2007

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article version: accepted manuscript

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Desrochers, P. (2007). How did the Invisible Hand Handle Industrial Waste? By-product Development before the Modern Environmental Era. *Enterprise & Society*, 8(2), 348-374.
[doi:10.1017/S1467222700005887](https://doi.org/10.1017/S1467222700005887)

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How did the Invisible Hand Handle Industrial Waste? By-Product Development before the Modern Environmental Era.

Abstract:

A growing number of historians have turned their attention to the past behavior of industrialists towards their waste. Many have argued that the price system and competition typically fostered a short-term outlook that rewarded polluting emissions rather than the development of *loop-closing*, a modern term that refers to the creation of linkages between different industries in which the residual of one becomes the input of another. Others have identified precedents in this respect that are credited to Progressive Era reformers. Building on evidence that has, by and large, escaped the attention of the present generation of historical writers, this essay challenges both views by arguing that market institutions, which included both profit motive and property rights, actually resulted in much by-product development. While there is no point in arguing that past industrial activities did not generate important pollution problems, perhaps our ancestors should be given more credit than they generally are for the creativity and resourcefulness they displayed in profitably solving numerous environmental problems.

Introduction

In recent years, a growing number of business, technology, urban and environmental historians have written about the behavior of early industrialists towards their waste. Scholars sometimes have blamed them for failing to generate what is now termed *loop-closing*, i.e., the creation of direct linkages between different lines of work where the residual of one becomes the valuable input of another. This essay challenges this perception by building on the work of several past European and American writers who argued to the contrary that by-product development had always been a prominent feature of the market system. As the journalist Frederick Talbot put it almost a century ago: “To relate all the fortunes which have been amassed from the commercialization of what was once rejected and valueless would require a volume. Yet it is a story of fascinating romance and one difficult to parallel in the whole realm of human activity.”¹

This paper is structured as follows. The first section discusses the appearance and evolution of terms and concepts associated with industrial recycling linkages. A brief survey of recent historical work on this topic then follows, while the remainder of the essay examines some of the contributions of earlier generations of technicians and specialized journalists. If the details and extent of past achievements and analysis cannot be discussed within the confines of one paper, it is the hope of this writer that this paper will help lay the foundations for more detailed and balanced examinations of various industries’ track records in terms of creating wealth from waste, while mitigating their environmental impact in the process.

¹ Frederick A. Talbot, *Millions from Waste* (Philadelphia, 1920), pp. 17-18.

1. From “Waste Products” to “Loop-Closing”²

Any essay on the history of loop-closing must first address some conceptual considerations. According to the *Oxford English Dictionary* (henceforth, OED), the noun “waste” has historically had three different meanings. The first documented use, in 1200, had “waste” denote uninhabited or sparsely inhabited and uncultivated land. The second use, the useless expenditure or consumption of goods, time or money, was first recorded in the late 13th century. The third category, “waste matter” or “refuse”, is first documented in 1430, while the synonym “rubbish” (later mostly used for domestic, as opposed to industrial, waste) was documented even earlier, in 1392-93. The terms “waste material” or “waste products” were historically understood to encompass those materials which were produced as a result of the processing or manufacturing of a primary commodity, or were residues of finished products which were no longer fit for their original intended use.

“By-product” was first recorded by the OED in 1857 to refer to a commodity that arises incidentally and unavoidably in the production of something else. The concept became so commonly understood that it was used by Alfred Marshall in his *Principles of Economics* in 1890 as if it needed no explanation. “Salvage,” on the other hand, generally involved waste materials reclaimed from a manufacturing process for re-use in the same activity without substantial further processing beyond collection and separation by material. In an attempt to improve the image of the various waste trades, the term “secondary materials” came into widespread use in the 20th century to designate waste products that were not

² This section is largely based on the following contributions: Charles Lipsett, *Industrial Wastes and Salvage: Conservation and Utilization* (New York, 1963/1951); Brian William Clapp, *An Environmental History of Britain since the Industrial Revolution* (Harlow, 1994); Hugh S. Gorman, “Efficiency, Environmental Quality, and Oil Field Brines: The Success and Failure of Pollution Control by Self-Regulation,” *Business History Review* 73, no. 4 (Winter 1999): 601-640; John William Maher, *Retrieving the Obsolete: Formation of the American Scrap Steel Industry, 1870-1933*, PhD Dissertation (Geography) (University of Maryland at College Park, 1999); and Carl Abraham Zimring, *Recycling for a Profit: The Evolution of the American Scrap Industry*, PhD Dissertation (History), Carnegie-Mellon University (History) (Carnegie-Mellon University, 2002). For a more detailed taxonomy of the types of businesses involved in the waste trade, see Maher, *Retrieving the Obsolete*, pp.6-10 and Zimring, *Recycling for a profit*, pp.82-83.

produced directly in manufacturing activities (scrap steel, rags, used paper, etc.). This activity is more often referred to today as “recycling,” a term that was first recorded by the OED in 1926 (first hyphenated as re-cycling) and whose roots can be traced back to oil refining. In his popular usage, however, “recycling,” has increasingly come to refer to recovered domestic waste. In recent years, the term “loop-closing” has been promoted by proponents of the emerging “industrial ecology”³ perspective and essentially refers to by-product linkages. For the remainder of this essay, “industrial waste,” “industrial by-products” and “industrial refuse” will be used interchangeably, while “loop-closing” will be used interchangeably with “interindustrial waste recovery” and “by-product recovery between industries.”

