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Christa D. Jensen

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By: Christa D. Jensen, Graduate Research Fellow, RRI, West Virginia University

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Website address: rri.wvu.edu

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Abstract

Amid changing attitudes about the environment and increasing sustainability concerns, many countries around the world aim to curb waste generation, especially the generation of hazardous wastes. Beginning in the late 1970's and occurring increasingly since, governments and international bodies are passing legislation and treaties dealing with the reduction of hazardous waste generation and waste minimization in general. For future waste minimization policies to have an impact on hazardous waste generation, methods for determining where the ultimate responsibility for hazardous waste generation lies need to be explored. This paper examines hazardous waste generation in the United States at the industry level and uses two different specifications of the commodity by industry input-output framework to conduct attribution analyses. These analyses allow for the determination of direct and indirect responsibility of both industries and final consumers for hazardous waste generation. An industry level analysis shows that only a few industries are responsible for a majority of hazardous waste generated in the US. Both attribution analyses suggest that in general, household consumption is largely responsible for direct and indirect hazardous waste generation. Looking more closely, there are noticeable differences in final demand attribution across industries. These results can be used by policymakers to inform and fashion rational and effective laws according to more specific objectives aimed at minimizing hazardous waste generation in the United States.

Key words: Hazardous Waste, Input Output, Attribution

JEL Category: Q53, Q56, R15

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*Christa D. Jensen, Graduate Research Fellow, Regional Research Institute, Department of Economics, West Virginia University, PO Box 6825, Morgantown, WV 26506. Phone: (304) 293-8545; Fax: (304) 293-6699; Christa.Jensen@mail.wvu.edu

I. Introduction

Waste and waste reduction are increasingly becoming the focus of numerous national administrations and environmental agencies around the world. Over twenty years ago, on June 23, 1989, in a message to Congress regarding environmental quality, United States (US) President George H.W. Bush stated,

> *This country must make every effort to stem the rising tide of garbage and industrial waste through a more aggressive use of waste minimization and recycling practices. America as a nation is filling landfills faster than it can establish new ones. The waste problem is not going away, and it can no longer be neglected.* (Woolley & Peters)

More recently, governments in many nations, both developed and developing, have discussed or implemented waste minimization strategies. For example, since the late 1980's, the US has implemented multiple amendments to the Solid Waste Disposal Act of 1965 which aim to curb waste generation and better manage its disposal; in 2003, the Environment Ministry of Japan proposed that they would reduce by half the amount of trash they bury by the year 2010 (Reuters, 2003); the National Solid Waste Association of India sponsored a seminar in 2007 titled "Sustainable Solid Waste Management"; and the Welsh Assembly Government recently released, "Waste Strategy 2009 – 2050: Towards Zero Waste" which sets long term goals for waste management and resource efficiency (Welsh Assembly Government, 2009).

Many waste minimization strategies also include specific goals and regulations for the reduction of hazardous waste generation. The general definition of a hazardous waste as given by the US Environmental Protection Agency (EPA) is "waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment" (www.epa.gov). The most prominent regulation regarding hazardous wastes on an international scale is the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)*. Although international shipments of hazardous wastes are the primary focus of this document, the preamble states that the signatory parties to this convention were motivated by the idea that, "the most effective way of protecting human health and the environment from the dangers posed by [hazardous] wastes is the reduction of their generation to a minimum in terms of quantity and/or hazard potential" (UNEP, 1989).

In the US, prior to the 1970's, federal regulation of hazardous wastes was almost non-existent and regulations at other government levels only existed in a few states. Hazardous wastes were often treated and disposed of as though they were any other type of solid waste.

However, growing concern for both environmental and health hazards in the mid 1970's spawned the first true federal hazardous waste legislation. The Resource Conservation and Recovery Act (RCRA) of 1976 was implemented as a collection of amendments to the Solid Waste Disposal Act of 1965. One of the main goals of this legislation in its entirety was to reduce the amounts of municipal and industrial, hazardous and non-hazardous wastes (both hazardous and non-hazardous) generated within the US. Subtitle C of RCRA was and remains the primary regulatory document governing the generation, management, transportation, and disposal of hazardous wastes. RCRA Subtitle C not only identifies and defines different types of hazardous wastes and creates performance standards for their treatment, storage, and disposal within the environment, but also establishes a permitting and tracking system that allows the EPA to monitor the movements of hazardous wastes within the US.

An understanding of *how* and *why* hazardous waste is created is critical to the implementation of effective hazardous waste minimization strategies. A closer examination of the processes and interrelationships through which hazardous waste is created will provide some insight into answering these questions. While there are multiple attribution techniques that can be employed to determine producer and consumer responsibility, it is important to select an attribution method that is easily interpreted and consistent with the question at hand. This paper aims to examine the relationships between economic activity, consumption, and hazardous waste generation within the US. Two attribution specifications are discussed and proposed as a means to answer questions such as:

1. How much hazardous waste is produced in the US economy?
2. How much of this hazardous waste is produced by each industry?
3. How much hazardous waste is produced in the US to satisfy domestic final demand?
4. How much hazardous waste is produced in the US to satisfy export final demand?

Input output based environmental analyses date back to what is often referred to as the Full-Leontief model (Leontief, 1970) in which pollution is integrated within the input output model as an additional commodity, which is accompanied by an additional cleaning sector that cleans up, or prevents, the output of the pollution commodity. Afterwards, a divergence in the literature on quantifying the economy's impact on the environment ensued. One branch of the literature pursued the analytical adaptation of the Full-Leontief model (e.g. Lowe, 1979; Qayum, 1991; Arrous, 1994; Luptacik & Bohm, 1999; Allan et al., 2007) and the other followed more of a satellite accounts approach to measuring pollution generated as a result of economic activity (e.g. McNicoll & Blackmore, 1993; McGregor et al., 2001). The latter direction is directly related to another literature on input output based attribution analyses as they relate to environmental issues.

Wiedmann et al. (2006) introduces an input output based approach for reallocating ecological footprint data by sector, final consumption group, sub-national geographic specifications, and by socioeconomic groups. Using a commodity by industry input output approach (supply and use table framework) they allocate the UK Ecological Footprint to detailed consumption categories. Jensen et al. (2009) use a similar approach and outline four different IO based attribution techniques: traditional Type I and Type II models, as well as a Trade Endogenized Linear Attribution System (TELAS), and a Type I system under a Domestic Technology Assumption (DTA). The inherent assumptions, benefits, and drawbacks of each specification are described in detail and these techniques are applied to an analysis of total commercial and industrial waste arisings in the Welsh economy.

Although similar in motivation, this paper reverts back to the commodity by industry framework, similar to that set forth in Wiedmann et al. (2006), and attempts to match attribution techniques to specific questions and policy goals. Here, both model specifications use a Type I approach. Jensen et al. (2009) discuss each formulation, its assumptions, benefits, and shortcomings but stop short of explicitly identifying the types of policy-related questions that can be addressed.

The remainder of this paper is organized as follows. Section II describes the attribution methodology employed in this paper and Section III describes the data on both the US economy and US hazardous waste generation. Section IV presents the results from an industry level analysis and discusses the results of the different attribution analyses. Section V concludes and provides direction for future research.

II. Attribution Methodology

This paper uses the commodity by industry input output framework derived from the Bureau of Economic Analysis (BEA) Annual Industry Accounts. The commodity by industry framework provides detailed accounts, which model the relationships that exist among industries and the commodities they use and produce. This framework, unlike the industry by industry framework, allows for the consideration of not only each industry's dominant output but also the production of secondary commodity outputs, or byproducts, which are also important in many environmental applications.

Standard BEA methodology is used to adjust for *Noncomparable Imports* and *Scrap, Second-hand and Used Goods*[1] and also to define the industry by commodity total requirements matrix (see Horowitz and Planting (2006) for more details). Equations (1) to (3) describe the basic identities underlying this framework:

$$q = U\iota + e \quad (1)$$

$$g = V\iota + h \quad (2)$$

$$h = \hat{p}g \quad (3)$$

where, U is the commodity by industry intermediate portion of the Use matrix where each column describes the corresponding industry's use of commodities in their production process, V is the industry by commodity Make matrix where each row describes the amount of each commodity produced by a given industry, ι is a summation vector of appropriate dimension, e is the vector of total final demand purchases by commodity, h is a vector of each industry's total production of scrap, q is a column vector of total commodity output, g is a column vector of total industry output, and p is a column vector where each entry represents an industry's ratio of the value of scrap produced to total industry output. The ^ symbol indicates the diagonalization of a vector.

