Chapter 2.

THE IMPACT OF AIR POLLUTION ON DEMAND FOR LIFE AND HEALTH INSURANCE

Air pollution has become a severe cause of some serious illnesses. The costs of medical care substantially increase for individuals exposed to high levels of air pollution. Air pollution also affects decision-making, as documented in some experimental research. With enormous air pollution, people have become more risk-averse and have increased their demand for life and health insurance. Theoretical and empirical arguments show that demand for life insurance is non-linear, meaning demand increases when air pollution reaches a certain threshold considered dangerous for health. Below this level of pollution, demand for life insurance might fall when air pollution increases. Demand for health insurance also exhibits a non-monotonic pattern similar to life insurance. In addition, there is a heterogeneous impact of air pollution on different individuals based on their income level, education, gender, marital status, the number of children, and the geographic location of their household. Risk perception plays an important role in insurance purchase decisions, and the impact of advertising and the behavior of friends and relatives is an important factor for air pollution risk perception. Empirical studies based on the micro-data show that the impact of air pollution is stronger on the demand for health than on the demand for life insurance.

1. HEALTHCARE COSTS OF AIR POLLUTION

One of the significant environmental and public health problems today is air pollution. Air pollution affects millions of people worldwide. Pollution is recognised as the most important environmental cause of multiple mental and physical diseases and premature deaths. The higher mortality is caused by primary air pollutants, heavy metals, organic pollutants, and several morbidity impacts (including chronic effects such as bronchitis, IQ reduction, cancer or acute effects such as cardiac and respiratory hospital admissions). In addition, pollution significantly contributes to the loss of biodiversity and reduces ecosystems' resilience and capacity to act as carbon sinks. The principal sources of pollution in 2020 were road transport, energy consumption, manufacturing, the extractive industry, agriculture, waste, and energy supply.

According to the European Environment Agency (EEA), air pollution is Europe's single most significant environmental health risk and a major cause of various diseases and premature death. The latest estimates from the EEA indicate that fine particulate matter ($PMI_{2.5}$) remains the most significant contributor to health risks.[51] The EEA also estimates that, in 2020, approximately 238,000 premature deaths were attributable to $PMI_{2.5}$ in the 27 EU Member States. This accounts for 6% of annual mortality and half of the deaths in the first year of the COVID-19 pandemic. According to Fuller et al. (2022), air pollution is one of the leading causes of mortality, with exposure to indoor and outdoor air pollution associated with approximately 6.7 million premature deaths in 2019.[52]

The impact of large $PMI_{2.5}$ concentration in China on long-term healthcare costs (LTC) was estimated by Liu and Wan (2024)[53]. They show that a higher concentration of $PMI_{2.5}$ raises the likelihood that older persons need long-term care by 6.4%. On the other hand, higher pollution reduces the time spent in LTC by 0.54 years due to older persons' higher mortality rates. The first effect overweighs the second one and the total costs of LTC increase with higher air pollution. Furthermore, higher $PMI_{2.5}$ concentration reduces a person's healthy life by 1.51 years and life expectancy by slightly more than 2 years.

According to the Awe et al. (2022), approximately 6.45 million people died from $PMI_{2.5}$ air pollution in 2019, including ambient (outdoor) and household sources. This makes $PMI_{2.5}$ exposure the fifth-largest health risk factor contributing to global deaths, following high blood pressure, dietary risks, tobacco smoking, and diabetes among various risk factors (Figure 1). Nearly two-thirds of these deaths (approximately 4.14 million) were attributed to ambient air pollution, while almost one-third (around 2.31 million) were linked to household air pollution. Notably, 95 percent of fatalities from $PMI_{2.5}$ exposure occurred in low- and middle-income countries.

Table 1 presents the three countries (and two in one region) with the highest death rates from $PMI_{2.5}$ air pollution in each region. The countries with the highest death rates are located in East Asia and the Pacific, Europe and Central Asia, South Asia, and Sub-Saharan Africa, with rates ranging from 106 to 202 deaths per 100,000 people. There are 32 countries with death rates exceeding 100 per 100,000 people; thirty-one are in the four regions above, while one is located in Latin America and the Caribbean.

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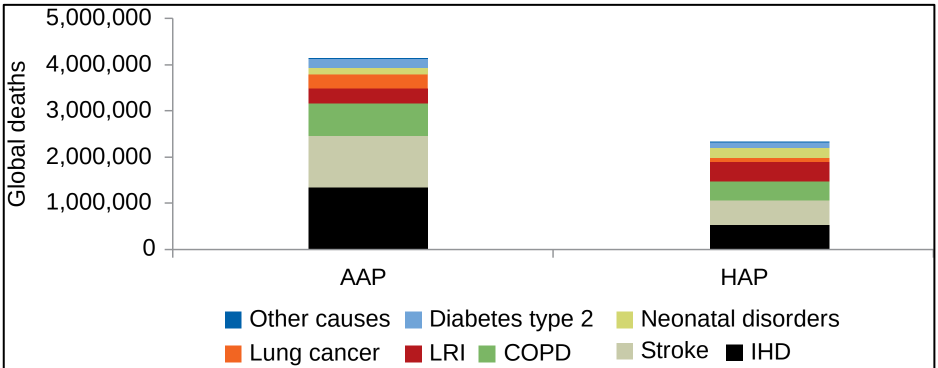
[51] https://www.eea.europa.eu/en/topics/in-depth/air-pollution/eow-it-affects-our-health

[52] Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., et al. (2022). Pollution and Health: A Progress Update. *Lancet Planet Health, 6*(6), 535-547.

