Did Covid-19 Precautions and Lockdowns Cause Better Air Quality? Empirical Findings from Turkish Provinces

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Abstract

The Covid-19 pandemic have dramatically affected the socio-economic structure in the world since governments put into action considerable precautions including lockdowns to reduce the speed of the contagion. Focusing on this point, we empirically investigate the environmental outcomes of the Covid-19 precautions and lockdowns in Turkey. The empirical analysis through the data obtained from different measurement stations indicate that the air pollution in the selected Turkish cities decreased due to the implemented precautions. The findings suggest that the Covid-19 might be an opportunity to rethink some economic and behavioral practices, as demonstrated by the reduction in the emission of air pollutants.

Keywords	***DOI***	***JEL code***
Covid-19 pandemic, social interaction, greenhouse gas emission	*https://doi.org/10.54694/stat.2021.34*	*Q53, Q56, R19*

INTRODUCTION

The Covid-19 pandemic has been radically affecting the world economy since February 2020. The governments implemented different measures including lockdowns to reduce the spread of the disease. Many companies have switched then to remote-working system and many others have adjusted their production systems to the new pandemic order. Precautions that were efficient in reducing the contagion

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of the pandemic caused severe repercussions for economies across the world. The "Great Lockdown" has triggered the deepest global recession (–5.2%) since World War II and the highest synchronization of national recessions since 1870 according to the World Bank estimates (WB, 2020).

Although economic issues caused by the pandemic are undoubtedly important, the recession and social isolation had some positive environmental consequences. Lower production and reduced social interactions increased the air quality, especially in industrial zones, metropolitan areas, and city centers. At this point, a new literature in the environmental science has emerged. For instance, Sharma et al. (2020) analyzed whether the restricted population activities during the Covid-19 pandemic led to better air quality in 22 cities of India. Their findings showed that the air quality got better due to lockdown enforcements. Dantas et al. (2020) investigated the impact of Covid-19 lockdowns on air quality in Rio de Janeiro, Brazil. The findings indicated that the air polluting gas amount decreased by about 24%–43% compared to the past year. Similarly, Nakada and Urban (2020) did an analysis for São Paulo, Brazil and they found even higher rate of decrease in greenhouse gas emission (more than 50%). Berman and Ebisu (2020) compared the 2017–2019 mean air pollution level with the Covid-19 period for the US. Their findings showed that especially the nitrogen dioxide level decreased by 25% during the Covid-19 period. Xu et al. (2020) analyzed the impact of pandemic on air quality of the selected Chinese provinces. Their analysis showed that the harmful gas emissions decreased by almost 50% compared to the previous years. By analyzing the air pollution data of Korea, Ju et al. (2021) found that due to the decreasing social and traffic activities, the harmful particles in the air decreased during the Covid-19 pandemic. Muhammad et al. (2020) examined the same issue for some major epicenters of Covid-19 such as China, Italy, Spain, and the US. Their findings based on the data obtained from NASA (National Aeronautics and Space Administration) revealed that air pollution in these countries decreased up to 30%. Venter et al. (2020) investigated whether Covid-19 lockdowns caused a global air pollution decline and found that there were significant reductions in harmful gas emissions. Zambrano-Monserrate et al. (2020) focused on both positive and negative outcomes of the lockdowns during the Covid-19 pandemic in China, Italy, Spain, and the US. They emphasized that decreasing production activities positively influenced the environment by improving the air quality. However, millions of people staying at home adversely affected the environment due to the increasing amount of inorganic and organic domestic wastes.

