Does Air Pollution Impact Consumer Sentiment in Pakistan: A City-Level Analysis

Syed Zulqernain Hussain, University of Otago, New Zealand

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Abstract
Air pollution is a rising concern in Pakistan for the past few years. Apart from a direct bearing on the health of households, and a significant risk to the environment; it is hypothesized that poor air quality has an impact on consumer sentiment in major cities of Pakistan. In this study, the impact of air quality on consumer sentiment is estimated for major cities of Pakistan. Consumer confidence survey conducted by the State Bank of Pakistan is one of the leading indicators of economic activity. This survey primarily reflects consumers' perceptions about the current and expected economic conditions. Consumer sentiment is measured by the Diffusion Index, while the Air Quality Index is used to capture the magnitude of air pollution. Using city fixed effects model on balanced panel data of ten cities and 36 time periods, results show air pollution has a negative impact on consumer sentiment in Pakistan. The coefficient of air pollution is statistically significant and is consistent in all specifications – reflecting that air pollution does impact consumer sentiment. Reverse causality test validates that consumer sentiment do not impact air pollution. Control variables such as dummies for floods, terrorist attacks, and household characteristics for each city are included in this study to gain improved model fit. The government of Pakistan needs to acknowledge the severity of air pollution and its impact on consumer sentiment—a leading indicator of economic activity.

Keywords: Air Pollution, Consumer Sentiment, Diffusion Index, Balanced Panel, Environment

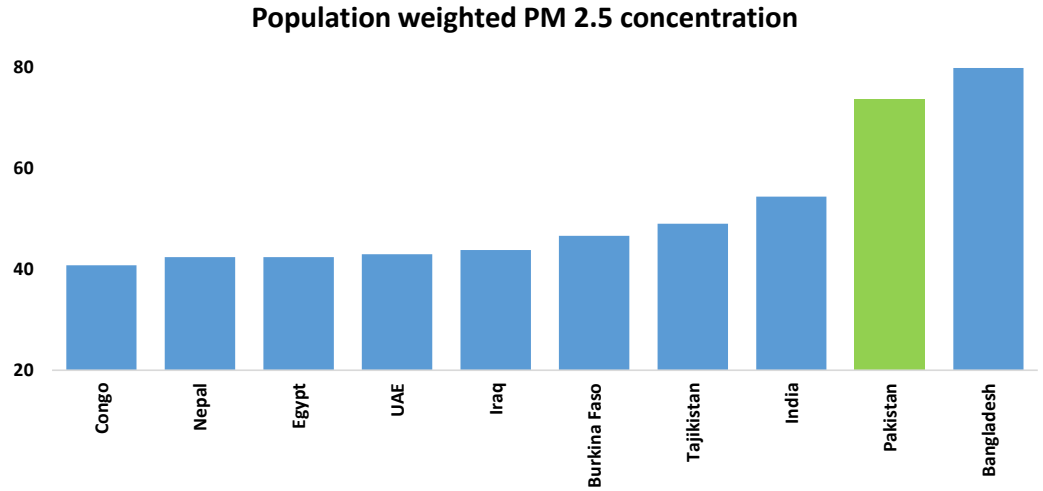
Introduction

Being categorized as an emerging financial economy, the economy of Pakistan is the 24th largest based on GDP using purchasing power parity (PPP). Pakistan is the fifth-most populous country in the world. Rampant urbanization and an increase in vehicular loads have left the air saturated with harmful pollutants at an unprecedented rate (Anjum et al., 2021). Pakistan is ranked second in the world in terms of most polluted country (Figure A**)**. The persistent poor air quality reduces the life expectancy by almost 4 years in Pakistan (The Air Quality Life Index, 2023). In Pakistan, twenty-five deaths per 100,000 are attributable to outdoor air pollution and thirty deaths per 100,000 are attributable to indoor air pollution (World Health Organization, 2024).