2. Current Assessments of Past By-Product Development

In their survey of how historians of technology have dealt with the environment, Jeffrey Stine and Joel Tarr concluded that, while it is difficult to write technological history without touching on some environmental element, it was not until the turn of the 1990s that practitioners of this sub-discipline began to pay sustained attention to this issue. Christine Rosen and Christopher Sellers similarly observed the paucity of environmental considerations within the field of business history, while Mart Stewart suggested that environmental historians had traditionally put more emphasis on industrial pollution than efforts to remedy it.⁴

In recent years, however, a growing body of historical research has dealt with the

3 The main idea behind industrial ecology (IE) is that modern economies should mimic the cycling of materials in ecosystems. Although the immediate roots of IE are to be found in 1960s systems analysis, it can also be viewed as the current incarnation of a long history of materials flow analysis. For broad surveys of the history and current thinking associated with IE, see Robert U. Ayres and Leslie W. Ayres, *A Handbook of Industrial Ecology* (Cheltenham, 2002); Marina Fischer-Kowalski, “Society’s Metabolism. The Intellectual History of Materials Flow Analysis, Part I, 1860-1970,” *Journal of Industrial Ecology* 2, no. 1 (Winter 1998): 61-78; and Marina Fischer-Kowalski and Walter Hüttler, “Society’s Metabolism. The Intellectual History of Materials Flow Analysis, Part II, 1970-1998,” *Journal of Industrial Ecology* 2, vol. 4 (Fall 1998): 107-136

4 Jeffrey K. Stine and Joel A. Tarr, “At the Intersection of Histories: Technology and the Environment,” *Technology and Culture* 39, no. 4 (Oct. 1998): 601-640; Christine Rosen and Christopher Sellers, “The Nature of the Firm: Towards and Ecocultural History of Business,” *Business History Review* 73, no. 4 (Winter 1999): 577-600; and Mart A. Stewart, “Environmental History: Profile of a Developing Field,” *The History Teacher* 31 (3) (May 1998): 351-368.

relationships between industry, technology and the environment over time, although there is still no sustained or systematic body of literature that explores the issue of industrial waste for either small or large industries.⁵ Perhaps the most interesting general historical treatment of by-product development is to be found in a chapter of Brian Clapp's popular environmental history of England – a book that seems to have escaped the attention of American scholars – in which he argues that the creation of wealth from industrial waste is “an untidy story, a mixture of success and failure, with no clearcut trend towards or away from full use of the byproducts available.”⁶ He further speculates that byproducts “were relatively more common in pre-industrial economies than they are now” because they were primarily derived from living organisms (timber, wool, cotton, leather, dyestuffs, and animal and vegetable oils), a statement that is nonetheless often contradicted in his own writings.⁷ One can also find incidental treatments of by-product development in studies on the alkali trade, the development of the manufacturing gas and petroleum refining industries, the Chicago meat-packing district, the early brewing and distilling industries and the synthetic dye industries, among others.⁸

One possible explanation for the lack of detailed historical analysis of the environmental behavior of firms is a widespread belief that the invisible hand of the market was quick to discharge industrial waste into the environment. For example, James Winter argues that, despite a widely held belief that “market mechanisms, when allowed to run freely, not only encouraged innovation but also eventually rewarded the thrifty and punished the

5 See comments to this effect in Joel A. Tarr, “Industrial Waste Disposal in the United States as a Historical Problem,” *Ambix* 49, no. 1 (March 2002): 4-20; and Christine Rosen, “Knowing Industrial Pollution: Nuisance Law and the Power of Tradition in a Time of Rapid Economic Change, 1840-1864,” *Environmental History* 8, no. 4, (Oct. 2003): 565-597.

6 Clapp, *An Environmental History of Britain since the Industrial Revolution*, p. 220.

7 Clapp, *An Environmental History of Britain since the Industrial Revolution*, p. 223.

8 See, among others, Anthony E. Dingle, “‘The Monster Nuisance of All’: Landowners, Alkali Manufacturers, and Air Pollution, 1828-64,” *Economic History Review* 35, no.4 (Nov. 1982): 529-548; James Donnelly, “Consultants, Managers, Testing Slaves: Changing Roles for Chemists in the British Alkali Industry, 1850-1920,” *Technology and Culture* 35, no.1 (Jan. 1994): 100-128; Kendall Beaton, “Dr. Gesner's Kerosene: The Start of American Oil Refining,” *Business History Review* 29, no.1 (Mar. 1955): 28-53; Godfrey Boyle, Bob Everett and Janet Ramage, *Energy Systems and Sustainability. Power for a Sustainable Future*. Oxford, 2003; William Cronon, *Nature's Metropolis. Chicago and the Great West*, (New York, 1991); Peter Mathias, “Agriculture and the Brewing and Distilling Industries in the Eighteenth Century,” *Economic History Review* NS 5, no.2 (1952): 249-257; and Anthony S. Travis, *The Rainbow Makers. The Origins of the Synthetic Dyestuffs Industry in Western Europe* (Bethlehem, 1993).

wasteful,” Victorian industrialists’ interest in developing wealth out of waste “lagged behind developments in the relevant science and technology” unless it was “stimulated by protest or threat of regulating legislation.”⁹ In his study of attempts to control industrial waste in New England during the Progressive Era, John T. Cumbler similarly argued: “Historically business has tended to look on the pollution costs of production as an external cost to be born by society in the form of dirtier water or air or depleted natural resources. Externalizing environmental costs encouraged economic expansion and employment by reducing costs to the manufacturer.”¹⁰ For her part, Christine Rosen thought it more productive to focus her attention on American litigation regarding nuisance pollution. It is her belief that past engineers and technicians “lacked the technological know-how to optimize waste minimization and reuse” as a direct result of having had virtually no economic incentive to develop and implement such know-how.¹¹ Among other restatements of this position, she argues that early-twentieth-century engineers dealt with industrial emissions through the development of “end-of-pipe pollution-abatement and treatment technologies” rather than loop-closing.¹²

John K. Smith also contends that not all past waste could be profitably utilized, despite the fact that the treatment and minimization of refuse has always been a less desirable alternative than their use, sale or elimination through increased productivity (i.e., by diminishing the amount of residuals generated from the use of primary inputs).¹³ Other researchers have documented some success in this latter area, but have argued that the

9 James Winter, *Secure from Rash Assault. Sustaining the Victorian Environment* (Berkeley, 1999), 144 and 147.

10 John T. Cumbler, “Conflict, Accommodation and Compromise: Connecticut's Attempt to Control Industrial Waste in the Progressive Era,” *Environmental History* 5, no.3 (July 2000): 314.