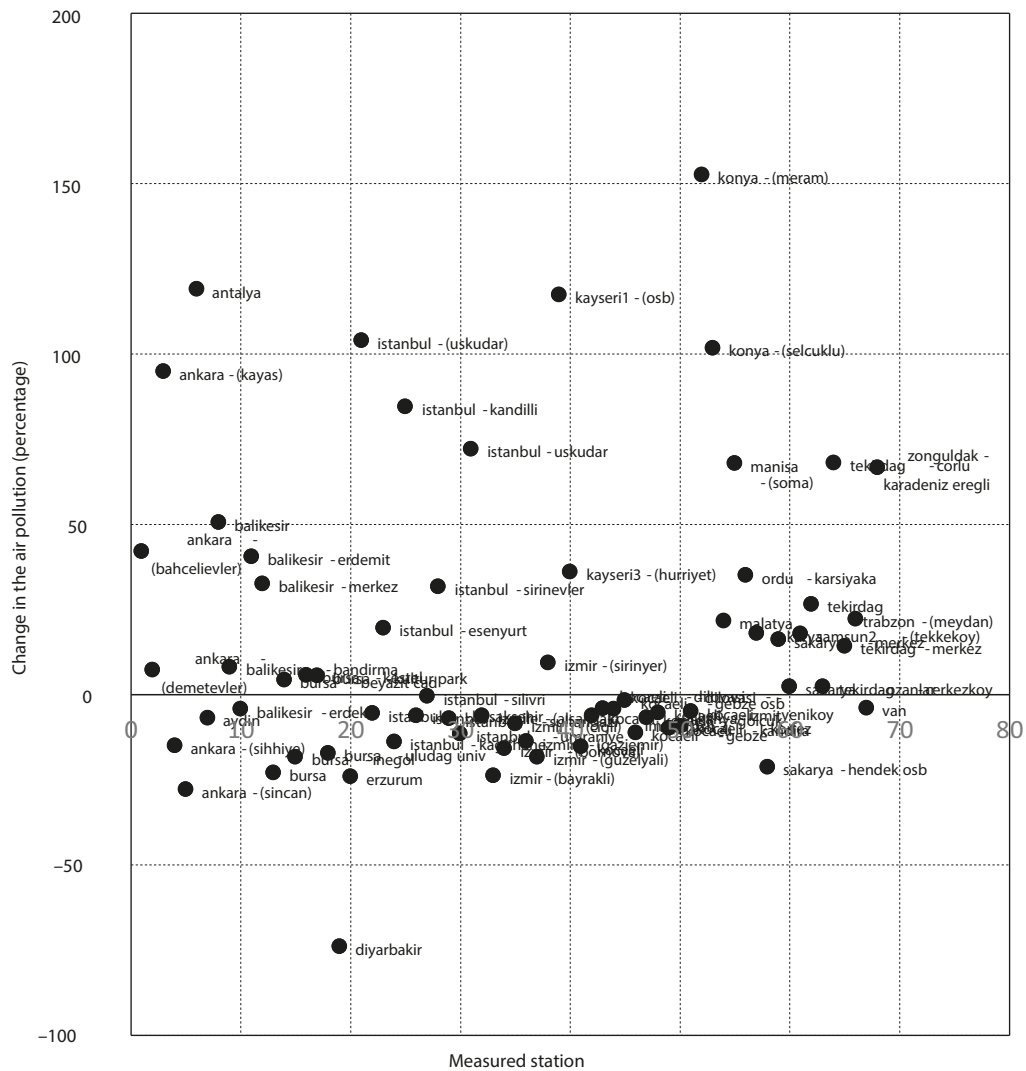
Some other studies, on the other hand, dealt with the issue for the Turkish case. Aydin et al. (2020) found that the air quality in terms of 2.5μm particulate matter (PM2.5) improved in Turkey during the lockdown period. Yet another study considering the PM2.5 is Rodríguez-Urrego and Rodríguez-Urrego (2020) which focused on the air quality for the 50 capital cities around the world during the pandemic period. Despite some retrograding capitals, they found a significant air quality improvement after the lockdown enforcements for the overall sample. As for Ankara, the capital city of Turkey, their results showed a decrease in the PM2.5 emissions. Sahin (2020) investigated the changes in selected particulate matters during March 2020 in Istanbul which is the biggest city of Turkey. The findings of the study revealed notable reductions in emission levels during March.