[53] Liu, Z., & Wan, C. (2024). Air Pollution and the Burden of Long-term Care: Evidence from China. *Health Economics, 33*(6), pp. 1241-1265.

Figure 1. Global deaths from $PMI_{2.5}$ air pollution by cause, 2019



Source: Based on data from IHME, GBD 2019 study.
Note: AAP = ambient air pollution; HAP = household air pollution; COPD = chronic obstructive pulmonary disease; IHD = ischemic heart disease; LC = lung cancer; LRI = lower respiratory infections

Source: Awe, Y. A., Larsen, B. K., & Sanchez-Triana, E. (2022). The Global Health Cost of PM 2.5 Air Pollution: A Case for Action Beyond 2021. Washington, DC: World Bank Group.

Table 1. Number of deaths from $PMI_{2.5}$ exposure per 100,000 people, by country in 2019

REGION	COUNTRY	DEATH RATE	REGION	COUNTRY	DEATH RATE
EAP	Korea, Dem. People's Rep.	202	NA	United States	15
	Myanmar	134		Canada	10
	China	126	SA	Nepal	130
ECA	Bulgaria	157		India	114
	North Macedonia	153		Bangladesh	106
	Bosnia and Herzegovina	145	SSA	Central African Republic	149
LAC	Haiti	113		Somalia	139
	Trinidad and Tobago	64		Chad	132
	Guyana	60			
MNA	Egypt, Arab Rep.	91			
	Morocco	80			
	Syria	72			

Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and Caribbean; MNA = Middle East and North Africa, NA = North America; SA = South Asia; SSA = Sub-Saharan Africa.

Source: Awe et al. (2022), op. cit.

The adverse health effects of air pollution also have significant economic consequences. The health impacts involve substantial costs related to treating and managing illnesses caused by air pollution and indirect expenses resulting from lower productivity due to reduced working days. In 2019, the World Bank estimated that the overall cost of air pollution on health and well-being amounted to approximately USD 8.1 trillion, representing 6.1% of global GDP.

About 85% of the total global costs associated with health damages from air pollution in 2019 were due to premature mortality, while 15% were related to morbidity. The cost of morbidity as a share of the total cost of health damages varies by country, ranging between 4% and 33%. The costs of $PMI_{2.5}$ air pollution were equivalent to 8.9% of GDP (adjusted for purchasing power parity) in low- and middle-income countries, compared to 3% in high-income countries.

Table 2 presents the three countries (and for one region, two countries) in each region with the highest welfare costs of $PMI_{2.5}$ air pollution as a percentage of GDP. The countries with the highest costs are located in Eastern Europe and Central Asia (ECA), followed by the East Asia and Pacific (EAP) region and South Asia (SA). There are 17 countries where the welfare cost of $PMI_{2.5}$ exceeds 10% of GDP, with 15 of these countries in the ECA and EAP regions and two in SA. The high costs in many ECA countries can largely be attributed to their elevated baseline death rates.

Table 2. Annual cost of health damages from $PMI_{2.5}$ by country as a % of GDP in 2019

REGION	COUNTRY	COST	REGION	COUNTRY	COST
EAP	China	12.9%	NA	United States	1.7%
	Papua New Guinea	12.0%		Canada	1.2%
	Myanmar	11.4%	SA	India	10.6%
ECA	Serbia	18.9%		Nepal	10.2%
	Bulgaria	16.3%		Pakistan	8.9%
	North Macedonia	15.9%	SSA	Burkina Faso	9.1%
LAC	Barbados	8.8%		Mali	9.1%
	Haiti	8.1%		Central African Republic	8.7%
	Trinidad and Tobago	7.8%			
MNA	Egypt, Arab Rep.	8.6%			
	Morocco	7.3%			
	Tunisia	6.5%			