11 Christine Rosen, “Industrial Ecology and the Greening of Business History,” *Business and Economic History* 26, no.1 (Fall 1997): 126.

12 Christine Rosen, “Industrial Ecology and the Transformation of Corporate Environmental Management: A Business Historian's Perspective”. In Arthur Molella and Joyce Bedi (eds), *Inventing for the Environment* (Cambridge, 2003), 329. In her most recent work, however, Rosen documents a few cases of past loop-closing. To give one example, in an 1849 New Jersey legal case, representatives from the Passaic Chemical Works pointed out that their “waste gases were ‘valuable’ and that it was in their interest to prevent them from escaping and that in fact a large part of their business involved the sale of products formed from condensed forms of the gases.” See Rosen, “‘Knowing’ Industrial Pollution,” 575.

13 John K. Smith, “Turning Silk Purses into Sow's Ears: Environmental History and the Chemical Industry,” *Enterprise & Society* 1, no.4 (Dec. 2000): 789.

visible hands of public legislators and Progressive reformers in governmental outlets such as the U.S. Bureau of Mines, were necessary to guide or rein in the otherwise damaging behavior of industrialists.¹⁴

In what is probably the most detailed historical case study of loop-closing within a corporation, Tom McCarthy persuasively argues that the Ford Motor Company built its Dearborn (Michigan) River Rouge complex during the 1920s and 1930s with waste reduction and reuse in mind.¹⁵ Among by-products generated and used inside and outside the complex were coke oven gas, tar, ammonium sulfate and benzol (now called benzene), all derived from making coke from coal. By design, the first two items were used as fuels in various operations at the plant, while ammonium sulfate and benzol were respectively sold as fertilizer and fuel outside the confines of the facility. In addition, executives at the Ford company had a cement plant built to dispose of the 125 tons of blast furnace slag¹⁶ that were generated daily on the site. About a quarter of this output was used in its own construction activities, while the balance was sold on the open market. Ford similarly tried to use “every part of the tree except the shade” at his wood by-products processing operation at Iron Mountain in Michigan’s Upper Peninsula.

McCarthy observes that the fundamental rationale behind these efforts was economic rather than environmental., but that company executives also undertook unprofitable by-product recovery schemes at the behest of Henry Ford himself. Like many inventors, Ford seemed genuinely allergic to wasteful behavior and to have been of the opinion that further creative thinking would eventually make these operations profitable. Furthermore, many of the recovery linkages found in Ford’s operations were already widely practiced at the time in other industries. These observations led McCarthy to conclude that, to a

14 Carroll Pursell, *The Machine in America. A Social History of Technology* (Baltimore, 1995); Gorman, “Efficiency, Environmental Quality, and Oil Field Brines”; and Timothy LeCain, “The Limits of ‘Eco-Efficiency’: Arsenic Pollution and the Cottrell Electrical Precipitator in the U.S. Copper Smelting Industry,” *Environmental History* 5, no.3 (July 2000): 336-351.

15 Tom McCarthy, “Henry Ford, Industrial Ecologist or Industrial Conservationist? Waste Reduction and Recycling at the Rouge,” *Michigan Historical Review* 27, no.2 (Fall 2001): 53-89.

16 Slag is the more or less completely fused and vitrified matter separated during the reduction of a metal from its ore.

large extent, waste reduction and recycling had become commonplace in American industry in the 1920s. Like many other historians, he argues that, despite the lack of acknowledgement on the part of Ford's officials, these practices essentially derived from the "industrial conservation" philosophy that emerged from governmental outlets such as the Conservation Division of the War Industries Board, which were themselves an arm of the conservation movement. As will now be argued, however, much evidence that has so far remained neglected by the present generation of historians suggests that past industrialists and their employees were creating wealth out of waste long before public campaigns to this effect and that traditional market incentives encouraged this behavior.

3. Past Perspectives on By-Product Development

Any analysis of the extent of past by-product development must contend with a lack of appropriate statistical information. Of course, some contemporary academic researchers, like earlier ones, have made good use of the detailed and reliable information on the past trade in secondary materials such as scrap steel and aluminum, cotton and linen rags, old clothes and waste paper.¹⁷ Such commodities, however, were often not direct residuals of industrial production and were typically handled by third parties, such as waste traders and brokers.¹⁸ They do not, therefore, convey much knowledge about direct by-product

17 For recent studies, see Clapp, *An Environmental History of Britain*; Maher, *Retrieving the Obsolete*; Zimring, *Recycling for a Profit*; and Zimring, "Dirty Work: How Hygiene and Xenophobia Marginalized the American Waste Trades, 1870-1930," *Environmental History* 9, no.1 (2004): 80-101. For older material, see, among others, Albert S. Carlson and Charles B. Gow, "Scrap Iron and Steel Industry," *Economic Geography* 12, no.2 (Apr. 1936): 175-184 and Norman J. Pounds, "World Production and Use of Steel Scrap," *Economic Geography* 35, no.3 (Jul. 1959): 247-258. There is nonetheless some disagreement in current historical research on the topic. For example, Zimring, *Recycling for a profit*, supports the view put forward by the journalist Charles H. Lipsett in *A Hundred Years of Recycling History. From Yankee Tincart Peddlers to Wall Street Scrap Giants* (New York, 1974) and *The Fabulous Wall Street Scrap Giants* (New York, 1969) that the genesis of the American scrap industry had humble beginnings with late 19th and early 20th Century peddlers. Maher, in *Retrieving the Obsolete*, challenges both this story of the scrap industry's formation and the notion of scrap as a local good by identifying the initial large-scale generators of scrap as the railroad industry and by demonstrating that the range of this commodity was national from the beginning. Evidence provided by Peter Lund Simmonds in *Waste Products and Undeveloped Substances: A Synopsis of Progress Made in Their Economic Utilisation During the Last Quarter of a Century at Home and Abroad*, 3rd edition (London, 1876) supports the latter view.