Standardized tables are calculated as follows:

$$B = U\hat{g}^{-1} \quad (4)$$

$$D = V\hat{q}^{-1} \quad (5)$$

$$W = (I - \hat{p})^{-1} D \quad (6)$$

where, B is the standardized Use table, D is the standardized Make table, and W is the standardized Make table that has been adjusted for scrap output. Because commodity final demand and industry output are used within this paper, it is appropriate to define the total requirements matrix in industry by commodity space:

$$L_{IxC} = W(I - BW)^{-1} \quad (7)$$

[1] Sector (industry and commodity) names are listed in *italics* to set them apart from the text.

The set of models described in this paper is differentiated by the specifications of the final demand vector that drives the model and this total requirements matrix. Equation (7) is referred to as the BEA specification. Both specifications employ a full Use matrix which represents the production functions of each industry's use of commodities, irrespective of the origin (domestically produced or foreign imports) of the commodities used. This method uses a standardized Make matrix, W, which does not account for rest of the world commodity output (or imports). The matrix resulting from the multiplication of these Use and Make tables, BW, is the matrix of *technical coefficients* in commodity by commodity space. These coefficients represent the total commodity input per dollar of total commodity output, or the full production technology for each sector.

An alternative model formulation is outlined in Jackson (1998)[2],

$$\tilde{W} = (I - \hat{p})^{-1} V (\hat{\tilde{q}})^{-1} \qquad (8)$$

$$\tilde{L}_{IxC} = \tilde{W}(I - B\tilde{W})^{-1} \qquad (9)$$

where, $\tilde{q}$ is total commodity output, as defined in (1), plus commodity imports. Hereafter, the $\tilde{}$ symbol is used to refer to a matrix defined under the Jackson model. Although this method uses the same full Use matrix as the BEA specification, it now employs a Make matrix that takes account of imports within the standardization step. Within the commodity by industry framework the Make matrix can also be used as a transformation matrix for purposes of moving between industry and commodity vector space. The multiplication of the standardized Use matrix and this new Make matrix, $B\tilde{W}$, rids the Use matrix of imported commodity inputs, resulting in a matrix of *intraregional direct input coefficients* in commodity by commodity space. These coefficients represent the regional commodity input per dollar of total commodity output. Equation (9) is the industry by commodity equivalent of the method introduced in Jackson (1998) and $(I - B\tilde{W})^{-1}$ is the conceptual counterpart to the industry by industry multiplier appearing in Miller and Blair (1985).

To incorporate hazardous waste, the vector of output hazardous waste coefficients (tons of hazardous waste generated per million dollars of industry output), ω, is incorporated into the

[2] Lahr (2001) also demonstrates the conceptual equivalence of the approach outlined in Jackson (1998) and supply percentages outlined in Miller and Blair (1985).

two model specifications, along with final demand to form the following general equations for total hazardous waste generation:

$$\omega g = \omega W (I - BW)^{-1} e \quad (10)$$

$$\omega g = \omega \tilde{W} (I - B\tilde{W})^{-1} \tilde{e} \quad (11)$$

where, ωg translates to total hazardous waste generation under each specification. Both equations (10) and (11) are ways of determining the total amount of hazardous waste that is generated in the US economy. As shown in Table 2, the BEA specification shown in Equation (10) does indeed come within 0.001% of replicating the known hazardous waste total[3]. In this case, final demand includes household consumption, government expenditures, investment, and net exports (exports minus imports).However, as discussed in Section IV, when we attribute industrial hazardous waste generation to the final demand categories defined in this manner, we run into some interpretational issues.

Equation (11) employs the Jackson framework, which also reproduces the known hazardous waste totals (with negligible error). Here, final demand categories include household consumption, government expenditures, investment, and exports. However, as discussed in Section IV, this model allows us to attribute responsibility for hazardous waste generation to the final demand categories in a more meaningful way. This paper argues that for this reason, Jackson's method is more appropriate than the BEA specification for attribution results that inform policy decisions.

III. Data

Input output data for the US economy was obtained from the BEA Annual Industry Accounts. Make and Use matrices are used along with data on value-added by industry and various final demand categories by commodity. This paper uses the same aggregation scheme used in all BEA Annual tables, details can be found on the BEA website (www.bea.gov). Input output data for 2007 are used along with the data on total hazardous waste generation by industry, described below, for all attribution techniques.

[3] Minor differences in the known total of hazardous waste generated and the calculated total by each model specification can be attributed to rounding errors and the exclusion of hazardous waste generated in US territories which has been dropped as these territories are not included within the economic data.

Subtitle C of RCRA gave the US EPA the authority to collect data on the 'cradle to grave' life-cycle of hazardous wastes within the US. Eventually, the EPA introduced what is known as the Biennial Reporting System (BRS). The BRS is a national system that collects detailed data biennially from large quantity generators[4] on the generation, management, and transport of hazardous wastes. Generally, hazardous wastes are described as any waste that is potentially harmful to human health and/ or the environment. To tightly regulate hazardous wastes in accordance with RCRA legislation, the EPA needed a more descriptive and comprehensive definition. In this paper, and all BRS data, hazardous wastes are identified using the flowchart shown in Figure 1. For more information regarding the definitions for excluded, characteristic, listed, and delisted hazardous wastes, see EPA (a). Note also that RCRA hazardous wastes do not include nuclear wastes which are regulated by the Nuclear Regulatory Commission.

<Figure 1 Here>

BRS data for every other year between 1991 and 2007 are made publicly available by the US EPA. In 1991, the EPA began publishing biennial editions of *The National Biennial RCRA Hazardous Waste Report*. These reports publish data and descriptive analyses of hazardous waste generated, managed, shipped, and received within the US, at various levels of aggregation. These same data are also accessible through a database maintained by the Right-to-Know Network (RTK NET), a project of OMB Watch. Historical data on total hazardous waste generation were collected from both sources. Figure 2 shows biennial US hazardous waste generation in millions of tons for the period 1991-2007 as reported by both the EPA and RTK NET.

Although the two groups employ the same BRS data, the biennially published results for total hazardous waste generation are remarkably different. The RTK NET estimate is consistently higher by a significant amount. This difference could be partly due to different definitions of *total generation*. The EPA requires the generation of hazardous waste to be reported within the BRS system if it is:

[4] A hazardous waste generator is considered a federal large quantity generator if they "generated in any single month 1.000 kg (2,200 pounds or 1.1 tons) or more of RCRA hazardous waste; or the generator generated in any single month or accumulated at any time, 1kg (2.2 pounds) of RCRA acute hazardous waste; or the generator generated, or accumulated at any time, more than 100kg (220 pounds) of spill cleanup material contaminated with RCRA acute hazardous waste." (EPA, 2007)

- Generated and accumulated on site and subsequently managed on site or shipped off site in [the reporting year]; or
- Generated and accumulated on site in [the reporting year] but not managed on site or shipped off site until after [the reporting year]; or
- Generated and accumulated on site prior to [the reporting year] but either managed on site or shipped off site in [the reporting year]; or
- Imported from a foreign country in [the reporting year]. (EPA 2007 b)

RTK NET summary reports define tons generated as the total tons of waste generated at a BRS facility in the current (reporting) year that is either later managed on site or shipped offsite for management. They note the difference from the Biennial Report summary data:

> *Previous versions of RTK NET's BRS access program also referred to "RCRA" waste. This term has a varying meaning according to the reporting year, but it basically means "the amount of waste included in EPA's Biennial RCRA Hazardous Waste Report document". Because the method used to calculate this quantity varied from one year to the next, and because RTK NET's calculations could not be made to exactly match those from EPA's National Report, RTK NET has stopped trying to present its own calculations of these waste quantities.* (http://www.rtknet.org/db/brs/about)

<Figure 2 here>

Within the EPA data, the sharp decline between 1995 and 1997 corresponds to a major change in the definition of RCRA monitored hazardous wastes. After the 1995 Biennial Report, aqueous hazardous wastes or ‘wastewaters’, which account for a lot of weight in tons, became the responsibility of treatment systems that are regulated by the Clean Water Act and were no longer included in RCRA data collection. Therefore, casual comparisons of pre- and post-1997 data can be deceptive. In the post-1997 period, when definitional differences are minor or non-existent, there appears to be little, if any, downward trend in RCRA hazardous waste generation. This is also true when we consider RCRA hazardous waste generated per capita. Similar to the experience of RTK NET, the totals reported by the EPA Biennial Reports cannot be replicated. For this reason, and due to the amount of detail available in the RTK NET database, it is used for all hazardous waste data within this paper.

