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Air Pollution and Mobility in Singapore during COVID-19 Pandemic[*]

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September 2020

Abstract

Singapore government established the circuit breaker policy in April 2020 in response to the escalation of COVID-19 situation. With forced telecommuting and reduced business activities, workplace mobility has plunged. Besides the economic downside of such policy, the decrease in mobility might unintentionally lower air pollution. In this paper, we use the circuit breaker as an instrumental variable (IV) to study the impact of human mobility on air quality in Singapore. We find that as workplace mobility decreases 10 percentage points, the $PM_{2.5}$ concentration will decrease by about 0.1 to 0.2 $\mu g/m^3$. We also find that the air pollution in Hong Kong is not significantly affected through this channel, since no movement control measures are imposed.

Keywords: COVID-19, coronavirus, PM2.5, lockdown

JEL Classification: Q51, Q53, I18

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1. Introduction

Since the Coronavirus Disease 2019 (COVID-19) swept across China in December 2019 and subsequently hit the world, recent studies have focused on the economic costs and consequences of the pandemic. For example, McKibbin and Fernando (2020) simulate seven scenarios of how the pandemic might evolve and estimate the potential macroeconomic loss in 24 countries. Abeysinghe and Tan (2020) study the impact of the disease on different sectors in Singapore. Maliszewska, Mattoo, and Mensbrugghe (2020) make simulations under two conditions and research the reactions of GDP and trade in different countries.

With countries imposing stringent social distancing measures and temporary city lockdown to curb the spread of disease, the effectiveness of these measures has also drawn much attention from academia. Besides the enormous cost of such measures, they also unintentionally deliver social benefits by means of lowering people's mobility. He, Pan, and Tanaka (2020) and Bao and Zhang (2020) study the improvement of air quality as a subsequent result of the lower mobility. Chen et al. (2020) further investigate the mortality rate reduction resulting from better air.

In this paper, we study the relationship between human mobility and air quality for Singapore and Hong Kong. Both cities share similar economic conditions and have low pollution levels. The evolution of the COVID-19 situation in the two cities are also similar. As two of the most popular destinations for Chinese tourists, both cities have experienced imported pandemic shocks and confirmed their first cases as early as 23 January 2020.[1] However, the response measures of the two governments are different. Singapore implemented a circuit breaker policy to stop the pandemic from escalating. The policy took effect on 7 April and lasted until 1 June.[2] During this period, all business, social, and other activities except essential services were either conducted through telecommuting from home or suspended (MOH, 2020). Hong Kong, however, did not implement a similar lockdown nor force its employees to telecommute in response to the pandemic. Instead, it adopted dynamic social distancing measures like restricting the number of people gathering with respect to confirmed COVID-19 cases. As a result of the policy difference, the two cities exhibited different mobility trends. For Singapore, due to the circuit breaker, workplace mobility dropped sharply in April. On the contrary, workplace mobility in Hong Kong remained stable without any structural break.

The circuit breaker primarily affects workplace mobility since it requires all business activities (except essential services such as supermarkets) to be conducted through telecommuting or to suspend.

[1] First case in Singapore: https://www.moh.gov.sg/news-highlights/details/confirmed-imported-case-of-novel-coronavirus-infection-in-singapore-multi-ministry-taskforce-ramps-up-precautionary-measures
First case in Hong Kong: https://www.coronavirus.gov.hk/eng/index.html
[2] https://www.moh.gov.sg/news-highlights/details/circuit-breaker-to-minimise-further-spread-of-covid-19

The inactivity entails lower road traffic and thus less emission and better air quality.[3] This study attempts to test if the circuit breaker has a significant effect on Singapore's air pollution. Some related studies have already been done in China. Bao and Zhang (2020) study the air quality of the 44 northern cities in China and find that the lockdown negatively and significantly affects air pollution. Using data from 120 cities in China, Zhu et al. (2020) find that human mobility is positively linked to air pollution. He, Pan, and Tanaka (2020) employ the Difference in Differences (DID) model by comparing China's cities with and without lockdown and show that the lockdown policy leads to a remarkable improvement in air quality. As a country with a relatively high pollution level, it is predictable that the lockdown in China indirectly improved air quality. However, whether such an effect exists in countries with lower pollution levels is still unclear. Therefore, our study puts Singapore in the spotlight, trying to test whether the circuit breaker significantly affects Singapore's air quality. We will use Hong Kong as a control since there is no lockdown measure imposed.