The empirical evidence shows the air quality in many countries changed for the better during the pandemic period. Limited production capacity and minimized social activity led to lower greenhouse gas emission and higher air quality level. From this point of view, we aim to empirically analyze the same possible impact for Turkish provinces. To this end, we gather data about air quality from different measurement stations located in different parts of Turkey. As the first Covid-19 case in Turkey was observed on March 11, 2020 and the government decided to normalize the economic and social life starting from June 1, 2020, we consider this period in which many precautions and lockdowns were put into action.

First, we compare both the air quality levels of March 11–May 28 of 2019 and December 31–March 10 of 2020 periods with the period of March 11–May 28 of 2020 to find evidence favoring an increase in air quality in some Turkish cities. The preliminary outlook is shown in Figures 1 and 2. The Air Quality

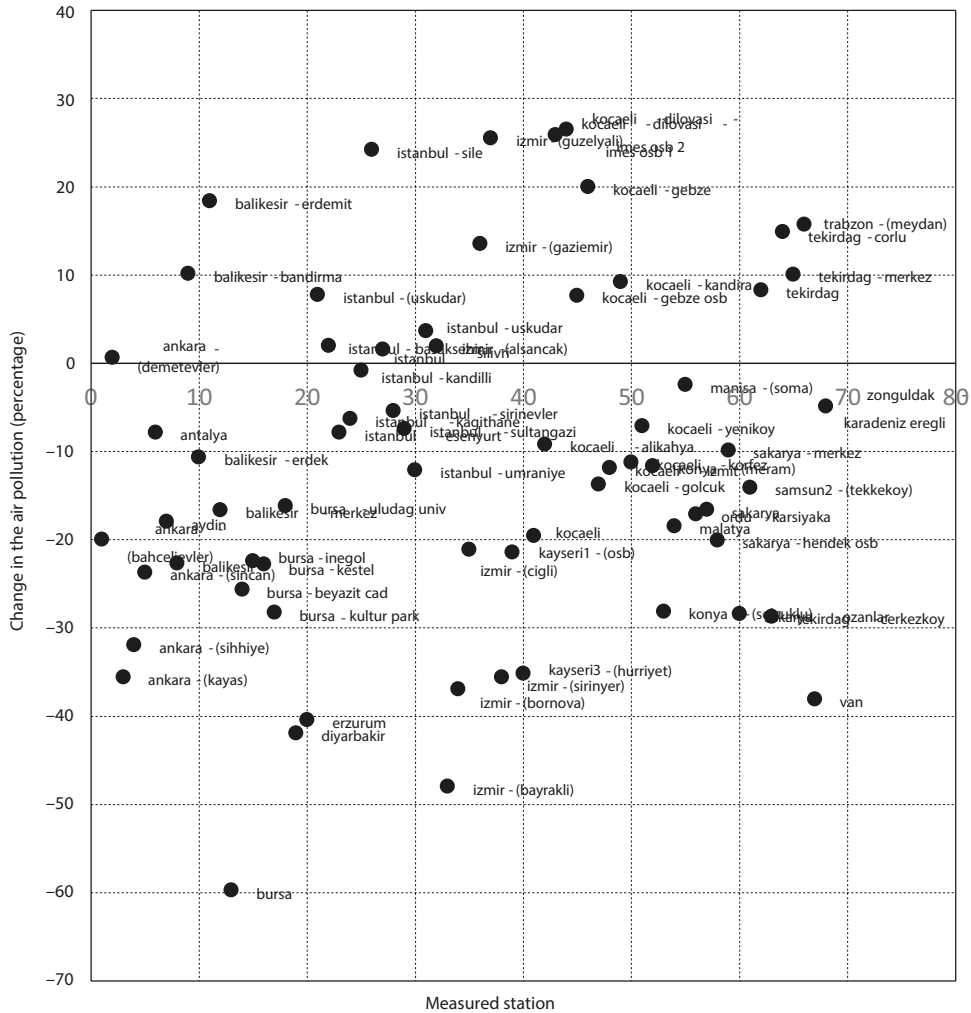
index which will be explained in detail in the next section is an inverse index and lower values indicate better air quality. As observed in Figure 1, there are improvements in air quality of more than 50% of the cities when we compare the active Covid-19 period in Turkey with the same period of the last year (2019). In the first Figure, on the other hand, we also see that the air quality of some other stations worsens. However, since we have not associated the air quality data with any explanatory factors yet, one may only focus on the improvements. When we check out for the December 31 of 2019–March 10 of 2020 period (which corresponds to an interval starting with the first Covid-19 case in the world and ending with the day before the first case in Turkey), we observe an improvement in air quality in 78% of the stations.