18 A number of trade publications covered that industry. In America, the pioneer in this respect was Charles Lipsett who launched in 1905 the *Atlas Publishing Company* and its flagships *Waste Trade Directory* and *Waste Trade Journal*, to which he would later add periodicals such as *The Daily Metal Reporter*, *The Daily Mill Stock Reporter* and *Rebuilt Tire Journal*, along with the occasional publication of

flows between different units of a firm or between different firms. Furthermore, while some loop-closing estimates could probably be derived from proxies such as the known output of particular primary products or information on manufacturers whose industry was for the most part based on residuals (such as glue and synthetic dyes manufacturers), they would only yield very crude approximations.

Documenting the development of by-product technologies, on the other hand, is a more manageable task because of the existence of an important technical literature. For example, one can find voluminous manuals and popular descriptions of the various branches of industrial chemistry that dealt extensively with by-products.¹⁹ Specialized sources on topics ranging from animal by-products to manufactured gas are also plentiful.²⁰ Informative by-product flow charts can also be found for most major industries, including bituminous coal (Figure 1).

Figure 1 (around here): Products Obtained from Bituminous Coal

Source: Lowy (1931: non-paginated)

Trade magazines also frequently dealt with this issue. As Michael Jensen pointed out,

books on different aspects of this industry, including his compendium *Industrial Wastes and Salvage: Conservation and Utilization*, first published in 1951. The first British periodical devoted exclusively to “the business of scrap and waste products in all their forms” was *Waste Trade World*, launched in 1912. Later renamed *Materials Reclamation Weekly* in 1969 and *Materials Recycling Week* in 1994, it is, according to its website, now read by over 22,000 professionals every week, while an annual subscription entitles its readers to the *Materials Recycling Handbook*, a reference source of over 3000 recyclers and waste specialists.

19 See, among others, Allen Rogers (ed.), *Industrial Chemistry. A Manual for the Student and Manufacturer. Volume One - Inorganic*, 5th edition (New York, 1931) and *Industrial Chemistry. A Manual for the Student and Manufacturer. Volume Two - Organic*, 5th edition (New York, 1931); and Edwin E. Slosson, *Creative Chemistry. Descriptive of Recent Achievements in the Chemical Industries* (New York, 1941).

20 Detailed books on animal by-products include Peter Lund Simmonds, *Animal Products. Their Preparation, Commercial Uses, and Value* (New York, 1875); Rudolf A. Clemen, *By-Products in the Packing Industry*. (Chicago, 1927); and Institute of Meat Packing. *Readings on By-Products of the Meat-Packing Industry* (Chicago, 1941). Manufactured gas, also known as coal gas or town gas, was the result of a process that converted coal partially or completely to combustible gases whose heating value was about 50% that of natural gas. It was mostly used as a fuel and illuminant until electricity and natural gas led to its demise. Past titles devoted to the productive uses of residuals generated in this process include W. Gluud, *International Handbook of the By-Product Coking Industry* (London, 1932); Frederick H. Wagner, *Coal Gas Residuals*, 2nd edition (New York, 1918); and Raphael Meldola, *Coal and what we Get from It* (London, 1905).

discussions of Ford's and other car-making firms' waste recovery practices in the 1920s and 1930s can be found in the following periodicals: *American Machinist*, *Automotive Industries*, *Brass World*, *Chemical and Metallurgical Engineering*, *Factory*, *Factory Management and Maintenance*, *Industrial Management*, *Iron Age*, *Management and Administration*, *Scientific American* and *Steel*.²¹

Going through the detail of these various records would be a formidable task. Not surprisingly in light of the importance of the topic, several generations ago a number of authors took it upon themselves to provide broad and accessible synthesis on the topic. Some were popular accounts, while others, listed in Table 1, were more detailed works aimed at managers, engineers and technicians.²² The purpose and relevance of these latter books was perhaps best conveyed by the German chemist Theodor Koller who pointed out that, despite their obvious interest, the occasional communications on waste matters dispersed in the bulk of the technical literature varied greatly in terms of quality and were simply too difficult to locate for busy professionals. There was therefore a need for works of synthesis that would "examine this abundant material, arrange it, excluding all that is doubtful and superfluous, and put the remainder in such a form that the practical man, engaged in a particular calling, may extract what is really useful."²³

Table 1 (around here):
Some Surveys of Industrial Waste Recovery, 1876-1963

While it is impossible to cover in any detail the extent of past practices, an 1881 summary of "The Utilization of Waste Products" gives an idea of their scope:²⁴

21 Michael Jensen, "... *Waste is Regarded as Almost Criminal.*" *The Policy and Practice of Waste Elimination in the Ford Motor Company, 1919-1946.* (Joint Senior Essay for History and Studies in the Environment, Yale University, 2000).

22 Popular accounts on by-product development include George Powell Perry, *Wealth from Waste, Or Gathering up the Fragments* (New York, 1908) and Frederick A. Talbot, *Millions from Waste* (Philadelphia, 1920).

23 Theodor Koller, *The Utilization of Waste Products: A Treatise on the Rational Utilization, Recovery, and Treatment of Waste Products of all Kinds* (3rd revised edition, translated from the 2nd revised German edition) (New York, 1918): 1

24 Anonymous. "Utilization of Waste Products", *The Manufacturer and Builder* 13, no.4 (April 1881): 86.

The glycerin industry, which has attained to large proportions, is a remarkable illustration of a great industry based entirely upon what was, until lately, a waste product of the soap boiler. As even more important in this category, we may name the industries connected with the manufacture of aniline dyes and artificial madder²⁵ from the refuse of coal tar, that was once the abomination and nuisance of the gas works. Old boots and shoes, and leather waste generally, are now turned to good account by the chemical manufacturer in producing the cyanides, ferro and ferrid-cyanides, that have become indispensable in color printing and in photography. Of the carcasses of slaughtered animals not a scrap or morsel is allowed to go to waste; and even the waste blood of the abattoir is utilized by the sugar refiners and the manufacturers of albumen.

