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HEA2014-1323

Athens' "Nephos": A Heating Oil Tax Hike, Particulate Matter, and Public Health

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This paper should be cited as follows:
Gilbert, S.Z., (2014) **"Athens' "Nephos": A Heating Oil Tax Hike, Particulate Matter, and Public Health",** Athens: ATINER'S Conference Paper Series, No: **HEA2014-1323.**

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URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN: **2241-2891**
30/12/2014

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Abstract

This paper focuses on the human health impacts of the increasing smog in Athens, Greece following a tax hike on home heating oil. The purpose of this work is to determine if the Greek government should lessen the current heating oil tax (or pursue another policy approach) in order to reduce Athenian smog and the subsequent effects of particulate matter on public health. This work contains a risk assessment, a synthesis of scientific and epidemiologic findings, an exploration of tax and health policy options, and a final, evidence-based policy recommendation.

In the wake of Greece's national debt crisis and supranational 2010-11 bailout negotiations, the Greek government raised heating oil taxes in late 2012. As a result, many residents have resorted to burning scrap wood, firewood, and even garbage for home heating. Biomass burning releases particulate matter, sulfur dioxide, carbon monoxide, and other carcinogens into the air, which becomes trapped in and around Athens as smog. This can be especially noxious to certain sub-populations, such as those with heart disease, hypertension, or asthma.

Two particulate matter types, PM2.5 and PM10, are of particular interest due to their established potency in human health and previous measurements in the Greek capital. This paper's synthesis of evidence summarizes strong dose-response relationships (in intervals of roughly 10 μg/m3) for PM2.5 and PM10 with various morbidity and mortality measures.

Greek political leadership is in neither a public health nor an ethical position to gamble with harmful aerosols over matters of taxation. Given the established human health impacts of PM2.5 and PM10 released by burning cheap fossil fuel alternatives, it is vital and time-sensitive that Ministers and public officials of the Hellenic Republic come together and enact the recommended home heating oil tax relief.

Keywords: environmental health policy, particulate matter, Athens, smog.

Acknowledgements: The author would like to thank Robert McLellan, MD MPH FACOEM FAAFP and Carolyn Murray, MD MPH for their valuable feedback and academic guidance in this work. She would also like to express great gratitude to Natalie Riblet, MD MPH for her keen insights and research suggestions.

Introduction

Athens, the capital of Greece, was built over two thousand years ago and is surrounded by mountains on three of its sides and the Mediterranean Sea on its fourth. Currently, Athens harbors 3.252 million people – over 30 percent of the country's overall population of 10.772 million (CIA World Factbook, 2014). Its municipal population density of 17,043 people/km^2 (44,140 people/mi^2) has exponentially risen since the population boom of the 1960s and 1970s (Απογραφή Πληθυσμού, 2011). This population density ranks 40th among the world's largest cities: a few places behind Paris, on par with Cairo and Seoul, and far ahead of London, which boasts only one fourth of Athens' population density (City Mayors Statistics, 2007; Government of South Korea, 2012; Forbes, 2006; GLA Demographic Projections, 2013).

The city has a geographic and geological predisposition to collecting smog, particularly in its downtown areas. During the early and mid-20th century, Athens attracted large energy-consuming industries. Environmental historian J.R. McNeill (2000) describes a rapid rise in the paint, paper, chemical, steel, shipbuilding, and other industries during this time, spawning a cascade of urban development and consequent air pollution. Just like notoriously smoggy Los Angeles, Athens too has a sunny and dry climate year-round, making it "ideal for smog formation" (Zervas et al., 2012). Locals dub the city's severe smog "το νέφος" (or "to nephos," which literally translates to "the cloud" or "the haze").

Home Heating in Greece

Until the Great Depression in the 1930s, Greek households primarily burned wood and charcoal for home heating (McNeill, 2000). Beginning around World War II, this practice was replaced by imported oil and domestic coal, which has since dominated the Greek home heating market. However, recent developments in the national political arena and a turbulent economy have led to a dangerous shift in home heating.

Since 2009, Greece has faced extremely difficult fiscal circumstances as a result of its debt crisis and the global recession. As part of Greece's 2010-11 bailout negotiations with representatives of "Troika" (a nickname for the tripartite Eurozone collaboration between the European Commission, the European Central Bank, and the International Monetary Fund), Greek leaders agreed to increase the motor fuel tax. In order to further generate federal revenue, the Greek Parliament also raised the heating oil tax six-fold in late 2012 (Petmesidou, 2013).

In reaction to this tax hike, many Greeks effectively boycotted this fuel. The Inka consumer group recently reported that four out of every five apartment blocks in Athens refused to buy heating oil during the 2013-4 winter season due to the higher cost of heating oil (Enet English, 2013). A significant portion of the population has turned to burning cheaper alternatives, including scrap wood, garbage, biomass, and even cutting down trees for firewood. By combusting these items, residents are releasing particulate matter, sulfur

dioxide, carbon monoxide, and other carcinogens and risk factors into the air, which can become trapped in and around downtown Athens.

The population of focus for this policy paper is the general Athenian population because the recent spike in smog has very acutely affected all of the capital's denizens. The sudden drop in temperature during December 2013 led to a particularly sharp uptick in the burning of the aforementioned cheaper, dirty fuel alternatives, thus contributing to already very high and noxious smog levels (Karamanolis, 2013).

Smog & Particular Matter

The scientific evidence agrees: smog poses a major deleterious threat to numerous facets of human health. To be clear, smog can be composed of many different chemicals; thus, its exact constituency depends on several variables. In this analysis of Athens' current smog issue, we are most concerned with two specific types of particulate matter (PM) already established as significantly high in Athens' air and smog composition: $PM_{2.5}$ and PM_{10} (Organisation for Economic Co-operation and Development, 2010). This paper will briefly touch on a few other harmful compounds. One such compound, ozone, is known to cause to a range of respiratory symptoms that can be particularly dangerous for those with cardiac or pulmonary conditions (Pryor 1992).