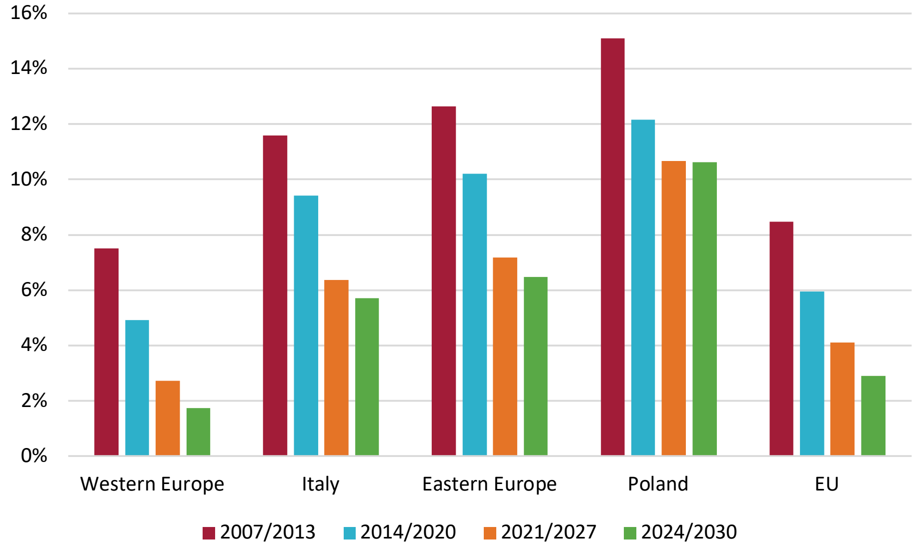
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and Caribbean; MNA = Middle East and North Africa, NA = North America; SA = South Asia; SSA = Sub-Saharan Africa.

Source: Awe et al. (2022), op. cit.

According to Mejino-López and Oliu-Barton (2024), the annual cost of air pollution in the EU from 2014 to 2021 is estimated at 770 billion EUR, or 6% of GDP. They represent less than 1% of GDP in Sweden, Finland, Estonia, and Lithuania but more than 5% in Bulgaria (6%), Italy (6%), Czechia, Croatia, Hungary (7%), Greece (8%), and Poland (10%) (Figure 1).[54]

[54] Mejino-López, J., & Oliu-Barton, M. (2024). How Much Does Europe Pay for Clean Air? *Working Paper*, No. 15/2024, Bruegel.

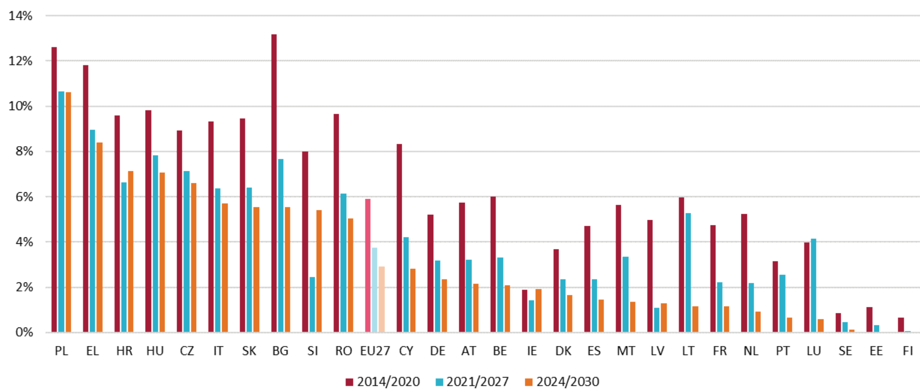
Figure 2. The costs of air pollution (% of the region's GDP over the period)



Source: Mejino-López and Oliu-Barton (2024).

Air pollution costs are disproportionately high in Eastern Europe and Italy, where losses will remain above 6% of GDP until 2030 (Figure 2). The EU's 10% most polluted regions bear 25% of the mortality burden attributed to air pollution.

Figure 3. The costs of air pollution for EU member states (% of GDP)



Source: Mejino-López and Oliu-Barton (2024).

Considering only the health and environmental costs of industrial air pollution in Europe from 2012 to 2021, the estimated external costs of industrial air emissions ranged between 2.7 trillion EUR and 4.3 trillion EUR. This averages between 268 billion EUR and 428 billion EUR per year, as shown in Table 3.

Table 3. External costs from industrial air pollution by pollutant group (EU-27, million EUR)

Pollutant group	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL
Main air pollutants (NH_3, NO_X, PM_{10}, SO_2, NMVOCs) VOLY	119,042	104,531	98,362	95,345	82,197	80,721	76,608	63,255	54,277	59,728	834,066
Main air pollutants (NH_3, NO_X, PM_{10}, SO_2, NMVOCs) VSL	329,152	291,050	274,609	277,302	237,010	238,591	226,419	186,285	173,111	193,056	2,426,585
Greenhouse gases (CO_2, CH_4, N_2O)	193,641	187,188	183,596	181,747	180,129	180,852	174,949	157,898	137,567	150,657	1,728,224
Heavy metals (As, Cd, Cr VI, Hg, Ni, Pb)	13,803	13,055	13,179	11,553	14,041	14,493	13,395	10,140	8,039	8,924	120,622
Organic pollutants (benzene, dioxins, and furans, B(a)P)	66	143	141	147	140	154	99	60	52	69	1,071
Sum VOLY	**326,553**	**304,919**	**295,277**	**288,791**	**276,507**	**276,219**	**265,051**	**231,354**	**199,935**	**219,378**	**2,683,984**
Sum VSL	**536,663**	**491,437**	**471,524**	**470,749**	**431,320**	**434,089**	**414,862**	**354,383**	**318,769**	**352,707**	**4,276,503**

Source: European Environmental Agency (2024). How air pollution affects our health. https://www.eea.europa.eu/en/topics/in-depth/air-pollution/eow-it-affects-our-health.