Figure 1 Change in air pollution (from March–May 2019 to March–May 2020)



Source: World Air Quality Index (WAQI) project

Figure 2 Change in air pollution (from December 31, 2019–March 10, 2020 to March 11–May 28, 2020)



Source: World Air Quality Index (WAQI) project

Although these basic statistical findings are important, they only reflect a potential relationship between the time trend (covering pre- and post-Covid-19 periods) and air quality level. Here, we aim to observe whether the air quality increased due to the precautions implemented by the government. To our knowledge, although some of the previous studies investigated the air quality in Turkey during the Covid-19 pandemic, this is the first study statistically estimating the impact of Covid-19 precautions on the air quality in Turkey via a constructed precaution series. In other words, the present study tries to observe the impacts of changing precautions enforced by the government. This is a more comprehensive approach compared to the previous studies dealing with the issue only by comparing pre- and post-pandemic periods. Our empirical results indicate that the air quality got better due to the implemented precautions in more than half of the selected stations.

The paper is organized as follows. Section 1 describes data and methodology. Section 2 discusses the empirical findings. Last section concludes with some policy implications.

1 DATA AND METHODOLOGY

We analyze the impact of the precautions implemented against Covid-19 on air quality in Turkey. For this purpose, we use the air quality index values at 68 stations in 21 provinces for the December 31, 2019–May 28, 2020 period. We use air quality index data gathered from the World Air Quality Index (WAQI) project. The WAQI is a non-profit project launched in 2007. The WAQI provides transparent air quality information for more than 130 countries, covering over 30 000 stations in 2000 major cities.[4] The composite air quality index is calculated as follows by using the individual pollutant variables in the WAQI project:

$$AQI = \max(AQI_{PM_{2.5}} AQI_{PM_{10}}, AQI_{O_3}, AQI_{NO_2}, AQI_{SO_2}, AQI_{CO}), \quad (1)$$

where Air Quality Index (AQI) is calculated by using particulate matter ($PM_{2.5}$ and PM_{10}), Ozone (O_3), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), and Carbon Monoxide (CO) emissions. The Air Quality Index is valued as the highest value of these measurements. In other words, if all the other measurements are zero but only one of them has a value greater than zero, then the AQI value is determined as this only value.

We choose the stations depending on the availability of data for the analysis period. Note that as some provinces have more than one station, air quality index values may differ for the same province. We use two explanatory variables in the econometric analysis. The first one is the lockdown variable which is a dummy variable that takes a value of 1 for the days when there is a lockdown in that province and 0 for the other days. Our second explanatory variable is the 'strength of precautions'. This variable reflects the effects of any additional precaution taken against the Covid-19. The value of the strength of precautions variable is based on the timetable given in Table 1. The Table indicates that the Turkish government augmented the level of measures through March and April, then relaxed those measures starting mid-May. This variable takes a value between 0 and 12 according to the number of implemented precautions. While the variable takes the value 0 on the day when there is no precaution, it takes the value equal to the number of each implemented precaution on other days. To be more explicit, note that the variable takes the value 2 from March 13th to March 15th as the government took two precautions, while it takes the value 6 starting from March 16th as four more measures were implemented.

$$The\ strenght\ of\ precautions = (precautions1 + precautions1 + ... + precautions12). \quad (2)$$