Sawdust, mixed with blood or other agglutinative substances, and compressed by powerful pressure in heated dies, is formed into door knobs, hardware and furniture trimmings, buttons, and many other useful and decorative articles. The spent tan-bark of the tanneries is utilized as fuel under steam boilers. Oyster shells are burned to lime; the waste of linseed oil factories is largely sought after as food for cattle; the waste ashes of wood fires are leached for alkali;... the waste gases of the blast furnace are utilized to heat the blast, and to generate the steam that drives the engine that furnishes the blast; and the slag of the iron furnaces that from time immemorial only served to decorate the hillsides, is now cast into building blocks, granulated to make building sand, made into cement, mixed with suitable chemicals and made into the commoner grades of glass, or blown by steam jets into the finest filaments to make the curious mineral wool for covering boilers, steam pipes, etc. The waste heat of the lime kiln, in England, is made to generate steam and to heat large buildings... And so the record might be indefinitely extended, showing how modern science with the most beneficent results is steadily teaching the world to utilize the waste substances of nature and the arts, enabling us to reap advantages where none were supposed to exist, or where, if they were suspected, they were undervalued or neglected.

Perhaps, however, the best concise summaries of the extent and benefits of these past practices are to be found in two figures on by-products (Figure 2) and the pollution resulting from their absence (Figure 3) that were drawn by the American zoologist Victor E. Shelford in 1919.²⁶

25 Madder is a plant from which various colors were derived and used as pigments in inks and paints.

26 Victor E. Shelford, "Fortunes in Wastes and Fortunes in Fish," *The Scientific Monthly* 9, no.2 (Aug. 1919): 100-101.

Figures 2 and 3 around here.

Why did so many individuals care enough about industrial waste recovery to write extensively about it? The obvious answer, at least for the technical literature, is that virtually all manufacturing activities generated residuals. Finding them a profitable use was therefore of obvious interest. By-product development might also have been a topic with a broader appeal than industry-specific “state of the art” accounts, for many individuals thought it worthwhile to point out that past successes provided ample justification to invest in creative ways to address pollution problems that had yet to be solved. For instance, the genesis of the British business and technology journalist Peter Lund Simmonds’ detailed books on waste products can be traced back to the activities of the (later Royal) Society of Arts where actual and potentially profitable solutions to noxious industrial emissions were discussed at length. Simmonds’ main goal was therefore “the diffusion of practical information on matters too much overlooked” and he took much pride in the fact that “many of the hints and suggestions [he had] thrown out... [had] led to the establishment of great and profitable economic industries.”²⁷ The worthiness of his contribution is further attested by the fact that it went through several printings and was soon adapted in French and German.²⁸ Interestingly, in the latter case, Simmonds’ work was translated and updated by a government industrial inspector, a position that was also occupied at a later point in time by the author of the best French synthesis on the topic, Paul Razous, thus perhaps suggesting the preferred mode of dealing with polluting emissions by public administrations at the time.²⁹

Most past authors who wrote extensively on by-product development generally believed

27 Peter Lund Simmonds, *Waste Products and Undeveloped Substances; or, Hints for Enterprise in Neglected Fields* (London, 1862: vi) and Simmonds, *Waste Products and Undeveloped Substances* (1876: iii-iv).

28 These adaptations of Simmonds’ work are Jul Morel’s *Les richesses de la nature: Le règne animal* (Gand, 1876) and Otto Suessenguth’s *Die industrie der abfallstoffe* (Leipzig, 1879). The former book, though 392 pages long, covered only a fraction of the topics discussed by Simmonds. The translator, a Belgian engineering professor and close friend of the author, originally planned to write three volumes on by-product recovery using Simmonds’ classification system (animal, vegetable and mineral), but volumes II and III, if they were written, could not be found.

29 Paul Razous, *Les déchets industriels. Récupération – Utilisation* (Paris: 1905).

that progress in this area was widespread and sustained, despite some highly problematic situations at particular points in time. For example, according to Simmonds: “In every manufacturing process there is more or less waste of the raw material, which it is the province of others following after the original manufacturer to collect and utilize. This is done now, more or less, in almost every manufacture.”³⁰ Simmonds added that this process was ongoing as new industries were continuously springing up, an observation that Koller would also make decades later: “Whilst we often find that some waste product is accumulating in such quantity as to injure and retard the continuous progress of a branch of industry, we also see, not rarely, that the rational treatment and utilization of such waste products either increases very considerably the general profits of an industry or even forms a separate and not inconsiderable source of gain.”³¹ The British chemical engineer John Kershaw would similarly observe that even though many new approaches to industrial waste recovery had not survived the laboratory stages of their development or had only proven temporarily profitable on an industrial scale, there was nonetheless ample evidence that “an even larger number of recovery processes [had] attained success.”³² A few decades later, the American journalist and publisher Charles Lipsett similarly observed that, as new products were developed, so were new types of refuse which in turn needed more research in order to discover new means by which they could be recovered and reused. In the end, however, just like “yesterday’s waste [had] become today’s new product or chemical or food,” so would the residuals generated in more recent industries eventually become, through research and development, “tomorrow’s new economic resource.”³³

The belief that by-product development was widespread in market economies was shared by authors whose views spanned the political spectrum. On the free-market side, the chemist and (classical) liberal Scottish politician Lyon Playfair wrote that the “whole history of manufactures” was replete with illustrations of how the refuse of yesterday had

30 Simmonds, *Waste Products and Undeveloped Substances*, 2.

31 Koller, *The Utilization of Waste Products*, 1.

32 John B. C. Kershaw, *The Recovery and Use of Industrial and Other Waste* (London, 1928): ix.

33 Lipsett, *Industrial Wastes and Salvage*, 355.

become an important source of profit and that, as a result, “scarcely a single article of use or ornament, after it has served its first purpose, is not used over again for another service, perhaps in a new and distinct form, or in composition with other materials.”³⁴ The Canadian-born agricultural economist Rudolf Alexander Clemen similarly stated that the “development of by-products in industry is one of the most outstanding phenomena in our economic life” and that “from the viewpoint of individual business, this manufacture of by-products has turned waste into such a source of revenue that in many cases the by-products have proved more profitable per pound than the main product.”³⁵