Environmental health scientists have long studied PM released by woodsmoke or by biomass burning due to the negative consequences on human health, quality of air, and changes to the atmosphere and climate (Pateraki et al., 2013; Balakrishnan et al., 2002; Ward, 1990; Li et al., 2012; Turn et al., 1997; Brauer et al., 1996; Regalado et al., 2006; Fang 1999; Andreae and Merlet, 2001; Hays et al., 2005; Jiang and Bell, 2008). PM is now known to cause and exacerbate myriad health issues in both humans and animals: asthma, lung and other cancer, cardiovascular issues, and neonatal mortality – just to name a few (American Lung Association, 2013). A risk characterization by the World Health Organization (WHO) in 2000 found that "inhalation is the only route of exposure that is of concern in relation to the effects of suspended particulate matter on human health," underscoring the need for the monitoring of air quality and its connection to wellness (Air Quality Guidelines, 2000).

Recent research efforts have shifted from coarser PM (such as PM_{10}) toward finer aerosols (like $PM_{2.5}$). The technical difference between these two PM types is a distinction in the aerodynamic diameter of their groups of compounds: 10 μg for PM_{10} and 2.5 μg for $PM_{2.5}$ (Marcazzan et al., 2001). A major consequence of the fact that $PM_{2.5}$ compounds are physically smaller than PM_{10} is a deeper and faster penetration into the upper parts of the respiratory tract; this process elicits stronger and earlier physiologic effects (Pateraki et al., 2013). PM_{10} is predominantly filtered by the nose and in the mouth and throat by cilia and the mucosal lining, though it can settle in some of the deepest, most terminal parts of the lungs: the bronchioles (Jiang and Bell, 2008). The smallest PM class, PM_1, can rapidly pass through the gas exchange in the lungs and reach other organs (Marcazzan et al., 2001; Bertsias et al., 2003).

Public Health Concerns

A seminal 1993 paper by Dockery et al. reported that fine particular matter contributes significantly to higher mortality in 6 US cities, Los Angeles being the one which most closely mirrors the climate and population density of Athens (American Lung Association, 2013). Even before the economic crisis hit Greece in 2009, the level of atmospheric PM_{10} (a pulmonary toxin) was already 31 micrograms per cubic meter ($\mu g/m^3$), much higher than the Organization for Economic Co-operation and Development (OECD)'s average of 20 $\mu g/m^3$ (2010). $PM_{2.5}$, a "fine," more potent aerosol than its cousin PM_{10}, was reported in Crete in 2007 to be significantly higher levels during summertime than the overall mean (27.9 vs. 25.4 $\mu g/m^3$) (Lazaridis et al., 2007). In Athens in 2003, the averaged measured $PM_{2.5}$ was 40.2 $\mu g/m^3$; as a matter of scientific reference, the United States Environmental Protection Agency's annual standard for $PM_{2.5}$ is 15 $\mu g/m^3$ (Chaloulakou et al., 2003).

Following their nation-wide survey of 2,191 participants, Zervas et al. (2012) reported that the highest asthma prevalence was found in Athens: 10.9%. In general, rural and urban areas of Greece had no statistically significant difference (8.5% vs. 7.8%). In another study by Bertsias et al. (2003), heart disease, diabetes, obesity, and other chronic illnesses were also found to be on the rise, thus increasing the proportion of those most vulnerable to smog and who will most likely incur the heaviest burden of PM exposure.

Given the epidemiological evidence and rising human health concerns about PM exposure, it is vital that the recent changes in Greeks' home heating practices are carefully assessed to inform effectual strategic policymaking.

Synthesis of Epidemiologic and Scientific Evidence

$PM_{2.5}$

Table 1 lists the nine peer-reviewed human studies on $PM_{2.5}$ included in this synthesis of epidemiological evidence (Dockery et al., 1993; Zanobetti et al., 2009; Ebisu and Bell, 2012; Ostro et al., 2009; Karr et al., 2006; Rich et al., 2008; Valdés et al., 2012; Kloog et al., 2012; Wellenius, 2012). With the exception of the study by Karr et al. (2006), the literature overwhelmingly supports a positive dose-response relationship between ambient $PM_{2.5}$ exposure and morbidity. The most common proxy for morbidity in the 8 studies was risk of hospitalization (n=3), though mortality rate-ratio, cardiovascular mortality, low birth weight, stroke, infant bronchiolitis, and blood pressure were also found to be associated with higher levels of measured $PM_{2.5}$. Incremental $PM_{2.5}$ increases of roughly 10-14 $\mu g/m^3$ were consistently and significantly associated with a rise in morbidity. Only Karr et al. did not find a statistically significant link between acute increases in $PM_{2.5}$ and their morbidity outcome: risk of infant bronchiolitis (2006).