Air pollution is tagged as a key environmental issue since the 1970s (The World Bank, 2019). The main cause of air pollution is fossil fuel burning, industrial processes, transport, and agriculture activities. In addition, anthropogenically induced climate change enhances the threat of exposures to air pollutants by changing the concentrations, transport process and lifetime of local and regional pollutants (Ministry of Finance, 2022). There are frequent episodes of hazardous levels of air quality emanating from crop burning stubble, deforestation, industrial and vehicle emissions (IQAir, 2023). The worsening situation compelled the government to declare an environmental and health emergency in three big cities of Pakistan. The public places in these cities were closed, and face mask was made mandatory for a week.

The effect of air pollution is not only limited to the environment, chronic diseases, and depression, but it has an impact on macroeconomic indicators as well, for instance high government expenditures, and surge in housing prices of areas with better air quality etc. A hypothesis that air quality impacts consumer sentiments is formulated and tested in this study. Consumer sentiment about current and expected economic conditions of the country is one of the leading indicators of economic activity. In this study, the year-on-year growth of consumer confidence index is used to see the impact of air pollution on consumer sentiments.

Figure 1: 2023 Country Ranking



Source: IQAir

Literature Review

Air pollution is a byproduct of urbanization and industrial development over the past few decades. Air pollution in cities is a serious environmental issue particularly in the developing economies (Mayer, 1999). Tagged as the greatest environment threat, air pollution accounts for almost 7 million deaths around the world every year. Air pollution is the main reason for diseases such as asthma, cancer, pulmonary illnesses, and heart diseases (United Nations Commission for Europe, 2024). The impact of air pollution is particularly evident on child growth and development (Balietti et al., 2022). The harm of air pollution extends to both physical and mental health (Xue et al., 2021). Air pollution further impedes and limits consumer choices (He et al., 2022). Peoples' trust on the local government is also compromised due to air pollution (Yao et al., 2022). In some cases, air pollution may lead to social conflicts, aggressive behaviours and contribute to violent crimes (Li & Meng, 2023). Sleep loss is another implication of air pollution (Heyes & Zhu, 2019).

The impact of air pollution spreads across various aspects of life, including health, the environment, the overall economy, mental health, and behaviour of the households & firms. The impact of air pollution on health seems obvious and there are several studies that estimate the association of air pollution and health issues. A study related to 6 cities of the United States of America (US) reveal that long-term exposure to air pollution leads to respiratory diseases and there exists a strong association between air pollution and mortality (Dockery et al., 1993). Air pollution also leads to lung cancer (Loomis et al., 2013). Air pollution also leads to adverse impact on child health. Air pollution may lead to premature birth, low-birth weight, and developmental disorders (Perera, 2008).

One of the major consequences of air pollution and climate change is high extinction of specific species and possible loss of biodiversity (Bellard et al., 2012). The macroeconomic consequences of air pollution are alarming and significant. The foremost macroeconomic cost to economies around the world is the health related expenditures. Air pollution related costs alone account for over US$ 5 trillion globally (The World Bank, 2016). The adverse impact of air pollution is substanial on the airlines industry as well. A study on China shows that higher the PM2.5 concentration levels, high is the probability of flight delays and/or cancellations (Chen et al., 2023). Migration to areas with cleaner air is also an outcome of pollution (Pan, 2023).

Another macroeconomic implication of air pollution is the loss in labor productivity. A study conducted at two industrial locations in China reveals that the output per worker reduces in proportion to severe air pollution (He et al., 2019). Environmental protection must be treated as an investment in human capital as ozone pollution leads to a loss in agricultural worker productivity (Zivin & Neidell, 2012). The link between air pollution and mental health is also well established. Air pollution is one of the contributing factors to mental health disorders and high exposure to PM2.5 is associated with high risk of depression (Power et al., 2016). A study on South Korea indicates that high levels and exposure to air pollution is correlated with a high sucide rate. Based on a meta-analysis, it is evident that exposure to air pollution negatively impacts mental health, mood swings, raises anxiety and depression (Lim et al., 2012). Air pollution also limits consumer choices and the impact of air pollution is disproportinate on different economic sectors. Air pollution leads to a slowdown in the sales of movie theater market in China (He et al., 2022). Brain drain and and a loss in firm productivity is one of the consequences of air pollution (Xue et al., 2021).

