

**Smoke from Factory Chimneys:
The Applied Economics of Air Pollution in the Progressive Era***

H. Spencer Banzhaf
(Georgia State University, PERC, NBER)

Randall Walsh
(University of Pittsburgh, NBER)

December 2022

* We thank participants at the 2022 History of Recent Economics Conference (HISRECO) in Lausanne for comments on a previous draft. We thank the University of Pittsburgh Library System for use of its special collection of the Smoke Investigation Activities of the Mellon Institute.



Russell Smith, Pittsburgh Fifty Years Ago from the Salt Works on Saw Mill Run (public domain)

Smoke from Factory Chimneys: The Applied Economics of Air Pollution in the Progressive Era

H. Spencer Banzhaf

Randall Walsh

1. Introduction

In his book *Wealth and Welfare* (1912), A.C. Pigou discussed "uncompensated services" that are rendered to others, a line of thought that evolved into today's notion of externalities. In a famous passage often thought to represent a kind of proto environmental economics, he gave the following examples:

uncompensated services are rendered when resources are invested in private parks in cities; for these, even though the public is not admitted to them, improve the air of the neighbourhood. The same thing is true—though here allowance should be made for a detriment elsewhere—of resources invested in roads and tramways that increase the value of the adjoining land.... It is true, in like manner, of resources devoted to afforestation, since the beneficial effect on climate often extends beyond the borders of the estates owned by the person responsible for the forest. It is true also of resources invested in lamps erected at the doors of private houses, for these necessarily throw light also on the streets. It is true of resources devoted to the prevention of smoke from factory chimneys: for this smoke in large towns inflicts a heavy uncharged loss on the community, in injury to buildings and vegetables, expenses for washing clothes and cleaning rooms, expenses for the provision of extra artificial light, and in many other ways. (Pigou 1912 159)

Pigou surely had England's smoky cities like London and Manchester in mind, but it appears that he had contemporaneous American counterparts thinking along somewhat similar lines. Indeed, when he later expanded his book and retitled it *The Economics of Welfare*, Pigou cited as evidence a report from Pittsburgh, PA which had quantified the economic costs of smoke, a report from about the same time he originally published this passage (Pigou 1920 160).

This report, published by John O'Connor in 1913 and titled *The Economic Cost of the Smoke Nuisance to Pittsburgh* (O'Connor 1913a), sought to estimate the "economic cost chargeable" to smoke and soot. It was part of a series of Smoke Investigations in the city. Those investigations, in turn, were just one wave in series of surveys and reports about the city. Just five years

earlier, the famous Pittsburgh Survey had documented poor living conditions, criticizing political and business leaders and calling for reform. In response, those leaders conducted a series of their own surveys and studies. Both leveraged Progressive Era social science in the name of civic improvement. But the latter focused on economic conditions in the city, including the cost of living and quality of life, and the extent to which they put the city at a disadvantage relative to its competitors. Surprisingly, perhaps, investigators pointed to smoke as the number one *economic* factor that the city had to address.

To our knowledge, this early research on the economics of smoke has been unexplored in the historical literature. In this paper, we summarize it and situate it in the context of Progressive Era intellectual movements, the Conservation Movement more specifically, and Pittsburgh's particular social context. Reading the Smoke Investigations in this context, we find a particularly American source for the future evolution of environmental economics. Coming at the same time as Pigou's own writing, it suggests the existence of parallel developments that cannot all be grouped together under a "Pigouvian" umbrella.

2. Pittsburgh: The Smoky City

Pittsburgh is strategically located in Western Pennsylvania at the confluence of the Allegheny and Monongahela Rivers, where they form the Ohio River, which in turn flows to the Mississippi. The French established Fort Duquesne at this strategic confluence in 1754. After the French burned it in retreat, the British built Fort Pitt on the site, completing construction in 1761. By the eve of the revolutionary war, the British fort found itself amidst a growing civilian township. Initially a center for boatbuilding, by the early 1800's iron and glass production were becoming increasingly important for the region's economy. Over the course of the century, geographical advantages in access to key coal deposits, helped to cement Pittsburgh's dominance in the production of steel.

The iron- and steelmaking industries, which became so much a part of Pittsburgh's identity, involve first smelting iron ore in a blast furnace using charcoal or coke, to extract pig iron. As pig iron is very brittle, in a second stage it is refined in a puddling furnace to burn away carbon, making stronger wrought iron, again using coal as a fuel. In the mid-19th century, some of this wrought iron would have been used in that form (essentially a substitute for steel), and some would have been further refined into steel in a third step. Around 1850, William Kelly and Henry Bessemer, working independently in Pittsburgh and Sheffield respectively, invented a new process by which

pig iron could be refined directly into steel, by blasting air into the molten iron to react with impurities and separating them off as slag.

The Bessemer process, along with the demands of the civil war, further spurred industrial output in Pittsburgh. Around the same time, the process of iron smelting switched from using wood-based charcoal to coal-based Coke. Bituminous coal fields, located less than 50 miles south of Pittsburgh in Connellsville, yielded large quantities of coal that was ideally suited for coking. Coke was produced by burning the coal in an oven, to expel water, sulfur, and hydrocarbons, leaving behind a solid residue of fixed carbon and ash. The Connellsville coal was the best in the world for this process, as it had few impurities but contained enough gas to ignite the coal and leave behind a porous product. Initially, this coking was performed in beehive ovens (with their characteristic domed shape).

At the turn of the 20th century, more than 10 million tons of coke was being produced in the Connellsville area annually. Coke production was also occurring in Pittsburgh proper. The Jones & Laughlin (J&L) Works, in Pittsburgh's Hazelwood neighborhood, had the largest concentration of beehive coke ovens in the world, with some 1500 ovens producing nearly 750,000 tons of coke annually (Figure 1). The J&L coke works was part of a larger facility that straddled some thirty city blocks on both sides of the Monongahela River (Tarr 1994, Hersh 1995). Figure 2 shows the growth in foundries and mills in Pittsburgh over time. It presents snapshots of mill locations at four time periods. Although visually the change from 1850-1880 to 1880-1920 does not look large, the immense J&L Works are indicated by the new dots at the bend of the Monongahela (in the lower right quadrant).

The beehive ovens may have been economically efficient for the times, but contemporaries saw them as inefficient in their utilization of resources, as they wasted a great deal of by-products. One retrospective study suggested that the 53m tons of coal processed into coke could produce 530b cf of gas, 400m gallons of coal tar, 150m gallons of light oil, and 600,000 tons of ammonium products (Schurr and Netschert 1960). Over the first quarter of the 20th century, in tandem with the growth of markets for these products, beehive ovens were replaced by the more efficient by-product ovens which captured these products, thereby reducing pollution (Tarr 1994).

All this coking, iron smelting, and steel making generated a great deal of smoke and soot, earning Pittsburgh the sobriquet, "the Smoky City." As early as 1807, a travel book commented

that "the great consumption of coal abounding in sulphur, and its smoke condensing into a vast quantity of lamp black, gives the outside of the houses a dirty and disagreeable appearance, even more than the most populous towns of Great Britain...", and many similar quotes from the early 19th century have been collected (O'Connor 1913b 352). Most vividly, James Parton, an English-born American author, made the following observation in *The Atlantic Monthly* about his visit in 1868:

The entire space lying between the hills was filled with blackest smoke, from out of which the hidden chimneys sent forth tongues of flame, while from the depths of the abyss came up the noise of hundreds of steam-hammers It is an unprofitable business, view-hunting; but if any one would enjoy a spectacle as striking as Niagara, he may do so by simply walking up a long hill to Cliff Street in Pittsburg, and looking over into hell with the lid taken off.

"Hell with the lid off," indeed. The smoke and soot consisted of lampblack carbon (used as pigment), tar, various acids of sulfur, ash, ammonia, and arsenic and other toxics (Benner and O'Connor 1913).

Based on raw data from the Smoke Investigations, we have calculated in a companion paper that in 1910-12, the average soot-fall in Pittsburgh was 81 tons per square mile per month (or 0.34 kg/m²/year), a figure which grew to 141 t/mi²/mo (0.59 kg/m²/yr) in 1916-23 before falling again (Banzhaf et al. 2022a,b). To place them in perspective, we have calibrated these figures to modern measures of total suspended particulate pollution (TSP), using later data when modern monitors operated close in time to later soot-fall studies.¹ Based on that calibration, Pittsburgh's air in the first quarter of the 20th century probably had TSP levels on the order of 300 to 500 µg/m³, vs. roughly 30 today. These levels appear comparable to those in London during the same period, though somewhat lower than London's of the late 1800s, when they were closer to 600 µg/m³ (Brimblecombe 1987).

Perhaps surprisingly, Pittsburghers had mixed feelings about all this smoke and soot (O'Connor 1913b, __ other cites). On one hand, they took pride in the sheer accomplishment of it all. They also associated it with jobs for hardworking men, building America's industrial might.

¹ Specifically, we took 1950-59 sootfall readings and extrapolated the trend out to 1970. We then took a ratio of that figure to 1970 TSP readings in Pittsburgh to find an adjustment factor. This procedure would not pass scientific peer review but it provides a reasonable gauge for comparison.

On the other hand, they were well aware of the nuisances it caused.

Courts and policy makers were aware too. Although they were rare, when lawsuits were brought, courts found beehive coke plants liable for damages, finding that they were not a part of the "natural and necessary use of land." However, they did not issue injunctions, reasoning that the social value of coking was too high. As early as 1869, Pittsburgh adopted an ordinance banning the beehive ovens within the city limits, although the ban appears never to have been enforced and the number of ovens continued to grow. Later, in 1892, a further ordinance required smoke control devices and/or higher chimneys and attempted to zone off certain sections of the city. Still further attempts at tougher ordinances between 1895 and 1907 were rejected by state courts as exceeding the city's delegated powers (O'Connor 1913b, Tarr 1994). Frustration with these failed efforts helped spur the Smoke Investigations and related work about the city's smoke problem.

