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The economic cost of particulate air pollution on health in Singapore

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Abstract

The rapid process of urbanization and industrialization in developing countries and newly industrialized countries (NIC) over the past few decades has resulted in degradation in air quality in these countries. However, accompanying this phenomenon has been the growing realization that economic development and environmental management are mutually supporting goals. The paper attempts to address this concern by estimating the economic cost of particulate air pollution on health in Singapore. Using the damage function/dose response approach, the mortality and morbidity effects of particulate air pollution on the population of Singapore are estimated. In addition, the economic values of these health impacts are also calculated in terms of the statistical lives which could be saved and the cost of illness incurred. The results show that the cost of particulate air pollution (PM_{10}) in Singapore is substantial both in absolute and relative terms. It is estimated that the total economic cost US $3662 million is about 4.31% of Singapore's GDP in 1999. The findings thus strengthen the assertion that policy-makers should not ignore the environment in their pursuit for economic progress.

JEL classification: Q25; Q28

Keywords: Singapore; Air pollution; PM_{10}; Health cost; Value of statistical life; Dose-response function

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1. Introduction

Developing countries and newly industrialized countries (NIC) face the twin challenges of protecting the environment while also strengthening their economies. Over the past few decades, the intensified process of urbanization and industrialization undertaken by these countries, coupled with rapid population growth, has resulted in the degradation of the environmental quality. Particularly, the emission of harmful pollutants such as sulfur dioxide (SO_2), nitrogen oxide (NO_2), lead, ozone and particulate matter has contributed considerably to a rapid drop in the air quality in the cities. Among the air pollutants, particulate matter was found to be the most damaging. Particulate includes dust, dirt, soot, smoke, and liquid droplets directly emitted into the atmosphere by sources such as factories, power plants, transportation sources, construction activity, fires, and windblown dust. They are also formed in the atmosphere by condensation of emitted gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds into tiny droplets.

The concentration of particles in the air can be measured either as an average over a defined time period, usually 20 h, or continuously using newer types of particle monitors called continuous samplers. Concentration is expressed in micrograms of particles per cubic meter of air sampled ($\mu g/m^3$). Particles get into the body through our lungs whereas larger particles settle in our mouth and nose. The particulate size measurement used, known as PM_{10}, includes particles with an aerodynamic diameter of 10 μm or less. These particles are of health concern as they are able to penetrate deep into the sensitive regions (thoracic or lower regions) of the respiratory tract. Thus, PM_{10} are also known as inhalable particles.

Recent studies on the effects of chronic exposure to air pollution have identified PM_{10} as the pollutant most responsible for the life-shortening effect of dirty air. The major concerns for human health include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. Particulate exposure might increase susceptibility to bacterial or viral respiratory infections, leading to an increased incidence of pneumonia in vulnerable members of the population. It might also aggravate the severity of underlying chronic lung disease, causing more frequent or severe exacerbation of airway disease or more rapid loss of lung function. Besides its adverse impact on human health, particulate matter can also result in visibility degradation. This can affect the residents and tourists' aesthetic visions of nature. Moreover, visibility degradation can take on a much more serious nature when it interferes with the navigation of vehicular traffic on highways and around airports. These environmental impacts are undoubtedly serious from a road and air safety perspective. The soiling effect of particulate matter is another environmental impact. When particulate fall out of the atmosphere, they can accumulate on people's cars, laundry drying outside, and in their homes. Thus, elevated levels of atmospheric particulate can have a ''nuisance impact'' on the environment.

In view of the various negative impacts particulate air pollution has on the environment, the issue of the improvement of this aspect of air quality (e.g., reduction in the concentration level of particles in the air) is becoming a major concern for both the general public and the governments of the developing countries and NICs. Nearly every