Beginning in 2001, BRS began requiring the industries to report their primary activity by North American Industry Classification System (NAICS) code. Data on total hazardous waste generation by industry for 2007 were collected and aggregated in accordance with the input output industries and are used in all subsequent analyses.

IV. Analytical Results

In 2007, the US generated 47,638, 238 tons of hazardous waste. By weight, this is the equivalent of 10, 356, 139 average sized adult African elephants. If we consider this amount by volume and assume that the hazardous waste is the same density as soil (or loose, dry sand) then it would fill 1,176,253 average sized garbage trucks or just over 3.5 Hubert H. Humphrey Metrodomes (home of the Minnesota Vikings).

Direct Industry Level Analysis

By simply allocating this national total to individual industries, a direct industry level analysis can take place. These data can address industry specific questions on hazardous waste generation by examining the data and producer responsibility in two different ways:

1. By examining direct hazardous waste generation by industry; or
2. By examining direct hazardous waste generation per million dollars of industry output, i.e. an industry's hazardous waste intensity

Table 1 displays the industry-detail results for both direct hazardous waste generation and hazardous waste intensity (waste output coefficients) for 2007. As shown in Figure 3, just five of the sixty-two industries are responsible for over 93% of total hazardous waste generation in the US: *Chemical Products*, *Petroleum and Coal Products*, *Waste Management and Remediation Services*, *Primary Metals*, and *Computer and Electronic Products*. The same five industries also appear at the top when ranked by waste intensity. These findings are consistent with an analysis of 1995 BRS data by McGlinn (2000), who also found that the petrochemical industries in the Gulf Coast region were responsible for a large majority of hazardous waste generation. It can also be noted that the only industry within this aggregation scheme that does not produce any hazardous waste is *Legal Services*.

<Insert Table 1>

<Insert Figure 3>

This type of simple industrial analysis provides insight into not only how much waste is produced in the US but also into producer, or industry, responsibility. Whether hazardous waste generation by industry is examined as total generation or hazardous waste intensity, it is clear that only a few industries are responsible for most of the hazardous waste in the US.

Using multiplier analysis, this responsibility can be broken into direct and indirect responsibilities which can vary widely by industry. The industry by industry total requirements matrix reported by the BEA can be used in conjunction with the hazardous waste intensities by industry to produce Type I output hazardous waste multipliers.

$$L_{IxI} = \omega(I - WB)^{-1} \qquad (12)$$

Table 2 below displays the breakdown of the Type I industry by industry multipliers for each sectors in terms of direct and indirect responsibility. There are notable differences across sectors in terms of how the direct and indirect hazardous waste generation relate to one another. Industries can be broken down into three general categories:

1. Relatively high direct hazardous waste intensity and relatively low indirect hazardous waste intensity
2. Relatively low direct hazardous waste intensity and relatively high indirect hazardous waste intensity
3. Similar shares of direct and indirect hazardous waste intensities

<Insert Table 2>

Figure 4 shows four key sectors and the breakdowns of their respective output hazardous waste multipliers in an attempt to highlight the general categories described above. *Waste Management and Remediation Services* represents an industry with relatively high direct waste intensity and relatively low indirect waste intensity. This implies that this sector itself is highly waste intensive but that the industries in its supply chain are not. *Plastics and Rubber Products* embodies the opposite relationship, relatively low direct waste intensity but relatively high indirect waste intensity. This sector does not directly produce large amounts of hazardous waste but does purchase its inputs from highly waste intensive sectors. *Computer and Electronic Products*, which was shown to be a front runner in terms of direct hazardous waste intensity, embodies a similar share of indirect hazardous waste intensity. Both this industry and those in its supply chain are similarly hazardous waste intensive. The final sector in Figure 4 is *Legal Services* and is included to show that even a sector that produces zero hazardous waste directly, is indirectly responsible for some hazardous waste generation.

<Insert Figure 4>

This simple analysis answers *how* hazardous waste is generated within the US and begins to attribute responsibility across industries (or producers). The next step is to determine *why* these industries are producing output in general and in turn hazardous waste. To answer this question, the input output based attribution methods described in Section II are applied.

Attribution Analyses

Using both the BEA and the Jackson specifications described in Section II, total hazardous waste generation is now attributed to the respective final consumption categories rather than across industries. Table 3 shows the results using the BEA specification of attributing both direct and indirect hazardous waste generation to different final demand categories as per Equation (10). Table 4 shows these same results in percentage form. Almost immediately, a glaring issue appears when attempting to interpret these results. As is the case with many economies in many years, the US ran a trade deficit in 2007; therefore net exports for almost all industries are negative in value. These negative values in Table 3, and the corresponding negative percentages of responsibility displayed in Table 4 have little, if any, meaningful interpretation. Consider, for example, *Oil and Gas Extraction*. The percentages in Table 4 imply that net exports are responsible for -140% of total hazardous waste generation in this industry. This issue also leads to possible misinterpretation of the responsibility of other final demand categories. Using the same example, this model suggests that household consumption is responsible for 169% of the hazardous waste generation in the *Oil and Gas Extraction* sector. Although the overall totals for all industries suggest that household consumption is responsible for the largest percentage of direct and indirect hazardous waste generation, even the totals for each final demand category can be misinterpreted due to the issue of negative net exports. The Jackson model gives us an alternative method to answer the same question of *why* industry output, and in turn hazardous waste, is generated.

<Insert Tables 3 and 4>

As shown in Table 5, virtually all values of final demand are positive within this specification. *Other Services except Government* has a negative value for investment final demand, but this is attributable to negative investment in this sector for 2007. Once again, percentage results are also presented and appear in Table 6. Rows can now easily be interpreted as follows: for each sector, each value measures the percentage of direct and indirect hazardous waste that can be attributed to each category of final demand. For example, we can interpret that household consumption is responsible for 63% of direct and indirect hazardous waste generation within the *Oil and Gas Extraction* sector, government expenditures are responsible for 17%, investment demand is responsible for 9%, and foreign exports are responsible for 11%.

<Insert Tables 5 and 6>

It is obvious that Jackson's approach yields more policy relevant results. Although considerably smaller than the percentage found using the BEA specification, the overall totals using this method imply that household consumption is responsible for a majority (58%) of the direct and indirect hazardous waste generation in the US. However, examining these totals also highlights a possible drawback of this approach from a policy standpoint. Table 6 shows that 20% of overall direct and indirect hazardous waste generation is attributed to export final demand which represents final demand activity that is outside of the jurisdiction of US policies. Although the US has few, if any, mechanisms to reduce foreign demand for commodities with waste intensive production processes, this may still be useful information for policymakers as they consider *why* hazardous wastes are produced.

Closer examination of Tables 5 and 6 remind us that these general results do not hold across all sectors. Although it is true that household consumption is responsible for a majority of direct and indirect hazardous waste generation in many sectors, final demand attribution varies widely across sectors. For example, investment demand drives hazardous waste generation in sectors such as *Support Activities for Mining, Construction, Machinery, Computer and Electronic Products*, and *Computer Systems Design and Related Services*. It is also interesting that hazardous waste generation within the *Government* sector is largely driven by government expenditures. These differences may be more noticeable in Figure 5 which provides a graphical display of Tables 5 and 6.

<Insert Figure 5>

V. Conclusions and Directions for Future Research

This paper provides a set of input output based attribution modeling techniques in an effort to understand *how* and *why* hazardous wastes are produced within the US. As shown in Section IV, interpretational issues often arise under the BEA specification largely due to its definition of final demand. As such, the Jackson (1998) approach is proposed as a more easily interpreted attribution technique and is deemed more useful for policy purposes. The results from this specification, pertaining to hazardous waste generation and its attribution to final consumers in the US, point to a few general suggestions for US policymakers.

Regarding the simple industry level analysis and producer responsibility, it is clear that only a few industries are responsible for a majority of the hazardous waste generation in the US. If policymakers desire to reduce hazardous waste generation from the production side of the economy (i.e. cleaner technology, restrictions on output), perhaps they should focus on these industries at the outset. The simple multiplier analysis also allows for the identification of industries that are indirectly responsible for hazardous waste generation in the US. Policymakers would have to consider whether this information changes their decisions on which groups of industries to focus on: those that are directly responsible for large amounts of hazardous waste, those that are indirectly responsible for large amounts of hazardous waste, or those that are holistically responsible (i.e. responsible for the most hazardous waste in total).

