"Business as usual" in the industrial age: (relatively) lean, green and eco-efficient?

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This paper discusses the creation of wealth from polluting waste in market economies before the birth of the modern environmental movement. The first section surveys some early English-language writings on the topic, with particular emphasis on books and monographs that have recently been made accessible online. The remainder of the essay describes historical cases of resource recovery that might be somewhat surprising to modern readers, illustrating in the process that economic profitability and pollution reduction have typically been far more compatible than is now believed.

"Our aim is now to utilise all things to the utmost possible extent. The uses to which they are turned are not always stale, flat, or unprofitable. We now produce valuable articles from what a few years ago was thrown away as nuisance. Once the raw material gets into the clutches of the manufacturer, it is tortured by a score of processes to yield up all its virtues. This system extends throughout all our modern actions in domestic and rural economy, and in our commercial undertakings...

Nothing comes amiss to our ingenuity. We consume our smoke, write and print on the remnants of our ragged shirts, and triumph over decomposition and stenches. Utilisation is the great law of Nature, and we are only following her teaching."

Peter Lund Simmonds. 1876. 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: Hardwicke and Bogue, p. 10.

Introduction

In their module on "eco-efficiency," anonymous writers for the World Business Council on Sustainable Development (2005: 3) describe the concept as a "management philosophy that encourages business to search for environmental improvements that yield parallel economic benefits", in the process allowing companies to become more environmentally responsible and profitable. Their basic message is a simple one: deliver more value while using fewer resources. For example, businesses that save energy cut down costs while simultaneously reducing emissions. According to the authors, hundreds of recent cases convincingly illustrate that eco-efficiency works "for companies of all sizes, in all industrial sectors and in all regions." Unlike the not-so-distant past where businesses "viewed the environment and sustainable development as problems and risk factors," innovative industries now continually strive "to optimize their processes" and "to turn their wastes into resources for other industries" (World Business Council on Sustainable Development 2005: 4).

While not disagreeing with the authors' recommendations, this article challenges their characterisation of past practices and suggests to the contrary that "eco-efficiency" has always been "business as usual" in market economies. In other words, market forces have long rewarded greater efficiency in the handling of scarce resources and creativity in turning polluting waste into wealth. While the long-term *dematerialisation* of our economies, for example the decline over time in the weight of materials used in industrial end products, is well documented (Wernick *et al*. 1996; Scarlett 1999; Simpson 1999), less has been said about the past development of valuable by-products out of industrial and other waste.

The goal of this paper is twofold. The first section surveys the content of some of the most significant writings on by-product development published in the English-speaking world from the middle of the nineteenth

century to the early 1960s. In an attempt to take advantage of the virtual nature of this journal, a particular emphasis is put on material freely accessible online. The remainder of the essay presents some cases that, while limited in number, should nonetheless help convey to twenty-first century readers the extent and sometimes surprising nature of past recovery practices.

I. Wealth from Waste in the Industrial Age: An Overview

The image of impoverished citizens making a livelihood from the careful collection, sorting and recovery of domestic garbage is today associated with third-world metropolises. However, unbeknown to most, a similar situation could be found in all industrial economies in the recent past. Large volumes of recovered commodities, such as rags, broken glass, scrap steel and used paper, were traded across regions, countries and oceans. While a growing number of academic studies and popular books have shed some light on these topics, less attention has been devoted to industrial waste recovery, perhaps at least in part because of a widespread belief that polluting emissions allowed manufacturers to reduce production costs (Desrochers 2002; 2007).[1] As will now be argued, however, much evidence suggests otherwise.

At least three broad categories of historical writings on the development of industrial wealth from waste have recently become accessible online.[2] The first are assessments by authors such as economists who have dealt only incidentally with the issue. The second are detailed descriptions of by-product development in particular lines of work written for specialists. The last are more accessible general overviews written for technical/managerial and broader audiences. I now turn to a brief survey of this literature.

Traditional economic analysis has typically concentrated on single-product processes of production, yet some economists discuss by-products through the concept of joint supply or joint production, which occurs when commodities such as beef and hide, mutton and wool, or wheat and straw, share a common origin and cannot easily be produced separately (Kurz 1986). Some authors, however, have said more on the topic than most. For example, after discussing a few recovery cases, the polymath and computer pioneer Charles Babbage observed in his influential 1832 treatise, *On the Economy of Machinery and Manufacture,* that competition between firms spontaneously resulted in more efficient use of resources in all the main manufactures of his time. In his opinion, the care taken "to prevent the absolute waste of any part of the raw material" was "amongst the causes which tend to the cheap production of any article." In a discussion that would remain influential for several decades, Babbage further argued that the possibilities for effectively using waste were generally improved in larger plants and that this circumstance often led to "the union of two trades in one factory, which otherwise might have been separated."[3]

Karl Marx similarly argued in the third volume of *Capital* that the "capitalist mode of production extends the utilisation of the excretions of production and consumption."[4] Through large scale production and scientific and technical advances, "materials, formerly useless in their prevailing form, are put into a state fit for new production." As a result, the "so-called waste plays an important role in almost every industry." Interestingly, Marx credits these developments to the search for increased profitability by observing that reworked residuals were not only valuable as new elements of production, but reduced "the cost of the raw material to the extent to which it is again saleable, for this cost always includes the normal waste, namely the quantity ordinarily lost in processing." In turn, cost reduction "increases *pro tanto* the rate of profit." Indeed, Marx even stated that industrial waste recovery was "the second big source of economy in the conditions of production" after economies of scale.[5]

Alfred Marshall, the most important British economist at the turn of the twentieth century, similarly commented in his *Principles of Economics* (first published in 1890) that there wasn't much waste "in any branch of industry in modern England, except agriculture and domestic cooking" and that "many of the most important advances of recent years [had] been due to the utilizing of what had been a waste product."[6] He further listed avoiding waste of the original material and utilising by-products as among the basic "recognized principles of factory management" that increased profitability.[7]

Babbage, Marx, Marshall and other well-known economists, however, were but superficial commentators on by-product development. Not surprisingly, more detailed treatments can be found in specialised monographs written for professional audiences or basic overviews for broader audiences. While a detailed history of such advances across industrial sectors is beyond the scope of this paper, many of these developments can be found in the detailed monographs on the following page.