3. Pittsburgh: A City Surveyed

Pittsburgh's Smoke Investigations were but the last of a series of social work and planning studies in the city over a five-year period, including the Pittsburgh Survey, the Men and Religion Forward surveys, investigations in preparation of an urban plan, and an Economic Survey.² The most prominent of these was the Pittsburgh Survey. In 1906, Alice B. Montgomery, the chief probation officer of Allegheny County's juvenile court, wrote Paul Kellogg, editor of New York's *Charity* magazine, about the possibility of commissioning a study to raise awareness about the city's living conditions. Kellogg responded enthusiastically. With funding from the Russell Sage Foundation, Kellogg formed a coalition that included local grassroots supporters organized by Pittsburgh's settlement house and others, leading national activists such as Florence Kelley and Robert A. Woods, and the expertise of such leading social scientists as John R. Commons.

The Social Survey had important precedents, including Charles Booth's *Life and Labour of the People in London*, research by Kelley at Chicago's Hull House, and W.E.B. Du Bois's *Philadelphia Negro*, as well as in the muckraking journalism of Upton Sinclair, Ida Tarbell, and others. However, Kellogg wanted to distance his survey from the muckrakers, preferring a cooperative approach that didn't make local enemies. The survey's sponsors at the Russell Sage Foundation

² For background on Pittsburgh's social survey and the social survey movement, see Chambers (1971), Bulmer et al. (1992), Greenwald and Anderson (1996), Bateman (2001), and Nadal (2019). Hays (1964) gives an overview of the civic reform movement in Pittsburgh circa 1910.

agreed, stating they wanted to inform the civic leaders of Pittsburgh, not humiliate them (Anderson and Greenwald 1996, Bulmer 1996, Turner 1996).

Accordingly, much of the survey reflected middle- to upper-class anxieties about the deleterious effects of Pittsburgh's urbanization and industrialization, in at least two ways. One was the way it weakened family life, especially when judged by middle class norms. Family life was weakened by the need for married women and high-school aged children to work in the formal labor market or to take in boarders; the long 12-hour days that working men put in, and the cost borne by families when their man suffered an industrial accident (Bulmer et al. 1992 1-2, Kleinberg 1996). The costs of these accidents were represented vividly by Crystal Eastman's image of "The Puddler." Figure 3 shows the original artwork juxtaposed against her version, in which she shows the range of compensation given for the loss of various body parts, all anchored on zero. The figure depicts clearly the relationship between the labor market and family life. Despite Kellogg's intentions, much of this work was accompanied by a strident indictment of corporate mistreatment of labor, which appalled many civic leaders (Bauman and Spratt 1996).

The Pittsburgh survey also reflected middle- to upper-class concerns through the lens of the City Beautiful movement, represented locally by the Civic Club of Allegheny County (CCAC), recently founded in 1895. The City Beautiful movement tapped into the related Sanitary Movement, which was centered on the belief in the environmental cause of disease, or "filth theory of disease," that tuberculosis, typhoid and other diseases were carried by noxious miasmas. The Sanitary Movement was widely accepted and championed by the American Public Health Association, National Board of Health, and other organizations, giving impetus to clean up America's cities (Tarr 1984). CCAC and other civic leaders had their work cut out for them. They were not unfounded in their emphasis on the need for cleaner water, for Pittsburgh had one of the highest rates of typhoid in the country, at nearly 10x the rate of most other northern cities (Tarr 1996).

The City Beautiful movement extended this logic to the entire aesthetic landscape of a city. Not unlike James Q. Wilson's "broken windows" theory of some 75 years later, it believed in a kind of "moral environmentalism," according to which the visual blight of urban and physical decay as well as the ingestion of noxious air and water pollute both mind and body, leading to crime, juvenile delinquency, labor violence and epidemic disease. In contrast, clean, attractive cities are morally uplifting, healthy for body, mind, and soul alike (Schultz 1989 112-4, Bauman

and Spratt 1996, Tarr 1996).

Although the City Beautiful movement was popular, others found some of its more aesthetic and feminine aspects frankly embarrassing. They wanted to take a more scientific and objective approach to urban planning. Leaders of this alternative model of urban renewal aligned themselves with the Conservation Movement led by Gifford Pinchot and represented in economics by Richard Ely.³ Borrowing that movement's motto of "wise use" of natural resources, they substituted the City Useful for the City Beautiful (Bauman and Spratt 1996).⁴

Along these lines, Charles M. Robinson, a city planner from Rochester, NY, wrote a Pittsburgh Survey report besetting the city's smoke, narrow and congested streets, outdated civic buildings, and inadequate parks and playgrounds. Parks and playgrounds were necessary as defenses against idleness and to keep children off the streets, with its twin threats of traffic and temptation (Robinson 1909; Bauman and Spratt 1996, Tarr 1996). Robinson introduced his piece by stating that,

In studying the civic improvement possibilities of Pittsburgh, one is impressed by a curious mingling of antagonistic conditions. A wonderful natural picturesqueness is contrasted with the utmost industrial defilement, smoke and grime and refuse pervading one of the finest city sites in the world. (801)

However, despite this opening acknowledgement of Pittsburgh smoke problem, the bulk of Robinson's essay addressed other issues, such as affordable housing, traffic, and open space, perhaps because those were more within his purview as an urban planner. This general line of inquiry, which was focused on Pittsburgh's urban environment, was favored by Kellogg and Pittsburgh's civic leaders. It also tapped into the concerns of the moment, as crippling floods had just hit the city in 1907, shutting down roads, electricity, and steel mills, and putting many temporarily out of

³ Hays (1959) gives an overview of the Conservation Movement and what he calls the "gospel of efficiency" that it espoused. Banzhaf (forthcoming) discusses its connection to Ely and other economists and to the development of environmental economics.

⁴ This move was part of a trend toward the language of objectivity, a trend which was to accelerate in the 1920s (Smith 1994, Turner 1996, Hawley 1990). For example, the Laura Spelman Rockefeller Memorial (now known as the Rockefeller Foundation) helped displace purposive social science, mixed with social work, with a more "pure" scientific approach. Typifying this trend, when Wesley Clair Mitchell founded the National Bureau of Economic Research (NBER), he forbade policy recommendations and insisted that the research speak for itself. His vision could not have been more different from Richard Ely's and John R. Commons's for the American Economic Association, which they began some 30 years earlier as an organization of social change (Bateman 1998, Bateman and Kapstein 1999).

work (Bauman and Spratt 1996).

These concerns carried into post-survey political movements. Pittsburgh's press, including the *Post* and the *Gazette-Times*, attacked the city's polluting smokestacks and traffic-congested streets, but it refrained from going after labor practices (Post 1910). Likewise, the city's political leaders capitalized on the momentum, increasing the number of sanitary inspectors and smoke inspectors, establishing a typhoid commission, creating an umbrella social welfare organization, and establishing a permanent civic improvement commission.

Finally, in January 1909, just before the end of his term, Mayor George Guthrie requested the Pittsburgh Civic Commission respond to the survey's recommendations. Henry D.W. English, an insurance company executive and head of the Chamber of Commerce, led the commission's effort. Other business leaders, such as H.J. Heinz, were also involved. The commission subdivided into some fourteen committees tasked with formulating plans by which "evils can be removed" and improvements made on the basis of community consensus. The commission's activities culminated in the hiring of Frederick Law Olmsted, Jr. to develop a city plan.

In early 1911, Olmsted released a preliminary report, *Pittsburgh Main Thoroughfares and the Down Town District* (Olmsted 1911). Two aspects of this report are notable from the outset. First, it opens, almost *in media res*, with a statement about the connection between Pittsburgh's land use and its cost of living:

Delays and congestion of traffic . . . add to the expenses of manufacturers, the costs borne by wholesale merchants, and the prices charged consumers by retail dealers; in short inadequate traffic facilities in Pittsburgh, as in other cities, add to the cost of doing business and of living. (Olmsted 1911 *xiii*)

Additionally, the report noted that some 25% of the hilly city was on a grade prohibitive of houses and streets. Consequently, the city had to "exercise greater ingenuity and foresight" than others, in order to increase the supply of its available land and decrease housing costs.

Second, Olmsted situated his report in the context of the national Conservation Movement. Pinchot, the movement's most famous spokesperson, had emphasized the conservation of forestland and other natural resources associated with rural areas. Rather than preserve wild landscapes, Pinchot wanted to develop those resources to the utmost for human use, but to use them

wisely, with minimal waste, so they would last as long as possible. Pivoting from Pinchot's application of this logic to rural resources, Olmsted noted that cities faced similar issues.

By offering solutions for the above and many other similar problems this report demonstrates that practical city planning—or better, replanning—is part of the world-wide conservation movement. City planning is municipal conservation. Pittsburgh, like other cities and to a greater extent than most of them, faces the problem of using her financial and territorial resources to the utmost. The "utmost" means making these resources go the furthest in securing ample streets for transportation and traffic, and easy communication between all parts of the city; in providing for the cheap distribution of food, fuel and clothing; in making all residence districts as nearly as possible equally healthful, un-congested, and provided with trees and yards; in establishing for all residents public accommodations for recreation and leisure; and in maintaining and developing adequate districts for retail and wholesale trade, manufacture and commerce. (Olmsted 1911 xv)

Thus, the city's resources had to be squeezed to obtain the most efficient outcomes, but these outcomes included a broad view of what constituted human welfare. Beyond a narrow and crass materialism, it included human health, recreation, and green space. All would "contribute to the economy, convenience, practicability and attractiveness of Pittsburgh's development and growth" (xv). Although higher taxes would be required, such taxes would not actually increase the cost of living if they were used wisely, as in that case they would actually increase the overall standard of living.

With these "ends in view," Olmsted and his team outlined future work on the city's plan, divided into the following topics (Olmsted 1911 xv):

- Steam Railroads
- Water Transportation
- Electric Railroads
- Street Systems
- Public Lands and Buildings
- Water System
- Sewerage System
- Control over Developments on Private Property
- Smoke Abatement
- Building Code

Thus, transportation improvements and environmental improvements, including better access to clean drinking water and smoke abatement, were all part of a coherent plan to decrease the city's

cost of living and to improve its economic development and growth.