Alternatively, if policymakers use the results from final demand attribution analyses as a reminder of *why* production, and in turn hazardous waste generation, takes place, a consumption based policy approach might be more appropriate. Rather than posing restrictions on producers, focus could be directed towards curbing the consumption of goods that are produced by hazardous waste intensive industries. The results from the attribution analyses indicate that overall, hazardous waste generation in the US is largely attributable to household consumption demand. However, it is important to remember that final consumer responsibility varies widely across commodities. The consumption group that is ‘most’ responsible should be the focus of attempts to make any consumption-based hazardous waste minimization policies.

This type of consumption-based policy may be far more difficult to implement than production-based policies. Although attribution analyses can identify which final consumption groups are responsible, as these vary by industry, it may be difficult to single out final consumption groups as policy targets when they vary so widely across industries. It may be that shared responsibility between producers and consumers also should be discussed. Who is *ultimately* responsible for waste generation, the industry that actually produces it, the consumer that required that production to satisfy their wants/needs, or both?

Directions for future research are twofold, the first dealing with issues of aggregation and the second with the relaxation of model assumptions. It is well known that different levels of aggregation on many dimensions can produce different results. Some interesting extensions of this research involve disaggregating the data and analyses with respect to geography, economic structure, and waste type. As consumption patterns and industry structure vary across space, results could be markedly different for different regions or states within the US. Input output data can be regionalized for use in conjunction with available hazardous waste generation data by region to test this. Also, as attribution results are already shown to vary across aggregate industry and commodity levels, it may be useful to examine results derived from less aggregated industries and commodities. These analyses could also be performed using more disaggregated final demand activities, such as different types of government expenditures, different types of investment, and/or different categories of household consumption. Further, this analysis was performed using *total* hazardous waste. Attribution relationships may also change across different types of hazardous waste. This framework could be used to examine more specific types of hazardous wastes and their ultimate responsibility structures to assess various policy impacts on different waste streams.

Future research also could extend to different modeling frameworks. It is often the case that production occurs and hazardous waste is generated in one region to satisfy final consumption demand in another region. Here, the first step may be to move forward with the regional analyses presented above and then use an interregional input output framework that would also capture interregional feedback effects within the attribution analyses. Lastly, some relatively restrictive assumptions inherent within the input output framework could be relaxed in a move toward a computable general equilibrium framework within which one could test different policy shocks and their comprehensive impacts on the economy and hazardous waste generation.

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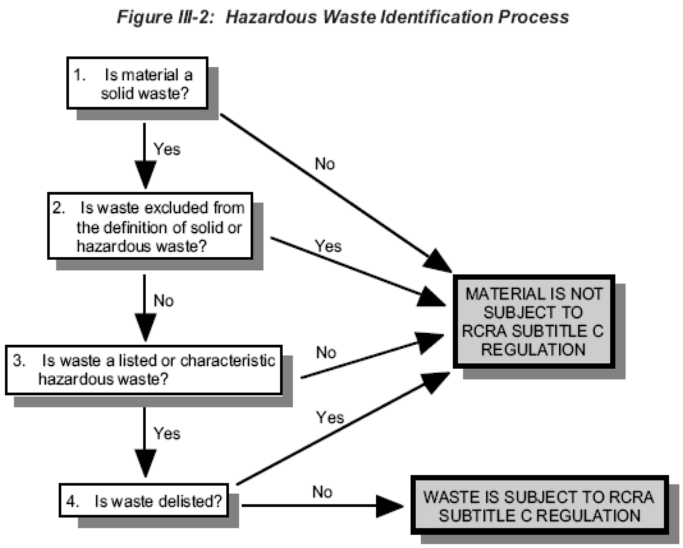
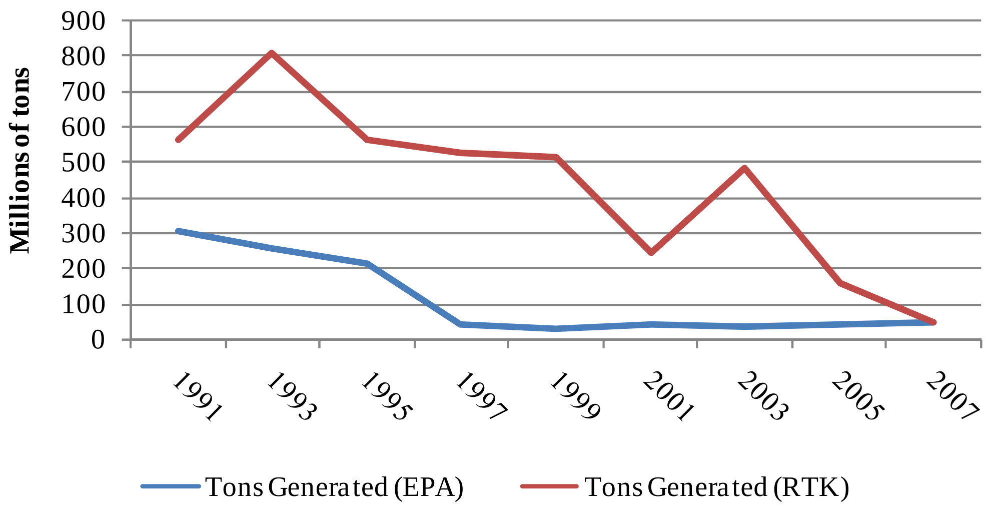
Figure 1: EPA Hazardous Waste Identification



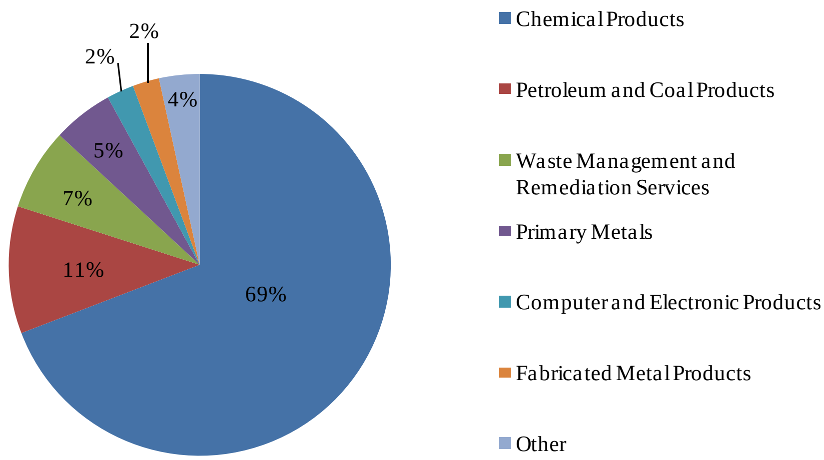
Source: http://www.epa.gov/osw/inforesources/pubs/orientat/rom31.pdf

Figure 2: Total US Hazardous Waste Generation: 1991-2007



Sources: US EPA 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, and http://www.rtknet.org/db/brs

