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U R D

PhD in Urban and Regional Development
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**Air Pollution Impact on Health
and its Economic Consequences:
from Atmospheric Analysis to
Global Burden Estimation.**

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Abstract

Air pollution is one of the most pressing environmental health threats worldwide. Despite significant efforts to improve air quality, evidence indicates persistent adverse health consequences. Exposure to ambient and household air pollution is linked to a wide spectrum of effects in the general population, from subclinical conditions to premature death, with an estimated 7.9 million premature deaths in 2023. Quantitative assessment of these health effects is therefore essential. This dissertation aims to connect atmospheric mechanisms with economic valuation to enable policy makers and other stakeholders to design and implement more effective local, national, and global policies for reducing air pollution.

The first part of the dissertation examines how meteorology shapes pollutant concentrations. It analyses how temperature, relative humidity, wind speed, precipitation, and boundary layer height influence dispersion and dilution of particulate matter (PM₁₀) and sulfur dioxide (SO₂). The study focuses on Türkiye, a major economy with high population where concentrations frequently exceed international standards. Hourly summer and winter observations are analysed with a generalised additive model (GAM), complemented by a sensitivity analysis, to

capture seasonal and regional heterogeneity. Projections for 2030 and 2050 under two IPCC scenarios are provided, assuming strong mitigation (RCP 4.5) and high emissions (RCP 8.5), to illustrate how changing atmospheric dynamics may alter pollution levels.

Air pollution is not only a critical public health issue but also a major economic burden. Beyond health expenditures, it imposes sizeable non-market costs through monetised welfare losses associated with mortality and morbidity.

To quantify the health costs of air pollution, policy assessment requires methods that balance the costs of risk reduction against expected benefits, measured as prevented premature deaths and preserved life expectancy. These benefits are captured by the Value of a Statistical Life (VSL), reflecting individuals' willingness to pay to reduce mortality risk, and the Value of a Life Year (VOLY), which accounts for impacts on life expectancy. Obtaining reliable VSL and VOLY is challenging because methods adopted in every study vary widely across, and even within, countries, and many lack robust country-specific estimates, limiting comparability in global assessments. To address this gap, the second part of the dissertation develops an econometric model based on a meta-analysis of literature-derived VSL estimates related to air pollution only, tailoring VSL to country-specific economic, socio-economic, demographic, and health characteristics. A corresponding VOLY database is derived from the VSL-based estimates. The framework has global coverage and enables more consistent, country-specific application of VSL and VOLY in air pollution policy analysis, improving comparability of estimated benefits across countries and income groups.

The third part of the dissertation quantifies the health costs of air pollution, accounting for both mortality and years of life lost (YLL). To estimate country-level external annual costs attributable to PM_{2.5} and O₃, it applies the model developed throughout the above-mentioned meta-analysis. The study covers five years (2000, 2005, 2010, 2015, and 2019), yielding a dataset covering 108 countries that together represent 86% of the global population. Two complementary economic approaches are implemented: VSL combined with mortality, and VOLY combined with YLL.

The three parts of the dissertation, each corresponding to a scientific paper, provide a structured pathway from atmospheric mechanisms to economic valuation and global burden estimation. **Paper I** clarifies how meteorology modulates pollution levels and how these relationships may evolve under a changing climate, informing exposure pathways and the timing and targeting of interventions. **Paper II** develops an evidence-based econometric valuation model, with VSL and VOLY tailored to country context, harmonised at the global level to a) address comparability gaps and b) supply estimates for countries lacking them. **Paper III** applies the own model developed in Paper II to produce internationally comparable trends of the economic costs of premature deaths due to air pollution. The combined evidence base supports more efficient resource allocation and the design of cost-effective policies that reduce exposure, prevent premature deaths, and limit long-term welfare losses.