The trends of the lockdowns and precautions series are shown in Figure 3. Even in this basic depiction, one may suggest that there is a negative relationship between Covid-19 precautions and air quality index. Note that, since the values show harmful particles in the air, lower values indicate better air quality. However, to make sure of our inferences, we need to employ further econometric techniques. Hence, we estimate two different models to analyze the effect of lockdowns and the strength of precautions on air quality. These models are as follows:

$$\text{Model 1: } AQI_t = \alpha_0 + \beta_1 LD_t + \varepsilon_{0t}, \quad (3)$$

$$\text{Model 2: } AQI_t = \alpha_1 + \beta_2 SP_t + \varepsilon_{1t}, \quad (4)$$

where α_0 and α_1 represent constant terms, *AQI* is air quality index, *LD* denotes lockdown, *SP* illustrates the strength of precautions, and ε_{0t} and ε_{1t} are error terms. The estimations are made via the ordinary least

[4] The AQI data can be reached through these two websites: <*http://www.aqicn.org*> *and* <*http://www.waqi.info*>.

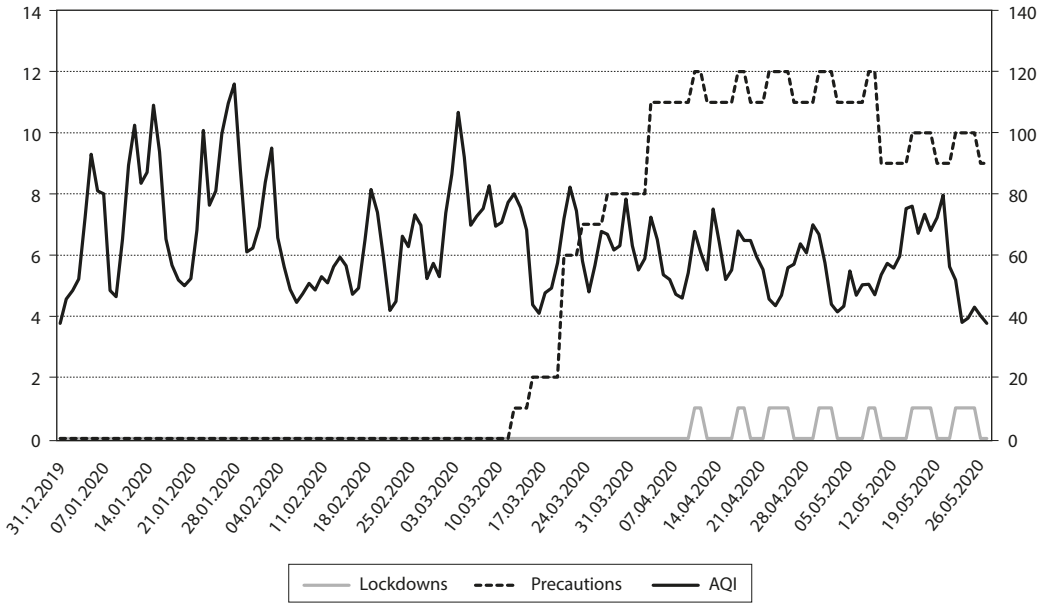
squares method (OLS). The General Linear Regression Model for k variable can be written as follows: $y = X\beta + u$. Where y is an $nx1$ vector of dependent variable, X is a nxk matrix of explanatory variables, β is a $kx1$ vector of the unknown parameters, and u is an vector of errors (Gujarati and Porter, 2009).