2. THE IMPACT OF AIR POLLUTION ON DECISION-MAKING

It is important to understand how air pollution affects decision-making to understand all possible ways in which it might affect economic and insurance purchase decisions. Some medical studies, such as Calderon-Garciduenas et al. (2008), show that a high level of $PMI_{2.5}$ concentration affects cognitive abilities.[55] Motivated by these studies, Chew et al. (2021)[56] experimentally study the impact of $PMI_{2.5}$ concentration on economic decision-making. The experiments were conducted in China during the five days of October 2012, when the pollution level was very high, but some variations were also recorded due to wind speed. The average level of $PMI_{2.5}$ concentration during the experiment was extremely

[55] Calderón-Garciduenas, L., Mora-Tiscareño, A., Ontiveros, E., Gómez-Garza, G., Barragán-Mejía, G., Broadway, J., Chapman, S., Valencia-Salazar, G., Jewells, V., Maronpot, R. R., Henríquez-Roldán, C., Pérez-Guillé, B., Torres-Jardón, R., Herrit, L., Brooks, D., Osnaya-Brizuela, N., Monroy, M. E., González-Maciel, A., Reynoso-Robles, R., Villarreal-Calderon, R., Solt, A. C., & Engle., R.W. (2008). Air Pollution, Cognitive Deficits, and Brain Abnormalities: A Pilot Study with Children and Dogs. *Brain and Cognition*, *68*(2), pp. 117-127.

[56] Chew, S. H., Huang, W., & Li, X. (2021). Does Haze Cloud Decision Making? A Natural Laboratory Experiment. *Journal of Economic Behavior & Organization*, *182*, pp. 132-161.

high, 288.5 μg/m^3. However, during the third day of the experiment, the level of $PMI_{2.5}$ concentration fell from 250 μg/m^3 to 30 μg/m^3 due to the high wind speed.

The experiments measured several aspects of decision-making. The first one is related to choices involving risk and ambiguity. In risky choices, the decision-maker knows the probability of occurrence of different outcomes, while in ambiguity, the decision-maker knows what the possible outcomes are but does not know the probability of occurrence of these outcomes. The experiments aimed to elicit certainty equivalents of risky and ambiguous lotteries. The second aspect was related to intertemporal preferences and personal discount factor.

The third aspect of the experiments was to deduce the impact of air pollution on social decision-making. In a dictator game, player A decides how to split a certain amount of money between himself and player B. If player B accepts, the money is divided according to player A's proposal. If player B rejects, both players receive zero payoff. In the ultimatum game, player A chooses how to split a certain amount of money. At the same time, player B decides on the minimum acceptable offer (MAO). If player A's offer exceeds player B's MAO, the money is divided according to player A's proposal. Otherwise, both players receive zero payoff. Both players have a certain amount of money in a public good game. They should decide how much to contribute to the public good and how much to retain for their private consumption. The contribution for acquiring the public good is multiplied by 1.6, while the money retained for private consumption is multiplied by 1. In a sequential prisoner's dilemma, player A moves first, and player B moves second. Based on player B's choice, this player can be uncooperative, conditionally, or unconditionally cooperative.

The experiment's results on behavior in risk and ambiguity lotteries show that individuals increase their risk aversion due to the high concentration of $PMI_{2.5}$. An increase in ambiguity aversion over gains was recorded, but not over losses. Concerning intertemporal preferences, individuals are more impatient (exhibit present bias) with a higher level of air pollution.

In the dictator game, players of A-type (dictators) were willing to give less to respondents (players of type B). The division of the money in the ultimatum game was unaffected by the level of air pollution. In the public goods game, individuals reduced their contribution to acquiring the public good by 18% due to a 100 μg/m^3 increase in $PMI_{2.5}$ concentration. In the sequential prisoner's dilemma game, the probability of uncooperative behavior increased significantly due to higher pollution. All these results imply that pollution reduces altruism in social decision-making. The most important result for further discussion in this text is that air pollution increases risk aversion and demand for health and life insurance.