Getting into the details of such comprehensive writings would be, as it was then, a formidable task. Fortunately, some long-deceased writers thought it useful to

Table 1 **Selected Online By-Product Monographs, 1877–1948**

Animal Products[8]

Simmonds, Peter Lund. 1877. *Animal Products; Their Preparation, Commercial Uses, and Value*. London: Chapman and Hall.

Lambert, Thomas. 1901. *Bone Products and Manures: An Account of the Most Recent Improvements in the Manufacture of Fat, Glue, Animal Charcoal, Size, Gelatine, and Manures*. London: Scott, Greenwood.

Rayner, Hollins. 1903. *Silk Throwing and Waste Silk Spinning*. London: Scott, Greenwood.

Larsen, Christian and William M. White. 1913. *Dairy Technology; A Treatise on the City Milk Supply, Milk as a Food, Ice Cream Making, By-Products of the Creamery and Cheesery, Fermented Milks, Condensed and Evaporated Milks, Milk Powder, Renovated Butter, and Oleomargarine*. New York: J. Wiley & Sons.

Grisdale, Joseph Hiram. 1918. *Utilization of Fish Waste in Canada*. Ottawa: Commission on Conservation. Committee on Fisheries, Game and Fur-bearing Animals.

Clemen, Rudolph A. 1927. *By-products in the Packing Industry*. Chicago: The University of Chicago Press.

Coal

Wames, Arthur. R. 1914. *Coal Tar Distillation and Working Up of Tar Products*. London: J. Allan and Company.

Stansfield, Edgar. 1915. *Products and By-Products of Coal*. Ottawa: Department of Mines.

Lange, Kurt Reinhold. 1915. *The By-Products of Coal-Gas Manufacture*. London: Scott, Greenwood & Sons.

Findlay, Alexander. 1917. *The Treasures of Coal Tar*. New York: D. Van Nostrand Company.

Crop Residues[9]

Thornley, Thomas. 1912. *Cotton Waste; Its Production, Manipulation and Uses*. London: Scott, Greenwood.

Howard, Albert. 1931. *The Waste Products of Agriculture; Their Utilization as Humus*. London: Oxford University Press.

Bailey, Alton Edward. 1948. *Cottonseed and Cottonseed Products: Their Chemistry and Chemical Technology*. New York: Interscience Publishers Inc.

Wood

Hubbard, Ernst. 1902. *The Utilisation of Wood-Waste*. London: Scott, Greenwood & Co.

Harper, Walter B. 1907. *The Utilization of Wood Waste by Distillation*. Saint-Louis: Journal of Commerce Co.

Bates, John Seaman. 1914. *Chemical Utilization of Southern Pine Waste*. Montreal and Toronto: Industrial and Education Press, Limited.

Campbell, W.B. 1914. *Chemical Methods for Utilizing Wood Wastes*. Ottawa: Government Printing Bureau.

Johnsen, Bjarne. 1919. *Utilization of Waste Sulphite Liquor; A Review of the Literature*. Ottawa: Department of the Interior.

Donk, Mario Gilbert and Charles Houston Shattuck. 1921. *The Distillation of Stumpwood and Logging Waste of Western Yellow Pine*. Washington: U.S. Department of Agriculture.

write more accessible compendiums on these topics. Among the latter contributions published in the English language, five are, in our opinion, particularly worthy contributions.[10]

The first was a popular essay first published in 1852 and again, in a reworked (and now online) form, in 1892 by the chemist and liberal politician Lyon Playfair (1818–1898). Perhaps the most remarkable aspect of the paper is that it anticipated, by almost a century and a half, the currently popular "industrial ecology" metaphor (Ayres and Ayres 2002). As the author put it, "as nature does not admit the idea of waste matter, man, when under the guidance of knowledge, should not be inclined to deem anything as a waste product."[11] He then added: "It may be unused, because he has not learned how to apply it to a useful purpose, but the time arrives when it will be converted into a practical utility" (Playfair 1892: 560). In his opinion, "the whole history of manufactures [was] a commentary on this text [because] the refuse of the produce of to-day may possibly become the chief source of profit to-morrow." Indeed, "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." (Playfair 1892)

To our knowledge, the first detailed waste

compendium was the work of the Danish-born British journalist Peter Lund Simmonds (1814–1897). The first edition of *Waste Products and Undeveloped Substances: Or, Hints for Enterprise in Neglected Fields* was published in 1862, while the much expanded *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* appeared in 1873 and in a final revised version in 1876. As the author explained in the preface to the 491-page final edition, his aim had been to systematically gather useful information for experimenters and manufacturers for it was "one of the characteristic and salient points of modern enterprise" in all developing economies "not only to allow nothing to be wasted, but to recover and utilise with profit the residues from former workings" (Simmonds 1876: 4). Like other analysts, the journalist attributed this pattern to intense competitive pressures:

> "Few among the minor tendencies of industries are more worthy of note than that shown in the utilization of waste materials. 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, which is the most apt illustration of Franklin's motto that "a penny saved is twopence earned:" our manufacturers have not been slow to appreciate this truth, as is shown in more than one branch of trade." (Science and Art Department of the Committee of Council on Education 1875: 4)

Simmonds' work was followed in 1880 by German chemist Theodor Koller's (1840-?) *Handbuch der rationellen Verwertung, Wiedergewinnung und Verarbeitung von Abfallstoffen jeder Art*. A later edition of the book was eventually translated into English in 1902 under the title *The Utilization of Waste Products: A Treatise on the Rational Utilization, Recovery, and Treatment of Waste Products of all Kinds*. The English edition would undergo two more revisions published in England and America in 1915 and 1918 (with the latter now being freely available online[12]), while a third and final German edition came out in 1921. The latter English version described successful by-product recovery in no less than 59 topical chapters and 338 pages. Like his British predecessor (whose contribution he did not acknowledged), Koller (1918: 1) viewed himself as a collector of widely dispersed information whose work might "act as a stimulant to still further advancements."