Figure 3: Total Hazardous Waste Generation by Industry for US in 2007



Source: http://www.rtknet.org/db/brs

Figure 4: Key Sector Waste Distributions

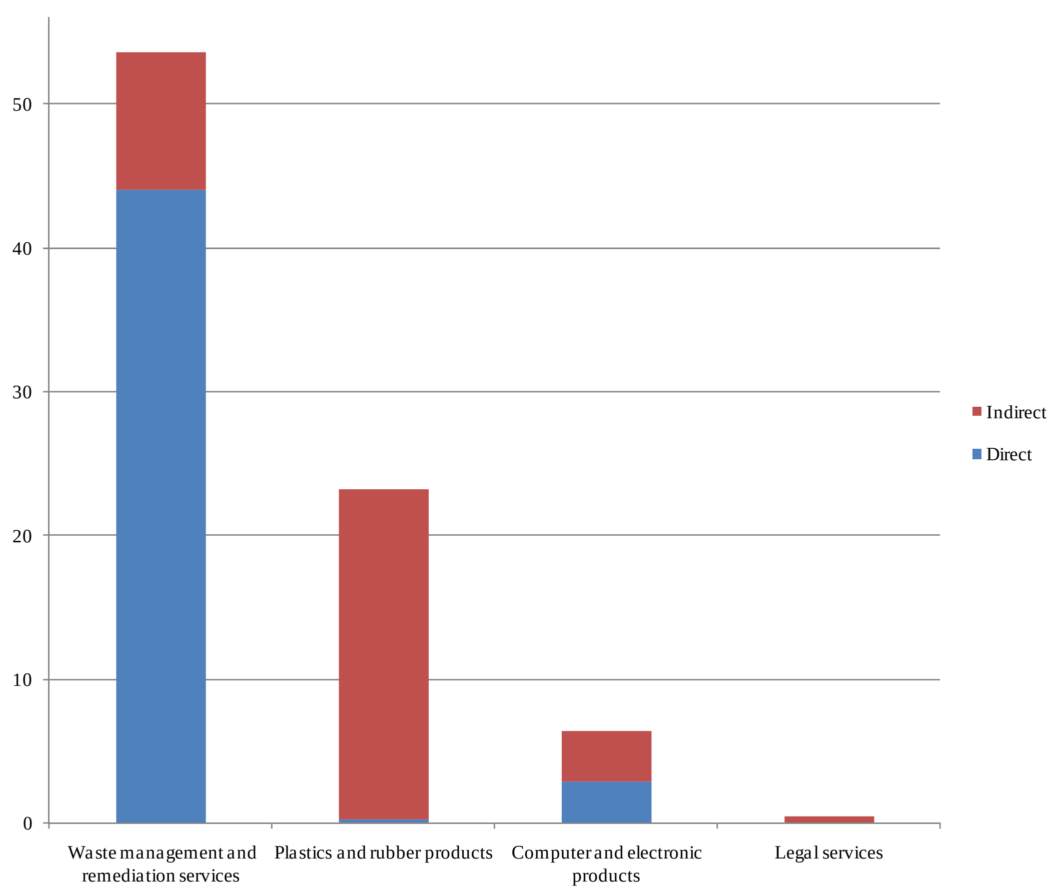


Figure 5: Hazardous Waste Attribution by Final Consumer, Jackson Specification

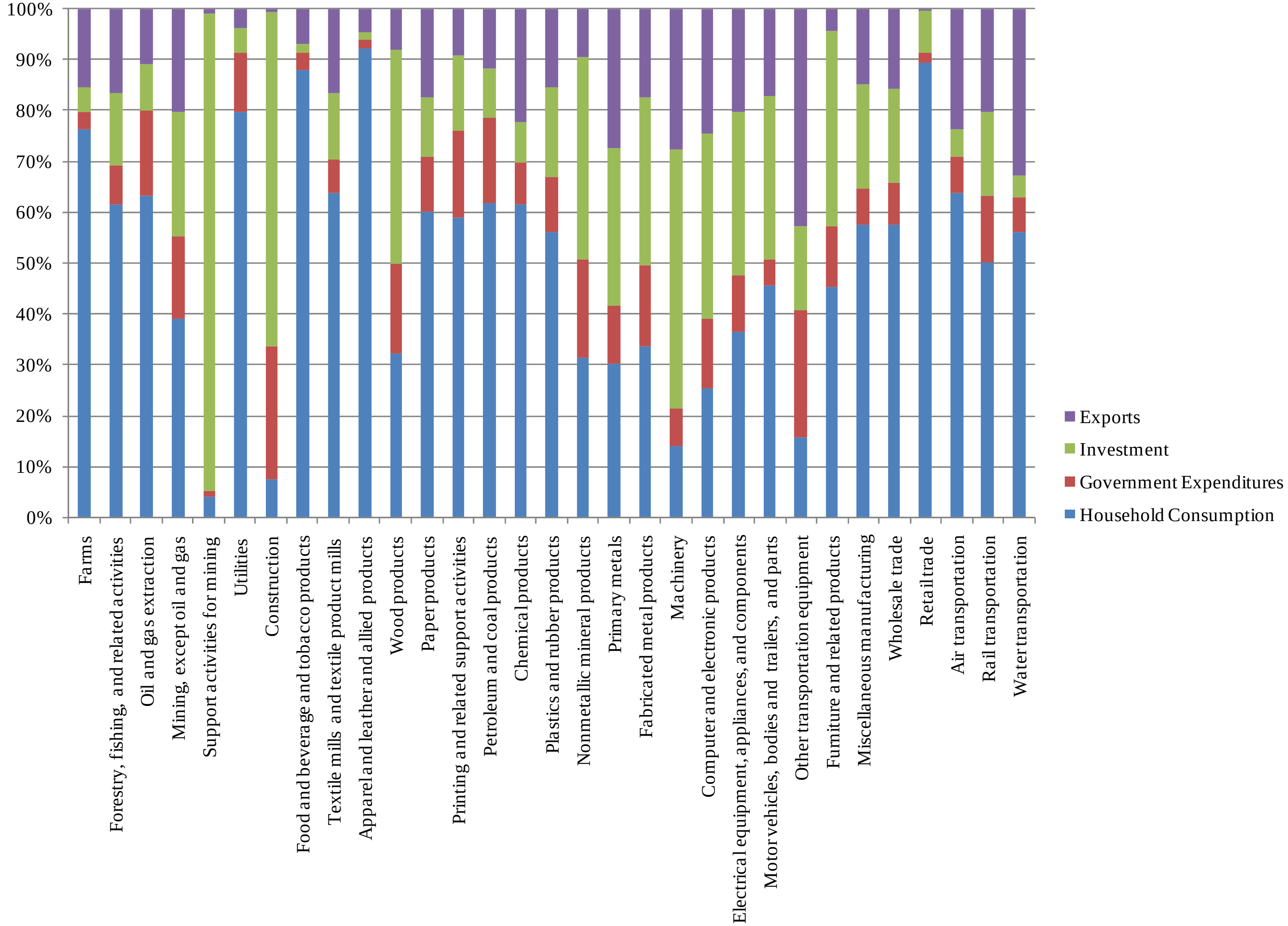


Figure 5: Hazardous Waste Attribution by Final Consumer, Jackson Specification (cntnd.)