3. DEMAND FOR LIFE INSURANCE

This section explains how demand for life insurance depends on air pollution and provides important theoretical background for subsequent discussion in the rest of the chapter. In contrast to other papers in this field, which are mainly empirical, Adetutu et al. (2024)[57] construct a theoretical model that explains the impact of air pollution on life insurance demand. The model is constructed in the Expected utility setup but the main conclusions also hold in the Prospect theory approach.

There are two states of nature. With probability p, the head of the household dies, and with probability 1-p, the head is alive. The probability p is an increasing function of the level of air pollution λ, $dp(\lambda)/d\lambda > 0$. When the head of the household dies, the household has smaller consumption c_0 than when he is alive, c_1, $c_0<c_1$. The head of the household wants to insure his family against the risk of his death, and for this reason, he buys life insurance. The head of the household maximizes the following expected utility function:

$$\max_I p\beta u(c_0 + I - \pi) + (1-p)u(c_1 - \pi), \tag{1}$$

where $u''(\cdot) < 0$ is a concave utility function since the head of the household is risk averse. The parameter β captures the bequest motive. When β=0, there is no bequest motive and no incentive to buy life insurance, and the necessary condition for positive demand for life insurance is that β>0. The life insurance premium is denoted by π, and the insurance coverage is I. When the insurance premium is fair, the premium equals the expected loss, $\pi = pI$. However, the insurance company has to earn some positive profit, and the variable load factor $a > 0$ captures this unfair premium. On top of this, a fixed load factor L>0 makes the insurance premium even more unfair. Hence, the unfair insurance premium in this model is $\pi = apI + L$. Adetutu et al. (2024) assume that the head of the household has a constant relative risk aversion utility function:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}, \tag{2}$$

where γ is the constant relative risk aversion parameter. Based on the previous assumptions, the head of the household maximizes the following expected utility:

$$\max_I p(\lambda)\beta \frac{(c_0 + I - ap(\lambda)I - L)^{1-\gamma}}{1-\gamma} + (1-p(\lambda))\frac{(c_1 - ap(\lambda)I - L)^{1-\gamma}}{1-\gamma}. \tag{3}$$

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[57] Adetutu, M. O., Odusanya, K. A., Rasciute, S., & Stathopoulou, E. (2024). Pollution Risk and Life Insurance Decisions: Microgeographic Evidence from the United Kingdom. *Risk Analysis, 44*, pp. 1907-1930.

The first-order condition yields the optimal amount of life insurance coverage:

$$I = \frac{\theta^{1/\gamma}(c_1 - L) - c_0 + L}{1 - ap(\lambda)(1 - \theta^{1/\gamma})}, \tag{4}$$

where $\theta = \frac{\beta(1 - ap(\lambda))}{a(1 - p(\lambda))}$. It is straightforward to conclude that the amount of life insurance coverage is increasing in c_1, which means that when the consumption in the state of nature when the head of the family is alive increases, the family has more wealth and buys more life insurance. In contrast, demand for life insurance is decreasing in c_0. This implies that when the consumption in the state of nature increases when the head of the family is not alive is high, the family buys less life insurance. This result is intuitive; if the family has high consumption despite the head's death, there is less need for life insurance. The most important comparative statics result is that the partial derivative $\partial I / \partial \lambda$ can have any sign, and demand for insurance can increase or decrease with air pollution. Therefore, this model implies a non-linear relationship between insurance demand and pollution.

The results of the model are robust when the Prospect theory of Kahneman and Tversky (1979)[58] is used instead of Expected utility. Prospect theory is based on experimental results showing that individuals underestimate the probability of the occurrence of low-probability events and overestimate the probability of high-probability events. For this reason, the probability weights in the valuation of the prospect (lottery) are non-linear $\pi(p(\lambda))$ and $\pi(1 - p(\lambda))$, where $\pi(\cdot)$ is a non-linear function. The valuation function is different for gains and losses. Namely, the same absolute amount of gain relative to some reference income level increases the prospect's value less than the same absolute amount of loss reduces the prospect's value. In other words, individuals exhibit loss aversion. If we denote the change in income relative to the reference level of income by Δc, the valuation of gains and losses is:

$$v(\Delta c) = \begin{cases} (\Delta c)^{\rho}, \text{ for } \Delta c \geq 0 \\ -\psi(\Delta c)^{\rho}, \text{ for } \Delta c < 0 \end{cases}, \tag{5}$$

where $v(\cdot)$ is the valuation of gains and losses, $\rho < 1$ is the diminishing sensitivity parameter, and $\psi > 1$ captures the loss aversion. Thus, for gains

[58] Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), pp. 263-291.

relative to the reference income level, the valuation is $(\Delta c)^{\rho}$, while for losses, the valuation is $-\psi(\Delta c)^{\rho}$.