Table 1 The timeline of the first wave of Covid-19 in Turkey

Date	Precautions
March 11, 2020	• The first COVID-19 case observed in Turkey.
March 13, 2020	• Sports competitions without spectators. • Flights to some major European countries are stopped.
March 16, 2020	• Temporary break in education. (One week for primary and secondary schools; three weeks for colleges. After this break, the primary, secondary, and tertiary educations in the country have turned into distance-learning.) • Prayer gatherings are banned. • Gatherings for social and cultural activities (concerts, theaters, etc.) are banned. • More countries are added in the flight ban list.
March 21, 2020	• All the scientific, cultural, and artistic events are postponed. • A general lockdown is announced for people aged 65 and over. • 46 more countries are added in the flight ban list. Thus, the air transport with 68 countries is completely cut.
March 24, 2020	• The number of customers in groceries and shops is limited to 10% of their capacity. • The number of passengers in public transportation vehicles is limited to 50% of their capacity.
March 28, 2020	• All the international flights are stopped. • Domestic flights are limited to some major cities from Istanbul and Ankara. • All the intercity transport is subjected to the permission of the state governors.
April 3, 2020	• A general lockdown is announced for people aged under 20. • Wearing a facemask is made mandatory in shops and bazaars. • The entrance (and exit) ban is announced for 30 metropolitan cities and Zonguldak which is the main coal producing city in the country. • Turkish Airlines stops all the domestic flights.
April 11, 2020	• A general lockdown for the weekends is announced until June 1, 2020.
May 4, 2020	• People aged 65 and over on Saturdays; young people (15–20 years) on Fridays; children (under 14 years) on Wednesdays are allowed to go out for 4 hours. • The lockdown enforcement has been expanded for more cities.
May 11, 2020	• Shopping malls, barbershops, and beauty salons are reopened on condition with extra hygiene measures taken.
June 1, 2020	• The government decided to normalize the economic and social life.

Source: Compiled from different daily newspapers

Figure 3 The outlook of the lockdowns, precautions, and air quality in Turkey



Note: The air quality data is the mean of the AQI values of the selected 68 measurement stations. Since the values show harmful particles in the air, lower values indicate better air quality. The left axis is the scale for the lockdown and precautions while the right axis is the scale for the air quality index.

Source: World Air Quality Index (for AQI variable) and authors' own methodology described in this section (for lockdown and precautions variables)

2 EMPIRICAL FINDINGS

The empirical findings are presented in Table 2. Although the precautions were enforced for 31 metropolitan cities in Turkey, due to lack of data we can include only 21 cities into the analysis. The estimation results show that lockdowns lead to better air quality in 25 stations over 68, while for other stations there is no significant evidence. This result is explicable since lockdowns in Turkey were only enforced during the weekends and national holidays. On the other hand, our second explanatory variable yields significant evidence for more cities and stations (39 over 68). This result is also quite meaningful since the precautions were implemented over a longer period and the strength of precautions was augmented as the Covid-19 cases increased in Turkey. Overall, our results suggest that the air quality in the majority of provinces got better as the government took stronger precautions to cope with the Covid-19 pandemic.

The Table 2 also shows us some interesting results: despite increasing precautions during the Covid-19 period, the air quality worsened in some stations. These stations such as Kocaeli-Dilovası-imes (oiz 1), Kocaeli-dilovası-imes (oiz 2), and Kocaeli-Gebze (oiz) are located in the organized industrial zones (OIZ, briefly listed with the obs abbreviation in Turkish), or stations such as Istanbul-Esenyurt and Tekirdağ are located nearby OIZs. On the other hand, the estimated coefficients of Izmır-Çiğli (located nearby an OIZ) and Sakarya-Hendek (oiz) imply that the air quality in these zones thrived as the precautions tightened. Moreover, the models employed for Kayseri1 (oiz), Kocaeli-Gebze (oiz), Samsun2-Tekkeköy and Tekirdağ-Çorlu stations do not yield statistically significant results.

This intriguing result may be explained by the sectoral characteristics of OIZs. For instance, Dilovası OIZ mainly covers chemical, plastic, and pharmaceutical industries in which the production level increased with the Covid-19. Thus, one may clearly suggest the production level to be the key factor for air pollution.