It is evident that air pollution does impact mental health. The important question is whether the impact also entails decision making of consumers? A few studies emphasizes that air pollution influences consumer behavior, including preferences, spending habits, and lifestyle choices. Air pollution redcues recreational activities which does hamper overall demand in the economy (Zivin & Neidell, 2009). Consumer spending patterns change due to air pollution. Consumer may swap outdoor activities and expenses with indoor activities. Subjective well-being is influenced by air pollution (Welsch, 2006). Dynamics of the housing market change due to air pollution. Areas with clean and quality air have a high demand and the property prices rise in such areas (Chay & Greenstone, 2005).

The impact of air pollution on health, infrastructure and overall economy has been estimated to some extent for Pakistan. However the literature is scarce in terms of assessing the impact of air pollution on consumer sentiment and economic activity. This novel study fills the gap by analyzing the impact of air quality on ten major cities of Pakistan from January 2018 till December 2023. At least one city is chosen from each province (state) of Pakistan.

The hypothesis formulated and tested in this study is as follows:

H_0 : There is no impact of air pollution on consumer sentiment in Pakistan

H_a : There is a impact of air pollution on consumer sentiment in Pakistan

Method

Most of the previous studies which estimated the impact of poor air quality relied on time series data and employed autoregressive distributive lag model to find out the relationship between air pollution and variable of interests. Some studies also used Granger causality to check the direction and nature of the relationships between air pollution and other variables.

However, in this study, panel linear fixed effects models are used to estimate the impact of air pollution on consumer sentiment for 10 cities and 36 time periods.[1] Panel variable is city, and it is strongly balanced. Panel data allows one to control for variables one cannot observe or measure like cultural factors across cities; or variables that change over time but not across cities (i.e. national policies, federal regulations, international agreements, etc.).

$$CS_{it} = \beta_0 + \beta_1 AQI_{it} + \alpha_i + \mu_{it} \quad (1)$$

CS = Consumer Sentiment measured by diffusion index
AQI = Air quality index
α_i = city fixed effects
i= 10
t = 36

In specification (1), consumer sentiment (CS) is the dependent variable; air quality index is the main explanatory variable that vary over time. YoY growth of consumer sentiment and air quality index is used in the estimations to avoid any seasonality. β_0 is the intercept that maybe different for each period. As mentioned earlier, city-fixed effects are employed in this specification. The two terms α_i and u_{it} behave somewhat differently from each other. There is

[1] Panel data (also known as longitudinal or cross-sectional time-series data) is a dataset in which the behaviour of entities is observed across time.

a different u_{it} for each city at each point in time but α_i only varies across cities, not over time (Allison, 2009). However, μ represents purely random variation at each point in time.

The central bank of Pakistan -the State Bank of Pakistan (SBP) - in collaboration with one of the top universities of Pakistan, conducts the Consumer Confidence Survey on a national scale. The information collected through this survey is used to construct current, expected, and overall confidence indices which are useful in monetary policy formulation and short-term forecasting (State Bank of Pakistan, 2024).[2] Three different measures of consumer sentiments are used in this study: (i) Current economic conditions, (ii) Expected economic conditions, and (iii) Consumer confidence index.

For the data on air quality, the live Major Cities Ranking by IQAir is used. This ranking constitutes 120 major cities of the globe. The data used to generate the live ranking is aggregated from thousands of regulatory air quality monitoring stations and low-cost air quality sensors operated by governmental bodies, research institutions, non-profit organizations, companies, and citizen scientists. The number shown for each major city is the average (median) Air Quality Index (AQI) from all the stations in that city for that specific time. Comparing the air quality of only major cities rather than an exhaustive list of all cities provides a concise, meaningful, and eye-opening comparison of air quality in urban centres across the globe (IQAir, 2023).