Koller's main contention was that many wastes and emissions, when treated in the correct manner, were capable of yielding a product or a series of products that would not only repay the cost of their treatment, but even equal or surpass the value of the primary manufactured article. Not surprisingly, the chemist argued that competitive pressures were crucial in this respect because "even with the most economical – and therefore the most rational – labour", it remained difficult to ensure the profitability of manufacturing operations. It was therefore "only by utilizing to the full every product which is handled that prosperity for all may be assured" (Koller 1918: vi).

Another technical survey on the topic was published in 1928 by the British chemical engineer John Baker Cannington Kershaw (1861–1943). With 212 pages and 12 chapters, *The Recovery and Use of Industrial and Other Wastes* was relatively concise, although more abundantly illustrated than previous books on the topic. As the author stated in the opening sentence, his aim was not only to describe the recovery methods then used in the United Kingdom and the United States, but also to suggest various lines of work where further progress was possible. Kershaw further added that, even though he may be criticised for discussing such a wide array of subjects in one volume, he felt that this was the only valid approach, for it was a common mistake "to imagine that our industries can be carried on efficiently in water-tight compartments" because "the waste material or by-product of one manufacture is quite often the starting-point or raw material of another" (Kershaw 1928: ix).

Kershaw's opening sentences echo the sentiments of several prior writers: "Dirt, from the philosopher's standpoint, is simply matter in the wrong place, and industrial waste may be regarded similarly as useful material produced or dumped in places where it is not required. When transported to the right spot an industrial waste will often form the raw material for some secondary industry or manufacture" (Kershaw 1928: 1). He identifies two main reasons that justified this treatment. The first was "the desire to make a profit from some waste material which, if unutilised [*sic*], could be otherwise disposed of without causing any nuisance." The other is 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." In this context, producing something profitable from them was "entirely secondary in importance" (Kershaw 1928: 2). Kershaw added that the amount of products in this

second class was increasing rapidly and that new anti-pollution legislation had been adopted or was pending. He viewed these regulations in a positive light by arguing that 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" (Kershaw 1928: 3), thus anticipating the so-called "Porter hypothesis" (Porter 1991) by more than six decades.[13]

Perhaps the last significant compendium on by-product development published in English before the modern environmental era is the work of the American journalist Charles Lipsett. This last author was uniquely qualified, as he had founded the Atlas Publishing Company in 1905, and several specialised periodicals in following years, for the specific purpose of covering the waste-trading community. Lipsett eventually wrote a compendium on industrial by-product recovery in 1951, which he thoroughly revised and updated in a new edition published in 1963. With 66 topical chapters and over 400 pages, the revised version of *Industrial Wastes and Salvage: Conservation and Utilization* aimed to respond "to the long unfilled need for a semi-technical book dealing with the conservation and utilization of industrial wastes, popularly known as 'scrap' or waste materials, but perhaps better described today as 'secondary raw materials' since they constitute an important source of supply for basic industries, having similar or identical properties, available at lower cost." (Lipsett 1963: iv)

Like previous writers, Lipsett saw himself as a gatherer of widely dispersed information and similarly hoped that "besides giving the reader an insight into the industry, this volume may stimulate research in the various types of waste materials for new usages" (Lipsett 1963: vi). He observed that there was "hardly a commodity in which this process of producing and utilizing some form of scrap or waste materials does not occur, whether it be textile fibers, leather, glass, paper, chemicals, metals, etc." Indeed, had it not been for those, "there would not be sufficient raw materials in the world to take care of the need of basic industries" (Lipsett 1963: v).

While Lipsett provided short descriptions of the recovery and reuse of numerous types of by-products, it is perhaps his final chapter on "Research in Waste Recovery" that is of lasting interest. In discussing the topic, he identifies a recurring pattern: "Yesterday's waste has become today's new product or chemical or food, with its own waste which through research and development will become tomorrow's new economic resource" (Lipsett 1963: 355). Yet, much work remained to be done because as new products were developed, so were new types of refuse "which in turn call for research into the best means of recovery and reuse" (Lipsett 1963: 357). As a result, the "waste material industry, from time to time, is faced with the problem of shrinking markets and oversupply, and it is only through research methods for new outlets and new usages, that market conditions for wastes may be stabilized and reasonable values maintained for the various products and grades" (Lipsett 1963: 360).

What follows are a few selected examples of varying importance to illustrate the creativity of some of our predecessors, both in terms of final products and production processes.

II. Illustrations

Past industrial behaviour in market economies offers countless illustrations of the careful sorting and transformation of what had previously been (often problematic) waste products. Of course, some residuals were more valuable or extensively traded than others. It is therefore more appropriate to first describe briefly some facts and figures on two widely traded past commodities, woollen rags and old iron, before examining some practices that might be more surprising to modern readers.