Table 1. *Studies on the Human Health Effects of Ambient Particulate Matter ≤2.5 μg ($PM_{2.5}$) and Particulate Matter ≤10 μg (PM_{10}), Two Compounds (aerosols) released into the Air by Wood and Biomass Burning*

Aero-sol	Study Design	Population & Setting	N	Main Effect (Dose Response)	Authors & Year
$PM_{2.5}$	Prospective cohort	6 US cities, 1974-7 with 14-16 year follow-up periods	8111 randomly selected US adults	Estimated relative rate ratio for fine ($PM_{2.5}$) particles was 1.26 (95% CI: 1.08, 1.47)	Dockery et al., 1993
	Cross-sectional	2000-2003; 26 US communities	Medicare hospital records (685,716 CVD; 121,652 MI; 238,652 CHF; 46,192 diabetes; 261,449 resp. admissions)	Each 10 μg/m^3 increase in $PM_{2.5}$ was associated with increases in CI (1.89%); CVD (2.25%); MI (1.85%); CHF (2.74%). diabetes (2.07%) in respiratory hospital admissions	Zanobetti et al., 2009
	Cross-sectional	2000-2007; CT, DE, MD, MA, NH, NJ, NY, PA, RI, VT, VA, DC, WV; National Center for Health Statistics data	1,207,800 births	Low birth weight risk increased per interquartile range increase of $PM_{2.5}$ (species: aluminum [4.9%], elemental carbon [4.7%], nickel [5.7%], and titanium [5.0%])	Ebisu and Bell, 2012
	Cross-sectional	2003; 6 California counties; children (5-19 years old)	Unclear total N; data from CA Office of Statewide Health Planning & Development	Excess respiratory hospitalization risk of 4.1% was associated with increasing interquartile range of $PM_{2.5}$ species (full-year IQR =14.6 μg/m^3)	Ostro et al., 2009
	Case-Control	1995-2000; South Coast Air Basin of California	19,901 infants	No increased risk of bronchiolitis after acute exposure to $PM_{2.5}$	Karr et al., 2006
	Prospective cohort	1995-2000; New Jersey; patients under specialized care for class III heart failure	11 patients with CIII heart failure	Each 11.62-μg/m^3 increase in same-day $PM_{2.5}$ concentration was associated with small but significant increases in estimated PA diastolic pressure	Rich et al., 2008
	Time-series analysis	1998-2007; Santiago, Chile	~6 million; "National Institute of Statistic" data	1.33% increase in cardiovascular mortality per 10μg/m^3 increase in the 2-day $PM_{2.5}$ mean	Valdés et al., 2012
	Cross-sectional	2000-2006; 65+ year old adults; EPA data used for analysis	Unclear total N; Medicare records	Each 10-μg/m^3 increase in short-term $PM_{2.5}$ exposure increases risk of hospital admission by 0.70%; every 10 μg/m^3 increase in long-term $PM_{2.5}$ exposure increases risk of admission by 4.22%	Kloog et al., 2012
	Time-stratified case-crossover	1999-2008; Boston, MA; patients with confirmed ischemic stroke	1705 stroke patients	OR of ischemic stroke onset was 1.11 (p=0.006) per interquartile range increase in $PM_{2.5}$ (IQR = 6.4 μg/m^3)	Wellenius, 2012

PM_{10}	Ecological Study	April-October 2000; Darwin, Australia ER Department	265 asthma presentations	Increase in asthma presentations with each 10 $\mu g/m^3$ increase in PM_{10} concentration ($p<0.001$)	Johnston et al., 2002
	Prospective cohort	June-July 2008; Beijing, China	60 office workers; 60 truck drivers	A 10 $\mu g/m^3$ increase in 8-day ambient PM_{10} was associated with increases in systolic (0.98; p=0.003), diastolic (0.7; p=0.01), and mean BP (0.81; p=0.002)	Baccarelli et al., 2011
	Time-series analysis	1995-2004; Nicosia, Cyprus	178,091 all-cause, 10,896 cardiovascular, and 14,827 respiratory admissions	For each 10 $\mu g/m^3$ increase in daily PM_{10}, a 0.9% increase in all-cause and 1.2% increase in cardiovascular hospital admissions was observed	Middleton et al., 2008
	Time-series analysis	2001-2005; 7 Chilean cities (Santiago province)	5.37 million people; data from Comision Nacional Del Medio Ambiente	RR for migraine was 1.10 for each 37.79-$\mu g/m^3$ increase in PM_{10}	Dales et al., 2009
	Case-crossover	1998-2006; Flanders, Belgium	2,382 neonates	Risk of neonatal death increased by 11% for each 10 $\mu g/m^3$ increase in daily mean PM_{10}	Scheers et al., 2011
	Time-stratified case-crossover	2006-2008; 4 hospitals in Wuhan, China	10,663 hospital admissions with primary discharge stroke diagnosis	Each 10 $\mu g/m^3$ increase in PM_{10} was significantly associated with ~1% increase in risk for stroke hospitalization	Xiang et al., 2013
	Prospective cohort	6 US cities, 1974-7 with 14-16 year follow-up periods	8111 randomly selected US adults	Estimated relative rate ratio for inhalable (PM_{10}) particles was 1.27 (95% CI: 1.08, 1.48)	Dockery et al., 1993

PM_{10}

The seven peer-reviewed human studies on PM_{10} included in Table 1 agree: in general, each increase of 10 $\mu g/m^3$ in ambient PM_{10} is correlated with a higher risk of morbidity, mortality rate ratio, and neonatal mortality (Dockery et al., 1993; Johnston et al., 2002; Baccarelli et al., 2011; Middleton et al., 2008; Dales, Cakmak & Vidal, 2009; Scheers et al., 2011; Xiang et al., 2013). Just as the studies for $PM_{2.5}$ used proxies for morbidity, so did most of the PM_{10} studies: hospitalization, asthma presentation, blood pressure, and risk of migraine. The incremental dose-response relationship between PM_{10} and adverse health outcomes was consistently observed across study designs, age groups, geography, and non-clinical demographics.