Unfortunately for Olmsted and his team, the city's 1911 elections put a speed bump in their plans. Mayor Guthrie, who had set the project in motion, was not running for re-election. Instead, William Stevenson, a businessman and reformer, was carrying forward his legacy for the Civic Party. However, William Magee, the Republican Party candidate, won the election, outmaneuvering him with a more successful grassroots campaign. Actually, in substance, Magee accepted most of the Civic Commission's goals and recommendations. However, as it was too closely tied to his political opposition, he did not officially endorse it. Moreover, he was unwilling to turn over all the decisions to experts. Instead, using the planning process as a political trough, he sprinkled a series of individual projects around the city's wards, thus securing political support. In the end, he adopted a plan to spend some \$10.3 m on bridges, street improvements, a new city hall, an improved water filtration plant, extensions of water lines, raising streets in flood prone areas, and a new tuberculous hospital. Many of the professional urban planners were appalled by this grab-bag of *ad hoc* projects, as they ran counter to their rational, holistic plans, but Olmsted was pragmatic enough to work with the new regime (Bauman and Spratt 1996).

4. The Economic Survey

With a new mayor came also a new survey. The City Council authorized the mayor to appoint a team to "investigate the economic and other conditions of the city affecting its industrial and commercial prosperity" (Holdsworth 1912 3). Magee appointed J.T. Holdsworth, an economist at the University of Pittsburgh, to conduct in 1911-12 what became known as the Economic Survey. Additionally, it had the cooperation and imprimatur of the Chamber of Commerce, which had been arguing that bad air and water were a "tax" on the people of Pittsburgh.⁵ Thus, in contrast to the earlier social survey, which was a combined effort of settlement house activists and outside experts, the Economic Survey was a creation of political and business leaders and led by an economist. Not surprisingly, it eschewed the muckraking and critical language that, despite Kellogg's efforts, crept into the earlier Pittsburgh Survey. Instead, it focused on Pittsburgh's competitiveness against rival industrial cities, from Buffalo to Milwaukee. Thus avoiding criticisms of labor practices, it adhered to the issues of smoke abatement, flood protection, affordable housing, and the

⁵ __add cite to Pittsburgh CoC annual report 1908

cost of living, all of which affected the desirability of living and working in the city, and around which consensus could be formed.⁶

John Thom Holdsworth (1873 - 1965), the study's author, had received a BA from NYU and undertook graduate work at the University of Wisconsin and the University of Pennsylvania, where he received his PhD in 1907. Just five years later, when the survey was published, he was dean of the University of Pittsburgh's school of economics, and, later, from 1926 to 1941, the first dean of the University of Miami's business school.⁷ His primary specialty was in money and banking, an area where he published extensively, taking a historical approach. Indeed, Murray Rothbard referred to him as "the premier historian" of early US banking (Rothbard 2002 72).

Although it was in the genre of a survey rather than an urban plan, in many ways Holdsworth's report was consonant with Olmsted's and sounded similar themes. However, it differed in two fundamental ways. First, rooted in the logic of competitiveness, it took a comparative approach, juxtaposing Pittsburgh's conditions with its industrial rivals. Second, it gave even more emphasis to the issues of the cost of living and, surprisingly for an economic document, smoke.

Indeed, the Economic Survey actually opened with smoke at the top of its list of items Pittsburgh needed to tackle:

The first fundamental need in Pittsburgh is the eradication of smoke. The smoke nuisance is the greatest single obstacle to progress. It involves an enormous direct loss to manufacturers, and an even greater indirect loss to all citizens through injury to health, vegetation, buildings and stocks of merchandise. It increases the labor and cost of housekeeping, and undoubtedly deters many from establishing permanent residence in Pittsburgh. (Holdsworth 1912 10)

Thus, the smoke nuisance was "fundamentally" an economic problem (31). Fortunately, "practical elimination of smoke is possible." Although, as noted previously, Pittsburgh's ordinance of 1906 had just been voided by the courts, Holdsworth suggested that a new one should be passed at once.

⁶ See Anderson and Greenwald (1996) for background on the Economic Survey and a comparison with the Social Survey. The Economic Survey's emphasis did not mean that activist research was dead. At the same time (1910-11), the "Men and Religion Forward Movement" conducted a series of social surveys nationally, including Pittsburgh, on broader social ills, as a way to scientifically direct the improvement of social life in the name of the Gospel (Bateman 2001).

⁷ Biographical details from *Who's Who in America*, 1914-15 and from the University of Miami, <https://atom.library.miami.edu/asu0135>

It should be enforced strictly, and exemptions for heating and puddling furnaces should be eliminated. Cooperation among all civic groups should "attack" this "greatest single obstacle in the path of Pittsburgh's economic progress" (10). The potential for such an attack would soon become more plausible, when Pittsburgh was empowered by the Pennsylvania legislature to regulate its smoke, an opportunity it soon took advantage of (O'Connor 1913b).

The earlier pride in the sobriquet "Smoky City" was obviously cracking. With the dawning of a new day "of civic enlightenment and business efficiency," it was understood as a sign of the city's *inefficiency* (31). It represented wasteful combustion at the industrial plant, leaving unused a great deal of heat, residual carbon, and other byproducts. It also increased the cost to retailers and households, in the form of damaged merchandise and higher cleaning expenses. Guestimates from experts in Chicago and Cleveland had put the annual loss due to smoke at \$50 m and \$6 m respectively, although those were not based on systematic study (32).⁸ Finally, recent medical evidence was coming around to the conclusion that smoke damaged the lungs, increasing the risk of tuberculosis, pneumonia, and respiratory diseases (35).

Why this waste? It is "passing strange," Holdsworth remarked, that firms employing highly paid engineering and business experts, whose job it was to squeeze out every dollar of profits, would allow it to happen. The only explanation he could find was in the cheapness of the fuel, which did not incentivize efficiency. But is that a valid excuse, he asked? Similar habits of "prodigal wastefulness" had been practiced "in earlier days in the extractive industries such as farming, mining, timbering," but now as a consequence the country "is agitated over the question of conservation of natural resources." By the same logic it should be agitated over the waste of coal and other energy in the form of smoke. Moreover, recent experiment proved the wastefulness of standard practice. The American Steel & Manufacturing Co. found that powdering coal greatly reduced both its smoke and its coal bills (37-8). Other technologies could effect similar efficiencies (38-41). Chicago in particular was held up as a leading city where improvements were leaving Pittsburgh behind. It had reduced smoke by one-third in three years, and though plant operators were at first resistant, they had become increasingly cooperative as they realized the economic savings

⁸ The investigators queried representatives from Chicago and Cleveland on their methodology, but received no satisfactory response (Smoke Investigation Activities of the Mellon Institute archives, Series I, box 2, folder 21 [hereafter, denoted by SIA I.2.21]).

on fuel costs from more efficient combustion (42-43).

Holdsworth here sounded the themes of efficiency and waste, which were common in conservation economics in the period. However, he did not use the modern language of externalities, which did not develop for many years (Medema 2020, Banzhaf forthcoming). Nor did he make a distinction between what Pigou, who published *Wealth and Welfare* in the same year, would have called "internal" and "external" economies. American land economists were making similar distinctions, although the signature developments in that literature were just around the corner.

Although Holdsworth was sure that Pittsburgh's smoke was tremendously wasteful, he acknowledged that his numbers were anything but definitive. The same could be said about all the findings and recommendations in the report, which was put together in what he clearly thought was much too compressed a timeline. Thus, like all good grant recipients, he recommended further study.

5. The Mellon Smoke Investigations

He was not the only one. Pittsburgh's business leaders also wanted to continue to study the city's problems, using the Economic Survey and follow up work to advance reform. Notably, Richard B. Mellon especially wanted to further study the smoke problem. Mellon was a wealthy industrialist and banker with close ties to coal and metals industries. He served as President of the Aluminum Company of America (Alcoa) and later succeeded his more famous brother Andrew as president of the Mellon bank, after Andrew left for Washington to serve as US Treasury Secretary.

In 1910, the Mellon brothers founded the Department of Industrial Research at the University of Pittsburgh, although just three years later it split off from the university with a new endowment and was rechristened the Mellon Institute of Industrial Research. (Much later, in 1967, it merged with the Carnegie Institute of Technology to form what is now known as Carnegie-Mellon University.)⁹ R.B. Mellon gave the department \$40,000 over three years to conduct its Smoke Investigation (Benner and O'Connor 1913).¹⁰ Indicating at least some nominal continuity with

⁹ Details on the various institutes and the Mellons' role can be found at "Guide to the Smoke Investigation Activities of the Mellon Institute, Pittsburgh, PA. Research Records, 1911-1957." AIS.1983.07. <https://digital.library.pitt.edu/islandora/object/pitt%3AUS-PPiU-ais198307>

¹⁰ This figure seems to contradict one from the Mellon Inst. archive (*op cit.*), which puts it at \$21,000 over three years.

previous surveys, Kellogg was consulted on the outline of the overall project, and Holdsworth commented on O'Connor's economic study. Efforts to consult with Commons were less successful.¹¹

But these investigations constituted only the first of a two-pronged attack. Through the Chamber of Commerce, Mellon and others also created a new civic organization known as the Smoke and Dust Abatement League, which would serve as the activist wing, complementing the research wing. Thus, "Pittsburgh will present a solid front—'that it may be a cleaner, more healthful and more beautiful place in which to live, as well as in which to work'" (O'Connor 1913c 133).

Consistent with Kellogg's vision for the Social Survey and with the Economic Survey, "Cooperation [was] the watchword of the campaign" (O'Connor 1913c 132). In early correspondence with industrial and civic leaders, the investigators emphasized that "the spirit of the investigation is not mainly destructive and critical, but rather constructive and reformatory."¹² Exemplifying the Progressive Era's naïve optimism, they initially hoped that research into new abatement technologies would yield technical solutions to the smoke problem. Paired with research that rigorously documented the injuries, economic damages, and economic waste of smoke, polluters and civic leaders alike would have an epiphany which opened their eyes to the smoke problem and led them to reform. At least, that was the initial hope.