Table 2 The impacts of lockdowns and precautions on air quality (OLS results)

Measurement station	Dependent variable: air quality			
	Model I		Model II	
	Constant	Lockdown enforcement	Constant	Strength of precautions
Ankara-Bahçelievler	65.450***	–8.260	70.184***	–1.253***
Ankara-Demetevler	65.907***	29.998***	69.232***	0.186
Ankara-Kayas	95.070***	–39.070***	108.609***	–4.044***
Ankara-Sıhhiye	67.225***	–15.606***	75.712***	–2.271***
Ankara-Sincan	59.961***	–18.295***	65.076***	–1.633***
Antalya	64.480***	–3.719	65.978***	–0.445**
Aydin	43.163***	–4.353	45.940***	–0.747***
Balıkesir	74.062***	–9.967*	8.826***	–1.736***
Balıkesir-Bandirma	39.760***	3.669	38.796***	0.314
Balıkesir-Erdek	55.085***	–16.228**	60.021***	–1.534***
Balıkesir-Edremit	45.178***	12.679***	41.879***	1.080***
Balıkesir-Merkez	71.612***	–7.517	76.322***	–1.226***
Bursa	128.764***	–66.291**	162.884***	–9.234***
Bursa-Beyazit Cad.	85.093***	–21.284**	93.388***	–2.399***
Bursa-İnegol	48.372***	–11.515***	52.796***	–1.284***
Bursa-Kestel	82.651***	–19.413**	89.612***	–2.059***
Bursa-Kültür park	86.985***	–23.175**	96.416***	–2.697***
Bursa-Uludağ Üniv.	80.380***	–11.523*	85.766***	–1.490***
Diyarbakır	24.860***	–13.718***	29.564***	–1.446***
Erzurum	89.907***	–34.717***	106.247***	–4.677***
İstanbul-Üsküdar	53.814***	2.281	52.779***	0.288
İstanbul-Başakşehir	58.225***	0.680	58.872***	–0.117
İstanbul-Esenyurt	59.597***	–6.787	62.448***	0.809**
İstanbul-Kağıthane	79.682***	–11.635*	82.272***	–0.898*
İstanbul-Kandilli	58.651***	3.539	59.305***	–0.034
İstanbul-Şile	55.140***	0.003	51.261***	0.825***
İstanbul-Silivri	63.023***	0.834	62.862***	0.059
İstanbul-Şirinevler	62.612***	–6.374	64.449***	–0.581*
İstanbul-Sultangazi	63.116***	–6.116	65.693***	–0.730**
İstanbul-Ümraniye	59.589***	–8.494**	62.652***	–0.905***
İstanbul-Üsküdar2	54.868***	1.227	54.517***	0.111
İzmir-Alsancak	24.054***	–0.435	23.740***	0.054
İzmir-Bayrakli	43.256***	–17.875	52.416***	–2.481*
İzmir-Bornova	42.085***	–12.181	48.722***	–1.775
İzmir-Çiğli	29.163***	–7.829**	32.193***	–0.878***

Table 2 (continuation)