By using all these assumptions, the maximization problem of the life insurance purchase decision in Adetutu et al. (2024) is:

$$\max_{I} \pi[p(\lambda)]\beta[I - ap(\lambda)I - L]^{\rho} - \pi[(1-p(\lambda))]\psi[ap(\lambda)I + L]^{\rho}. \quad (6)$$

In the first part of (6), the gain is measured relative to the reference income c_0, and the loss relative to the reference income c_1. The maximization problem yields the optimal level of life insurance coverage, I. The most important comparative statics result in this case also shows that the sign of the partial derivative $\partial I / \partial \lambda$ can be either positive or negative, implying a non-linear relationship between air pollution and life insurance demand as in the model with expected utility maximization.

In the empirical part of the paper, Adetutu et al. (2024) use $PMI_{2.5}$ as the measure of air pollution. The reason is that these particles may cause respiratory and cardiovascular problems and lung cancer. The empirical results confirm previous theoretical findings on the non-linear relationship between air pollution and demand for life insurance. Namely, when air pollution increases above a certain threshold, which is considered dangerous for health, the demand for life insurance increases. In contrast, below this threshold value, when the level of air pollution increases, the demand for life insurance falls. The same pattern is identified when nitrogen dioxide (NO_2) measures the pollution level. Regarding the control variables in the regressions, demand for life insurance is higher among individuals with higher incomes, higher education levels, married individuals, and those holding other insurance policies.

4. NON-LINEAR AND HETEROGENOUS DEMAND FOR HEALTH INSURANCE

The same non-linear relationship between air pollution and demand for health insurance was determined in empirical papers. The impact of air pollution on the demand for health insurance in China was studied by Chang et al. (2018)[59]. Health insurance policies in China have a cancellation option. The insurance policy can be canceled without cost within ten days after the insurance purchase. The air quality is measured by AQI (Air Quality Index). The impact of the AQI on demand for health insurance becomes statistically significant when the AQI

[59] Chang, T. Y., Huang, W., & Wang, Y. (2018). Something in the Air: Pollution and the Demand for Health Insurance. *Review of Economic Studies, 85*(3), pp. 1609-1634.

becomes larger than 150. When the AQI is in the region from 150 to 200 (unhealthy) and in the region from 200 to 300 (very unhealthy), demand for health insurance increases by 16.8% compared to days when the AQI is in the healthy region (below 50). When the AQI is above 300 (Hazardous), demand for health insurance increases by 23.4% compared to days when the AQI is in the healthy region.

There is another phenomenon that Chang et al. (2018) identified that confirms non-linear form of health insurance demand. Namely, when the AQI level falls relative to the AQI level when the insurance purchase decision was made, the probability of cancellation in the ten-day window increases. Specifically, when the AQI falls by one standard deviation relative to the purchase date, the probability of cancelation increases by 4%. It is important to emphasize that this cancellation decision is triggered by the relative difference in air quality between the cancelation decision day and the purchase day, not by the absolute level of air pollution. Only the current level of pollution has a significant impact on the demand for health insurance. In contrast, past pollution levels do not significantly impact the current demand for health insurance. There is no similar effect for other insurance policies. The reduction in the AQI has no significant effect on the decision to cancel other types of insurance policies.

Based on the empirical results, Chang et al. (2018) searched for a behavioral explanation of the identified phenomena. One explanation is based on the projection bias identified by Augenblick and Rabin (2019)[60] among others. According to this hypothesis, individuals buy health insurance when high pollution levels cause an adverse health shock and cancel health insurance if their health is better than in the period of insurance purchase. According to this hypothesis, these decisions are governed by the absolute level of air pollution. The second explanation is based on the salience hypothesis identified by Bordalo et al. (2013[61], 2022[62]). According to this hypothesis, individuals purchase health insurance when air pollution exceeds some benchmark value. In other words, individuals buy health insurance when there is a negative surprise (higher pollution) relative to the benchmark. In contrast, individuals cancel health insurance when there is a positive surprise (lower pollution) relative to the benchmark. The salience assumption implies that people buy more insurance

60 Augenblick, N., & Rabin, M. (2019). An Experiment on Time Preference and Misprediction in Unpleasant Tasks. *Review of Economic Studies, 86*(3), pp. 941-975.

61 Bordalo, P., Gennaioli, N., & Shleifer, A. (2013). Salience and Consumer Choice. *Journal of Political Economy, 121*(5), pp. 803-843.

62 Bordalo, P., Gennaioli, N., & Shleifer, A. (2022). Salience. *Annual Review of Economics, 14*(1), pp. 521-544.

when pollution is higher than the average for that month in a year, while the projection bias predicts that people buy health insurance when pollution is high regardless of the benchmark value of the pollution level for that particular month. Another example is that if people follow salience behavior, they will increase their demand for health insurance on days with high pollution if these days are preceded by days with low pollution levels. If people follow projection bias behavior, they buy insurance when pollution is high and don't consider pollution in the preceding days when making this decision.