The Smoke Investigation had a staff of 28-30 researchers over its first two years. The Chief Fellow first leading the investigation was Raymond C. Benner, a chemist. The initial team included, in addition to a secretary and a librarian, nine physicians and surgeons, an additional chemist, a botanist and a bacteriologist, a physicist, a meteorologist, four engineers, five architects, one attorney—and one economist.¹³

The economist on the team was John J. O'Connor, Jr. (1887 - ?). O'Connor received his BA from the University of Pittsburgh in 1910 and his MA in 1913 under Holdsworth, while working first as an assistant to the Economic Survey, compiling the statistical tables related to the cost

¹¹ Veditz to Commons 3-8-12, SIA III.4.6.

¹² Veditz to McArdle 3-30-12, SIA III.4.6.

¹³ Actually, for a brief period in 1912, there were two economists. The more senior member was C.W.A. Veditz, a founding member of the American Sociological Association (indeed, arguably the instigator of its founding) (ASA undated). Veditz left the team early, before any reports were published.

of living and collecting recreation data. He joined the Mellon Institute in 1912. Originally, he had hoped to specialize in sociology, writing a thesis that followed up on the Pittsburgh social survey, but he found that his work for the Mellon Institute was too demanding and so worked that into his thesis along with his earlier work on the Economic Survey.¹⁴ By 1914, O'Connor was the Chief Fellow (i.e. leader) and public relations director of the Smoke Investigation, associate director of the institute, and secretary of the Smoke and Dust Abatement League. Later, after working on finance issues for the Army from 1918-19, he became the director of Duquesne University's School of Social Work for two years, before moving to the Carnegie Institute's college of fine arts, first as the business manager and eventually rising to director.¹⁵

The smoke investigators published their work in nine bulletins between 1912 and 1914. Bulletin No. 1 was a short introduction and outline of their research strategy and No. 2 was a detailed bibliography. The eighth, banally titled *Some Engineering Phases of the Smoke Problem* (Mellon Institute 1914), was probably the single most important publication from the standpoint of the overall enterprise. It analyzed fuel consumption and smoke and soot emissions from furnaces, and it evaluated abatement strategies. In doing so, it considered economic factors, such as the scale economies of abatement technologies. For example, a survey of engineers working in private industry asked, "what is the smallest plant in which you would consider it economical to install mechanical stokers?" which regulated the feeding of fresh fuel to the furnace.¹⁶

It also analyzed concentrations of pollution around the city with its pioneering soot-fall study. This study involved placing jars around the city and weighing the ash content monthly, as well as analyzing its chemical contents. Figures 4 and 5 summarize the data from these studies. The first shows a map of where the jars were placed, with larger dots representing higher soot-fall. The second shows the data in tabular form, by month and site.

Five of the bulletins investigated various effects of this smoke. Specifically, they studied "psychological aspects" of smoke, including its effects on mental health (No. 3); meteorological

¹⁴ O'Connor to Kellogg 5-7-12 and 9-20-12, Kellogg to O'Connor 5-10-12, SIA I.2.16.

¹⁵ Biographical details from *American Catholic's Who's Who*, 1960-61, "Guide to the Smoke Investigation Activities..." *op cit.*, and Holdsworth (1912 4).

¹⁶ SIA I.1.5.

aspects, including effects on sunshine and climate (No. 5); the effects of smoke on building materials including paint, stone, and metals, and on the interior of buildings (No. 6); the effects on vegetation (No. 7), and the effects on human health (No. 9). As the studies progressed, they increasingly relied on data from the soot-fall studies to correlate pollution by space or time with observed outcomes of interest. For example, in Bulletin No. 9, W.C. White, a physician, and C.H. Marcy, a bacteriologist, correlated pneumonia death rates in the city's wards with sootfall measures. Their results are summarized in Figure 6, which shows a striking correlation.

The Economic Cost of the Smoke Nuisance to Pittsburgh, by O'Connor, appeared as Bulletin No. 4. O'Connor's economic study is characterized by four notable features. The first is an emphasis on the *physical* effects of smoke and resulting damages. O'Connor organized his bulletin in five sections, each corresponding to a category of effects borne by a specific group of people. Tellingly, O'Connor's first category was the cost to the smoke makers themselves. Said O'Connor, "the abolition of the smoke nuisance—unlike many other social nuisances against which outcry has been made—would result in direct and immediate gain both to the public at large and to those chiefly responsible for the nuisance" (1913a 11).

Like Holdsworth in the Economic Survey, O'Connor reasoned that the making of smoke represents a "direct waste of fuel to the manufacturer." This kind of rhetoric aligned O'Connor's work with the conservation movement and its focus on eliminating waste.¹⁷ Indeed, Benner and O'Connor titled one article summarizing the Smoke Investigations as "The Smoke Nuisance: A Question of Conservation" (Benner and O'Connor 1913). O'Connor thought of the smoke-makers as a key target audience of their research, hoping it would move them to action, for otherwise there would be little to show for their work.¹⁸

The other four categories might, in retrospect, all be classified as external costs to others, although O'Connor did not use that language. Rather, he spoke of costs to the individual in the form of higher laundry and dry-cleaning bills; costs to the household in the form of cleaning walls and curtains, of more frequent painting walls or replacing paper, and of higher lighting costs to

¹⁷ Similar rhetoric continues to be used today, as summarized in the language of "an energy efficiency gap" relative to the level of efficiency that would be privately optimal. See Allcott and Greenstone (2012) for a summary and critical evaluation of the modern literature.

¹⁸ O'Connor to Benner (undated [1913?]) SIA I.1.2.

offset the dark; costs to commerce in the form of cleaning, lighting, and damaged merchandise; costs to office buildings, hotels, and hospitals; and "miscellaneous" costs including lower property values and the absence of certain industries. With the exception of these final miscellaneous costs, O'Connor thought in terms of a series of linkages, from smoke and soot in the air, to physical effects on matter, to valuation of those effects by people. In this respect, his analysis is surprisingly similar to modern-day "integrated assessment models" that work through the same sets of linkages. Many of the effects were informed by the other investigations, although his ability to make use of them was limited by the fact that many were still ongoing.

Notably absent from O'Connor's list are health effects. He believed that there was no question that there is some "economic cost chargeable" to smoke for adverse health effects, but he felt the data were not available yet, nor the science advanced enough yet, to quantify them (5). Also absent are the more qualitative and aesthetic effects of smoke on the quality of life, and their extension to criminality and delinquency, such as had been emphasized by the City Beautiful movement. These were partially addressed qualitatively in Bulletin No. 3, on "psychological aspects" (Wallin 1913). But at a time when economics was defined as the study of material welfare, it had difficulty coming to terms with how to value such "intangible" factors (Banzhaf, forthcoming). Additionally, the hard-headed, objective approach to science did not allow for speculation about the mental effects of the aesthetic factors. In the introductory bulletin, it was noted that housekeepers shut their windows

For fear of the soot that floats in when they are open, and it has been asserted that this also contributes to the "mentally and physically depressing effect of the pall that shuts out the life-giving and germ-destroying air and sunshine." Indeed, English official investigators have declared it "more than probable that living in a foul atmosphere which diminishes vitality increases the desire for stimulants, induces drunkenness and its concomitants of brutality, immorality and crime." (University of Pittsburgh 1912 8).

"Whether such statements are scientifically warranted" was a question "the staff have undertaken to answer." However, a year later, the bulletin on "Psychological Aspects..." shut the door on this speculation. It concluded that, although surely there were mental effects, there was no evidence of an effect on suicide, murder, other forms of criminality, or drunkenness (Wallin 1913 25-31).

A second feature of O'Connor's economic investigation was that, like the Economic Study,

it was rooted in the logic of competitiveness. Smoke increased the cost of living and doing business in Pittsburgh, putting it at a disadvantage. Indeed, O'Connor found that people were avoiding the city because of its smoke. Pittsburgh's rival cities, he pointed out elsewhere, have ordinances, and Pittsburgh needed to catch up with them (Benner and O'Connor 1913). This logic of competitiveness also helped clarify his empirical methodology. In contrast to previous research in Chicago and Cleveland, as well as London, O'Connor did not try to quantify damages in the abstract. Rather, he was trying to quantify damages relative to some plausible counterfactual, or baseline. Thus, his estimated costs are "not compared with ideal conditions," but with "attainable conditions" (O'Connor 1913a 5). Specifically, wherever possible, he computed damages relative to what they would have been if Pittsburgh's air were comparable to a set of average industrial cities, including Buffalo, Chicago, Cincinnati, Cleveland, Detroit, Milwaukee, and St. Louis.

A third feature of O'Connor's investigation was that he noted the occurrence of what economists would later term "averting," "mitigating," or "avoidance" behavior. O'Connor noted that even James Parton (he who called Pittsburgh "Hell with the lid taken off") had observed that everything in Pittsburgh was arranged with reference to the ease with which it could be cleaned (O'Connor 1913a 22). People wore darker clothes that didn't show smudges, or washable clothes rather than woollens requiring dry cleaning. They used washable paints and were less likely to use wallpaper. Retailers reduced the damage to merchandise by refraining from displaying goods attractively, covering them with screens or glass, and so forth. Echoing the Chamber of Commerce's language, he concluded that, Pittsburgh bears "a heavy tax" on certain industries, which of course they could avoid with the simple expedience of keeping away. Thus, O'Connor argued that a smoke ordinance would attract industry and commerce, not repel it, as some thought. Comparing the industry classifications of businesses operating in different cities, O'Connor observed that Pittsburgh had a much smaller variety than Boston, Cleveland, Cincinnati, and Detroit. The textile industry, for example, seemed to shun Pittsburgh, presumably because the smoke would damage its materials. Additionally, across the board, industries knew that they had to pay higher wages in Pittsburgh in order to compensate workers to live in such a dirty and unhealthy city.

A fourth feature of O'Connor's work was that, although he tried to quantify costs scientifically, he believed that most of the effects he was considering would be acknowledged by any casual observers with common sense. It is "axiomatic," he would say, that smoke causes this or that effect, that everybody knows it, or that "nobody will deny" the various forms of damage

(1913a *passim*). "The interesting and difficult matter is to compute that economic cost" (5).