Our study follows the Instrumental Variable (IV) approach used by Lu, Sun, and Zheng (2017). In their research on the causal effect of traffic congestion on air pollution, the summer and winter vacations are used as instrumental variables for congestion to mitigate endogeneity. Their results not only confirm the causal relationship between congestion and pollution but also reveal the impact of driving-to-school trips on congestion. Similarly, our study uses circuit breaker as an instrument, concerning two potential sources of endogeneity. First, unobserved variables such as manufacturing activities might correlate with mobility and affect pollution. Second, the use of workplace mobility to reflect road traffic might cause measurement errors. We expect this IV approach to give the true effect of workplace mobility. Our results show that in Singapore, mobility is positively and significantly linked to air pollution. For a 10 percentage point decrease in workplace mobility, $PM_{2.5}$ concentration will decrease by about 0.1 to 0.2 $\mu g/m^3$. As air pollution is positively associated with short-term risk of mortality in Singapore (Ho et al., 2019), our study also suggests potential public health benefits that might be of interest to future research. We run an Ordinary Least Square (OLS) regression for Hong Kong as there is no lockdown imposed. The insignificant results are explained by the lack of variation in Hong Kong's data.

The remainder of this paper is presented as follows. Section 2 and 3 introduce the data and models used in our analysis. Section 4 shows the empirical findings. Section 5 concludes.

2. Data Description

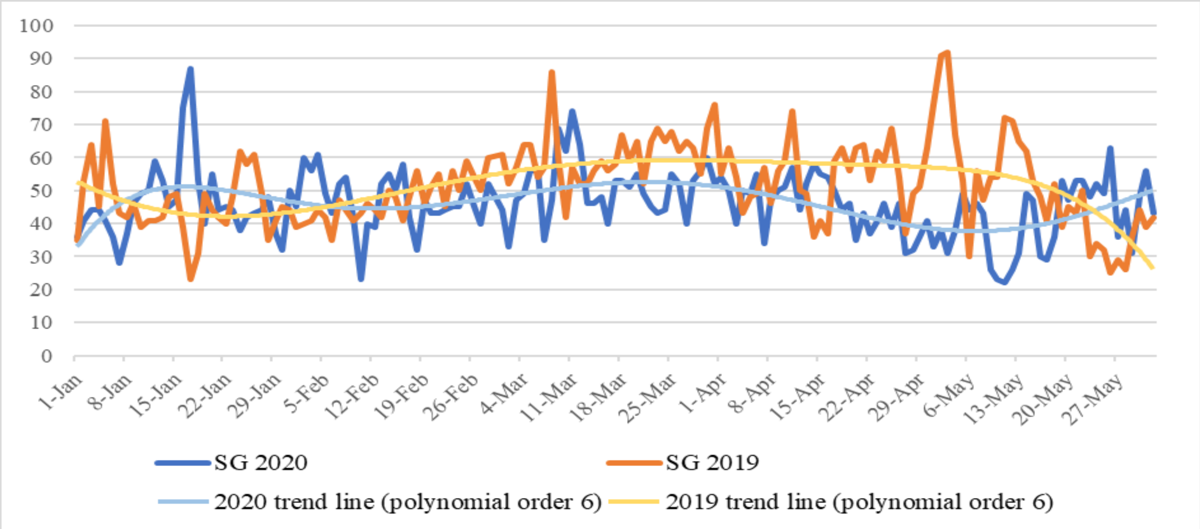
Our study employs three sets of data: pollutant level, mobility and meteorological variables. We use the first one as the dependent variable, the second one as the main independent variable, and the third one as the control.

[3] Holman (1999) aruges that road traffic and economic activities are major sources of pollution in a city.