Woollen Rags

According to Simmonds (1859: 176), woollen rags that were at first "regarded as entirely waste and useless" eventually proved, after much entrepreneurial and technical work, "a striking illustration of the adaptive ingenuity of the present day." As he put it, if in the woollen manufacture a considerable portion did not end up in the primary product, numerous "waste merchants" located in different parts of the United Kingdom bought up "everything like wool, and [sent] it to Leeds, Dewsbury, and Batley, to be made into shoddy or mungo."[14] Mixing it with some new wool, it was spun into yarn, and made into "broadcloth, doeskins, pilot cloths, druggets, and coarse carpeting." Indeed, the demand for rags was so strong at the time that a significant amount had to be imported from the European continent.

Simmonds (1876: 106) would later give a more detailed account of the fate of woollen rag that comprised "every variety of fabric" that could possibly be produced from wool, "from a coarse and harsh carpet to the finest and softest product of the loom." After having been collected, these refuses were first piled up in huge heaps on a warehouse floor where "women and girls attack them

on all sides and 'sort' them into no less than ten grades, each of which has a special use and an established value." They then underwent several "peculiar metamorphoses" depending on their state, being usually converted over time into "mungo, shoddy, and devil's dust," reappearing as "ladies's superfine cloth," then degenerating into "druggets"[15] before being used in the manufacture of "flock paper." After undergoing all these transformations, they were finally used as manure on account of their large nitrogen content. Indeed, Simmonds observed that this latter characteristic made them valuable to chemical manufacturers who boiled them down with "pearlash, horns and hoofs of cattle, old iron hoops, blood, chippings of leather, and broken horse-shoes," and produce the "beautiful yellow and red salts known as prussiates of potash" out of which the "rich and valuable pigment called Prussian blue" was made. Thus, he wrote, "do our old rags enter upon a fresh career of beauty and usefulness, to form, in their turn, other waste products, which may again be utilised through the power of man's intelligence." (Simmonds 1876: 105–106)

The fate of woollen rags was not lost on other writers. Two generations later, the journalist and author Frederick Ambrose Talbot similarly wrote that it was an "indisputable axiom in woollen circles [that] wool can never be worn out." As he put it:

> "It does not matter how many years ago the textile may first have been prepared, nor the many and varied vicissitudes through which it may have passed; it can be used over and over again. It may have travelled through the machines forty or fifty times, may have graced the form of a hundred persons, may have clothed a scarecrow or have been retrieved from a river in the course of its career. True, with each new lease of life it suffers a certain depreciation, but blended with new wool or cotton it is effectively revived. The history of a fibre of wool would be distinctly romantic and thrilling could it be but written, and even the wildest flights of imagination would be unable to rival stern fact." (Talbot 1920: 18–19)

Old Iron

Metals have been melted and reused ever since they were first developed; at some point in time all metallic objects become worn and are no longer suitable for their original purpose. This is not to say, however, that new uses were not found for what was left of them. For example, Babbage (1832: non-paginated)[16] wrote that the "worn-out saucepans and tinware of our kitchens," no matter how degraded, was never "utterly worthless" as the carts "loaded with old tin kettles and worn-out iron coal-skuttles" seen in English cities could attest. Less corroded parts were "cut into strips, punched with small holes, and varnished with a coarse black varnish for the use of the trunk-maker, who protects the edges and angles of his boxes with them." The remainder would be conveyed to manufacturing chemists located in the outskirts of towns, who combined them with pyroligneous acid to prepare a black die used by calico printers.

The (admittedly low) value of some of these worn-out objects is also attested to by their export to other countries. As Simmonds (1859: 184) pointed out almost three decades later, visitors to the main British docks would occasionally see "barge-loads of old iron being shipped as dunnage or ballast in vessels bound for the United States or for the continent." These worn-out materials comprised all sorts of articles, "frying pans and gridirons" to "saucepans and candlesticks, tea-trays and boilers, shovels, and old corrugated roofing." Many of these, we are told, were the source of jokes on the part of men who bundled them." In 1857, 36,500 tons of "accumulated produce of the old-iron shops, the collection of the mud-larks of the rivers and other itinerants" was exported from the United Kingdom, chiefly to other European countries.

While the past trade in commodities such as woollen rags and old iron might not come as a surprise to modern readers, the commerce in other waste products might, as a few illustrations related to animal products will demonstrate.

Manure

Humans have been developing wealth out of the non-edible portions of animals ever since they started making clothes and shelter out of hides and sinews, jewellery and musical instruments out of bones and horns, light out of fat and tallow, and, with the development of sedentary (as opposed to shifting) agriculture, crops out of manure. Not surprisingly, all these originally worthless residuals became valuable as soon as new desirable uses were found for them. For example, dung was a valuable commodity in pre-industrial society and it was not unusual for a dung-heap in 17th century England to be part of a bequest, its value listed in shillings and pence (King 1992). Indeed, despite the development of substitutes such as guano and non-animal fertilisers, it was estimated

that in the middle of the nineteenth century, 90 million tons of farmyard or animal manures were used annually in the United Kingdom (Simmonds 1876: 162). In 1850 this material was worth approximately £103,369,139,[17] a sum greatly exceeding the entire value of U.K. foreign trade at the time (Carey 1883/1858: 275).

The collection of dung and faeces was not limited to farm animals. For instance, Playfair (1852: 177–8) noted in 1852 that about fifty people were employed in London to collect the sweepings of dog-kennels for the purpose of tanning leather. The sum annually paid to the collectors and the workmen using this substance was not less than £5,000 in the metropolis alone.[18] Two decades later, Simmonds observed that in the City of London, forty wagons were kept constantly employed in carting away the dust and sweepings from the streets and that 55,000 loads of mud and other refuse were removed from the footpaths and roadways every year (Science and Art Department of the Council on Education 1872).