Assessment of Included Studies

Eight of the nine $PM_{2.5}$ studies and all seven of the PM_{10} studies boast large sample sizes (N>100), mostly thanks to public insurance or city health records (e.g. US Medicare, US National Center for Health Statistics, Chile "National Institute of Statistic"). The large number and the diversity of

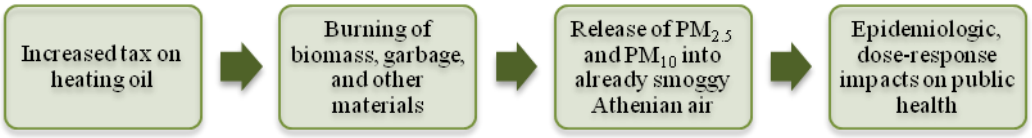
included patients can statistically strengthen the authors' validity of results and enable greater generalizability of their findings. In terms of drawing conclusions about Athens, it is important to note the dense, urban settings of the included studies: Santiago, Beijing, Flanders, Boston, Wuhan, and Nicosia. The last of these densely population cities (Nicosia, Cyprus) is also the most ethnically, geographically, and climatically akin to Athens; it is thus especially important that Athenian officials pay attention to the significant increase of 0.9% in all-cause and 1.2% in cardiovascular hospital admissions per 10 $\mu g/m^3$ rise in PM_{10} observed by Middleton et al. (2008).

A number of weaknesses exist in the included studies. While a number of Hill criteria for causality are met in this paper (e.g. dose-response relationship, biologic plausibility, consistency, coherence, and strength of association), it would be scientifically unsound to deduce from statistical associations that $PM_{2.5}$ and PM_{10} definitively cause morbidity and mortality. Notably, we lack a single measured outcome for comparison as well as human or animal experiments – though they would be extraordinarily difficult to conduct with humans due to obvious ethical considerations. The included study designs also do not all possess a time component, raising questions about a possible missing temporal component, or one of the Hill criteria, in our analysis. Finally, four of the included reports (all with a focus on $PM_{2.5}$) are cross-sectional studies and are thereby limited with respect to contributory conclusions due to the chance of effect-cause (Zanobetti et al., 2009; Ebisu and Bell, 2012; Ostro et al., 2009; Kloog et al., 2012).

Beyond the relationship between particular matter and human health, it is also critical to connect particulate matter with the rise of incineration of biomass, waste, and other non-oil materials. The upstream link between particulate matter and burning of biomass is not incorporated in Table 1. However, this causal relationship has been studied by numerous researchers and upheld in both rural and urban studies across the globe (Balakrishnan et al., 2002; Ward, 1990; Li et al., 2012; Turn et al., 1997; Brauer et al., 1996; Regalado et al., 2006; Fang 1999; Andreae and Merlet, 2001; Hays et al., 2005; Jiang and Bell, 2008). A prominent example, Balakrishnan et al. (2002) studied 5,028 households in southern India and determined that biomass burned while cooking yielded in-home "concentrations of respirable particulate matter [between] 500 to 2,000 $\mu g/m^3$ during cooking [and] average 24-hr exposures [of] 90 ± 21 $\mu g/m^3$ for those not involved in cooking to 231 ± 109 $\mu g/m^3$ for those who cooked. The 24-hr exposures were around 82 ± 39 micro $\mu g/m^3$ for those in households using clean fuels."

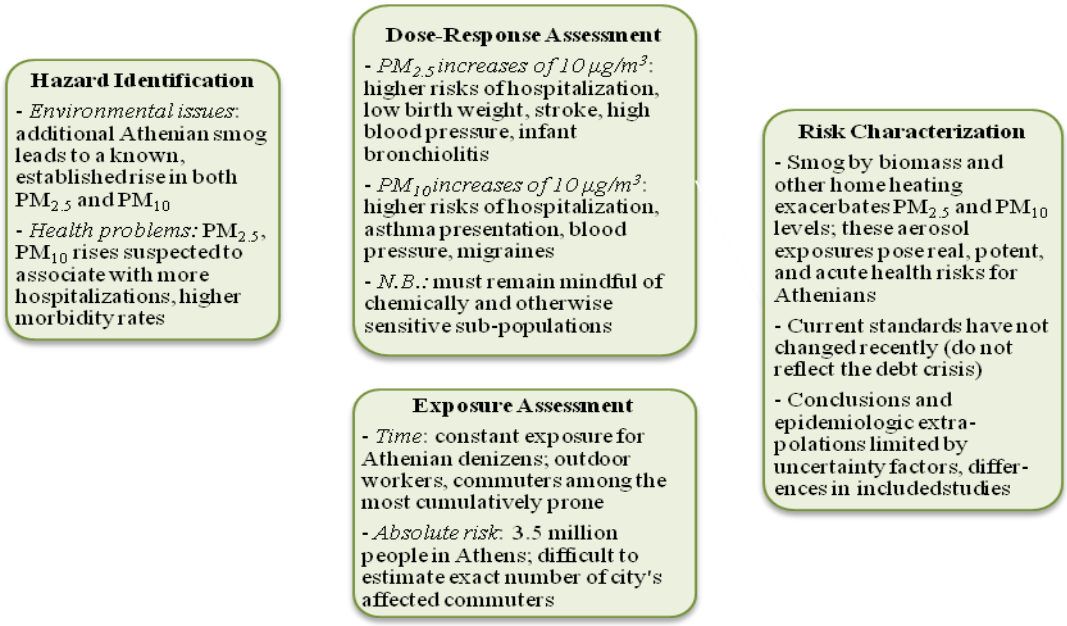
These findings epitomize the observed dose-response in the extant literature between biomass burning and PM (link B in Figure 1), sustaining our hypothesized chain reaction as a result of the increase in heating oil taxation:

Figure 1. *A Cascade of Downstream Events has resulted from the Recent Heating Oil Tax Hike in Greece. Link (A) has been Widely described in Recent News Publications, Literature, and the Mass Media; Links (B) and (C) are described in the Synthesis of Epidemiologic Evidence in this Paper*