Comments to this effect were also made by several authors not usually known for their affinity to *laissez faire*, including Karl Marx: “The capitalist mode of production extends the utilisation of the excretions of production and consumption...The so-called waste plays an important role in almost every industry.”³⁶ The British political economist John Hobson, who throughout his career was closely associated with the Marxian and Socialist Schools, shared a similar assessment: “New industrial arts owing their origin to scientific inventions and their practice to machinery arise for utilising waste products... Conspicuous examples of this economy are found in many trades. During the interval between great new inventions in machinery or in the application of power many of the principal improvements are of this order.”³⁷

The political scientist James Thomas Young, a man who would eventually lose his position as Director of the Wharton School of Finance and Commerce (University of Pennsylvania) when he was deemed too “progressive” by conservative trustees, nonetheless wrote that the “perfection of industrial chemistry [in many diverse fields] has brought with it the by-product, and the by-product has revolutionized manufacturing industry.”³⁸ The German-born American economist Erich Zimmermann, a man who,

34 Lyon Playfair, “Waste Products Made Useful,” *North American Review* 155, no.432 (Nov. 1892): 560.

35 Clemen, *By-Products in the Packing Industry*, vii.

36 From a non-paginated web version of Karl Marx’s *Capital*, Volume III, Part I, Chapter 5.

37 John A. Hobson, *The Evolution of Modern Capitalism. A Study of Machine Production* (New York, 1917/1894), p.75.

38 James T. Young, “Business and Science,” *Annals of the American Academy of Political and Social*

according to a former student, rejected “the ‘harmonic’ view of the workings of the price system and [willingly accepted] a large role for government as regulator and active contributor to stability,” also observed that “a comprehensive survey of waste elimination would fill volumes” and that “the boundary lines between waste products and by-products are vague [and in] our modern dynamic economy the transfer from one category to the other is an almost daily occurrence.”³⁹

These and other writers who analyzed the incentives promoting industrial resource recovery highlighted the importance of two types of pressures. The first, and most important in the opinion of the majority, was the search for increased, or at least constant, profitability. The second was the necessity of removing nuisances to other parties that could result in legal actions and significant costs or even injunctions against polluters. These topics will now be examined in more detail.

4. Incentives, Institutions and By-Product Development

According to several past writers, competitive pressures gave business people a constant incentive to find new ways to pass as much of their inputs as possible through the economy instead of dumping it back in the environment. Thus Playfair observed that, in the gratification of the wants of civilization, “there is a constant aim to render objects apparently of little value useful and productive.”⁴⁰ Simmonds further added in the catalogue of a waste exhibit he organized: “As competition becomes sharper, manufacturers have to look more closely to those items which may make the slight difference between profit and loss, and convert useless products into those possessed of commercial value.”⁴¹ This analysis was further echoed by Koller a generation later:

Science 28 (1906), p.28. Information about Young’s fate as an administrator is taken from an unidentified newspaper account from the folders of James Thomas Young, Office of Alumni Records, Biographical Records, 1950-2002, Collection UPF 1.9 AR, University of Pennsylvania Archives.

39 Erich Zimmermann, *World Resources and Industries. A Functional Appraisal of the Availability of Agricultural and Industrial Resources* (New York, 1933), pp.768- 69. The quote from the former student is taken from Stephen L. McDonald, “Erich W. Zimmerman, The Dynamics of Resourceship”, in Ronnie J. Philipps (ed.), *Economic Mavericks: The Texas Institutionalists* (Greenwich, 1995), p.152.

40 Lyon Playfair, *On the Chemical Principles Involved in the Manufactures of the Exhibition as Indicating the Necessity of Industrial Instruction* (London, 1852), pp.162-63.

41 Anonymous. *Descriptive Catalogue of the Collection Illustrating the Utilization of Waste Products*

“Competition compels all round the most economical, and consequently the most rational, labour; and apart from proper management -- economical execution, division of labour, and the replacement of manual labour by the exact machine-power -- the means of prosperity for everyone is to be found in the greatest possible utilization of all waste.”⁴² The German chemist restated this argument in a later edition of his book: “In these days it is more than ever necessary to give careful attention to what may at the present appear to be valueless. Competition is so keen that even with the most economical -- and therefore the most rational -- labour it is difficult to make manufacturing operations profitable, and it is therefore only by utilizing to the full every product which is handled that prosperity for all may be assured.”⁴³

Clemen similarly pointed out that “the change to intensive utilization of these materials for by-product manufacture has been brought about by the ever-increasing force of competition in American business, both between individual concerns within a single industry and among different ones.”⁴⁴ The beneficial role of competition was even acknowledged by Karl Marx when he observed that by-product development “reduces the cost of the raw material to the extent to which it is again saleable” and that this “reduction of the cost of this portion of constant capital increases *pro tanto* the rate of profit.” Indeed, Marx went so far as to write that industrial waste recovery was “the second big source of economy in the conditions of production” after economies of scale.⁴⁵

Competitive pressures might have been the dominant incentive in promoting by-product development, but they were not the only driver, for past market economies were not only based on profits and losses, but also on property rights and the rule of law. In this context, polluting someone else’s property was no more acceptable than vandalizing it. Polluters were therefore early on subjected to legal sanctions based on the common law doctrines

(London, 1875), p.4.

42 Theodor Koller, *The Utilisation of Waste Products: A Treatise on the Rational Utilisation, Recovery, and Treatment of Waste Products of All Kinds*. (Translated from the 2nd revised edition) (London, 1902), v.