We collected daily air pollutant levels for Singapore and Hong Kong from the World Air Quality Index (WAQI) project (https://aqicn.org/data-platform/register/). For both cities, we consider only $PM_{2.5}$ and PM_{10} since these are the two major pollutants. Other pollutants such as O_3, NO_2, SO_2, and CO remain at low levels and lack fluctuation in the period of analysis.[4] Notice that the pollutant level is an Air Quality Index (AQI) in accordance with the US EPA standard but not raw concentration in air.[5]

Figure 1 demonstrates Singapore's $PM_{2.5}$ levels between January 1 and June 1 in 2019 and 2020, respectively. From January to March, the $PM_{2.5}$ values in the two years are roughly the same. From March to mid-May, the $PM_{2.5}$ in 2020 is visibly lower than that in 2019. This period coincides with the worsening of the COVID-19 situation in Singapore. Though the trend line of $PM_{2.5}$ in 2020 alone does not show an obvious downward trajectory, contrasting it with the data from the same period in 2019 clearly reveals the improvement in air quality. We hypothesise that this improvement is due to the circuit breaker policy in Singapore, which reduced workplace mobility.

Figure 1. Singapore PM2.5 in 2019 and 2020



Source: https://aqicn.org/

Figure 2 shows the Hong Kong's $PM_{2.5}$ levels. The $PM_{2.5}$ level from March in either year shows a slightly downward trend, although in 2020 the slope is steeper. Since there is no strict lockdown in Hong Kong, workplace mobility drops might not be the primary cause of this change.

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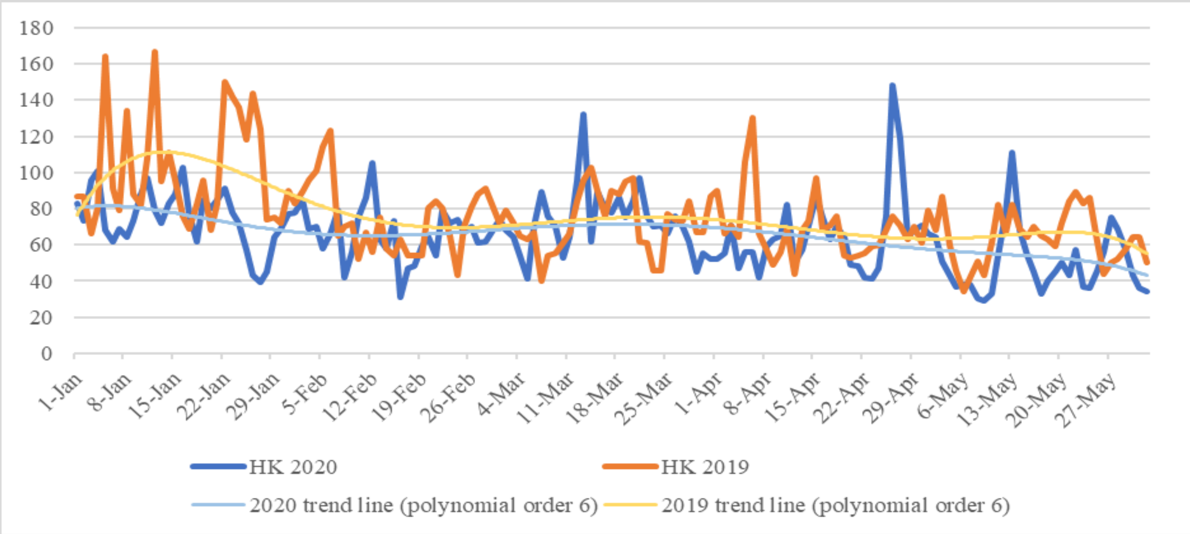
[4] $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, and CO are the most commonly used pollutants in the literature (Bao & Zhang, 2020; Lu et al., 2017; Zhu et al., 2020).

[5] The US EPA calculating methods for AQI: https://www.airnow.gov/publications/air-quality-index/technical-assistance-document-for-reporting-the-daily-aqi/

Figure 2. Hong Kong $PM_{2.5}$ in 2019 and 2020



Source: https://aqicn.org/

The data for the independent variable, daily workplace mobility, is collected from the COVID-19 Community Mobility Reports by Google between February 15, 2020 and June 1, 2020. It measures the workplace visits, and thus reflects the road traffic during this period. The underlying assumption here is that workplace mobility affects traffic only through affecting private transport usage. Public transport operates on its own schedule and won't be affected by the number of people using it. We further discuss in section 2.2 about the potential problem of using workplace mobility as a proxy of traffic and our strategy to circumvent it.