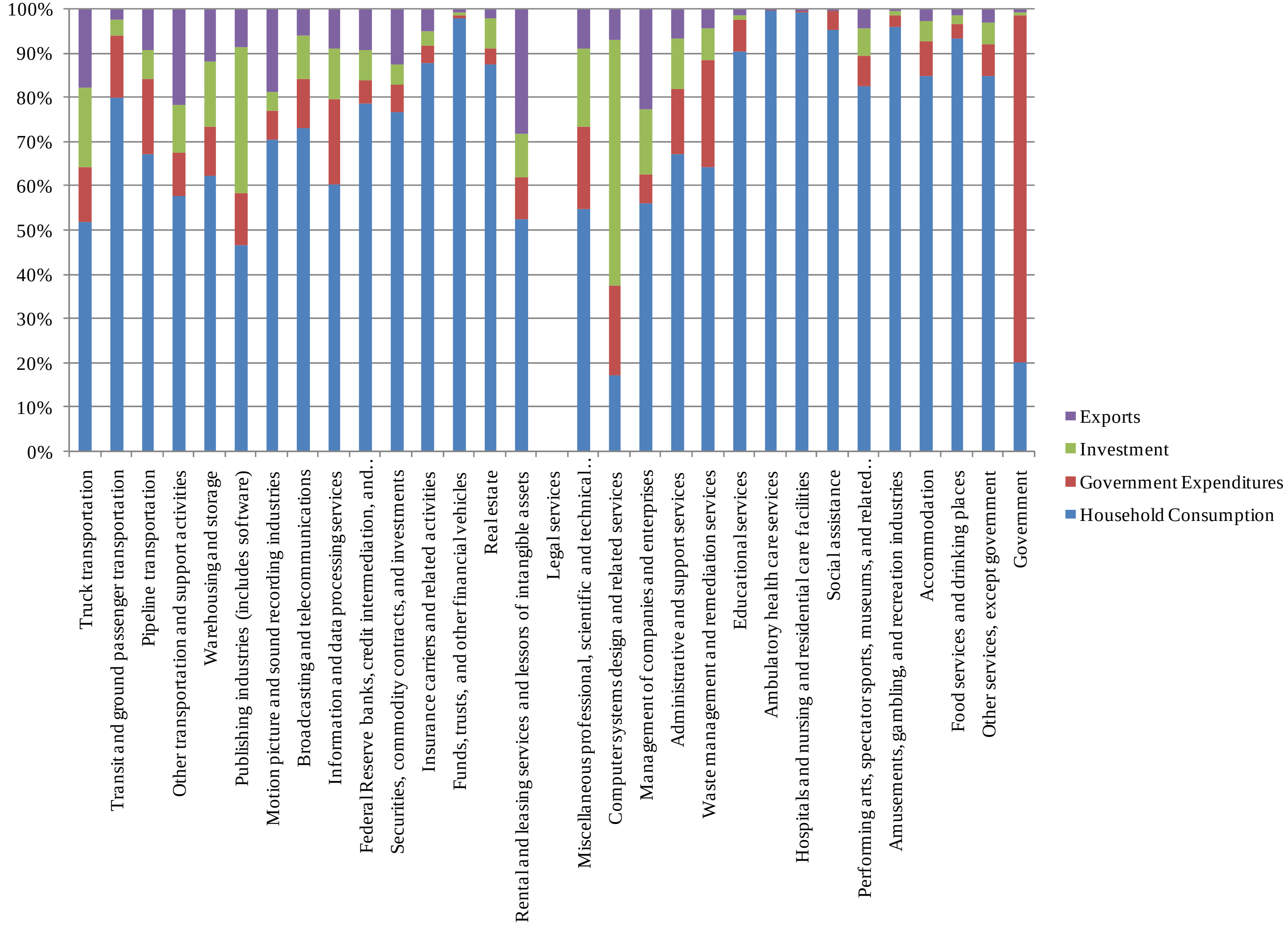


Table 1: Total Waste Generation and Waste Intensity for 2007 by Industry

Sector #	Sector Name	Total Waste Generation	Waste Output Coefficients
1	Farms	1,667.00	0.01
2	Forestry, fishing, and related activities	442.00	0.01
3	Oil and gas extraction	11,990.00	0.04
4	Mining, except oil and gas	4,259.00	0.05
5	Support activities for mining	2,234.00	0.02
6	Utilities	31,605.00	0.07
7	Construction	43,057.00	0.03
8	Food and beverage and tobacco products	4,664.00	0.01
9	Textile mills and textile product mills	6,806.00	0.11
10	Apparel and leather and allied products	6,895.00	0.22
11	Wood products	48,901.00	0.50
12	Paper products	18,305.00	0.11
13	Printing and related support activities	27,813.00	0.28
14	Petroleum and coal products	5,131,780.00	8.83
15	Chemical products	32,958,436.00	52.92
16	Plastics and rubber products	62,896.00	0.31
17	Nonmetallic mineral products	60,961.00	0.52
18	Primary metals	2,443,574.00	10.21
19	Fabricated metal products	1,071,080.00	3.37
20	Machinery	53,916.00	0.17
21	Computer and electronic products	1,096,636.00	2.90
22	Electrical equipment, appliances, and components	257,748.00	2.11
23	Motor vehicles, bodies and trailers, and parts	84,512.00	0.18
24	Other transportation equipment	103,741.00	0.48
25	Furniture and related products	17,146.00	0.22
26	Miscellaneous manufacturing	40,781.00	0.26
27	Wholesale trade	96,358.00	0.08
28	Retail trade	3,643.00	0.00
29	Air transportation	3,730.00	0.02
30	Rail transportation	12,227.00	0.19
31	Water transportation	5,186.00	0.14
32	Truck transportation	2,334.00	0.01
33	Transit and ground passenger transportation	13,410.00	0.43
34	Pipeline transportation	6,379.00	0.18
35	Other transportation and support activities	31,411.00	0.23
36	Warehousing and storage	138,068.00	2.57
37	Publishing industries (includes software)	136.00	0.00
38	Motion picture and sound recording industries	3,851.00	0.04
39	Broadcasting and telecommunications	6,994.00	0.01
40	Information and data processing services	28.00	0.00
41	Federal Reserve banks, credit intermediation, and related activities	30.00	0.00
42	Securities, commodity contracts, and investments	757.00	0.00
43	Insurance carriers and related activities	3.00	0.00
44	Funds, trusts, and other financial vehicles	4.00	0.00
45	Real estate	29,742.00	0.01
46	Rental and leasing services and lessors of intangible assets	13,544.00	0.04
47	Legal services	-	0.00
48	Miscellaneous professional, scientific and technical services	45,465.00	0.04
49	Computer systems design and related services	170.00	0.00
50	Management of companies and enterprises	187.00	0.00
51	Administrative and support services	96,723.00	0.16
52	Waste management and remediation services	3,300,083.00	44.11
53	Educational services	17,375.00	0.09
54	Ambulatory health care services	4,087.00	0.01
55	Hospitals and nursing and residential care facilities	11,599.00	0.02
56	Social assistance	41.00	0.00
57	Performing arts, spectator sports, museums, and related activities	158.00	0.00
58	Amusements, gambling, and recreation industries	1,947.00	0.02
59	Accommodation	81.00	0.00
60	Food services and drinking places	11,472.00	0.02
61	Other services, except government	22,980.00	0.03
62	Government	166,197.00	0.06

Table 2: Breakdown of Type I Industry by Industry Output Hazardous Waste Multipliers

		Direct	Indirect	Total
1	Farms	0.01	6.36	6.37
2	Forestry, fishing, and related activities	0.01	3.13	3.13
3	Oil and gas extraction	0.04	2.29	2.34
4	Mining, except oil and gas	0.05	2.52	2.57
5	Support activities for mining	0.02	3.68	3.70
6	Utilities	0.07	1.24	1.31
7	Construction	0.03	3.31	3.34
8	Food and beverage and tobacco products	0.01	4.13	4.14
9	Textile mills and textile product mills	0.11	17.89	18.00
10	Apparel and leather and allied products	0.22	4.32	4.55
11	Wood products	0.50	3.53	4.02
12	Paper products	0.11	6.76	6.87
13	Printing and related support activities	0.28	4.63	4.91
14	Petroleum and coal products	8.83	4.41	13.24
15	Chemical products	52.92	18.64	71.55
16	Plastics and rubber products	0.31	22.91	23.22
17	Nonmetallic mineral products	0.52	3.62	4.14
18	Primary metals	10.21	6.72	16.93
19	Fabricated metal products	3.37	6.31	9.68
20	Machinery	0.17	5.23	5.40
21	Computer and electronic products	2.90	3.56	6.46
22	Electrical equipment, appliances, and components	2.11	6.55	8.66
23	Motor vehicles, bodies and trailers, and parts	0.18	6.58	6.76
24	Other transportation equipment	0.48	4.54	5.02
25	Furniture and related products	0.22	4.76	4.98
26	Miscellaneous manufacturing	0.26	6.27	6.53
27	Wholesale trade	0.08	0.95	1.03
28	Retail trade	0.00	0.85	0.85
29	Air transportation	0.02	3.62	3.64
30	Rail transportation	0.19	1.84	2.03
31	Water transportation	0.14	1.97	2.11
32	Truck transportation	0.01	2.85	2.86
33	Transit and ground passenger transportation	0.43	2.38	2.80
34	Pipeline transportation	0.18	3.54	3.72
35	Other transportation and support activities	0.23	1.29	1.52
36	Warehousing and storage	2.57	0.73	3.30
37	Publishing industries (includes software)	0.00	1.66	1.66
38	Motion picture and sound recording industries	0.04	1.06	1.10
39	Broadcasting and telecommunications	0.01	1.34	1.35
40	Information and data processing services	0.00	1.66	1.66
41	Federal Reserve banks, credit intermediation, and related activities	0.00	0.54	0.54
42	Securities, commodity contracts, and investments	0.00	0.47	0.47
43	Insurance carriers and related activities	0.00	0.28	0.28
44	Funds, trusts, and other financial vehicles	0.00	0.56	0.56
45	Real estate	0.01	0.94	0.96
46	Rental and leasing services and lessors of intangible assets	0.04	1.18	1.22
47	Legal services	0.00	0.52	0.52
48	Miscellaneous professional, scientific and technical services	0.04	1.52	1.56
49	Computer systems design and related services	0.00	0.60	0.60
50	Management of companies and enterprises	0.00	0.99	1.00
51	Administrative and support services	0.16	1.88	2.04
52	Waste management and remediation services	44.11	9.51	53.61
53	Educational services	0.09	1.33	1.42
54	Ambulatory health care services	0.01	2.58	2.58
55	Hospitals and nursing and residential care facilities	0.02	3.76	3.78
56	Social assistance	0.00	1.82	1.82
57	Performing arts, spectator sports, museums, and related activities	0.00	0.68	0.68
58	Amusements, gambling, and recreation industries	0.02	1.26	1.28
59	Accommodation	0.00	1.42	1.42
60	Food services and drinking places	0.02	1.79	1.81
61	Other services, except government	0.03	2.80	2.83
62	Government	0.06	2.55	2.60

