with a progressive rollout over the following years. A third of the counties that received SEZ status that are still around today had zones first established between 1991 and 1994. There was a small wave of counties first establishing zones in 2000–2003 (14 percent), followed by a large expansion in 2006 (39 percent).

Over the period 2000–2010, population grew disproportionately in newly established zones. As shown in Table 1, counties with existing zones experienced population growth rates of 4.6 percent over the following decade, in line with the rate of non-SEZ counties. In contrast, newly established zones, representing 19 percent of counties and 26 percent of national population in 2000, experienced population growth rates of 15.6 percent, over 3 times the rate of non-SEZ counties.

Martin and Zhang (2020) document that the population in SEZs experienced, on average, significantly larger increases in air pollution than populations in non-SEZs. Table 2 presents raw figures. In 2000, prior to establishment, counties that later established SEZs had below-average annual mean levels of $PM_{2.5}$: 32.7 $\mu g/m^3$ in 2000 compared to 34.7 for never treated. In 2000, SEZs established earlier had pollution levels that were at the same level as non-SEZ counties. A gap formed and increased over the following years: by 2015, newer SEZs had pollution levels that were 8 percent higher than same-year non-SEZ counties, and older SEZs had pollution levels that were 11 percent higher.

Table 2—Average Levels of $PM_{2.5}$ Experienced

	2000	2005	2010	2015
Never SEZ	34.7	45.8	48.5	45.9
SEZ before 2000	34.5	50.5	54.0	50.8
SEZ 2000–2010	32.7	49.3	51.5	49.6

Notes: County-level pollution weighted by current-year population. 2005 and 2015 population interpolated and extrapolated, respectively, from 2000 and 2010 census data.

To determine how much migration contributed to national population exposure to pollution, we produce a histogram of population exposed to different levels of pollution in 2010 with two different sets of weights: exposure frequency given the current distribution of population and exposure frequency had county-level population proportions stayed at 2000 levels.[1] Figure 1 shows the results: large flows of migration, which include significant migration into SEZs, hardly change the distribution of pollution exposure. At the national level, population-weighted pollution in 2010 is 50.85 $\mu g/m^3$ using actual population and would have been 50.91 $\mu g/m^3$ under 2000 population patterns, representing a *decrease*, albeit a very small one (0.1 percent).

Key to understanding the small role of migration on pollution exposure, despite the large

[1] We note that this counterfactual does not represent where workers might otherwise have moved had it not been for pro-SEZ policies.

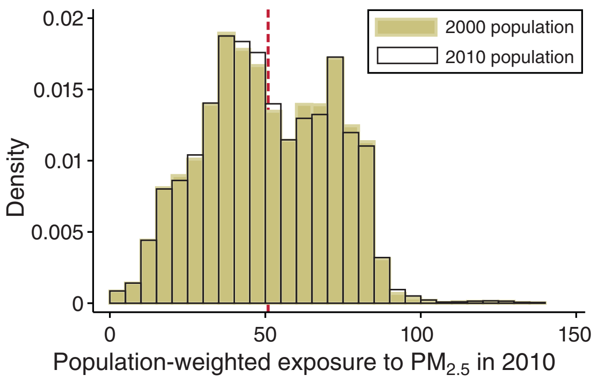

Figure 1. Exposure to Pollution in 2010 Based on Distribution of Population in 2010 (experienced) versus Distribution of Population in 2000 (had relocation not occurred)

Notes: Histogram of pollution in 2010. Outlined area is exposure frequency based on actual population in 2010; shaded area represents exposure frequency had county-level population proportions stayed at 2000 levels. Population-weighted pollution in 2010 is 50.85 $\mu g/m^3$ (shown in dashed red). Air quality data is $PM_{2.5}$ $(\mu g/m^3)$ from van Donkelaar et al. (2016).