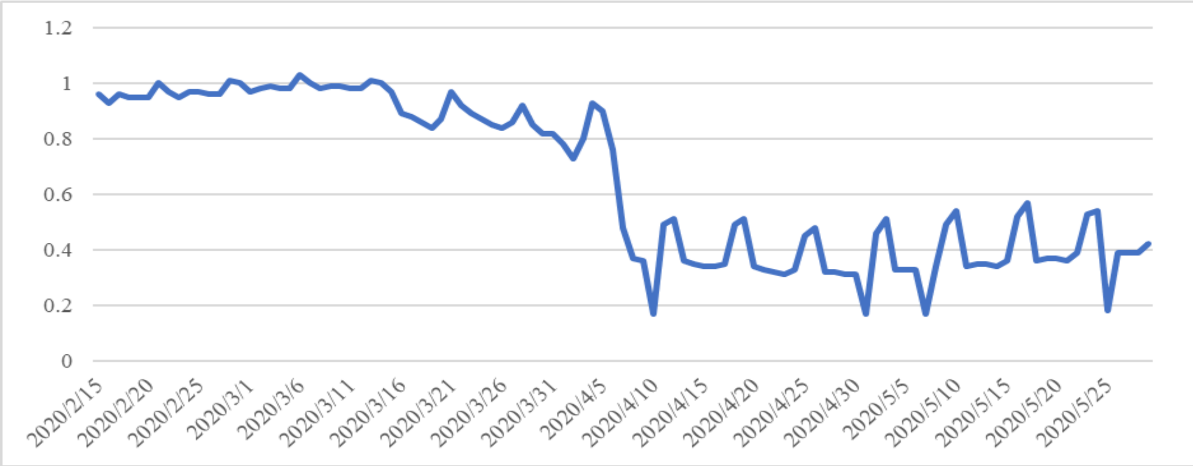
Also, it is worth noting that Google reports the mobility value for each day as the percentage of a baseline value for that day of the week. This baseline is the median mobility, for the respective weekday, during the five-week period from January 3 to February 6, 2020. Thus, we have to assume that the baseline is the same for each weekday or data points at two given times cannot be compared.

Another caveat of the dataset is that the mobility values are lower on weekdays than on weekends. This seasonality could be attributed to the fact that traveling to work sharply drops with people switching to telecommuting on workdays. On the other hand, people who work on weekends are likely to be in the essential services. Thus, the mobility on weekends doesn't change that much.

Figure 3 shows the workplace mobility in Singapore. There's a sharp drop in mobility to about 40% of the baseline level in early April when the circuit breaker began. The several troughs during this period are consistent with public holidays. We introduce the circuit breaker dummy (CB = 1 from April 7, 2020 to June 1, 2020) to capture the structural break.

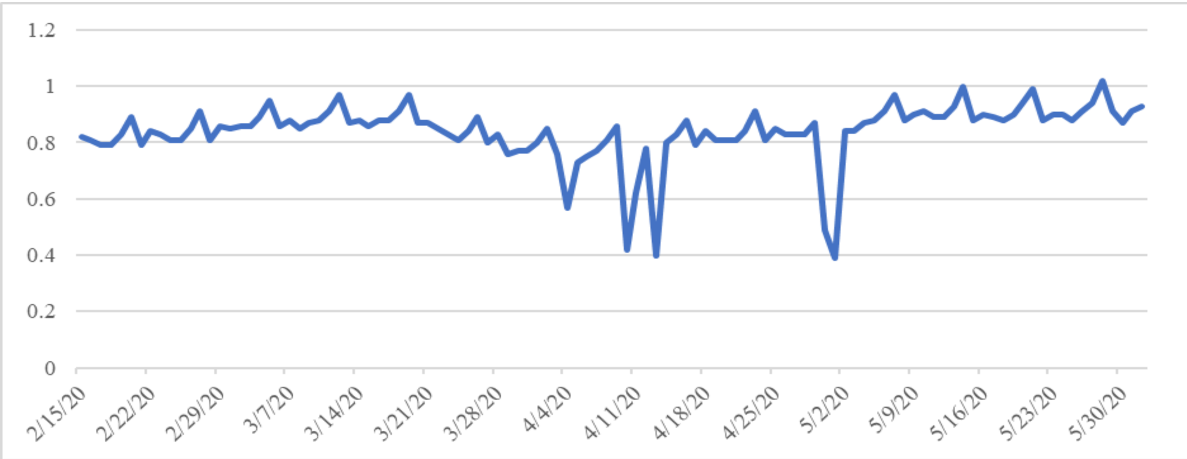
Figure 4 shows that workplace mobility remained stable in Hong Kong at about 85% of the baseline level.