A final feature of O'Connor's investigation was that he attempted to be conservative, that is, to find a "safe minimum" or lower bound on the damages from smoke (1913a 5). He accomplished this goal in several ways. First, many categories of damages, including health damages, were omitted because they could not be quantified. Second, he recognized that when there are avoidance behaviors, then the observed physical damages are only part of the story. These behaviors reduce the observed level of physical damages, but they also have costs associated with them which he had failed to capture. Third, he avoided double counting wherever possible. For example, he found that Pittsburgh almost certainly had lower property values because of the smoke. He based this conclusion on the fact that Philadelphia tax assessors decreased their assessments in the two dirtiest wards of the city, on court decisions awarding damages to neighboring property, and the expert opinion of Pittsburgh's real estate firms, which would sometimes advertise property as free from smoke.¹⁹ Yet O'Connor did not include these effects in his final totals, perhaps because he assumed they existed *because* of the other damages quantified, rather than as a separate category.

Each of these generic features can be further illustrated by summarizing his investigation of just one category of costs, higher laundry bills, including shirts and collars and "soft laundering" (dry cleaning was in a separate sub-category).²⁰ O'Connor noted the common sense of these effects.

It is safe to say that Pittsburghers know by experience that smoke and soot increase the dirtiness of their linens, necessitate their more frequent renewal and hence increase the cost of dressing and laundering beyond what it would if this city were cleaner. It is almost axiomatic with laundrymen of other cities that Pittsburgh is the greatest laundry town in the country. (13)

But, again, the difficult matter was to answer the question of how *much* more Pittsburghers pay for these costs.

¹⁹ In a companion paper, our research confirms O'Connor's conclusions. Properties in Pittsburgh's dirtiest wards did sell for a discount relative to others (Banzhaf et al. 2022a). Interestingly, John R. Commons attempted (apparently unsuccessfully) to follow up on his work for the Social Survey with a survey of quality-adjusted housing costs in different neighborhoods. One of many factors in the quality adjustment was to be neighborhood smoke (Commons 1908).

²⁰ This category of damages continued to be a motivating example in the economics literature, long after it had become quaint or whimsical, superseded in both policy considerations and economic damage estimates by health effects or acid rain (e.g. Baumol and Oates 1988).

O'Connor first broached this problem with data from the 1910 US Census on the per-capita costs for steam laundries—costs, not revenues—gathered from surveys. O'Connor noted that the total cost in Pittsburgh were \$5.95 per person, on the high end of the range of \$3.67 to \$5.98 for a set of 11 comparison cities. He stated that, ideally, he would have liked to correlate costs in these cities with their soot-fall, but of course the comparison cities did not have ongoing studies as Pittsburgh did. However, the US Weather Bureau counted the number of "smoky days" in each city. Pittsburgh was tops, with 342 smoky days from 1907-9, compared to a range of 9 to 231 smoky days in six comparison cities. Eyeballing the two data series, he concluded that "it bears out the contention that the amount of laundry business depends in a measure upon the amount of dirt in the atmosphere" (16). Figure 7 illustrates the data visually, with Pittsburgh to the far right of the graph. O'Connor did not fit this line, and we include it only as a concise way to represent his data and his thinking. That the smoke investigators thought in terms of such relationships is clear from Figure 6, correlating smoke and pneumonia. However, O'Connor concluded that both data series were too suspect to push them that far.

As an alternative, O'Connor obtained what he called "schedules on laundry bills" from 40 men and 20 Women. Importantly, these 60 people had lived elsewhere until recently. Thus, O'Connor could leverage within-person variation in their exposure to pollution when they moved to Pittsburgh. He did not explain the virtue of these data, but presumably he felt they allowed him to net out any differences in the average habits or professions of people in different cities.²¹ One particular respondent was a travelling auditor who had actual bills from his travels. They were \$3 to \$5 per month in Philadelphia and Minneapolis, \$4 to \$7 in Chicago, and \$6.50 to \$8 in Pittsburgh. Other survey participants had only their Pittsburgh bills, but they reported their estimate of how much their bills had changed when they moved. O'Connor found that, for men, the average bill in Pittsburgh was \$3.64 for a four-week period and that this figure was 33 to 50 percent more than it had been before they moved. Starting with these figures, multiplying by the number of men in the city, making allowance for the fact that many do not use laundry services or do so only for collars, and pro-rating up from the 4-week period, he estimated the annual "excess cost" of laundry in Pittsburgh to be \$618,000, relative to other cities. A similar procedure for women resulted in a

²¹ O'Connor used a similar methodology when estimating the damages to merchandise at department stores, looking at the difference in damages within a national chain between Pittsburgh and another, cleaner city.

figure of \$240,000. Thus, "Pittsburgh pays an excess toll of \$858,000 to the steam laundries because of the smoke and soot. Anyone who will take the trouble to study the situation . . . will find this estimate very conservative" (17).

Of course, expenditures by households represent revenues to the laundries. Heading off any optimistic interpretation of his results, O'Connor hastened to add that his figures represented *costs*, not profits. He based this argument on the Census data mentioned earlier, which showed the expense of conducting a laundry in Pittsburgh to be greater than other cities. He claimed this added expense was due to the need to take extra precautions to assure the clothing comes out clean and not smudged with soot. Thus, "the laundry business like many other industries suffers because of that same smoke and soot" (17).²²

Additionally, with both laundry and dry cleaning, the industry had not reached its fullest potential because these expenses "forced Pittsburghers to seek means of evading the problem" (19). Pittsburgh, O'Connor said, was known as "the mourning town" because the men were notorious for wearing dark suits to avoid showing dirt. The women surveyed stated that their bills were not larger because, although they did sometimes wear bright colors, they wore few woolens and more washable fabrics. Finally, O'Connor noted that many households do their laundry at home. But in this they are working "under a handicap, for it is a common complaint that people are unable to hang a washing outside to dry because of soot or a grimy fog. The extra cost in labor, time and effort of laundering is greatest to the housewife" (18). These non-market costs could not be calculated, but O'Connor asserted that a total laundry cost of \$1.5m, which is about 75% more than the estimated costs from marketed laundry services, would be a safe lower bound.

As noted previously, O'Connor and his colleagues initially hoped that such research would persuade Pittsburgh's leaders to aggressively reduce its smoke. The Smoke and Dust Abatement League, of which O'Connor was a leading officer, was created to translate the research into action. Thinking collectively, the city's leaders would see their common self-interest in reducing smoke. Even leaders of industry would recognize such action as compatible with their self interest in reducing waste and the cost of doing business. Initially, there were reasons for such hope. After

²² O'Connor may have stretched his point here. In fact, the Census data showed only that total expenses for laundromats were greater in Pittsburgh per capita, not that the costs per item of washing were higher. The former is also consistent with more washing per capita, and thus with moving along a cost curve, without having to shift the curve higher.

lobbying the state to explicitly authorize smoke ordinances, the city adopted tough new ordinances. Then, in *Northwestern Laundry v. City of Des Moines* (1916), the US Supreme Court upheld such rules as compatible with the US constitution. It seemed momentum was on the side of smoke control. Wrote the league in one of its pamphlets:

Do not fail to secure copies of the latest annual reports and other publications available, which will inform you as to the economic value of smoke abatement to every man, woman and child in our city—the city which may be recognized as—PITTSBURGH—THE IRON CITY BEAUTIFUL.

However, hopes for a beautiful city soon faded. Industrial leaders did not appear inclined to voluntarily control their smoke. The city was lax in enforcing its new ordinances. By late 1913, the league itself was torn by internal dissent. O'Connor and others wanted the league to be a forward leaning advocate, fighting aggressively for cleaner air. In contrast, the powerful business leaders of the chamber appeared to want to use only persuasion. Mellon appears not to have committed himself. Although O'Connor and others successfully moved to oust the conservative leadership in favor of a more moderate slate, aggressive enforcement of the city's new ordinances was not forthcoming. Volunteers from the league's Committee on Smoke Observation observed smokestacks and reported violators, threatening letters were drafted by O'Connor on behalf of the league, but still nothing was done.²³

In the end, like so much of the Progressive Era, the smoke abatement movement was interrupted by World War I. The league at first tried to fold anti-smoke actions as a necessary tool to conserve coal resources during wartime. Illustrating these efforts, Figures 8 and 9 display propaganda from the period voicing this message. But in 1917 O'Connor left for the army and the movement faded. The Mellon Institute conducted additional smoke studies in 1923 and 1929 and the Works Progress Administration did so in 1938, but Pittsburgh did not adopt an effective smoke control ordinance until 1941 (Tarr 1994).

6. Conclusions

The historical evolution from the Conservation Movement at the turn of the 20th century to the stabilization of something resembling contemporary environmental economics around 1970 was

²³ O'Connor to Holdsworth 11-22-13, SIA I.2.2; O'Connor to Bishop 11-22-13, SIA III.4.6. See also extensive correspondence between O'Connor and J.W. Henderson (head of the city's Bureau of Smoke Regulation), SIA III.5.18.

facilitated by three key moves (Banzhaf, forthcoming). One was a shift from thinking in terms of institutions for governing common property and the incentives they created to thinking in terms of "externalities." For although Pigou had famously introduced "uncompensated services" that are rendered to others, his analysis jumbled together a number of external economies and diseconomies, with the modern definition of externalities not arising until the post-war period, and furthermore the connection to environmental issues was not made until much later (Banzhaf forthcoming, Medema 2020). A second move was the shift in the definition of economics, from the study of material welfare at the turn of the century to Lionel Robbins's definition of the field as a way of thinking in terms of opportunity costs in the 1960s (Backhouse and Medema 2009a,b). A third was a shift from focusing on production, or the supply side of the economy, to a focus on the consumer, accompanied by an expansion of what counted as "consumption" to encompass "intangible" pleasures such as recreation and the enjoyment of scenic landscapes.