Animal Parts

Dead dogs and cats, whether picked up from sewers, rivers, and dung-heaps or killed for the purpose, once were a profitable business (Science and Art Department of the Committee of Council on Education 1872). Simmonds (1876: 66) describes how every part of the thousands of dogs drowned every year in New York City was put to some useful account. Among other things, the fat was rendered for soap, the skins sold to glove makers and the bones and flesh made into an "excellent compost." Interestingly, the skins of the biggest mastiffs were fit to be tanned for boots and shoes or turned into thick riding-gloves, while those of smaller dogs could be "dressed white for gloves." Meanwhile, in Paris, a tax on dogs had led to a large number of canines being drowned in the Seine. Soon afterwards, however, many of the dead bodies were recovered and boiled down in order to extract the fat for the preparation of kid gloves, especially of straw-coloured one. Of course, the Paris glove trade had long relied on the same material and the carcasses of dogs at the time were worth "from 7d. to 8d. each, the skin fetching 2d. to 3d.; the fat, boiled down, 5d. a pound; and the bones from 1/2d. to 1d., according to weight."[19]

Not surprisingly, dead horses were much more valuable than dogs. Simmonds (1876: 56–7) describes thus the fate of the up to 400 horse carcasses collected each week from within a five mile radius of Charing Cross (London):

> A dead horse will fetch from 20s. to 50s.,[20] or an average value of 35s. The total weight in pounds of the carcase is from 672 lbs. to 1138 lbs., or an average of 905 lbs. The following is the comparative value and uses of the several parts in the metropolis:
>
> Hair, about 1 lb., worth 1s. to 1s.3d.; used for haircloth, mattresses, bags for crushing oilseed, plumes, &c.
> Hide, 50 lbs., worth 12s.; used for tanning and covering tables, &c.
> Tendons, 6lbs., made into glue and gelatine.
> Boiled flesh, 252 lbs., worth 31s. 6 d.; meat for cats, dogs, and poultry.
> Blood, 60 lbs.; for prussiate of potash and manure.
> Intestines, 25 lbs., worth 1s.; for covering sausages, &c.
> Grease, 28 lbs., worth 4s 8d.; for candles, soap, &c.
> Bones, 60lbs., 4s. 6d. per cwt.; used for knife-handles, manure, phosphorus, and superphosphate of lime.
> Hoofs, 12 lbs, 8s. per cwt.; made into pincushions and snuff-boxes when polished, or for gelatine, glue, and prussiate.
> Old shoes, 10 lbs.; worth 5s. to 10s. the cwt. for old iron; sometimes re-worked up into shoes.

An interesting aspect of the recovery of animal parts involved the occasional use of rats. Simmonds (1876: 124) described a common pound in Paris, which covered some ten acres and was surrounded by a stone wall, to which dead carcasses of large animals were brought. Animal bones were at the time a valuable commodity used in the preparation of fertilisers, but needed to be cleaned and divested of adhesive and putrid flesh in order to be saleable. It was at this point that rats entered the picture. A colony of rodents would be brought to the pound to ensure that the dead carcases would be stripped overnight, leaving nothing but neat, polished skeletons by morning. To keep the number of rats at a manageable level, a "grande battue" took place every three months in the following way:

> "Horizontal and cylindrical holes are bored all around, in and at the foot of the enclosing walls – the depth and diameter being respectively the

> length and thickness of the rat's body. Upon the morning of the "battue," men armed with tin pans, kettles, drums, &c., rush in at the peep of day, and "charivari" the poor rats, who, frightened to death, poke their heads into the first opening. Of course all those in the wall holes have tails sticking out. The rat collector, with bag over left shoulder, now makes a tour of the premises, and the scientific and rapid manner with which the rats are seized by the tail, and safely (both to the rats and operator) transferred to the bag, challenges admiration." (Simmonds 1876: 124–125)

The use of rats did not stop there, however; their fur, skin, bones, and flesh would then all be turned into profitable items. Furs were valuable and found a ready market, skins made superior gloves because of their strength and elasticity, bones were turned into toothpicks and tendons were boiled up to make gelatine wrappers for bonbons (Playfair 1892: 568). The flesh would be fed to pigs in domestic farms or salted and cured and packed onto ships to be sent in the millions to China where it was considered appropriate for human consumption.

If much was done to extract value from all parts of land animals, the same was true of fish. For example, once the saleable meat had been removed, the remaining heads, bones, entrails, and blood from European commercial fisheries were often collected, drained, heated in a pan and pressed. The resulting cakes would then be dried and ground to produce fertilisers. Perhaps more interestingly, in the nineteenth and early twentieth century, fish scales were used in the production of ornaments, artificial flowers, inlaid work, and similar items. As Koller (1918: 66) observes, the preparation of scales for these purposes was often very elaborate:

> "The fish scales are cleaned in a suitable manner until they appear transparent and horny. The large scales of fresh fish are the most suitable; old scales are useless, since they have lost their elasticity and transparency. In the process of Huebner the fresh scales are first treated for 24 hours with clean salt water, in order to loosen and remove partially the upper layers. They are then washed in distilled or clean rain-water, which is renewed every 2–3 hours. This is done five or six times. The scales are then separately and carefully rubbed with a fine linen cloth, gently squeezed in a press to remove moisture, and finally are laid for an hour in spirit, and again, as before, rubbed and pressed until dry. They have now the appearance of mother-of-pearl, and are very elastic and durable. They may either be used without further treatment or may be coloured as required."