Figure 3. Singapore workplace mobility



Source: COVID-19 Community Mobility Reports

Figure 4. Hong Kong workplaces mobility



Source: COVID-19 Community Mobility Reports

Since weather conditions also affect air quality (Orlic et al., 1999), we include temperature, wind speed, and humidity in our models as controls to capture the meteorological effect. The data is also collected from the WAQI project. We exclude temperature in modeling Singapore's pollution because its tropical climate features almost invariant temperature throughout the year with indistinguishable seasonal effect.

We have two regression designs. In the first one, we treat weekends and public holidays as two different dummies because they have opposite effects on mobility (workplace mobility is higher on weekends but lower on public holidays than on weekdays). However, since our dataset is small and contains only a few public holidays, in our second design, we treat the weekends and public holidays as one dummy for non-working days.

Table 1 and 2 report the descriptive statistics of the variables for Singapore and Hong Kong, respectively. The period of analysis falls between February 15, 2020 and June 1, 2020, when the Google Mobility data is available.

Table 1: Descriptive statistics for Singapore data

	Definition	Obs.	Mean	Max	Min	Std. Dev.
$PM_{2.5}$	The $PM_{2.5}$ in the AQI form	155	41.877	78	21	9.061
PM_{10}	The PM_{10} in the AQI form	155	24.994	45	14	4.289
Workplace mobility	Workplaces mobility as a percentage of the original level before the COVID-19 outbreak	108	0.647	1.030	0.170	0.284
Circuit breaker	1 = circuit breaker period; 0 = otherwise	155	0.361	1	0	0.482
Humidity	Daily humidity (%)	136	80.041	94	70	4.448
Wind speed	Daily wind speed (m/s)	136	2.417	5.60	1	0.921
Public holiday	1 = holidays; 0 = otherwise	155	0.052	1	0	0.222
Weekends	1 = weekends; 0 = otherwise	155	0.284	1	0	0.452

Source: Asia Competitiveness Institute

Table 2: Descriptive statistics for Hong Kong data

	Definition	Obs.	Mean	Max	Min	Std. Dev.
$PM_{2.5}$	The $PM_{2.5}$ in the AQI form	155	58.290	139	22	17.227
PM_{10}	The PM_{10} in the AQI form	155	25.303	58	8	10.364
Workplace mobility	Workplaces mobility as a percentage of the original level before the COVID-19 outbreak	108	0.840	1.020	0.390	0.105
Temperature	Daily temperature (℃)	136	22.002	30	12	4.207
Humidity	Daily humidity (%)	136	73.793	93	32	11.637
Wind speed	Daily wind speed (m/s)	136	6.455	19	1.4	3.334
Public holiday	1 = holidays; 0 = otherwise	155	0.065	1	0	0.246
Weekends	1 = weekends; 0 = otherwise	155	0.284	1	0	0.452

Source: Asia Competitiveness Institute

3. Empirical Model

We employ the instrumental variable approach in our study because using workplace mobility directly as an independent variable creates potential problems. For one thing, we might omit some unobserved variables that correlate with both mobility and pollution, for instance, manufacturing activities. For another, workplace mobility cannot precisely measure the traffic condition. People can commute to work by either private or public transport, but only private transport is of concern since everyday pollution from public transport is unchanged. However, we cannot accurately identify the daily share of people taking private transport. Thus, the use of workplace mobility as a proxy of traffic condition might cause measurement errors.

To mitigate these endogeneity issues, we use the circuit breaker policy as an IV for mobility. As discussed earlier, the circuit breaker policy requires compulsory telecommuting. Thus, we are confident that the IV is highly correlated with workplace mobility. Besides, we justify that there is little relationship between the circuit breaker and manufacturing activity in that the circuit breaker policy did not give direct instructions on manufacturing. Any change in manufacturing activity might be attributed to the supply and demand shock resulting from the world-wide pandemic, but not the circuit breaker policy itself.