Wang et al. (2021)[63] study the impact of the AQI level on individuals' demand for health insurance for their children and parents in China. The first result of this empirical study is that the more severe the pollution level, individuals are more willing to buy health insurance for their children and less for their parents. Individuals with higher incomes have a higher demand for health insurance for their children and parents. Older individuals have a lower demand for health insurance for their children since children are more economically independent. People living in large, economically developed urban agglomerations have a higher demand for health insurance for their children than their parents. The reason might be that their parents already have good health insurance protection in large developed cities. Furthermore, the relationship between a city's GDP per capita level and the demand for children's health insurance is non-linear. Demand for health insurance for children first increases and then falls with GDP per capita. In contrast, the demand for health insurance for parents monotonically falls with GDP per capita. People with better financial education are more willing to buy health insurance for their children since they can better understand underlying risks. Finally, the demand for health insurance for children and parents is larger in regions with generally higher demand for all types of insurance.

Air pollution causes various diseases, increases health care expenditures, reduces workers' productivity, and increases their absence from work. The empirical research of Hou et al. (2024)[64] is based on the fact that temperature inversion causes more pollution. Temperature inversion is the phenomenon when the air temperature is lower at the surface than at higher layers of air, which induces a higher concentration of $PM_{2,5}$ at the surface. This empirical research finds that 1% of the increase in temperature inversion frequency incre-ases the

[63] Wang, Q., Wang, J., & Gao, F. (2021). Who is More Important, Parents or Children? Economic and Environmental Factors and Health Insurance Purchase. *The North American Journal of Economics and Finance, 58*, 101479.

[64] Hou, Z., Zhang, G., Lohmann, P., Kontoleon, A., & Zhang, N. (2024). The Effect of Air Pollution on Defensive Expenditures: Evidence from Individual Commercial Health Insurance in China. *Journal of Environmental Management, 370*, 122379.

concentration of $PM_{2,5}$ particles by 2.52%. Furthermore, a 1% increase in $PM_{2,5}$ concentration increases individual health expenditures by 11%.

Among different age groups, middle-aged individuals are the most responsive to the increase in pollution concentration, followed by younger individuals. Individuals in the oldest group are the least responsive. There are no significant gender differences regarding sensitivity to pollution. Paradoxically, less educated individuals are more sensitive to pollution. The explanation is that more educated individuals have higher health protection financed by their employers. In addition, less educated people are more exposed to polluted air during work due to the nature of their jobs. In accordance with other studies, married individuals are more responsive due to their preoccupation with their families' security. Finally, individuals living in urban agglomerations are more responsive due to higher exposure to pollution and higher costs of medical services in cities.

5. RISK PERCEPTION AND DEMAND FOR HEALTH INSURANCE

Risk perception related to air pollution plays an important mediating role in health insurance purchase decisions. Li and Tian (2024)[65] study the relationship between air pollution and demand for health insurance through the mediating effect of individuals' risk perception. This study finds a similar impact on control variables as in previous studies. Individuals with higher incomes demand more health insurance. Women are more sensitive to higher pollution than men and buy more health insurance. Residents in urban areas and regions with higher mortality rates are more sensitive to haze pollution.

The paper's main finding is that the increase in pollution in regions with high climate risk perception reduces the demand for health insurance. This counterintuitive result stems from the fact that increasing current pollution reduces demand for health insurance since residents try to mitigate this effect by buying more masks and air filters. In contrast to other papers, Li and Tian (2024) find that lagged pollution levels increase the demand for health insurance. This phenomenon of the lagged impact of pollution on decisions to buy health insurance mainly exists in regions with high climate risk perception.

The study also identifies spillover effects, namely that demand for health insurance depends not only on lagged pollution levels in the region but also on the lagged pollution levels in nearby regions. In the central and western regions

[65] Li, X., & Tian, Q. (2024). Haze Pollution, Climate Risk Perception and Demand for Commercial Health Insurance. *SAGE Open*, *14*(2), 21582440241242544.

of China, the impact of air pollution on the demand for health insurance is not statistically significant. Nevertheless, this impact is statistically significant in eastern regions. This effect stems from higher income and higher levels of education of residents in eastern regions. The spillover effect is significant in the eastern and central regions of China, while it is not significant in the western regions of China.

The moderating effect of pollution perception on demand for commercial health insurance in China was studied by Sun et al. (2024)[66]. This empirical study reveals that advertising of commercial health insurance and the behavior of friends and relatives significantly impacted the demand for commercial health insurance, which is moderated through pollution perception. The impact of friends' and relatives' behavior on pollution risk perception is more substantial for women than men. Advertising positively affected women's pollution risk perception and their intention to buy health insurance but negatively impacted men's perception. Furthermore, the impact of advertising and family and friends' behavior on risk perception and the intention to buy health insurance was stronger for individuals living in rural than for individuals living in urban areas. Finally, the air pollution level significantly affects pollution risk perception and increases the willingness to buy commercial health insurance. In contrast, the level of water pollution does not significantly impact pollution risk perception and willingness to buy commercial health insurance.