Characterization of Risk

Figure 2. *The Four-step Risk Assessment Process Specific to the Athenian "Nephos," its Particulate Matter Aerosols $PM_{2.5}$ and PM_{10}, and their Public Health Impacts (US Environmental Protection Agency, 2000; Maxwell, 2009; Fowle and Dearfield, 2000)*



Risk characterization is the concluding step of the risk assessment process depicted in Figure 2 – a culmination of the hazard identification (Background) as well as the Dose-Response and Exposure Assessments (Synthesis of Epidemiologic and Scientific Evidence) (US Environmental Protection Agency, 2000; Fowle and Dearfield, 2000). The hazards of interest, $PM_{2.5}$ and PM_{10}, have been identified in Athenian air in previous studies of air quality and are consistently present at higher concentrations than in peer European Union nations' major cities (Organisation for Economic Co-operation and Development, 2010; Lazardis et al., 2007; Chaloulakou et al., 2003). Scientifically speaking, the exact chemical constituency of fine particulate

matter in Athens' "nephos" has not been published in the literature. Thus, while numerous peer-reviewed publications have studied a number of fine aerosols in this smog, the complete profile of air pollution remains elusive.

Following hazard identification, a dose-response evaluation was performed regarding the health effects of particulate matter in Athens' smog. With each increase of 10 $\mu g/m^3$ in airborne exposure, $PM_{2.5}$ and PM_{10} each yielded statistically significantly higher risks of various morbidities: hospitalization, low birth weight, stroke, high blood pressure, and infant bronchiolitis; hospitalization, asthma presentation, blood pressure, and migraines; respectively. Some of the Athenian population may already be particularly prone to these events, as the capital boasts very high prevalence of asthma – estimated by Zervas et al. (2012) to affect 1 in 10 Athenians. On a national scale, the rising prevalence of chronic illnesses might cause these specific sub-populations (especially the elderly) a chemical or biological handicap for dealing with the $PM_{2.5}$- and PM_{10}-laden smog (Bertsias et al., 2003). Minas et al.'s 2010 prospective cohort study of 12 health centers in Greece led to national prevalence estimates of several specific conditions (summarized in Table 2).

Table 2. *Estimated Disease Prevalence in Greece, Minas et al. 2010*

Condition	Estimated prevalence (per 10,000 residents)
Asthma	54
Chronic obstructive pulmonary disease (COPD)	350
Diabetes	715
Coronary heart disease	1,107
Elevated blood pressure	1,813

Exposure assessment and burden of harm were very difficult to quantify, especially in terms of the distribution of Athenians' estimated duration and absolute risk of harmful exposure. A January 2014 visitor-driven web survey of 33 self-declared Athenians found that roughly 18% of the city's dwellers walk to work, 15% and 12% take the bus or train, respectively, and 3% each bicycle or motorbike; the average walker travels 19.5 minutes on foot outdoors, while public transportation users (bus and train) spend 8 to 10.5 minutes walking and 10 to 16.25 minutes waiting, on average (Numbeo, 2014). These statistics are a marked departure from the 1997 and 1998 reports by the Athens Labour Centre (EKA, a trade union-based research institute), which then reported only 12.8% of Athenians walked, and 30% used public transportation, to get to work (Theohari, 1998; Antonopoulou and Fthenou, 1997). This is a possible consequence of the current economic crisis that compels workers to save money by foot, bus, or train (the structures for which were entirely updated in time for the 2004 Summer Olympics).

The increased reliance on these means of transport means that the roughly 3 million commuting Athenians and regional residents likely – and unwittingly – face numerous health risks each business day due to $PM_{2.5}$ and PM_{10}

exposure. The probability of harm as a result of prolonged daily exposure to these PM types is even more difficult to estimate, though their scientifically and statistically significant dose-responses underscore the importance of addressing this rise in smog with an evidence-based solution. In the long-term, this rapid, public health-conscious approach will benefit the Athenian community and Greek society as a whole by reducing healthcare costs, sustaining a healthy workforce, and eschewing the costs of lost productivity.

This risk characterization of $PM_{2.5}$ and PM_{10} benefitted from the epidemiologic inclusion of only human studies and a range of putative adverse effects (Maxwell, 2009). Despite these advantages, it remains virtually impossible at this time to extrapolate a safe dose estimate (and either a NOAEL or LOAEL value) based on the included studies; a retrospective cohort in Athens, another site in Greece, or a location with a similar population (e.g. Cyprus) would provide the closest such reference values.

In characterizing the risk of $PM_{2.5}$ and PM_{10} in Athens using the epidemiologic and scientific evidence presented thus far, a number of uncertainties have been assumed. First, it is generally understood that risk characterization is often extrapolated to some degree (as in this case, to Athens from other urban centers around the world). One of the key assumptions in this analysis is that the chemical compositions of $PM_{2.5}$ and PM_{10} are the same, or at least similar, across the included studies and in Athens. Many of the uncertainty factors embedded in this statement would be difficult to standardize across cities: aerosol sources (vehicular pollution, industrial waste), study participant variables (such as duration and intensity of exposure as well as other relevant measurable individual risks like smoking or health status), and beyond (US Environmental Protection Agency, 2000; Maxwell, 2009). Thus, based on these unknowns and the aforementioned methodological limitations to data synthesis, it is imperative that the characterized risk is both handled and communicated (particularly to the public or a layperson audience) in a scientifically sound, accurate manner (Maxwell, 2009; Santos, 2007).