Equation (1) shows the detailed specification of our model.

$$Pollution_t = \beta_0 + \beta_1 Mobility_t + \beta_2 pollution_{t-1} + \beta_3 Weather_t + \beta_4 Days_t + \varepsilon_t \qquad (1)$$

The dependent variable $Pollution_t$ measures air pollution. We use two pollutants, $PM_{2.5}$ and PM_{10} as the indicators of air quality, respectively. We also include lag one air pollution $Pollution_{t-1}$ as a control besides the weather and non-working day. We expect this variable to be positively related to $Pollution_t$. The coefficient of mobility is expected to be positive as well, indicating a positive relationship between mobility and pollution. We apply the IV estimator for Singapore and OLS estimator for Hong Kong. No instrument is used for Hong Kong's case study because Hong Kong has no massive mobility control.

4. Empirical Results

This section reports our results. Note that the models presented here use the holiday and weekends as separate dummies. For models with holiday and weekends as one dummy, see Table A1 to A4 in the Appendix.

4.1. Results of Singapore

Table 3 presents the regression results for Singapore. The coefficients of workplace mobility in all models are positive and significant. Meanwhile, the first-stage F-statistics in columns (2) and (4) are large. This assures us that our IV is not weak and confirms our hypothesis that the circuit breaker leads to lower mobility, resulting in lower air pollution. Our models with IV indicate that as workplace mobility increases 10 percentage points, the $PM_{2.5}$ AQI will increase about 0.99 to 1.48, which is equivalent to an increase of 0.1 to 0.2 μg/m^3 in $PM_{2.5}$ concentration.[6] Given the low pollution level in Singapore, this is about a 1% to 2% increase in pollution. The lagged $PM_{2.5}$ is significant in Models (1) and (2), showing that the pollution level is highly dependent on the past. The coefficients of mobility are slightly larger in IV regressions than in OLS ones. This finding might imply that the measurement error (due to the proxy of traffic condition by mobility) and not the omitted-variable bias is the dominant source of endogeneity.

Table 3: Regression results of Singapore

Dependent variable: $PM_{2.5}$	(2) OLS	(2) IV	(3) OLS	(4) IV
First lag of $PM_{2.5}$	0.4035***	0.3952***	-	-
	(0.1100)	(0.1069)		
Workplace mobility	8.9726**	9.9254***	14.2679***	14.7715***
	(3.5523)	(3.4224)	(3.6791)	(3.5313)
Wind speed	-3.0674**	-3.2746***	-4.2598***	-4.3688***
	(1.2368)	(1.1480)	(1.2799)	(1.2126)
Humidity	-0.4779**	-0.4978***	-0.7161***	-0.7250***
	(0.2013)	(0.1927)	(0.1995)	(0.1917)
Holiday	1.5652	1.8176	4.2971*	4.4141*
	(2.2209)	(2.2033)	(2.5253)	(2.4796)
Weekends	-3.7997**	-3.9387***	-5.1415***	-5.2079***
	(1.5817)	(1.5081)	(1.8800)	(1.8174)
Obs.	98	98	98	98
First-stage F-test	-	247.63	-	290.27

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

4.2. Results of Hong Kong

Table 4 shows the OLS regression results for Hong Kong. The coefficients of workplace mobility are insignificant in both models. However, this insignificance alone cannot negate the effect of mobility on air pollution as it may as well arise from the invariability of Hong Kong's data. As shown in Figure 4, Hong Kong's mobility data in the period of analysis lacks variation and is hence insufficient for identifying a linear relationship to pollution. As a result, the coefficient of workplace mobility in each model registers a large standard error that causes insignificance.