Dependent variable: air quality

Measurement station	Model I		Model II	
	Constant	Lockdown enforcement	Constant	Strength of precautions
İzmir-Gaziemir	37.388***	0.708	36.007***	0.315
İzmir-Güzelyalı	21.512***	5.441	19.950***	0.494**
İzmir-Şirinyer	41.147***	–13.052	46.815***	–1.595
Kayseri1-OIZ	129.705***	–20.039	134.793***	–1.679
Kayseri3-Hürriyet	94.333***	–33.286***	107.424***	–3.777***
Kocaeli	71.496***	–10.687*	77.088***	–1.508***
Kocaeli-Alikahya	66.876***	–6.066	69.481***	–0.735*
Kocaeli-Dilovası-imes OIZ 1	53.891***	1.680	50.117***	0.853**
Kocaeli-Dilovası-imes OIZ 2	53.760***	1.907	49.836***	0.892***
Kocaeli-Gebze OIZ	59.465***	–0.037	58.019***	0.307
Kocaeli-Gebze	53.752***	–3.085	50.591***	0.581*
Kocaeli-Gölcük	68.395***	–7.348	72.611***	–1.116***
Kocaeli-İzmit	67.876***	–7.066	71.248***	–0.928**
Kocaeli-Kandıra	45.178***	–2.274	44.011***	0.181
Kocaeli-Körfez	65.821***	–5.584	69.167***	–0.878**
Kocaeli-Yeniköy	66.093***	–4.712	68.274***	–0.604
Konya-Meram	77.147***	–8.243	81.122***	–1.091**
Konya-Selçuklu	88.775***	–23.870***	98.940***	–2.874***
Malatya	49.504***	–8.171*	54.14***	–1.247***
Manisa-Soma	81.085***	–0.466	81.951***	–0.198
Ordu-Karşıyaka	72.155***	–12.298***	76.222***	–1.264***
Sakarya	81.248***	–14.486	85.65***	–1.368*
Sakarya-Hendek OIZ	84.147***	–11.814**	90.647***	–1.735***
Sakarya-Merkez	77.411***	–10.649	79.765***	–0.818
Sakarya-Ozanlar	78.574***	–20.812***	87.523***	–2.524***
Samsun-Tekkekoy	67.643***	–10.310	71.128***	–1.048
Tekirdağ	78.442***	6.653	73.734***	1.200*
Tekirdağ-Çerkezköy	76.558***	–16.606**	85.402***	–2.376***
Tekirdağ-Çorlu	59.023***	1.072	57.974***	0.262
Tekirdağ-Merkez	70.225***	5.347	66.714***	0.930***
Trabzon-Meydan	70.767***	–3.529	68.581***	0.369
Van	33.628***	–8.056**	40.650***	–1.734***
Zonguldak-Karadeniz Ereğli	76.403***	–8.260	80.167***	–1.047*

Note: ***, **, and * denote 1%, 5%, and 10% statistical significance, respectively.
Source: Authors' own estimations

Another interesting empirical result is that the air quality worsened in stations such as Balıkesir-Edremit, İstanbul-Şile, and Izmir-Güzelyalı. This is plausible because many people from big cities have their summer or secondary houses in those provinces. With the start of the disease, some people went away from big cities to reduce the risk of contamination.

There might also be other explanations for these results: although the measured AQI levels provide important information about the air quality of the cities, there might be misleading biases due to wind, climate, and any other factors that may blow the harmful particles from one location to another one. Therefore, the estimated coefficients for some stations may yield insignificant results or even an opposite (positive) impact.

CONCLUSION

In this study, we empirically examined whether the lockdowns and implemented precautions during the Covid-19 pandemic constitute a positive externality favoring the air quality in Turkey. To do so, we used daily data obtained from the WAQI project for the period of December 31, 2019 and May 28, 2020. Although the data obtained from selected measurement stations basically shows that there are significant improvements in air quality, we decided to move one step forward and estimated the potential impact of government precautions on air quality for each of the measurement stations. The empirical findings suggest that the air quality recovered itself due to the implemented precautions in more than half of the selected stations. This result based on the Turkish experience is consistent with the early literature measuring the impact of the Covid-19 on air quality for different countries.

Our results also show that there are some stations where the air quality worsened despite increasing precautions during the Covid-19 period. Most of these stations are located in OIZs where the production level did increase during the pandemic. The findings suggest that the Covid-19 might be an opportunity to rethink some economic and behavioral practices, as demonstrated by the reduction in the emission of air pollutants from the perspective of sustainable development.

Since the empirical analysis of the present study covers only the first wave of the Covid-19 pandemic and the precautions-air quality relationship within this period, the interaction between these two indicators has a potential to change in the next waves of the pandemic. The reactions of households, firms and governments were quite strict during the first months. Nowadays, after the first three waves, some countries decide to implement precautions to prevent the spread of the pandemic while some others bend the rules. No one can know whether there should be an absolute need for lockdown-type precautions during the following periods of the Covid-19 pandemic. However, in the following years, in case of some new pandemics these kinds of precautions might be implemented again. Further research might focus on the impact of the upcoming waves and pandemics; and even may conduct comparative analyses covering a longer period.

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