Scales from the most common fish were made into "pearl essence" or "fish-scale essence," used in the making of false pearls. Scales were carefully removed, collected and kept in a vessel of water until a sufficient volume had been reached. This residual matter was then treated as follows:

> "The vessel in which the scales are collected is best placed in an airy loft, since the scales very soon decompose and then give off a most unpleasant odour. In order to avid this inconvenience the following process is adopted: The scales are covered, not with hot water, but with a solution of salicylic acid obtained by dissolving 3 grms. of the acid in 1 litre of water (3 in 1000). The salicylic acid is tied up in a little linen bag, which is suspended in the water, so that the acid gradually dissolves. By using this simple precaution the collecting vessel for the scales may be allowed to stand in the summer without the least injury. When a sufficient quantity of scales has been collected, the liquid above them is allowed to run off, and a portion of the mass of scales transferred to a large porcelain mortar, in which they are ground for a long time with a flat pestle. In consequence of the grinding, those particles are removed from the scales which are the cause of their silvery appearance." (Koller 1918: 67)

Further colouring, washing, and grinding treatments were then applied to the matter until a soft silver-grey powder was obtained. Scales from almost 40,000 fish were required to prepare 1 kilo of pearl essence in this way. The essence was then mixed with heated colourless gelatine in an aqueous solution of salicylic acid:

> "The mixture is kept melted on a water-bath, and introduced into the glass pearls by sucking it up into a glass tube drawn out to a point, allowing a drop to fall inside the glass pearl, and turning the latter until the inner surface appears to be quite covered by the pearl essence. In order to prevent the solidified mass from becoming detached from the glass wall, and to give the pearls a greater weight, they are filled with melted wax or a mixture of wax and paraffin… the opening closed by a small drop of melted pearl essence." (Koller 1918: 68)

Butter-Making Waste

Butter making always required the separation of the cream from fresh milk by centrifugal means, leaving as a residue a considerable proportion of skim milk containing only about 0.3 per cent of fat. At the turn of the twentieth century, this skim milk was converted into condensed skim milk. Condensed milk is made by introducing the liquids into a vacuum pan at 100–120 °F until sufficiently concentrated and then adding sugar. This condensed milk was a cheap foodstuff, but was not suitable for feeding infants because it has a low fat content. Alternatively, the skim milk could also be made into low quality cheese, in some case, to produce a better tasting product the missing butter fat would be replaced with margarine or lard.

Another use for the left-over skim milk was the production of casein, the main protein present in milk, which was then used in processed foods and in adhesives, paints, and other industrial products. Again, these processes required considerable knowledge:

> "For this purpose it is slightly acidified or treated with rennet, the curd which separates being washed to free it from soluble impurities and then dried by centrifugal means, followed by hot air with or without a partial vacuum. The casein thus produced forms a very light flocculent powder which is easily dissolved, or rendered fluid by ammonia or borax, the paste thus formed being used as an adhesive also in the dressing of cloth and surfacing of paper. Casein is also mixed with zinc oxide and other pigments and moulded into various articles... Another use for casein is as a food product. It is highly nitrogenous and is a valuable dietetic substance. It is mixed with flour and made into biscuits, also with cocoa, etc. A well-known blood enricher is also casein in an almost pure condition" (Koller 1918: 146).

The liquid or whey obtained from the separation process contains milk sugar, which was used in the preparation of lactic acid, alcohol, and other products, or neutralised and evaporated considerably until impure milk sugar separated in hard crystals. The hard crystals were then dissolved in water, purified by passing through animal charcoal (made from bones), and the solution again evaporated, until it turned into pure milk sugar. This sugar shares the same composition as cane sugar and could be added to cow's milk for making "humanized" milk or used in the preparation of lozenges and medical tablets, for which purpose it was said to be eminently well suited.

Conclusion

Many environmental activists postulate a fundamental opposition between economic growth and a cleaner environment. From their perspective, "business as usual" is an unsustainable approach that must be reformed or, ideally, curtailed in order to spare nature. While there is no point in denying that many past situations have been problematic and that industrial production did indeed occasion significant damage, much evidence suggests that traditional economic incentives have often promoted the development of more benign practices over time. In other words, creative entrepreneurs, managers and technicians have long understood that polluting emissions are a form of waste, which negatively affects profit margins.

If the material covered in this essay is indeed representative of the big picture, why do so many sustainable development theorists now believe otherwise? One can think of a few reasons. The first is that, despite much evidence to the contrary (Lomborg 2001; Anderson 2004; Goklany 2007), perceptions of environmental degradation in advanced industrialised economies have become so dominant that most people simply cannot envisage that manufacturing firms have been cleaning up their act for almost two centuries. Another problem is that the environmental record of some industries is indeed unimpressive, although the case can be made that many such situations can often be traced back to "perverse subsidies," which reward less efficient practices (Kjellingbro and Skotte 2005), or a lack of well-defined private property rights (Anderson and Leal 2001). It may also be the case that current inhabitants of advanced economies who have grown up surrounded by fossil-fuel-based synthetic products cannot readily imagine that earlier products fulfilling the same purposes were often made of animal and vegetable residues.

Be that as it may, a case can be made that the deep-seated environmental mistrust harboured by some policy makers, activists and concerned citizens towards "business as usual" in market economies is probably mistaken. Perhaps, in the end, the invisible hand has had a green thumb all along.