[6] We use the US EPA standards to convert between AQI and concentration: https://www.airnow.gov/publications/air-quality-index/technical-assistance-document-for-reporting-the-daily-aqi/

Table 4: Regression results of Hong Kong

Dependent variable: $PM_{2.5}$	(1)	(2)
	OLS	OLS
First lag of PM_{25}	0.5536***	-
	(0.0709)	
Workplace mobility	-5.8752	1.3424
	(23.5048)	(28.8266)
Temperature	-0.7115*	-1.4724***
	(0.4145)	(0.4846)
Wind speed	-0.9112**	-1.0058**
	(0.3954)	(0.4587)
Humidity	-0.1006	-0.3145**
	(0.1429)	(0.1558)
Holiday	-0.6621	1.6325
	(10.3788)	(12.1422)
Weekends	-0.3100	0.2604
	(3.8779)	(4.2159)
Obs.	98	98
R-squared	0.4623	0.2016

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

The empirical exercise draws an interesting comparison between Hong Kong and Singapore. With circuit breaker being the major policy difference during the COVID-19 outbreak, the workplace mobility in the two cities diverges; it drops in Singapore while remains almost unchanged in Hong Kong. This allows us to empirically test the effect of circuit breaker with Hong Kong serving as a control. Results for Singapore confirm that this circuit breaker effect is significant, and that air quality indeed improved during this period. Our study suggests that even with a low pollution level, countries like Singapore can benefit from lockdown measures.

4.3. Robustness Check

For a robustness check, we use the PM10 AQI as the dependent variable to test if the effects of circuit breaker and mobility vary across pollutant types. It is chosen because PM10 is the second-highest pollutants in both Singapore and Hong Kong. The results are shown in Table 5 and 6.

Our results are robust to varying pollutant types. Model (3) and (4) in Table 5 report results similar to that in Table 3, supporting our previous conclusion that the circuit breaker significantly improved the air quality in Singapore. Results in Table 6 are also consistent with our prior finding that with no measure like circuit breaker and thus little change in mobility, the air pollution in Hong Kong is not significantly affected.

Table 5: Regression results using PM10 in Singapore

Dependent variable: PM_{10}	(1) OLS	(2) IV	(3) OLS	(4) IV
First lag of PM_{10}	0.5515***	0.5619***	-	-
	(0.0867)	(0.0855)		
Workplace mobility	1.8039	1.1933	4.1167**	2.7221*
	(1.2511)	(1.1639)	(1.6307)	(1.4654)
Wind speed	-0.4527	-0.3221	-0.8708	-0.5690
	(0.4716)	(0.4337)	(0.5563)	(0.5137)
Humidity	-0.0170	-0.0054	-0.0977	-0.0730
	(0.0731)	(0.0690)	(0.0805)	(0.0775)
Holiday	-0.3927	-0.5395	0.4034	0.0793
	(1.4532)	(1.4423)	(1.3532)	(1.4247)
Weekend	-1.3627**	-1.2837**	-1.5858**	-1.4018**
	(0.6359)	(0.6204)	(0.7267)	(0.7082)
Obs.	98	98	98	98
First-stage F-test	-	276.60	-	290.27

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

Table 6: Regression results of PM10 in Hong Kong

Dependent variable: PM_{10}	(1) OLS	(2) OLS
First lag of PM_{10}	0.5245***	-
	(0.0771)	
Workplace mobility	20.9679	30.4264
	(17.2762)	(20.7566)
Temperature	-0.6678**	-1.0731***
	(0.2666)	(0.3275)
Wind speed	-0.0591	-0.1167
	(0.2624)	(0.3067)
Humidity	-0.1413	-0.2592**
	(0.1004)	(0.1036)
Holiday	7.8841	12.4442
	(8.7535)	(9.8789)
Weekend	-0.1481	-0.0709
	(2.4267)	(2.4456)
Obs.	98	98
R2	0.4389	0.1881

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

5. Conclusion

Governments around the world have established a series of measures to curb the spread of the COVID-19 virus. As one of the upsides of these measures, many major cities have seen an improvement in their air quality. This paper focuses on the air quality in two Asian cities, Singapore and Hong Kong, and studies the effect of mobility on pollution with or without massive movement control, such as Singapore's circuit breaker. By employing an instrumental variable approach and using the circuit breaker as an IV for workplace mobility, we find that workplace mobility is positively and significantly linked to the $PM_{2.5}$ level in Singapore. Specifically, our results find that there is an increase of about 0.1 to 0.2 $\mu g/m^3$ in $PM_{2.5}$ concentration for every 10 percentage point increase in workplace mobility. In contrast to Singapore, Hong Kong did not implement a forced telecommuting measure; its workplace mobility did not vary much to the extent that we even cannot find any significant relationship between its mobility and pollution.