43 Koller, *The Utilization of Waste Products*, vi.

44 Clemen, *By-Products in the Packing Industry*, 2.

45 Marx, *Capital, Volume III*, n.p..

of negligence, trespass, nuisance and strict liability for abnormally dangerous conditions and activities. Such a liability system mandated no specific conduct, but allowed private parties to recover monetary damages for harm caused and even to gain an injunction against offenders that could ultimately result in a polluter's obligation to shut down its operation. To this approach based on property rights were eventually added specific regulations. These were often justified by the need to deal with problematic emissions, such as when multiple polluters were each inflicting individually low levels of damage but causing significant harm in the aggregate⁴⁶

Several past authors alluded to the role of property rights and regulation in giving an additional incentive to industrialists to come up with creative solutions for their polluting emissions.⁴⁷ In my opinion, however, three treatments of this issue warrant further discussion. The first can be found in the French engineer (and later Prime Minister) Charles de Freycinet's reports on industrial hygiene in various European countries, written in the 1860s and summarized in 1870 in his *Traité d'assainissement industriel* (Treatise on industrial cleansing), and alluded to again in his 1912 memoirs.⁴⁸ According to Freycinet, manufacturers who damaged their surroundings through their activities were often subjected to specific regulations (when they existed) and civil actions based on property rights. They therefore had a direct and personal interest in making their operations less damaging. The French engineer praised British industrialists, especially in the wake of the Alkali Act of 1863, who, rather than trying to outwit the law, widely applied it and often went further than its prescription by striving to transform into useful

46 Of course, some regulations actually trampled property rights and ended up legalizing pollution for the benefits of polluters. For a more detailed discussion of this issue, see Elizabeth Brubaker, *Property Rights in the Defence of Nature* (Toronto, 1995) and Roger E. Meiners and Andrew P. Morriss, *The Common Law and the Environment. Rethinking the Statutory Basis for Modern Environmental Law* (Lanham, 2000).

47 See, among others, Simmonds, *Waste Products and Undeveloped Substances* and Razous, *Les déchets et sous-produits industriels. Récupération – Utilisation* (Paris, 1937).

48 Charles de Freycinet, *Traité d'assainissement industriel, comprenant la description des principaux procédés employés dans les centres manufacturiers de l'Europe occidentale pour protéger la santé publique et l'agriculture contre les effets des travaux industriels* (Paris, 1870) and Charles de Freycinet, *Souvenirs 1848-1878* (Paris, 1912). I am indebted to Laurence Lestel of the Conservatoire national des arts et métiers and Geneviève Massard-Guilbaud of Université Blaise Pascal for drawing my attention to the work of Freycinet.

by-products material that they could no longer discard freely.⁴⁹ In behaving that way, they were pushed by a grand natural law, “confirmed by everyday experience, that progress in sanitation is habitually a source of benefit for those who accomplish it.” Besides the hygienic result that he was going after, the manufacturer often ended up with an unexpected financial benefit that was “like a reward for efforts undertaken to achieve the first result.”⁵⁰ To be convinced of this, Freycinet argued, it was enough to look at what had been achieved for twenty years in the principal factories of France and other European countries.

Decades later, Kershaw distinguished between two broad classes of methods of treating industrial wastes. First were treatments dictated solely by a desire to make a profit from an essentially harmless residue. Secondly, there were treatments dictated by “the necessity of converting into an innocuous form some waste material, either solid or liquid, or gaseous, which, in its untreated state, is objectionable to the eyes or nose, or is detrimental to the health of the community; and the question of producing from it something which can be sold at a profit is entirely secondary in importance.”⁵¹ In his opinion, the number of products in this second class was increasing rapidly and a number of new pieces of legislation against pollution had been adopted or were pending. This, however, was not necessarily a bad thing because “many processes which were imposed upon the manufacturer originally by legal pressure have become profit-earning at a later date, and have thus passed from one class into the other.”⁵² The British chemical engineer had no doubt that this pattern would in all likelihood be again observed in the future.

Zimmermann similarly identified legal action as a third factor promoting a fuller utilization of energies and substances, after scientific advances and economies of scale triggered by increased competition. In some cases, waste elimination might have been

49 Clapp, *An Environmental History of Britain since the Industrial Revolution* and Christine Garwood, “Green Crusaders or Captives of Industry? The British Alkali Inspectorate and the Ethics of Environmental Decision Making, 1864-95,” *Annals of Science* 61, no.1 (Jan. 2004): 99-117, are more detailed discussions of this legislation and the individuals who enforced it.

50 Freycinet, *Traité d'assainissement industriel*, 5 (my translation).

51 Kershaw, *The Recovery and Use of Industrial and Other Waste*, p.2.

52 Kershaw, *The Recovery and Use of Industrial and Other Waste*, p.3.

mandated by law even if it did not pay in an economic sense. But it sometimes happened, however, “that a corporation compelled by legal action to eliminate a waste at great expense, and unable to pass the cost on to the consuming public, may succeed, with the aid of scientific research, in converting the waste products into paying by-products -- perhaps, even into a product of major importance.”⁵³

Reflective Conclusion

Despite widespread beliefs to the contrary among the current generation of historical writers and sustainable development theorists, much evidence suggests that competition, the price system and legal constraints based on property rights and/or specific legislation enactments historically led to significant reduction in the amounts of waste released into the environment by various industries. As past economies became more technically and commercially complex, their actors’ increasingly diverse technical, managerial and trading skills laid the foundations for developments that created new commodities out of residuals, along with new markets for them. Indeed, a case could probably be made that as long as human beings have been manufacturing things and have been free to indulge in creative experiments, some individuals saw the opportunity, and in many cases also probably felt a moral imperative, to create something valuable out of what was previously waste and often polluting. This is not to say, of course, that all attempts were successful and that significant environmental damage did not result from industrial activities at various locations and times.

Assuming that the analysis presented in this essay is by and large correct, why is it so much at odds with current historical analysis? One can think of a few reasons. A first is that, in some cases, pollution problems took years and even decades to be solved profitably. While they might have been considered an acceptable (or misunderstood) price to pay in societies that were emerging from mass poverty, vivid descriptions of burning rivers or cities covered with smoke and soot certainly do not help convey the impression that progress was being made in this respect.