In addition, several control variables (Z) for robustness check are included in specification (2). These control variables are: (i) *Education* - the average level of education of the respondents in a city, (ii) *income* - average level of income of the respondents in a city, (iii) dummy for *Floods* in a city, and (iv) dummy for terror incident in a city.

$$CS_{it} = \beta_0 + \beta_1 AQI_{it} + \beta_2 Z_{it} + \alpha_i + \mu_{it} \quad (2)$$

For robustness purpose, time fixed effect is also added in the above specification. Moreover, previous consumer sentiment is included as one of the control variables to check whether lagged sentiment influences the current consumer sentiment or not.

In all specification, clustered (by city) standard errors are used. Clustered standard errors are not underestimated like normal or robust standard errors. It is imperative to use clustered standard errors if there are several different covariance structures within the data sample that vary by a certain characteristic—a "cluster" which in this study is city. Clustered standard errors provide unbiased standard errors estimates.

Consumer sentiment is one of the leading indicators of economic activity. Perception about economic indicators such as inflation, interest rate and employment are important for an emerging economy like Pakistan in which forward-looking policy formulation is followed. The State Bank of Pakistan in partnership with one of the leading universities in Pakistan conducts the Consumer Confidence Survey on a national scale largely following the University of Michigan Consumer Sentiment Survey. The information obtained through this survey is used to construct current, expected, and overall confidence indices, which are then used in monetary policy formulation and short-term forecasting. [3,4]

[2] https://www.sbp.org.pk/research/CCS-m.asp
[3] State Bank of Pakistan. http://www.sbp.org.pk/research/CCS.asp. Accessed 15 May 2024.
[4] Each wave of this survey covers about 1800 households contacted through fixed line telephone across Pakistan

Each wave of this survey covers about 1800 households contacted through fixed line telephone across Pakistan started from January 2012 on a bi-monthly frequency but from January 2023, it is conducted monthly. In terms of coverage, it covers all regions of Pakistan. The questionnaire is asked in different regional languages to ensure maximum outreach. The population of Pakistan is divided into 59 strata and each strata gets representation in the sample according to its population.

In addition, household characteristics such as number of households, age, income, occupation, and qualification of the respondents are also part of the survey. These household characteristics are used as control variables in this study going forward. The SBP reports results of this survey in the form of a Diffusion Index (DI). The Diffusion Index shows the general tendency of respondents about a certain aspect of a particular survey.

The questionnaire for this survey offers five types of options to the respondents for each question.

PP=Increase/improve significantly.
P=Increase/improve.
E=Unchanged/neutral; N = decline /deteriorate; and
NN=Decline/deteriorate significantly.

Based on these five options, the Diffusion Index is computed in the following two steps:

Step 1: Net Response (NR) is computed as below:

$NR = (1.00*PP) + (0.50 \times P) + (-0.50 \times N) + (-1.00*NN)$.

Step 2: Diffusion Index (DI) is calculated as follows: $DI = (100 + NR) / 2$

Where DI ranges from 0 to 100; interpretation of which is as follows:

DI > 50 indicates that Positive views are more than Negative views.

DI = 50 indicates that Positive views and Negative views are equal.

DI < 50 indicates that Positive views are less than the Negative views.

Table 1: Summary Statistics of Consumer Sentiment and Air Quality Index

Variable	**Mean**	**Min**	**Max**	***s.d***
Consumer Confidence Index	37.43	17.0	58.0	*4.11*
Current Economic Conditions Index	34.23	16.0	61.0	*4.85*
Expected Economic Conditions Index	40.66	19.0	61.0	*4.75*
Education level of city (avg)	Graduate	Primary	Post-Graduate	-
Income level of city (avg per month)	300-500$	100-200$	1000-2000$	-
Air Quality Index	64.98	14.1	261	*48.1*

Source: Analyst's Calculations

The Consumer Confidence Survey (CCS) data used in this study covers the period from January 2018 to December 2023. Due to limited available data on the Air Quality Index, ten major cities of Pakistan—at least one from each province (state)—are analysed in this study. Thirty-six surveys consisting of almost 100,000 households are covered in the analysis.

started from January 2012 on a bi-monthly frequency but from January 2023, it is conducted monthly. In terms of coverage, it covers all regions of Pakistan. The questionnaire is asked in different regional languages to ensure maximum outreach. The population of Pakistan is divided into 59 strata and each strata gets representation in the sample according to its population.