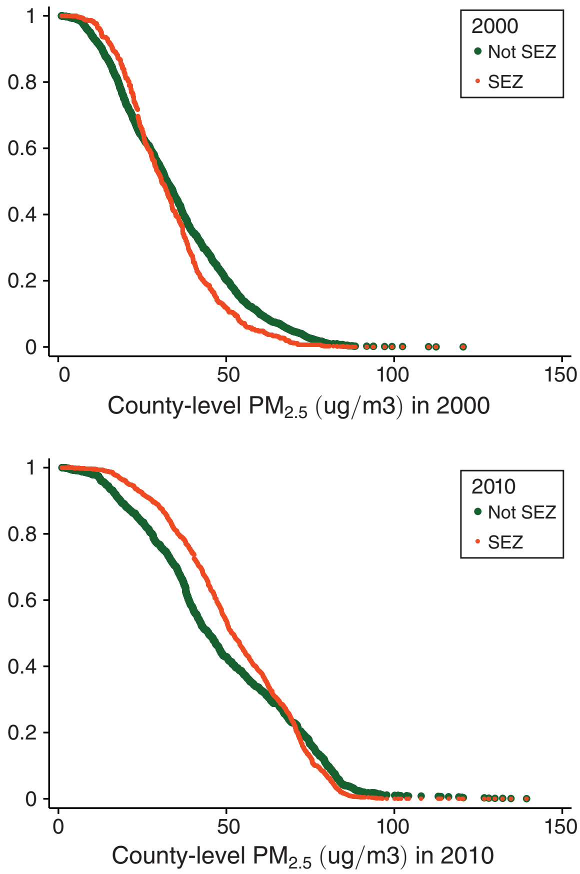

Figure 2. Fraction of Population Exposed to Pollution at a Given Level or Higher, by Year and SEZ Status

Notes: SEZ refers to any county that established an SEZ prior to 2010. Air quality data is $PM_{2.5}$ $(\mu g/m^3)$ from van Donkelaar et al. (2016).

flows into SEZs and the worsening average air quality in SEZs, is the heterogeneity in pollution across SEZs. Figure 2 presents cumulative distributions of the fraction of population exposed to pollution at a given level or higher by year and SEZ status. In each year, we see large variation in pollution exposure by residents of SEZ counties, similar to variation in exposure in non-SEZ counties. Ever-SEZ counties go from being, on average, cleaner in 2000 to dirtier in 2010. But the largest discrepancies between population exposure in an SEZ relative to the population exposure in other counties (the greatest horizontal distances between the two curves) in 2010 occur at relatively modest levels of pollution: 30–40 $\mu g/m^3$. In other words, although pollution does increase disproportionately in SEZs between 2000–2010, most of the difference comes from having a disproportionate number of counties at moderate levels of pollution and relatively fewer counties at very low levels.

The second part of the puzzle is where the migration takes place. Figure 3 plots changes in population between 2000–2010 as a function of county-level pollution averaged over 2000–2010; results are similar for both 2000 and 2010 levels. The bars to the right show population increases in SEZs, and the bars to the left, with axis flipped, show population increases in other counties. We see that population increases in SEZs between 2000 and 2010 occurred primarily in zones with relatively low levels of pollution: 72 percent of the population that moved into SEZs went into ones with average pollution levels no higher than 40 $\mu g/m^3$. Furthermore, the greatest differences in SEZ versus non-SEZ population increases occurred in SEZs with pollution levels in the middle 20–45 $\mu g/m^3$ range, while non-SEZ counties that gained population disproportionately had average pollution levels ranging from 70 to 125 $\mu g/m^3$. In non-SEZs, population growth was split almost equally across counties that by 2010 had above versus below average levels of pollution; in contrast, in SEZs, in-migration was almost twice as likely to favor lower-pollution counties.

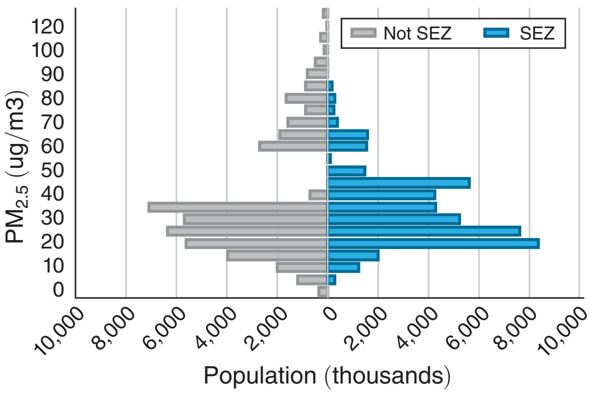

FIGURE 3. CHANGE IN POPULATION 2000–2010 BY EXPOSURE TO $PM_{2.5}$, AVERAGED OVER SAME PERIOD

Note: Air quality data is $PM_{2.5}$ ($\mu g/m^3$) from van Donkelaar et al. (2016).

In summary, between 2000 and 2010, pollution worsened across China, in particular among SEZs. There were also large flows of migration into SEZs, which awakens concerns that SEZ migration might have exacerbated population exposure to harmful pollution. We show, however, that because migrants moved into relatively cleaner SEZs, population movements did not worsen—if anything, they slightly improved—nationwide population exposure to pollution.

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