The Landscape

Key Stakeholders

Major parties interested in addressing the current spike in smog include Athenian denizens, particularly the elderly, who are financially strapped due to slashed social security benefits; low- and medium-income households; and unemployed individuals. The reason for these groups' interest stems from their economic and sociopolitical disenfranchisement in recent years, as these individuals have been financially hit the hardest by the increase in heating oil taxes (Staley, 2012). In Greece, approximately 15 percent of Gross Domestic Product (GDP) is attributable to tourism, an industry that employs many Hellenes (Invest in Greece Agency, n.d.). The mere possibility of smog affecting tourism could easily agitate an already highly mobilizable, large group of financially distressed tourism workers.

The Athens Medical Association (AMA) has also demonstrated its professional and ethical investment in the issue, as many of its doctors see Athenian children with asthma and individuals suffering both acutely and chronically from the smog's effect on cardiac and pulmonary health (Zervas et al., 2012; Karamanolis, 2013). Due to Greeks' declining income and deep cuts the national health and social insurance programs, clinicians have observed a decline in preventive testing and primary care visits in recent years (Karamanolis, 2013). In December 2013, the AMA warned Greeks to be careful with "what they burn in their fireplaces and called on the government to create a more comprehensive policy to deal with the problems people have in heating their homes" (Kathimerini English Edition: "Smog," 2013).

In the legislative arena, Greece's Government Ministers and Members of Parliament are facing significant pressure both from their constituents to act swiftly and from IMF's Troika (in addition to EU bigwigs like Germany and the United Kingdom) to generate enough revenue to sustain a strong economic recovery. To date, Ministers and Parliament Members have bowed to the latter over the former, making promises of higher taxes and austerity with the long-term intention of warding off national default (Balaras, 2013).

On a supranational scale, the "Troika" is obviously intimately involved with matters of taxation and other policies in the Hellenic Republic. The WHO (as part of the United Nations) and the European Commission (a branch of the EU) have proposed restrictions on atmospheric PM_{10} and have annually monitored a few $PM_{2.5}$ compounds; however, they have not made firm recommendations for the specific handling of these smaller chemicals (Koulouri et al., 2008; Country Profile: Greece, 2006).

The excise and value-added heating oil tax hikes have hit the oil industry hard because many Greeks have opted to burn biomass or alternative cheap materials instead. In January 2013, shortly after the tax went into effect, the Greek Fuel Suppliers' Association (Ένωση Βενζινοπωλών Ελλάδας) claimed a loss in sales of 75% to 80% for the previous 3 months (Λέντζου, 2013; Keep Talking Greece: "Measure backfires," 2013). These suppliers have eagerly and publicly proposed that the government reduce the "heating oil tax to the levels of 2010, so that consumers could buy it at a price of 0.88-0.90 euro per liter" (Λέντζου, 2013).

Finally, Greek and international media play an integral role in risk perception, risk communication, and public policy. Greek journalist and The Hellenic Foundation for European and Foreign Policy research fellow George Tzogopoulos (2013) notes the "discursive" coverage of important issues domestic to Greece prior to the economic crisis; unfortunately, since the country hit an economic in October 2009, international media have portrayed Greece in dramatic and poetic terms ("Greek tragedy," "chaos") – though these portrayals have not always been accurate. In the fall of 2013, the WHO was forced to retract a false report released just a few weeks prior where the reporter had "claimed about half of new H.I.V. cases in Greece were 'self-inflicted' as a way to get state benefits" and as a primary means of income (Hakim, 2013). It is all too easy for the public to simply trust the ethos of

organizations like the WHO; this faith is abused when incorrect information is hastily propagated on a global scale through news outlets, blogs, and social media. Thus, high quality healthcare reporting is paramount.

Within Greece, the media has been dealt severe financial blows, with roughly 4,000 journalists having lost their jobs due to the widespread national television and radio station closures (Greenslade, 2013). Due to the heavily state-funded media's known ties to political parties and the wealthy class, many Greeks hesitate to trust their media sources and have turned to the Internet and independent online start-ups for their news and "serious public dialogue" (Greenslade, 2013). As with other international media outlets, it is equally important to accurately communicate risk to these informal online news communities in order for Greeks to truly understand the health risks linked to $PM_{2.5}$ and PM_{10} in Athens' "nephos."

Regulatory and Sociopolitical Context

The issue of this paper is inextricably and deeply rooted in a serious regulatory, sociopolitical, and socioeconomic context. A member state of the EU since 1981, Greece is beholden to the European Commission's maximum PM_{10} 24-hour concentration of 50 $\mu g/m^3$, a limit established in 1999 with a compliance deadline of January 1, 2010; Athens continues to struggle to remain at or slightly below this value (Country Profile: Greece, 2006; Chapter 3, 2014). Additionally, Greece signed the Kyoto Protocol in April 1998 and has since independently approved pollutant-reducing measures like Law 3325, which was passed in 2005 with the objective of bringing down ambient SO_2, NO_x, and PM_{10} levels (Chapter 3, 2014).

The battle between controversial austerity measures (including the end of tenured public sector positions and pension cuts of over 50 percent) and fundraising to stay out of bankruptcy has made for an extraordinarily tense sociopolitical climate (Kitsantonis, 2013). The socioeconomic weakening of the seasonal workers (most of whom rely on tourism), the elderly, and a predominantly unemployed youth and young adult population has aggravated a passionate constituency known for its ability to organize, strike, and push forth democracy on a whim. Making matters worse for Athens' "nephos" and public health, the Finance Ministry in September 2013 dismissed cries to lower the heating oil tax, simply claiming, "there is no such issue" (Μορφούλη, 2013).

Economic Resources Required for Solutions

On the whole, modern Greece has not been a resource poor country. However, recent years have seen its credit rating plummet, the tourism industry – its beating financial heart – drop, and national fiscal confidence disappear. The economic impact of the heating oil tax has, thus far, not brought about the surefire revenue the government had anticipated, with estimated losses in the 2012-13 heating season of 400 million euros (Λέντζου, 2013).