One limitation of this paper is that our mobility data might be flatter than true mobility. Recall that our mobility data is a percentage of the baseline, and we assume the baseline mobility of each workday to be the same. If this assumption does not hold, the true mobility should have more fluctuation than ours. This innate feature of our dataset might also contribute to the insignificance of the Hong Kong results to some extent.

Our study unveils an interesting finding that even countries with rather low pollution levels can still benefit from lockdown policies. As of 2017, the lower respiratory infection was the number two cause of death in Singapore, despite the low pollution level.[7] The long-run impact of lockdown policy on public health remains an interesting topic for future investigation.

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Appendix

Table A1: Regression results of Singapore (weekend and holiday as one dummy)

Dependent variable: $PM_{2.5}$	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
First lag of $PM_{2.5}$	0.4267***	0.4125***	-	-
	(0.1079)	(0.1051)		
Workplace mobility	7.4113**	9.2288***	12.0224***	13.9421***
	(3.2562)	(3.2439)	(3.4681)	(3.4010)
Wind speed	-2.8275**	-3.2446***	-3.9997***	-4.4359***
	(1.2120)	(1.1516)	(1.2530)	(1.2391)
Humidity	-0.4346**	-0.4713**	-0.6661***	-0.6995***
	(0.1974)	(0.1950)	(0.2048)	(0.2048)
Holiday & weekends	-2.9646*	-3.1194**	-3.7735**	-3.9211**
	(1.4978)	(1.4511)	(1.8117)	(1.7662)
Obs.	98	98	98	98
First-stage F-test	-	192.78	-	242.31

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

Table A2: Regression results of Hong Kong (weekend and holiday as one dummy)

Dependent variable: $PM_{2.5}$	(1)	(2)
	OLS	OLS
First lag of $PM_{2.5}$	0.5533***	-
	(0.0707)	
Workplace mobility	-4.7683	-1.9964
	(12.5843)	(13.6201)
Temperature	-0.7200*	-1.4485***
	(0.3626)	(0.4251)
Wind speed	-0.9071**	-1.0168**
	(0.3719)	(0.4317)
Humidity	-0.1021	-0.3127**
	(0.1386)	(0.1526)
Holiday & weekends	-0.1831	0.0130
	(3.9016)	(4.2858)
Obs.	98	98
R2	0.4623	0.2015

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

Table A3: Regression results using PM10 in Singapore (weekend and holiday as one dummy)

Dependent variable: PM_{10}	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
First lag of PM_{10}	0.5543***	0.5626***	-	-
	(0.0858)	(0.0851)		
Workplace mobility	1.6051	1.1133	3.7019**	2.5802*
	(1.1222)	(1.1129)	(1.4604)	(1.4076)
Wind speed	-0.4229	-0.3123	-0.8268	-0.5719
	(0.4594)	(0.4240)	(0.5414)	(0.5079)
Humidity	-0.0102	-0.0011	-0.0868	-0.0673
	(0.0690)	(0.0659)	(0.0750)	(0.0730)
Holiday & weekends	-1.4462**	-1.4094**	-1.5362**	-1.4500**
	(0.5815)	(0.5708)	(0.6611)	(0.6516)
Obs.	98	98	98	98
First-stage F-test	-	209.95	-	242.31

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute

Table A4: Regression results of PM10 in Hong Kong (weekend and holiday as one dummy)

Dependent variable: PM_{10}	(1)	(2)
	OLS	OLS
First lag of PM_{10}	0.5343***	-
	(0.0781)	
Workplace mobility	5.3041	5.7409
	(9.3960)	(10.9654)
Temperature	-0.5623**	-0.9160***
	(0.2314)	(0.2859)
Wind speed	-0.1019	-0.1873
	(0.2652)	(0.3078)
Humidity	-0.1351	-0.2522**
	(0.1023)	(0.1041)
Holiday & weekends	0.0230	0.0861
	(2.4191)	(2.4572)
Obs.	98	98
R2	0.4307	0.1676

Notes: [a] Robust standard errors in parentheses; [b] *** p<0.01, ** p<0.05, * p<0.1.
Source: Asia Competitiveness Institute