Summary statistics related to consumer sentiment and air pollution are provided in Table 1.

Table 2: Air Quality Index – Categories

Category	US AQI level	PM 2.5 (ug/m^3)	Health Recommendation
Good	0-50	0-9.0	Air quality is satisfactory.
Moderate	51-100	9.1-35.4	Outdoor activities to be avoided by sensitive individuals.
Unhealthy for sensitive groups	101-150	35.5-55.4	General public and sensitive individuals face risk to experience irritation and respiratory problems.
Unhealthy	151-200	55.5-125.4	Increased likelihood of adverse effects and aggravation to the heart and lungs among general public.
Very unhealthy	201-300	125.5-225.4	General public will be noticeably affected. Sensitive groups should restrict outdoor activities.
Hazardous	301+	225.5+	General public at high risk of experiencing strong irritations and adverse health effects.

Air Pollution

Air pollution is proxied by the Air Quality Index (AQI). The AQI is a measurement of air pollutant concentrations in ambient air pollution and their associated health risks (IQAir, 2023). The index represents air pollutant concentrations with a number falling within a range of air quality categories. Within each category and number range, elevated health risks associated with rising air pollutant concentrations are identified.

The air quality index ranges from 0 to 500, though air quality can be indexed beyond 500 when there are higher levels of hazardous air pollution. Good air quality ranges from 0 to 50, while measurements over 300 are considered hazardous. Table 2 provides information on different categories of AQI.

Results and Discussion

Table 3 provides result of air quality index and the overall consumer confidence index. The coefficient of air quality index is statistically significant with a negative sign in all specifications which makes sense intuitively. If the air quality index rises (implying more air pollution), consumer sentiment is likely to deteriorate. This coefficient of air quality index is approximately equal to one-half standard deviation of the dependent variable (consumer confidence index), which implies that a considerable amount of variation in consumer sentiment is influenced by the air quality.

Table 3: Impact of Air Quality Index on Consumer Confidence Index

	(1)	(2)	(3)	(4)
AQI[a]	-0.06**	-0.09**	-0.100**	-0.09**
	(0.027)	*(0.028)*	*(0.024)*	*(0.033)*
Control Variables				
Level of Education (Avg of City)		Not sig	Not sig	Not sig
Level of Income (Avg of City)		Sig at 5%	Sig at 5%	Sig at 5%
Floods (binary variable)			Sig at 5%	Sig at 5%
Terrorist event (binary variable)			Sig at 5%	Sig at 5%
Lag of Sentiment			Not sig	Not sig
City Fixed Effect	***Yes***	***Yes***	***Yes***	***Yes***
Time Fixed Effect	No	No	No	***Yes***
Observations	360	360	360	360
Number of cities	10	10	10	10

Notes: Clustered (by city) standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
a: Year-on-year growth rate of air quality index.

In column (2) of Table 3, several control variables are added for robustness purpose. Socio-economic variables such as the average education level of the city and the average income level of the city, and the average household size in a city. These control variables (HH characteristics within a city) have important economic intuition. The results show that higher the level of income, sentiment is relatively positive. However, the coefficient of level of education is not statistically significant. Even by adding these two control variables, the coefficient of our main explanatory variable is statistically significant. Regarding the size of the coefficient, coefficient is still equal to one-half standard deviation of the dependent variable (consumer sentiment).

In the last two columns of Table 3, additional control variable such as a dummy for floods and a dummy for terrorist incidents in a city are added. In addition, time dummy variable has also been included; the result of this specification keeps our main variable of interest significant. Hence, all specifications are consistent, and we reject our null hypothesis that air pollution has no impact on consumer sentiment. Results validate the hypothesis that cities with higher air pollution tend to have more pessimistic sentiment. In columns 3-4, lag value of dependent variable (consumer sentiment in previous period) is also used as a predictor for the current value of the dependent variable (current sentiment); results indicate that previous sentiment does not impact the current sentiment.