⁵³ Zimmermann, *World Resources and Industries*, p.768.

Perhaps just as significant is the fact that, despite much evidence to the contrary, doomsday visions of the environment have become dominant over the last four decades. In this context, many historians simply assume that our ancestors were unable to solve environmental problems creatively.⁵⁴ This worldview might also explain the widespread belief among academics working in disciplines ranging from engineering to economics that past industrial development was characterized by a linear process of extraction, production, use and disposal.⁵⁵ For example, according to the editor of the engineering journal *Resources, Conservation and Recycling*, “historically, society and industry have operated as an open system, transforming resources to products or services and emitting wastes and pollutants to the environment at all stages of the life cycles.”⁵⁶ Not surprisingly, historians such as Christine Rosen, who borrowed heavily from this literature, uncritically endorsed this perspective.

Perhaps another problem is that much American historical scholarship on environmental pollution has been framed within a discussion of the work of Progressive Era reformers.⁵⁷ This emphasis might be somewhat problematic in setting the stage for historical inquiries into past industrial by-product development because of the claims of pervasive “waste” in market economies made at the time by numerous economists, industrial engineers, scientific management consultants, conservationists and popular writers. The concept of “waste” used by these writers, however, had almost nothing to do with residuals, but rather referred to, among other things, the presumed lack of coordination between market actors, the production of unnecessary goods and a short-term outlook created by the profit motive.⁵⁸ Interestingly, the few reformers who wrote about by-product development

54 For a more detailed look at environmental statistics, see Bjørn Lomborg, *The Skeptical Environmentalist. Measuring the Real State of the World* (Cambridge, 2001).

55 For several quotes to this effect, see Pierre Desrochers, “Industrial Ecology and the Rediscovery of Inter-Firm Recycling Linkages: Some Historical Perspective and Policy Implications,” *Industrial and Corporate Change* 11, no. 5 (Nov. 2002): 1031-1057.

56 Ernst Worrel, “Editorial,” *Resources, Conservation and Recycling* 28, no. 1/2 (2000): 1-2.

57 Martin V. Melosi, *Effluent America. Cities, Industry, Energy, and the Environment* (Pittsburgh, 2001); Joel A. Tarr, *The Search for the Ultimate Sink. Urban Pollution in Historical Perspective* (Akron, 1996).

58 William E. Akin, *Technocracy and the American Dream. The Technocrat Movement, 1900-1941* (Berkeley, 1977); Stuart Chase, *The Tragedy of Waste* (New York, 1926/1925); Samuel P. Hays,

suggested that central planning would prove much more successful in this respect, but later attempts to implement this approach in Eastern Europe proved an unmitigated disaster.⁵⁹

Be that as it may, while this essay has only scratched the surface of the history of the creation of wealth from industrial waste, it does at least validate Joel Tarr's claim that, by neglecting industrial waste disposal and recovery, "some obvious opportunities for important scholarship have been missed."⁶⁰ Indeed, it might be the case that historians could contribute much to current policy-making by looking at the issue in more depth and by providing more detailed assessment as to the way the invisible hand of market forces handled solid waste.⁶¹

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59 Henry J. Spooner, *Wealth from Waste. Elimination of Waste a World Problem* (London, 1918); Chase, *The Tragedy of Waste*; Zsuzsa Gille, "Legacy of Waste or Wasted Legacy? The End of Industrial Ecology in Post-Socialist Hungary," *Environmental Politics* 9, no.1 (Spring 2000): 203-231.

60 Tarr, "Industrial Waste Disposal in the United States as a Historical Problem," p.5.

61 Among current controversies to which an historical perspective might prove useful are the "Porter hypothesis" put forward by Harvard Business School's Michael Porter in a 1991 issue of the periodical *Scientific American*. Porter's hypothesis, although deemed highly original by the current generation of sustainable development theorists, is actually nothing more than a rediscovery of the idea that well-designed environmental regulations could stimulate innovations that, by enhancing productivity and reducing waste, would increase private and social benefits. Some historical perspective on the past trade in industrial waste could also prove valuable in current debates surrounding the Basle Convention on the international movement of hazardous waste. Historians could also document the advent of numerous policies that have discouraged industrial recovery, such as institutional barriers to resource recovery, transport cost discrimination against secondary materials, subsidies and tax breaks to the primary sector and minimum content laws mandating the use of "virgin materials."

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Table 1: Some Surveys on Industrial Waste Recovery, 1876-1963

Author, profession, nationality	Title	Year of last edition, number of pages, previous editions	Publisher of the last edition
Peter Lund Simmonds, business and technology journalist, Danish-born British citizen	Waste Products and Undeveloped Substances: A Synopsis of Progress Made in Their Economic Utilisation During the Last Quarter of a Century at Home and Abroad.	1876, 3 rd edition, 491 pages (2 nd edition 1873, 1 st edition 1862)	Hardwicke and Bogue (London)
Theodor Koller, chemist, German	The Utilization of Waste Products: A Treatise on the Rational Utilization, Recovery, and Treatment of Waste Products of all Kinds	1918, 3 rd revised edition, 338 pages (3 rd German edition 1921, 1 st German edition 1880)	D. Van Nostrand Company (New York)
John Kershaw, chemical engineer, British	The Recovery and Use of Industrial and Other Waste.	1928, 1 st edition, 212 pages	Ernest Benn Limited (London)
Paul Razous, engineer and actuary, French	Les déchets et sous-produits industriels. Récupération – Utilisation. (<i>Industrial Waste and By-Products. Recovery and Use.</i>)	1937, 3 rd revised edition, 604 pages (2 nd edition 1921, 1 st edition 1905)	Charles Dunod éditeur (Paris)
Charles S. Lipsett, specialized journalist, American	Industrial Wastes and Salvage: Conservation and Utilization.	1963, 2 nd revised edition, 407 pages (1 st edition 1951)	Atlas Publishing Co. (New York)

Figure 3

FIG. 2. Diagram showing the various wastes and the damage they do when **not** properly recovered.

Source: Shelford, 1919: 101.