O'Connor's *Economic Cost of the Smoke Nuisance to Pittsburgh* is a conspicuous landmark on this historical path. Reading backward from today's literature, it could easily be understood as another early articulation of the idea of externalities, one which appeared at essentially the same time as Pigou's (especially if we group it with Holdsworth's *Economic Study* as part of a larger enterprise). Interestingly, the Smoke Investigations considered smoke's effects on vegetation, materials, daylight, laundry, and other washing—a list of effects strikingly similar to Pigou's own. On this reading, O'Connor's quantification of the costs of these effects chargeable to smoke is as an early and extraordinarily detailed example of finding a Pigouvian price. That is, it is an early example of damage costing, using an integrated assessment model.

On the other hand, reading forward from the turn of the century, the Smoke Investigations appear to be a continuation of the Conservation Movement. At that time, the general sense in the economics literature was that natural resources were being excessively depleted for a mix of reasons, including ignorance of the costs, excessive discounting of the future, and poor property rights incentives, as when tenant farmers excessively depleted the soil, or when water or grazing rights were held in common. The solution was to find better property rights institutions to get the incentives right. For example, the conservation rhetoric frequently emphasized the importance of private ownership of farms, but at the same time called for public ownership of forests and other resources (Banzhaf, forthcoming). Thus, there was a sense that private property rights do not always capture all the relevant benefits and costs.

In the same way, the anti-smoke movement saw the need for rational government to bring efficiency to the city. Just as Olmsted was bringing an urban plan to the city's physical layout, the Smoke Abatement League, armed with scientific knowledge, could bring a plan to the city. Concluded Benner and O'Connor in a summary of their work,

The source of power of governmental authority to abate the smoke nuisance is the police power of the state. We are always tempted to think of this as extending only to the protection of life and property in its narrow sense and the maintenance of public order, but more and more we are coming to know that its great sphere is public health and general welfare. (1913 593)

Accordingly, proper control must be taken at the proper level. Elaborated O'Connor, the smoke nuisance has become a "community problem," not a matter for traditional nuisance gauged at the individual level, but a nuisance at the community level (O'Connor 1916).

Thus, how one sees *The Economic Cost of the Smoke Nuisance* depends on one's point of view. It is a quantification of costs. But not necessarily of *external* costs, for it makes no distinction between internal and external effects, and in fact it leads with the inefficient use of fuels and material resources which lowers private profits. It stands out for its attention to smoke's effects on households' ability to produce the final services they enjoy, such as clean clothing and materials. But, rhetorically, it turns these effects back onto the city's ability to compete for commerce, as they make Pittsburgh an expensive place to do business. Finally, it monetizes a great variety of effects, as a modern integrated assessment would do. But, in fact, it monetizes only very tangible physical effects, even when intangible effects are known to exist.

A comparison between the Smoke Investigations and a later survey by Randall et al. (1974), which also valued air pollution damages, is instructive. Randall et al. showed participants pictures of a Southwestern landscape under two conditions, one with good visibility and one with visibility impaired by smoke from a nearby power plant. They then elicited people's willingness to pay for the "aesthetic effect of increasing the number of days in the good condition." Interestingly, Pittsburgh's investigators also used photographs to document the visibility effects of smoke. They showed a series of pairs of photographs from different parts of the city, each pair being a photograph of a clear day and a smoky day, respectively, from the same vantage point (Mellon Inst. 1914). Figure 10 shows one such pair, for the downtown district. While such photographic evidence was a natural thing for the investigators to document, it was anything *but* natural to go

on and quantify the costs of such aesthetic or intangible effects in themselves. They were not yet conceivable as "economic costs."

References

- Allcott, Hunt, and Michael Greenstone. 2012. "Is there an Energy Efficiency Gap?" *Journal of Economic Perspectives* 26(1): 3-28.
- American Sociological Association (ASA). Undated. "History." <https://www.asanet.org/history-6/>. Accessed 12-30-22.
- Anderson, Margo, and Maurine W. Greenwald. 1996. "Introduction: The Pittsburgh Survey in Historical Perspective." In Greenwald and Anderson, eds., 1-14.
- Backhouse, Roger E., and Steve G. Medema. 2009a. "Defining Economics: The Long Road to Acceptance of the Robbins Definition." *Economica* 76: 805-20.
- Backhouse, Roger E., and Steven G. Medema. 2009b. "Retrospectives: On the Definition of Economics." *Journal of Economic Perspectives* 23(1): 221-33.
- Banzhaf, H. Spencer. Forthcoming. *Pricing the Priceless: A History of Environmental Economics*. Cambridge: Cambridge University Press.
- Banzhaf, H. Spencer, William Mathews, and Randall Walsh. 2022a. "Hell With the Lid Off: Locational Sorting in America's Most Polluted City." Working Paper.
- Banzhaf, H. Spencer, William Mathews, Brianna Smith, and Randall Walsh. 2022b. "One Hundred Years of Environmental Justice in America's 'Smoky City.'" Working Paper.
- Bateman, Bradley W. 1998. "Clearing the Ground: The Demise of the Social Gospel Movement and the Rise of Neoclassicism in American Economics." In *From Interwar Pluralism to Postwar Neoclassicism*, ed. by Mary S. Morgan and Malcolm Rutherford. *History of Political Economy* 30(S): 29-52. Durham, NC: Duke University Press.
- Bateman, Bradley W., and Ethan B. Kapstein. 1999. "Retrospectives: Between God and the Market: The Religious Roots of the American Economic Association." *Journal of Economic Perspectives* 13(4): 249-58.
- Bateman, Bradley W. 2001. "Make a Righteous Number: Social Surveys, the Men and Religion Forward Movement, and Quantification in American Economics." In *The Age of Economic Measurement*, ed. by Judy L. Klein and Mary S. Morgan. *History of Political Economy* 33(S): 57-85. Durham, NC: Duke University Press.
- Bauman, John F., and Margaret Spratt. 1996. "Civic Leaders and Environmental Reform: The Pittsburgh Survey and Urban Planning." In Greenwald and Anderson, eds., 153-69.
- Baumol, William J., and Wallace E. Oates. 1988. *The Theory of Environmental Policy*, 2nd ed. Cambridge: Cambridge University Press.
- Benner, Raymond C., and J.J. O'Connor, Jr. 1913. "The Smoke Nuisance: A Question of Conservation." *Journal of Industrial and Engineering Chemistry* 5(7): 587-93.

- Bulmer, Martin. 1996. "The Social Survey Movement and early Twentieth Century Sociological Methodology." In Greenwald and Anderson, eds., 15-34.
- Bulmer, Martin, Kevin Bales, and Kathryn Kish Sklar, eds. 1992. *The Social Survey in Historical Perspective: 1880-1940*. Cambridge: Cambridge University Press.
- Chambers, Clarke A. 1971. *Paul Kellogg and the Survey: Voices for Social Welfare and Social Justice*. Minneapolis: University of Minnesota Press.
- Commons, John R. 1908. "Standardization of Housing Investigations." *Publications of the American Statistical Association* 11(84): 319-26.
- Greenwald, Maurine W., and Margo Anderson, eds. 1996. *Pittsburgh Surveyed: Social Science and Social Reform in the early Twentieth Century*. Pittsburgh: University of Pittsburgh Press.
- Hawley, Ellis W. 1990. "Economic Inquiry and the State in New Era America: Antistatist Corporatism and Positive Statism in Uneasy Coexistence." In *The State and Economic Knowledge*, ed. Mary O. Furner and Barry Supple, 287-324. Cambridge: Cambridge University Press.
- Hays, Samuel P. 1959. *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920*. Cambridge, MA: Harvard University Press.
- Hays, Samuel P. 1964. "The Politics of Reform in Municipal Government." *The Pacific Northwest Quarterly* 55(4): 157-69.
- Hersh, Robert. 1995. "Race and Industrial Hazards: An Historical Geography of the Pittsburgh Region, 1900-1990." Discussion Paper 95-18. Washington, DC: Resources for the Future.
- Holdsworth, J.T. 1912. *Report of the Economic Survey of Pittsburgh*.
- Kleinberg, S.J. 1996. "Seeking the Meaning of Life: The Pittsburgh Survey and the Family." In Greenwald and Anderson, eds., 88-105.
- Medema, Steven G. 2020. "'Exceptional and Unimportant'? Externalities, Competitive Equilibrium, and the Myth of a Pigovian Tradition." *History of Political Economy* 52(1): 135-70.
- Mellon Institute of Industrial Research and School of Specific Industries. 1914. *Some Engineering Phases of Pittsburgh's Smoke Problem*. Smoke Investigation Bulletin No. 8. Pittsburgh: University of Pittsburgh.
- Nadel, Meryl. 2019. "The Pittsburgh Social Survey of 1907-1908: Divergent Paths to Change." *Social Service Review* (Dec.): 678-711.
- O'Connor, John J., Jr. 1913a. *The Economic Cost of the Smoke Nuisance to Pittsburgh*. Mellon Institute of Industrial Research and School of Specific Industries, Smoke Investigation Bulletin No. 4. Pittsburgh, PA: University of Pittsburgh.