Notes

1. On the recovery of domestic waste, see, among others, Bertolini (1978, 1990); De Silguy (1989); Rathje and Murphy (1992); Strasser (1999); and Winiwarter (2002). For a contemporary account of the various waste trades in London, see Mayhew (1851) and Simmonds (1862). For more recent analysis of some of the most valuable past scrap commodities and by-products, see Maher (1999), Zimring (2005) and a recent special issue of the periodical *Progress in Industrial Ecology* 3 (4): 273–407 (2006). While much statistical information is available on recovered commodities that were not direct residuals of industrial production, such as scrap steel and rags, this is not the case for direct by-product flows between different units of a single firm or between different firms. As Clapp (1994: 234–5) points out in his discussion of UK statistics: "Evidence would be preferable to argument, but reliable evidence is hard to come by. Since 1801 there has been a ten-yearly population census. It has been organised with a variety of users in mind, but it is pretty clear that the historian of waste and byproducts has not been among them." He further adds that "censuses of production throw as little light on the place of waste trades in the economy as do the censuses of population."
2. Among relevant material not discussed here are specialised periodicals that dealt exclusively or occasionally with waste materials, patents, and scholarly theses. Our rationale for excluding these sources is that much of their valuable information is covered in the monographs referenced later in this section.
3. From the non-paginated version of Babbage's *On the Economy of Machinery and Manufactures*, Section II, Chapter 22,
4. From the non-paginated version of Karl Marx's *Capita*l, Volume III, Part I, Chapter 5.
5. As above.
6. From the non-paginated version of Alfred Marshall's *Principles of Economics*. Book IV, Chapter XI in paragraph IV.XI.2.
7. From the non-paginated version of Alfred Marshall's *Principles of Economics*. Notes to Book VI, Chapter I, footnote aa124.
8. For a recent treatment of this issue, see Ockerman and Hansen (2000).
9. For a recent overview of the topic, see Smil (1999).
10. To our knowledge, the French engineer Paul Razous (1937, 1921, 1905) wrote the best book on the topic, but his work was never translated.
11. Playfair's essay can be accessed here.
12. The last edition of Koller's book is available here.
13. The Porter hypothesis, named from Harvard University Professor Michael Porter, states that well-designed environmental regulations can stimulate innovations that, by enhancing productivity and reducing waste, increase private and social benefits.
14. Shoddy and mungo are terms for industrial rags.
15. A course floor covering of felted wool.
16. Babbage (1832), Part 1, Chapter 1.
17. According to *MeasuringWorth.com*, using the retail price index, in 2005 £ 7,913,262,651.52 was worth £103 369 139 in the year 1850.
18. According to *MeasuringWorth.com*, using the retail price index, in 2005 £ 385 684 was worth £5000 in the year 1850.
19. According to *MeasuringWorth.com*, using the retail price index, in 2005 £0.26 was worth 1d in the year 1875.
20. According to *MeasuringWorth.com*, using the retail price index, in 2005 £3.14 was worth 1s in the year 1875.

References

Anderson, Terry (ed.). 2004. *You Have to Admit It's Getting Better: From Economic Prosperity to Environmental Quality*. Palo Alto: Hoover Institution Press.

Anderson, Terry and Donald Leal. 2001. *Free-Market Environmentalism, Revised Edition*. New York: Palgrave.

Ayres, Robert U. and Leslie W. Ayres. 2002. *A Handbook of Industrial Ecology*. Cheltenham: Edward Elgar.

Babbage, Charles. 1832. *On the Economy of Machinery and Manufactures*.

Bailey, Alton Edward. 1948. *Cottonseed and Cottonseed Products: Their Chemistry and Chemical Technology*. New York: Interscience Publishers Inc.

Bates, John Seaman. 1914. *Chemical Utilization of Southern Pine Waste*. Montreal and Toronto: Industrial and Education Press, Limited.

Bertolini, Gérard. 1990. *Le marché des ordures*. Paris: Éditions l'Harmattan.

Bertolini, Gérard. 1978. *Rebuts ou ressources? La socio-économie du déchet*. Paris : Éditions Entente.

Campbell, W.B. 1914. *Chemical Methods for Utilizing Wood Wastes*. Ottawa: Government Printing Bureau.

Carey, Henry Charles. 1883/1858. *Principles of Social Science, volume 1*. Philadelphia: J.B. Lippincott & Co.

Clapp, Brian William. 1994. *An Environmental History of Britain since the Industrial Revolution*. London: Longman.

Clemen, Rudolph A. 1927. *By-products in the Packing Industry*. Chicago: The University of Chicago Press.

De Silguy, Catherine. 1989. *La saga des ordures du Moyen Âge à nos jours*. Paris : Éditions de l'Instant.

Desrochers, Pierre. 2007. "How did the Invisible Hand Handle Industrial Waste? By-Product Development before the Modern Environmental Era." *Enterprise & Society* 8 (2): 348–374.

Desrochers, Pierre. 2002. "Industrial Ecology and the Rediscovery of Inter-Firm Recycling Linkages. Historical

Evidence and Policy Implications." *Industrial and Corporate Change* 11 (5): 1031–1057.

Donk, Mario Gilbert and Charles Houston Shattuck. 1921. *The Distillation of Stumpwood and Logging Waste of Western Yellow Pine*. Washington: U.S. Department of Agriculture.

Findlay, Alexander. 1917. *The Treasures of Coal Tar*. New York: D. Van Nostrand Company.

Goklany, Indur. 2007. *The Improving State of the World: Why We're Living Longer, Healthier, More Comfortable Lives on a Cleaner Planet.* Washington: Cato Institute.

Grisdale, Joseph Hiram. 1918. *Utilization of Fish Waste in Canada*. Ottawa: Commission on Conservation. Committee on Fisheries, Game and Fur-bearing Animals.

Harper, Walter B. 1907. *The Utilization of Wood Waste by Distillation.* Saint-Louis: Journal of Commerce Co.

Howard, Albert. 1931. *The Waste Products of Agriculture: Their Utilization as Humus.* London: Oxford University Press.

Hubbard, Ernst. 1902. *The Utilisation of Wood-Waste.* London: Scott, Greenwood & Co.

Johnsen, Bjarne. 1919. *Utilization of Waste Sulphite Liquor; A Review of the Literature*. Ottawa: Department of the Interior.

Kershaw, John B. C. 1928. *The Recovery and Use of Industrial and Other Waste*. London: Ernest Benn Limited.

King, Walter. 1992. "How High is Too High? Disposing of Dung in Seventeenth-Century Prescot." *Sixteenth Century Journal* 23 (3): 443–457.

Kjellingbro, Peter Marcus and Maria Skotte. 2005. *Environmentally Harmful Subsidies: Linkages between Subsidies, the Environment and the Economy.* Copenhagen: Danish Environmental Assessment Institute.