The burden, of course, is not felt by the government, which will almost certainly survive – even if it must pull the dreaded trigger to default. Instead, it is the consumers who must suffer the tax-induced pain each day, driven away

from traditional, less dirty energy sources as they burn biomass and other materials, unconsciously creating a public health issue. A restoration of taxes to 2010 levels, as proposed by the Greek Fuel Suppliers' Association, would hardly cost the government a cent – most likely just the cost of the paper and ink needed to sign this reduction back into law.

Policy Recommendations

Potential Actions

In view of the body of evidence that supports a dose-response relationship between $PM_{2.5}$ and PM_{10} with significantly negative health outcomes, it is vital that potential courses of action are explored in order to recommend an evidence-based policy. Reducing levels of particulate matter is incredibly important as Greece continues to take hits on numerous fronts (in addition to the ever-more expensive healthcare realm): tourism, social security and disability costs, worker (particularly outdoor commuter) productivity, and even the possible chemical degradation of monuments. The following proposals should be weighed against one another in the context of the epidemiologic evidence, the landscape, and additional salient factors:

1) Status quo: aside from public health warnings, doing nothing in response to the rising smog levels and public outcry due to the tax hike. Understandably, this has been an extremely unpopular move by Greek public officials. A few months into the tax increase, the news blog "Keep Talking Greece" featured an editorial piece on the government's inaction and continued superficial warnings:

> "The Environment Ministry, the National Centre for Disease Control & Prevention, the Greek Doctors' Association. They all urge us to immediately stop burning wood in the fireplaces and stoves and turn on the heating oil or natural gas system to comfortably pass through the cold winter days. They tell us of unhealthy fumes, of cancer causing particles, of respiratory and heart problems and allergies… But all those caring institutions do not advice us where we all find the money to pay the heating bills, that went up by 50% when compared to those of last year. We sit right in front of the fire place and cough our lungs out. But who cares? At least, we will die... warmed up" (Keep Talking Greece: Greeks, 2013).

Some may argue that the tax is intended to change behavior so that Greeks become less reliant on heating oil; similar taxes on vehicle gasoline have been levied over the years in Greece with decent success in controlling automobile use and resultant air pollution (Kathimerini English Edition: "Emergency measures," 2013). While the argument for behavioral change might be valid in a more democratic and open policymaking

process, this particular heating oil tax was, in a top-down manner from Troika leaders, externally forced upon the Greek people. The combined economic, population health, political risks incurred by nearly all stakeholders under this approach make it the least advisable of the options.

2) Selectively provide heating oil subsidies to low-income families, the prone elderly, and tourist hotspots. This option would effectively uphold the current tax for all citizens. However, at the beginning of each fiscal quarter, subsidies of up to 3,000 euros per 3-month quarter (providing roughly 2 kiloliters of heating oil) would be selectively given to vulnerable citizens (Keep Talking Greece: Greeks, 2013). These subsidies would be most likely triaged first to low-income families. "Low-income" status would require meeting at least one of the following criteria: elderly who can demonstrate a net worth below 6,000 euros; living below the national poverty level (adjusting for family size in accordance with tax law); or households with both parents unemployed and with at least one child under 18 years of age. Tourism businesses like hotels, motels, restaurants, and national sites should be provided with subsidies of a politically negotiable monetary value. Over the past decade, Greece has increasingly weathered fierce rivalries with other Balkan and Mediterranean vacation spots, including Turkey, Croatia, and Spain (Association of Greek Tourism Enterprises, 2014). In order to remain competitive, Greek leaders mustn't forget the role of these businesses in the economic recovery. The advantage of this option is that it would be well received (and long politically remembered and electorally rewarded) by the beneficiary constituents. However, it would unlikely ease the unbending tensions among the majority of Greeks and would probably anger those Troika leaders simply out for taxable Greek blood.
3) Tighten regulations on which days public, non-residential buildings can be heated with oil. This potential action is inspired, in large part, by the Athens Ring program, or Δακτύλιος Αθηνών ("Daktylios Athinon") (Living in Greece, 2010). The Athens Ring system, which bans cars from entering the city center on specific days based on the car's odd or even number at the end of its license plate, was initially implemented in July 1979 to conserve fuel during the then-oil crisis; it was fully instituted by permanent statue in 1982 (Living in Greece, 2010). A similar on-off regulation of public, non-residential buildings' heating systems might be effective in both energy conservation and cost control. However, this measure would be extraordinarily unpopular among public workers, who comprise 14% of the entire Greek workforce and, until last year, enjoyed tenure for life (Lubin, 2010). Public workers have a long history of flexing their democratic, unionized arm either in reaction to an issue or in collective action for a cause. Strikes would certainly result in reaction to this option, despite the analogous success and tolerance of the Athens Ring statute.
4) Reduce heating oil tax to 2010 levels. On the surface, this may seem like the most obvious and straightforward solution. Indeed, in terms of the

feasibility and impact of proposals, lowering taxes appears to be the correct course of action as it can be accomplished in a joint administrative and legislative effort (see Figures 3 and 4). The only major caveat is Troika: their leaders might try to pressure Greece's leaders and Parliament members against bringing the heating oil tax to that of 2010 (1 euro per liter) in the name of revenue generation (Nikolas, 2012). In rebuttal to Troika's continued demands for austerity and higher taxation, Greece can point to the Inka consumer group's findings that Athenians are turning down home heating oil. Just as the tax hike on home heating oil failed to meet the expectations of surefire revenue, an analogous scenario involving a 2010 gasoline tax failed to generate Greek federal money as well, thereby bolstering the argument for tax relief:

> "[The spike in gasoline tax] was expected to bring an additional 934 million euros per year for state coffers, but instead it only raised 100.9 million last year. It is likely to be half that in 2012. Looking back to 2004 the state received 907.8 million euros in fuel tax revenue even though tax levels were lower" (Nikolas, 2012).