- O'Connor, John, Jr. 1913b. "The History of the Smoke Nuisance and of Smoke Abatement in Pittsburgh." *Industrial World*, March 24, pp. 352-55.
- O'Connor, John, Jr. 1913c. "The Smoke Investigation of the University of Pittsburgh." *Industrial World*, Feb. 3, pp. 132-33.
- O'Connor, John, Jr. 1916. "Civic Phases of the Smoke Problem." *The Heating and Ventilating Magazine* (Oct.): 40-44.
- Olmsted, Frederick Law. 1911. *Pittsburgh Main Thoroughfares and the Down Town District*. Pittsburgh Civic Commission Publication No. 8. <https://www.gutenberg.org/files/49972/49972-h/49972-h.htm>
- Pigou, A.C. 1912. *Wealth and Welfare*. London: Macmillan and Co.
- Pigou, A.C. 1920. *Economics of Welfare*. London: Macmillan and Co.
- __Post 1910
- Randall, Alan, Berry Ives, and Clyde Eastman. 1974. "Bidding Games for Valuation of Aesthetic Environmental Improvements." *Journal of Environmental Economics and Management* 1: 132-49.
- Robinson, Charles Mulford. 1909. "Civic Improvement Possibilities of Pittsburgh." *Charities and the Commons* 21(6 Feb.): 801-26.
- Rothbard, Murray. 2002. *A History of Money and Banking in the United States*. Auburn, AL: Ludwig von Mises Inst.
- Schultz, Stanley K. 1989. *Constructing Urban Culture...*
- Smith, Mark C. 1994. *Social Science in the Crucible: The American Debate over Objectivity and Purpose, 1918-1941*. Durham, NC: Duke University Press.
- Tarr, Joel A. 1984. "The Search for the Ultimate Sink: Urban Air, Land, and Water Pollution in Historical Perspective." *Records of the Columbia Historical Society of Washington, DC* 51: 1-29.
- Tarr, Joel A. 1994. "Searching for a 'Sink' for an Industrial Waste: Iron-Making Fuels and the Environment." *Environmental History Review* 18: 9-34.
- Tarr, Joel A. 1996. "The Pittsburgh Survey as an Environmental Statement." In Greenwald and Anderson, eds., 170-89.
- Tarr, Joel A., and Bill C. Lamperes. 1981. "Changing Fuel Use Behavior and Energy Transitions: The Pittsburgh Smoke Control Movement, 1940-1950." *Journal of Social History* 14(4): 561-88.

Turner, Stephen. 1996. "The Pittsburgh Social Survey and the Survey Movement." In Greenwald and Anderson, eds., 35-49.

University of Pittsburgh. 1912. *Outline of the Smoke Investigation*. Department of Industrial Research, Bulletin No. 1.

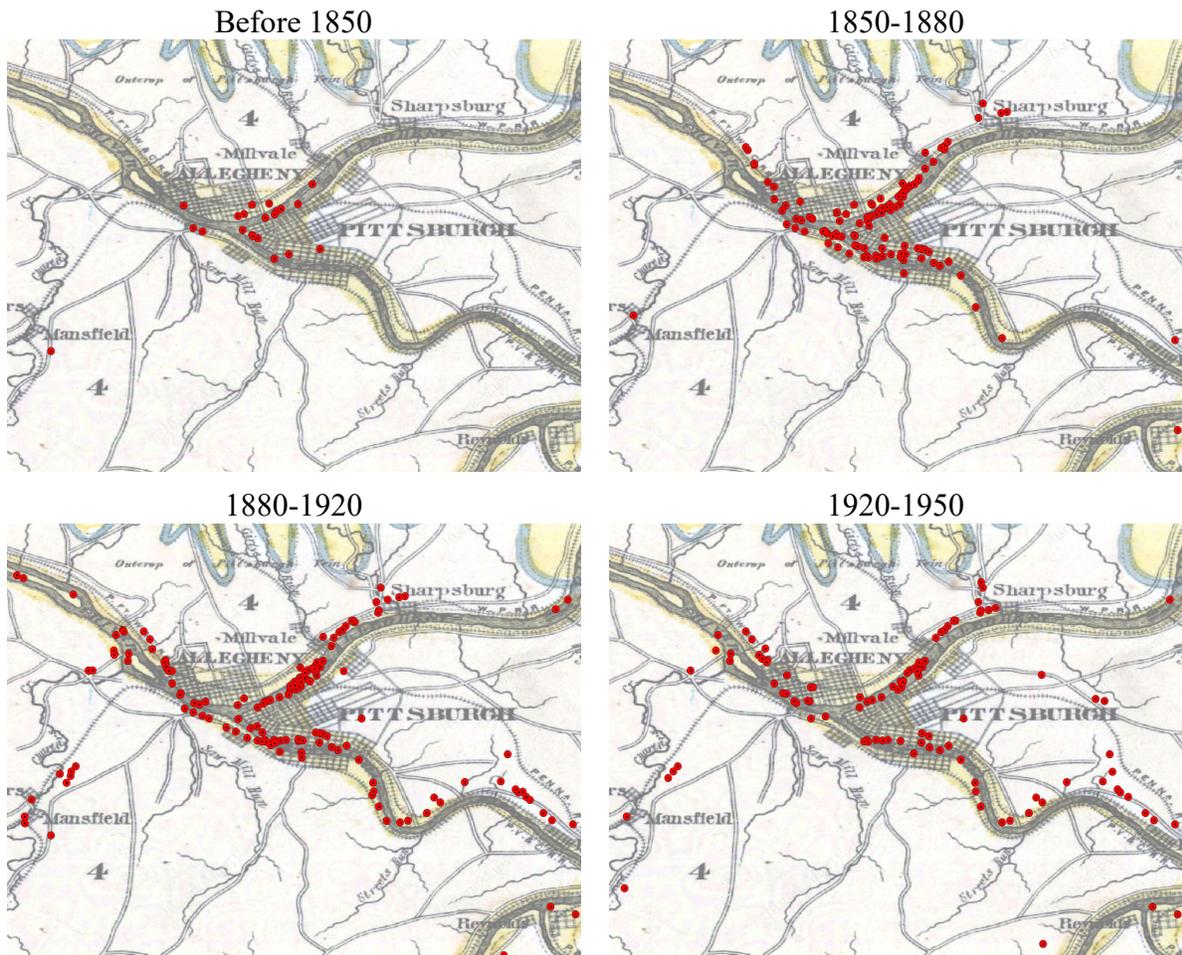
Wallin, J.E. Wallace. 1913. *Psychological Aspects of the Problem of Atmospheric Smoke Pollution*. Mellon Institute of Industrial Research and School of Specific Industries, Smoke Investigation Bulletin No. 3. Pittsburgh, PA: University of Pittsburgh.

White, William Charles and C.H. Marcy. 1914. "A Study of the Influence of Varying Densities of City Smoke on Mortality from Pneumonia and Tuberculosis." In *Papers on the Influence of Smoke on Health*, ed. by Oskar Klotz and William Charles White, 155-63. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 9. Pittsburgh: University of Pittsburgh, 1914.

Figure 1. The Jones and Laughlin Works



Figure 2. Expansion of Mills in Pittsburgh



The figure shows the location of foundries and mills that were confirmed to be operating at some point in the time window noted. Data from Ronald Baraff of Rivers of Steel.