Table 4: Impact of Air Quality Index on Current Economic Conditions Index

	(1)	(2)	(3)	(4)
AQI[a]	-0.07**	-0.10**	-0.11**	-0.09**
	(0.025)	*(0.026)*	*(0.023)*	*(0.031)*
Control Variables				
Level of Education (Avg of City)		Not sig	Not sig	Not sig
Level of Income (Avg of City)		Sig at 5%	Sig at 5%	Sig at 5%
Floods (binary variable)			Sig at 5%	Sig at 5%
Terrorist event (binary variable)			Sig at 5%	Sig at 5%
Lag of Sentiment			Not sig	Not sig
City Fixed Effect	***Yes***	***Yes***	***Yes***	***Yes***
Time Fixed Effect	No	No	No	***Yes***
Observations	360	360	360	360
Number of cities	10	10	10	10

Notes: Clustered (by city) standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
a: Year-on-year growth rate of air quality index.

Table 4 and Table 5 provide result of air quality index on the current economic condition index and the expected economic condition index respectively. The results are in line with the overall consumer confidence index. The coefficient of air quality index is statistically significant with a negative sign in all specifications.

Table 5: Impact of Air Quality Index on Expected Economic Conditions Index

	(1)	(2)	(3)	(4)
AQI[a]	-0.06**	-0.09**	-0.10**	-0.09**
	(0.026)	*(0.027)*	*(0.024)*	*(0.030)*
Control Variables				
Level of Education (Avg of City)		Not sig	Not sig	Not sig
Level of Income (Avg of City)		Sig at 5%	Sig at 5%	Sig at 5%
Floods (binary variable)			Sig at 5%	Sig at 5%
Terrorist event (binary variable)			Sig at 5%	Sig at 5%
Lag of Sentiment			Not sig	Not sig
City Fixed Effect	***Yes***	***Yes***	***Yes***	***Yes***
Time Fixed Effect	No	No	No	***Yes***
Observations	360	360	360	360
Number of cities	10	10	10	10

Notes: Clustered (by city) standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
a: Year-on-year growth rate of air quality index.

One of the possibilities is that air pollution itself is due to high economic activity in Pakistan. To check this, reverse causality test is estimated as well. Results of reverse causality indicates that consumer sentiment does not impact air pollution in Pakistan. Even during the COVID-pandemic period, when smart lockdowns were imposed and the industrial sector was completely shut down, air quality remained poor in Pakistan. It appears and to some extent validated by the reverse causality test that air pollution is largely exogenous and probably due to global climate change.

Conclusion

As one of the most polluted countries in the world, Pakistan is facing problems such as premature deaths, respiratory diseases, and a reduction in life expectancy. Agricultural productivity also suffers as crops get damaged due to pollutant exposure. A visible fall in tourism is also a byproduct of pollution. As pointed out in previous studies, air pollution leads to depression and anxiety. Another possible impact of air pollution on consumer sentiment related to current and expected economic conditions is estimated in this study. Consumer sentiment is a leading indicator of economic activity and consumer confidence index is treated as an important variable during the process of monetary policy formulation. Using city fixed effects model on balanced panel data of ten cities and 36 time periods, main findings indicate that air pollution has a negative impact on consumer sentiment. The impact is significant for the overall consumer confidence index, the current economic conditions index and the expected economic conditions index. The coefficient of air quality index is roughly equal to one standard deviation of the consumer confidence index. Reverse causality test shows that consumer sentiment or economic activity does not impact air pollution and the relationship is only one way. Control variables such as dummies for floods, terrorist attacks, average level of education and average level of income for each city are included in this study to gain improved model fit. Results are consistent in all specifications. Given a significant impact of air pollution on consumer sentiment – a leading indicator of economic activity, the stakeholders, particularly the government of Pakistan needs to address the problem of air pollution.

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