Figure 3. *Hierarchy of Controls with Respect to the Proposed Actions to Reduce $PM_{2.5}$ and PM_{10} in Athenian Smog; Plan I (status quo) is Outside the Scope of this Figure, as this Hierarchy Assumes Action over Inaction (Hazard Control, 2006; Curtin University, 2014)*

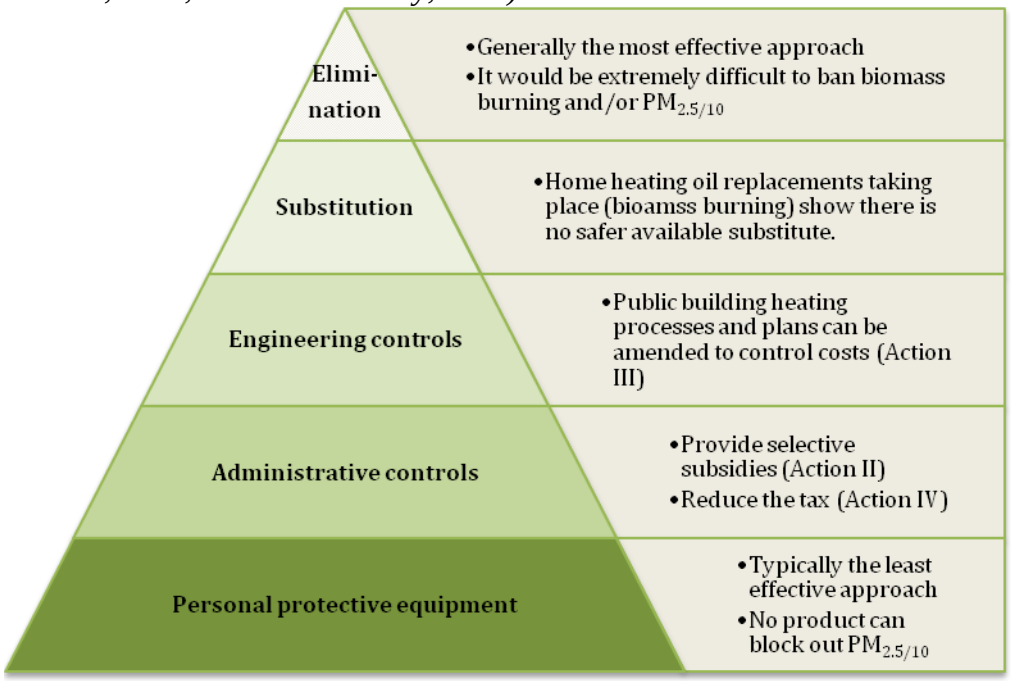
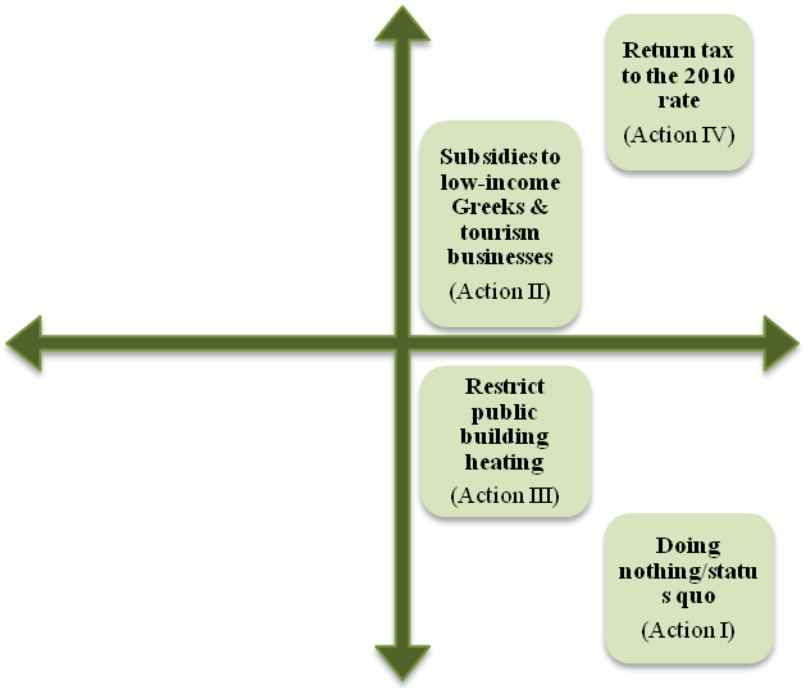


Figure 4. *Analysis of Potential Actions along two Dimensions: Feasibility and Impac*



Conclusions

The Greek population and its political leaders are in no public health or ethical position to gamble with noxious $PM_{2.5}$ and PM_{10} over matters of taxation. Given the human health impacts of these aerosols' release by the burning of cheap fossil fuel alternatives (biomass, wood, and garbage), it is imperative and time-sensitive that the Ministers of the Environment, Finance, and Health pursue Action IV and lead its legislative passage through the Hellenic Parliament. More explicitly, this entails a return the current tax relief on home heating oil to its rate in 2010: 1 euro per liter. While there may be initial pushback from Troika officials, it is imperative that Greek leaders keep their financially restricted, smog-threatened population in mind as they enter future deliberations and re-negotiations with these supranational stakeholders. The tax has not been effective in generating revenue and has already cost the public health of Greece – and, more acutely, Athenians – enough.

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