Table 3: Hazardous Waste Attribution by Final Consumer, BEA Specification

		Household Consumption	Government Expenditures	Investment	Net Exports	SUM
1	Farms	1,528	70	102	(31)	**1,668**
2	Forestry, fishing, and related activities	410	56	108	(133)	**441**
3	Oil and gas extraction	20,320	5,269	3,153	(16,751)	**11,991**
4	Mining, except oil and gas	2,276	860	1,463	(338)	**4,260**
5	Support activities for mining	225	60	2,128	(178)	**2,235**
6	Utilities	26,635	3,891	2,121	(1,043)	**31,603**
7	Construction	3,396	11,232	28,477	(50)	**43,055**
8	Food and beverage and tobacco products	4,601	178	94	(212)	**4,662**
9	Textile mills and textile product mills	9,641	815	1,708	(5,357)	**6,807**
10	Apparel and leather and allied products	34,031	588	562	(28,285)	**6,896**
11	Wood products	22,870	11,494	27,466	(12,929)	**48,901**
12	Paper products	14,733	2,679	3,141	(2,248)	**18,305**
13	Printing and related support activities	18,976	5,192	4,846	(1,201)	**27,814**
14	Petroleum and coal products	3,964,927	1,049,917	659,987	(543,052)	**5,131,779**
15	Chemical products	30,645,267	4,161,068	4,761,877	(6,609,781)	**32,958,431**
16	Plastics and rubber products	48,153	9,226	16,601	(11,083)	**62,897**
17	Nonmetallic mineral products	26,677	14,931	31,520	(12,167)	**60,961**
18	Primary metals	1,748,846	576,638	1,698,913	(1,580,824)	**2,443,573**
19	Fabricated metal products	544,283	230,192	512,883	(216,276)	**1,071,081**
20	Machinery	13,474	6,267	40,631	(6,460)	**53,913**
21	Computer and electronic products	562,756	285,318	778,997	(530,436)	**1,096,635**
22	Electrical equipment, appliances, and components	168,713	50,334	150,245	(111,545)	**257,747**
23	Motor vehicles, bodies and trailers, and parts	66,614	7,586	47,156	(36,844)	**84,512**
24	Other transportation equipment	20,299	32,048	21,198	30,196	**103,741**
25	Furniture and related products	11,097	2,900	9,420	(6,271)	**17,146**
26	Miscellaneous manufacturing	38,531	4,724	13,917	(16,390)	**40,781**
27	Wholesale trade	61,240	9,192	21,334	4,592	**96,358**
28	Retail trade	3,269	77	307	(11)	**3,642**
29	Air transportation	2,904	323	291	210	**3,729**
30	Rail transportation	7,350	1,847	2,644	386	**12,227**
31	Water transportation	2,289	281	217	2,400	**5,187**
32	Truck transportation	1,453	334	546	3	**2,335**
33	Transit and ground passenger transportation	10,947	1,921	578	(37)	**13,410**
34	Pipeline transportation	5,069	1,268	601	(559)	**6,379**
35	Other transportation and support activities	19,310	3,269	4,046	4,788	**31,413**
36	Warehousing and storage	101,673	18,733	27,454	(9,792)	**138,068**
37	Publishing industries (includes software)	69	17	49	2	**137**
38	Motion picture and sound recording industries	2,968	285	208	390	**3,851**
39	Broadcasting and telecommunications	5,330	829	808	26	**6,993**
40	Information and data processing services	19	6	4	0	**29**
41	Federal Reserve banks, credit intermediation, and related activities	25	2	3	1	**30**
42	Securities, commodity contracts, and investments	600	51	41	65	**757**
43	Insurance carriers and related activities	3	0	0	(0)	**3**
44	Funds, trusts, and other financial vehicles	4	0	0	(0)	**4**
45	Real estate	26,384	1,167	2,205	(15)	**29,741**
46	Rental and leasing services and lessors of intangible assets	8,371	1,551	1,728	1,895	**13,545**
47	Legal services	-	-	-	-	**-**
48	Miscellaneous professional, scientific and technical services	27,992	9,280	9,488	(1,297)	**45,464**
49	Computer systems design and related services	35	36	98	1	**170**
50	Management of companies and enterprises	124	16	37	11	**188**
51	Administrative and support services	69,275	14,716	12,987	(253)	**96,724**
52	Waste management and remediation services	2,288,617	837,783	305,571	(131,889)	**3,300,082**
53	Educational services	15,912	1,225	266	(28)	**17,375**
54	Ambulatory health care services	4,078	10	1	(0)	**4,088**
55	Hospitals and nursing and residential care facilities	11,514	83	1	(0)	**11,597**
56	Social assistance	41	2	0	(0)	**43**
57	Performing arts, spectator sports, museums, and related activities	134	12	12	(1)	**157**
58	Amusements, gambling, and recreation industries	1,879	50	22	(4)	**1,947**
59	Accommodation	70	7	4	(1)	**81**
60	Food services and drinking places	10,834	396	264	(22)	**11,472**
61	Other services, except government	20,172	1,720	1,469	(443)	**22,918**
62	Government	34,505	130,304	1,699	(312)	**166,196**
	SUM	**40,763,740**	**7,510,322**	**9,213,695**	**(9,849,582)**	**47,638,176**

**Parentheses indicate a negative value*

Table 4: Hazardous Waste Attribution by Final Consumer, BEA Specification (Percentage)

		Household Consumption	Government Expenditures	Investment	Net Exports	SUM
1	Farms	92%	4%	6%	-2%	100%
2	Forestry, fishing, and related activities	93%	13%	24%	-30%	100%
3	Oil and gas extraction	169%	44%	26%	-140%	100%
4	Mining, except oil and gas	53%	20%	34%	-8%	100%
5	Support activities for mining	10%	3%	95%	-8%	100%
6	Utilities	84%	12%	7%	-3%	100%
7	Construction	8%	26%	66%	0%	100%
8	Food and beverage and tobacco products	99%	4%	2%	-5%	100%
9	Textile mills and textile product mills	142%	12%	25%	-79%	100%
10	Apparel and leather and allied products	494%	9%	8%	-410%	100%
11	Wood products	47%	24%	56%	-26%	100%
12	Paper products	80%	15%	17%	-12%	100%
13	Printing and related support activities	68%	19%	17%	-4%	100%
14	Petroleum and coal products	77%	20%	13%	-11%	100%
15	Chemical products	93%	13%	14%	-20%	100%
16	Plastics and rubber products	77%	15%	26%	-18%	100%
17	Nonmetallic mineral products	44%	24%	52%	-20%	100%
18	Primary metals	72%	24%	70%	-65%	100%
19	Fabricated metal products	51%	21%	48%	-20%	100%
20	Machinery	25%	12%	75%	-12%	100%
21	Computer and electronic products	51%	26%	71%	-48%	100%
22	Electrical equipment, appliances, and components	65%	20%	58%	-43%	100%
23	Motor vehicles, bodies and trailers, and parts	79%	9%	56%	-44%	100%
24	Other transportation equipment	20%	31%	20%	29%	100%
25	Furniture and related products	65%	17%	55%	-37%	100%
26	Miscellaneous manufacturing	94%	12%	34%	-40%	100%
27	Wholesale trade	64%	10%	22%	5%	100%
28	Retail trade	90%	2%	8%	0%	100%
29	Air transportation	78%	9%	8%	6%	100%
30	Rail transportation	60%	15%	22%	3%	100%
31	Water transportation	44%	5%	4%	46%	100%
32	Truck transportation	62%	14%	23%	0%	100%
33	Transit and ground passenger transportation	82%	14%	4%	0%	100%
34	Pipeline transportation	79%	20%	9%	-9%	100%
35	Other transportation and support activities	61%	10%	13%	15%	100%
36	Warehousing and storage	74%	14%	20%	-7%	100%
37	Publishing industries (includes software)	50%	13%	36%	1%	100%
38	Motion picture and sound recording industries	77%	7%	5%	10%	100%
39	Broadcasting and telecommunications	76%	12%	12%	0%	100%
40	Information and data processing services	65%	20%	14%	1%	100%
41	Federal Reserve banks, credit intermediation, and related activities	82%	6%	8%	3%	100%
42	Securities, commodity contracts, and investments	79%	7%	5%	9%	100%
43	Insurance carriers and related activities	98%	5%	4%	-8%	100%
44	Funds, trusts, and other financial vehicles	99%	1%	1%	-1%	100%
45	Real estate	89%	4%	7%	0%	100%
46	Rental and leasing services and lessors of intangible assets	62%	11%	13%	14%	100%
47	Legal services	0%	0%	0%	0%	0%
48	Miscellaneous professional, scientific and technical services	62%	20%	21%	-3%	100%
49	Computer systems design and related services	20%	21%	58%	1%	100%
50	Management of companies and enterprises	66%	8%	20%	6%	100%
51	Administrative and support services	72%	15%	13%	0%	100%
52	Waste management and remediation services	69%	25%	9%	-4%	100%
53	Educational services	92%	7%	2%	0%	100%
54	Ambulatory health care services	100%	0%	0%	0%	100%
55	Hospitals and nursing and residential care facilities	99%	1%	0%	0%	100%
56	Social assistance	95%	5%	0%	0%	100%
57	Performing arts, spectator sports, museums, and related activities	85%	7%	7%	0%	100%
58	Amusements, gambling, and recreation industries	97%	3%	1%	0%	100%
59	Accommodation	87%	8%	6%	-1%	100%
60	Food services and drinking places	94%	3%	2%	0%	100%
61	Other services, except government	88%	8%	6%	-2%	100%
62	Government	21%	78%	1%	0%	100%
	SUM	86%	16%	19%	-21%	100%