Koller, Theodor. 1918. *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: D. Van Nostrand Company

Kurz, Heinz D. 1986. "Classical and Early Neoclassical Economists on Joint Production." *Metroeconomica* 38 (1): 1–37.

Lambert, Thomas. 1901. *Bone Products and Manures: An Account of the Most Recent Improvements in the Manufacture of Fat, Glue, Animal Charcoal, Size, Gelatine, and Manures.* London: Scott, Greenwood.

Lange, Kurt Reinhold. 1915. *The By-Products of Coal-Gas Manufacture*. London: Scott, Greenwood & Sons.

Larsen, Christian and William M. White. 1913. *Dairy Technology: A Treatise on the City Milk Supply, Milk as a Food, Ice Cream Making, By-Products of the Creamery and Cheesery, Fermented Milks, Condensed and Evaporated Milks, Milk Powder, Renovated Butter, and Oleomargarine*. New York: J. Wiley & Sons.

Lipsett, Charles H. 1963/1951. *Industrial Wastes and Salvage: Conservation and Utilization*. New York: The Atlas Publishing Co., Inc.

Lomborg, Bjørn. 2001. *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge: Cambridge University Press.

Maher, John William. 1999. *Retrieving the Obsolete: Formation of the American Scrap Steel Industry, 1870–1933*. Ph.D. Dissertation. Department of Geography, University of Maryland at College Park.

Marshall Alfred. 1950/1920. *Principles of Economics, 8th edition*. New York: The MacMillan Company

Marx, Karl. 1909/1894. *Capital: A Critique of Political Economy, Vol. III. The Process of Capitalist Production as a Whole.* Chicago: Charles H. Kerr and Co.

Mayhew, Henry. 1851. *London Labour and the London Poor*, Volumes 1, 2 and 3. London. Griffen, Bohn and Company, Stationer's Hall Court.

Ockerman, H.W. and C.L. Hansen. 2000. *Animal By-Product Processing & Utilization*. Lancaster (PA): Technomic Publishing Co., Inc.

Playfair, Lyon. 1892. "Waste Products Made Useful". *North American Review* 155 (432): 560–568.

Porter, Michael. 1991. "America's Green Strategy". *Scientific American* 264 (4): 96.

Rayner, Hollins. 1903. *Silk Throwing and Waste Silk Spinning*. London: Scott, Greenwood.

Razous, Paul. 1937/1921. *Les déchets et sous-produits industriels. Récupération – Utilisation*. Paris : Ch. Dunod, éditeur.

Razous, Paul. 1905. *Les déchets industriels. Récupération – Utilisation*. Paris: Ch. Dunod, éditeur.

Rathje, W. and Cullen Murphy. 1992. *Rubbish! The Archeology of Garbage*. New York: Harper Collins.

Scarlett, Lynn. 1999. "Doing More with Less: Dematerialization – Unsung Environmental Triump." In Ronald Bailey (ed.), *Earth Report 2000*, New York: McGraw-Hill. 41–62.

Science and Art Department of the Committee of Council on Education. 1875. *Descriptive Catalogue of the Collection Illustrating the Utilization of Waste Products* [Bethnal Green Branch of the South Kensington Museum]. London: George E. Eyre and William Spottiswoode for Her Majesty's Stationery Office.

Science and Art Department of the Committee of Council on Education. 1872. *A Brief Guide to the Animal Products Collection*. [Bethnal Green Branch of the South Kensington Museum]. London: George E. Eyre and William Spottiswoode for Her Majesty's Stationery Office.

Simmonds, Peter Lund. 1877. *Animal Products. Their Preparation, Commercial Uses, and Value.* London: Chapman and Hall.

Simmonds, Peter Lund. 1876. *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: Hardwicke and Bogue.

Simmonds, Peter Lund. 1875. *Animal Products. Their Preparation, Commercial Uses, and Value*. New York: Scribner, Welford and Armstrong.

Simmonds, Peter Lund. 1862. *Waste Products and Undeveloped Substances; or, Hints for Enterprise in Neglected Fields*. London: Robert Hardwicke.

Simmonds, Peter Lund. 1859. "On the Utilization of Waste Substances." *Journal of the Society of Arts* 7 (325): 175–188.

Simpson, R. David (ed.). 1999. *Productivity in Natural Resource Industries: Improvement through Innovation*. Washington, D.C.: Resources for the Future.

Smil, Vaclav. 1999. "Crop Residues: Agriculture's Largest Harvest." *BioScience* 49 (4): 299–308.

Stansfield, Edgar. 1915. *Products and By-Products of Coal*. Ottawa: Department of Mines.

Strasser, Susan. 1999. *Waste and Want: A Social History of Trash*. New York: Henry Holt and Company.

Talbot, Frederick A. 1920. *Millions from Waste*. Philadelphia: J. B. Lippincott Company.

Thornley, Thomas. 1912. *Cotton Waste: Its Production, Manipulation and Uses.* London: Scott, Greenwood.

Wames, Arthur. R. 1914. *Coal Tar Distillation and Working Up of Tar Products*. London: J. Allan and Company.

Wernick, Iddo K., Robert Herman, Shekhar Govind and Jesse H. Ausubel. 1996. "Materialization and Dematerialization: Measures and Trends." *Daedalus* 125 (3):171–198.

Winiwarter, Verena. 2002. "History of Waste." In Katy Bisson and John Proops' *Waste in Ecological Economics*, Cheltenham: Edward Elgar. 38–54.

World Business Council on Sustainable Development. 2005. *Eco-Efficiency Module.*

Zimring, Carl Abraham. 2005. *Cash for Your Trash: Scrap Recycling in America*. Piscataway, N.J.: Rutgers University Press, 2005.