6. DEMAND FOR HEALTH AND LIFE INSURANCE BASED ON MICRO-DATA

Micro-data are based on information on individual household’s decisions to buy health or life insurance. The impact of pollution on health and life insurance in China based on micro-data was studied by Zhao (2020)[67]. The dependent variable in the empirical study is a binary variable that takes the value of 1 if a family has commercial health or life insurance. Otherwise, it has a value of 0. The independent variable is the AQI (Air Quality Index), which measures the concentration of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), $PM_{2,5}$, and PM_{10}. The results of the empirical study reveal that a unitary increase in the pollution index increases the probability that a household buys either commercial health or life insurance by 17.5%.

[66] Sun, D., Chen, W., & Dou, X. (2024). Formation Mechanism of Residents' Intention to Purchase Commercial Health Insurance: The Moderating Effect of Environmental Pollution Perception. *Journal of Public Health, 32*(6), pp. 917-930.

[67] Zhao, W. (2020). Effect of Air Pollution on Household Insurance Purchases. Evidence from China Household Finance Survey Data. *Plos one, 15*(11), e0242282.

Concerning the control variables, households with a woman as the head of the family are 18.3% more likely to buy commercial health and life insurance than households with a man as the head. In addition, the former households have 11.7% higher expenditures on health and life insurance premiums than the latter households. As in previous studies, households with higher levels of education, higher incomes, and households in urban areas are more likely to buy commercial health and life insurance. Larger families are also more likely to buy commercial health and life insurance than small families. In contrast to other studies, households with more children under 14 years are less likely to buy commercial health and life insurance, possibly due to the more restrictive household's budget constraint. However, families with more children under 14 who buy commercial health and life insurance spend more on health and life insurance premiums than families with fewer children.

Air pollution's effect on health insurance demand is more substantial than on life insurance. The unit increase in the AQI index increases the probability of buying commercial health insurance by 10.71%, the likelihood of buying commercial life insurance by 7.95%, and the likelihood of buying other insurance types by 6.72%.

The most surprising result is that the level of $PM_{2,5}$ does not significantly impact the probability of buying commercial health and life insurance. This result might be explained by the fact that this study uses Logit and Poisson regressions, while other studies are mainly based on OLS or two-stage LS. Finally, Zhao (2020) finds that households are the most sensitive to the level of nitrogen dioxide (NO_2) and ozone (O_3).

Wang et al. (2021)[68] also used micro-data in their study, but the dataset is much richer than that of Zhao (2020). They study the impact of sulfur dioxide concentration (SO_2) on the probability of buying commercial health insurance in China. The dependent variable is a binary variable that takes the value of 1 if a household has commercial health insurance and 0 otherwise. Slightly more than 5% of the households in the sample possessed commercial health insurance. The independent variable is the level of SO_2. The empirical results are based on the Probit and Tobit models. Both specifications show that the increase in air pollution measured by the concentration of SO_2 increases the likelihood that households buy commercial health insurance. This impact is larger for wealthier households and households with more children. Concerning the age of the head

[68] Wang, R., Zhang, L., Tang, T., Yan, F., & Jiang, D. (2021). Effects of SO2 Pollution on Household Insurance Purchasing in China: A Cross-sectional Study. *Frontiers in Public Health, 9,* 777943.

of the household, the probability of buying commercial health insurance first increases with the age of the household's principal and, after that, falls. In contrast to some other studies, in this study, there is no significant difference between rural and urban households concerning demand for commercial health insurance. Finally, woman-led households are more sensitive to air pollution than man-led households.

Previous papers considered only commercial health insurance, while Chen and Chen (2020)[69] consider the impact of air pollution on both basic and commercial health insurance based on micro-data. Since 2009, China has been reforming its medical system, and from then, there has been a substitution between commercial and basic health insurance in favor of basic health insurance.

The dependent variable in this empirical research is a binary variable that takes the value of 1 when an individual has either commercial or basic health insurance and zero otherwise. When both types of insurance are considered together, 70% of individuals have some form of health insurance. Probit and two-stage LS regressions show a significant impact of air pollution on the demand for health insurance. Concerning the control variables, an individual's age, income, and level of education positively impact the demand for health insurance when the level of air pollution increases. In contrast to some previous studies, there are no significant gender differences regarding demand for health insurance.

Air pollution causes serious health problems and increases health expenses. It also negatively affects the labour force, reducing productivity and increasing absence from work due to illness. In the short run, individuals buy health and life insurance to protect themselves against these adverse effects of air pollution. However, from the long-run perspective, high air pollution may become a serious obstacle to further economic development, and ecological concerns related to reducing air pollution represent an important factor for long-run economic development.

[69] Chen, F., & Chen, Z. (2020). Air Pollution and Avoidance Behavior: A Perspective from the Demand for Medical Insurance. *Journal of Cleaner Production, 259,* 120970.