Figure 3. The Puddler

A. Constantin Meunier



B. à la Crystal Eastman

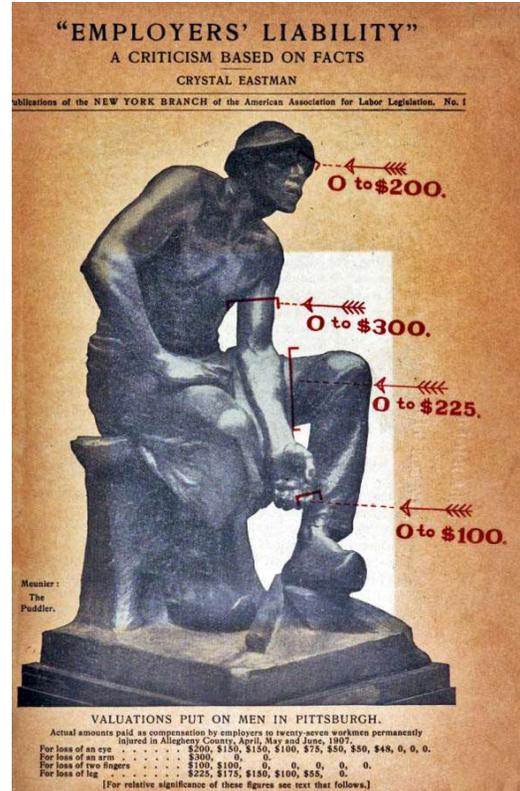


Figure 4. Location of Soot-fall Jars

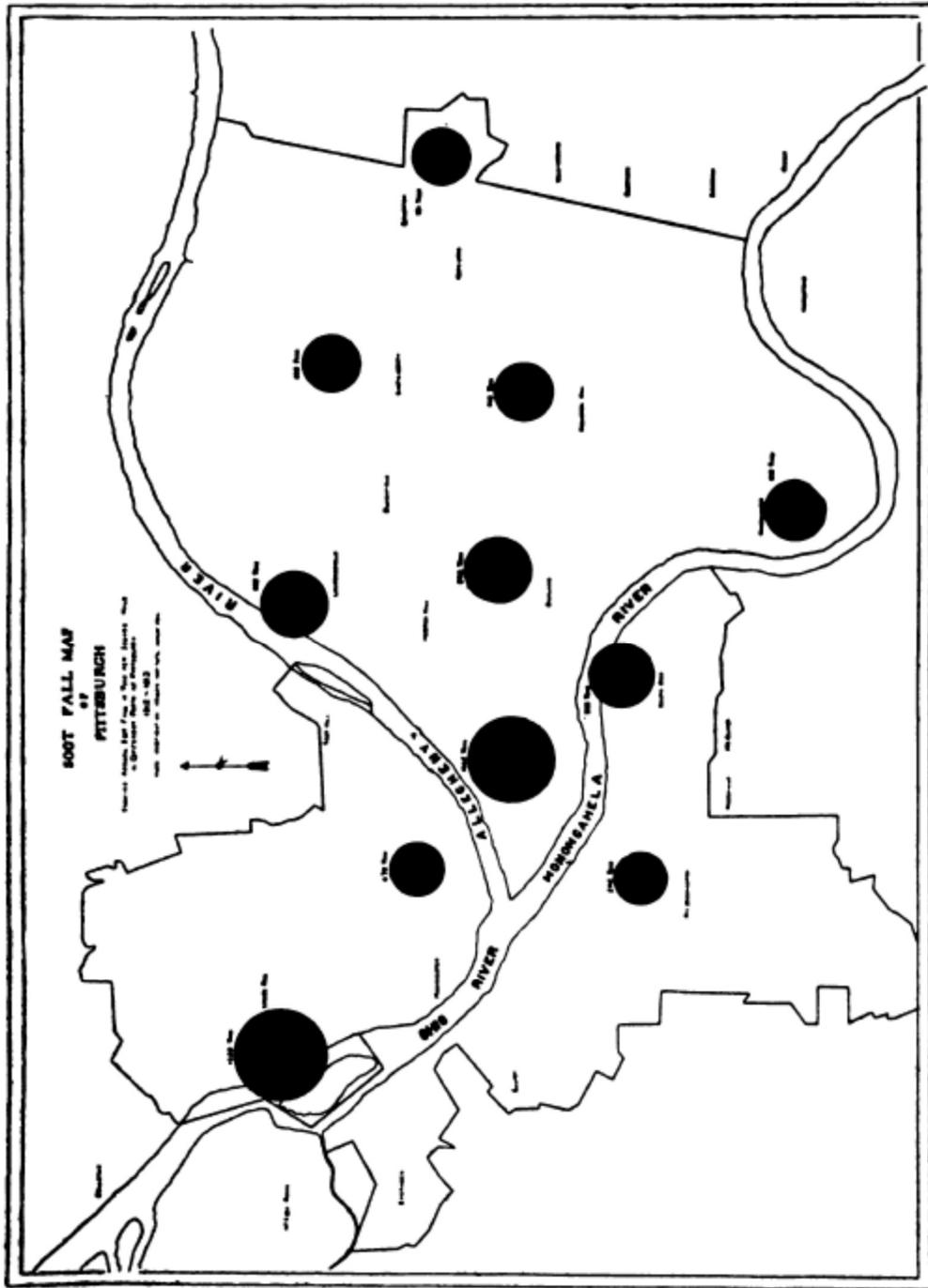


Figure 3—Soot-fall map of Pittsburgh.

From Mellon Institute (1914 21).

Figure 5. Sootfall data, as recorded and as published

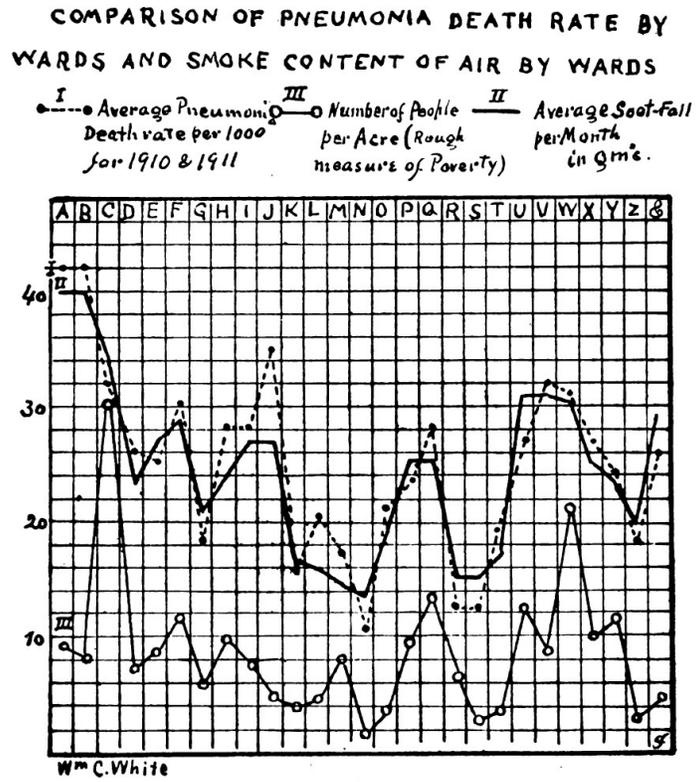
TABLE I—PITTSBURGH'S SOOT-FALL SAMPLES IN GRAMS PER MONTH, APRIL 1912 TO APRIL 1913.

Month.	STATION NUMBERS.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
April, '12	.3806	.5106	.2722	.5308	.5501	.4186	.1184	.2596	.1821	.1341	.2599	.1603
May	.1081	.4146	.1142	.5198	.5882	.0873	.1384	.1915	.1332	.1192	.1676	.2778
June	.2552	.5714	.2752	.4872	.4000	.3604	.2142	.3306	.1863	.1374	.2026	.1315
July	.1450	.6924	.2570	.3900	.5520	.2282	.2030	.3364	.1732	.1564	.2678	.1938
August	.1104	.5154	.1460	.2608	.3570	.1828	.2022	.2266	.1732	.1142	.2024	.1210
September	.1114	.5038	.1910	.2022	.3278	.1830	.1832	.2040	.1826	.1282	.2136	.1426
October	.1380	.5610	.2182	.3124	.4622	.2488*	.2072	.3254	.1664	.1636	.2942	.1554
November	.0526	.7700	.1290	.2188	.3860	.2166	.2076	.1734	.1586	.1836	.2088	.1742
December	.1380	.7522	.3428	.4896	.3788	.3988	.2860	.1484	.4282	.3702	.4276	.2518
January, '13	.1278	.5232	.2660	.6398	.2828	.2742	.3092	.2456	.2094*	.3154	.3206	.1948
February	.1034	.6200	.2642	.4574	.3746	.2042	.0914	.1462	.1278	.1420	.2894	.1242
March	.1550	.5438	.1956	.5876	.3342	.1972	.3236	.3346	.1750	.2462	.1924	.1946
Total	1.8255	6.9784	2.6814	5.0964	4.9937	3.0001	2.4846	2.9223	2.2960	2.2075	3.0469	2.1220
Tons per sq. mi.	595	1,950	670	1,660	1,630	978	812	922	748	721	995	693

*The October jar from Station No. 6 was broken and the January sample from Station No. 9 froze and the jar was broken. The weights of the soot-fall were calculated by taking, in the case of the October sample of No. 6, the average per cent. of the October precipitate of the total of 12 months for the 10 full year samples. From this and the weight of No. 6 for 11 months the October precipitate was calculated. No. 9 for January was calculated in the same way. This gives a better weight than a simple average would.

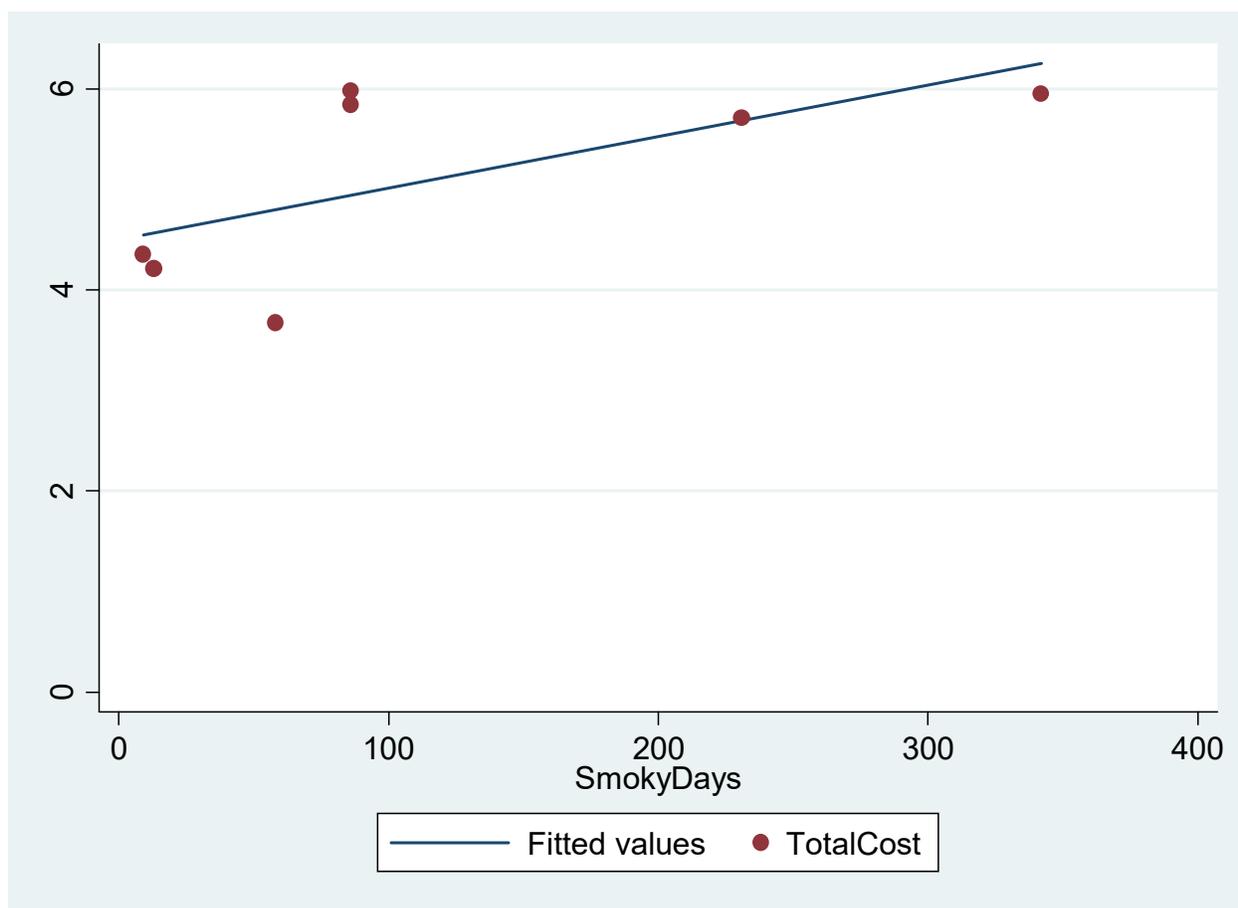
From Mellon Institute (1914 21).

Figure 6. Pneumonia rates correlated with soot-fall.



From White and Marcy (1914) p. 158.

Figure 7. Correlation of Laundry Costs and Smoky Days



Authors' figure using data from O'Connor (2013b).

__Insert Figures 8 and 9

Figure 10A. "View of the 'Downtown Section' when the City was Free from Smoke"



Figure 8—View of the "Downtown Section" when the city was free from smoke.

Photo by H. C. Anderson

Figure 10B. "Same View on a Smoky Day"



Figure 9—Same view as in Figure 8 on a smoky day.

Photo by H. C. Anderson

From Mellon Institute (1914 40-41)