Table 5: Hazardous Waste Attribution by Final Consumer, Jackson Specification

		Household Consumption	Government Expenditures	Investment	Exports	SUM
1	Farms	1,273	55	82	258	**1,668**
2	Forestry, fishing, and related activities	271	34	63	73	**441**
3	Oil and gas extraction	7,582	2,025	1,084	1,300	**11,991**
4	Mining, except oil and gas	1,660	698	1,038	865	**4,260**
5	Support activities for mining	88	25	2,104	18	**2,235**
6	Utilities	25,250	3,619	1,591	1,144	**31,603**
7	Construction	3,224	11,197	28,394	239	**43,055**
8	Food and beverage and tobacco products	4,107	156	75	324	**4,662**
9	Textile mills and textile product mills	4,339	454	890	1,124	**6,807**
10	Apparel and leather and allied products	6,359	116	108	313	**6,896**
11	Wood products	15,703	8,703	20,571	3,923	**48,901**
12	Paper products	10,993	2,018	2,090	3,204	**18,305**
13	Printing and related support activities	16,404	4,767	4,071	2,571	**27,814**
14	Petroleum and coal products	3,174,394	867,562	487,009	602,810	**5,131,776**
15	Chemical products	20,306,142	2,679,446	2,638,684	7,334,171	**32,958,443**
16	Plastics and rubber products	35,214	6,825	11,106	9,752	**62,897**
17	Nonmetallic mineral products	19,084	11,745	24,346	5,787	**60,961**
18	Primary metals	739,271	274,879	761,277	668,145	**2,443,572**
19	Fabricated metal products	359,235	170,334	354,581	186,930	**1,071,080**
20	Machinery	7,527	4,028	27,496	14,861	**53,913**
21	Computer and electronic products	278,396	148,108	401,702	268,429	**1,096,636**
22	Electrical equipment, appliances, and components	94,053	28,480	83,339	51,877	**257,748**
23	Motor vehicles, bodies and trailers, and parts	38,468	4,335	27,346	14,363	**84,512**
24	Other transportation equipment	16,116	26,284	17,032	44,310	**103,741**
25	Furniture and related products	7,768	2,038	6,630	711	**17,146**
26	Miscellaneous manufacturing	23,438	2,909	8,427	6,007	**40,781**
27	Wholesale trade	55,477	7,958	17,869	15,055	**96,358**
28	Retail trade	3,254	74	300	14	**3,642**
29	Air transportation	2,382	258	204	885	**3,729**
30	Rail transportation	6,142	1,604	2,005	2,475	**12,227**
31	Water transportation	2,916	344	223	1,705	**5,187**
32	Truck transportation	1,213	286	425	411	**2,335**
33	Transit and ground passenger transportation	10,732	1,877	476	325	**13,410**
34	Pipeline transportation	4,289	1,091	421	577	**6,379**
35	Other transportation and support activities	18,211	3,049	3,424	6,729	**31,413**
36	Warehousing and storage	85,960	15,713	20,199	16,196	**138,068**
37	Publishing industries (includes software)	64	16	45	12	**137**
38	Motion picture and sound recording industries	2,718	254	164	716	**3,851**
39	Broadcasting and telecommunications	5,112	783	695	403	**6,993**
40	Information and data processing services	17	6	3	3	**29**
41	Federal Reserve banks, credit intermediation, and related activities	24	2	2	3	**30**
42	Securities, commodity contracts, and investments	582	48	33	94	**757**
43	Insurance carriers and related activities	2	0	0	0	**3**
44	Funds, trusts, and other financial vehicles	4	0	0	0	**4**
45	Real estate	26,032	1,101	2,054	555	**29,741**
46	Rental and leasing services and lessors of intangible assets	7,129	1,259	1,348	3,808	**13,545**
47	Legal services	-	-	-	-	**-**
48	Miscellaneous professional, scientific and technical services	24,899	8,583	7,968	4,014	**45,464**
49	Computer systems design and related services	29	35	94	11	**170**
50	Management of companies and enterprises	105	12	28	42	**188**
51	Administrative and support services	65,233	13,969	11,315	6,206	**96,724**
52	Waste management and remediation services	2,124,519	801,617	232,201	141,755	**3,300,091**
53	Educational services	15,753	1,200	213	209	**17,375**
54	Ambulatory health care services	4,077	10	1	0	**4,088**
55	Hospitals and nursing and residential care facilities	11,513	83	1	1	**11,597**
56	Social assistance	41	2	0	0	**43**
57	Performing arts, spectator sports, museums, and related activities	130	11	10	6	**157**
58	Amusements, gambling, and recreation industries	1,871	49	18	9	**1,947**
59	Accommodation	69	6	4	2	**81**
60	Food services and drinking places	10,725	373	210	163	**11,472**
61	Other services, except government	19,510	1,601	1,147	660	**22,918**
62	Government	33,684	130,156	1,370	986	**166,196**
	SUM	**27,740,781**	**5,254,268**	**5,215,608**	**9,427,535**	**47,638,193**

Table 6: Hazardous Waste Attribution by Final Consumer, Jackson Specification (Percentage)

		Household Consumption	Government Expenditures	Investment	Exports	SUM
1	Farms	76%	3%	5%	15%	100%
2	Forestry, fishing, and related activitie:	62%	8%	14%	16%	100%
3	Oil and gas extraction	63%	17%	9%	11%	100%
4	Mining, except oil and gas	39%	16%	24%	20%	100%
5	Support activities for mining	4%	1%	94%	1%	100%
6	Utilities	80%	11%	5%	4%	100%
7	Construction	7%	26%	66%	1%	100%
8	Food and beverage and tobacco products	88%	3%	2%	7%	100%
9	Textile mills and textile product mill:	64%	7%	13%	17%	100%
10	Apparel and leather and allied products	92%	2%	2%	5%	100%
11	Wood products	32%	18%	42%	8%	100%
12	Paper products	60%	11%	11%	18%	100%
13	Printing and related support activities	59%	17%	15%	9%	100%
14	Petroleum and coal products	62%	17%	9%	12%	100%
15	Chemical products	62%	8%	8%	22%	100%
16	Plastics and rubber products	56%	11%	18%	16%	100%
17	Nonmetallic mineral products	31%	19%	40%	9%	100%
18	Primary metals	30%	11%	31%	27%	100%
19	Fabricated metal products	34%	16%	33%	17%	100%
20	Machinery	14%	7%	51%	28%	100%
21	Computer and electronic products	25%	14%	37%	24%	100%
22	Electrical equipment, appliances, and components	36%	11%	32%	20%	100%
23	Motor vehicles, bodies and trailers, and parts	46%	5%	32%	17%	100%
24	Other transportation equipment	16%	25%	16%	43%	100%
25	Furniture and related products	45%	12%	39%	4%	100%
26	Miscellaneous manufacturing	57%	7%	21%	15%	100%
27	Wholesale trade	58%	8%	19%	16%	100%
28	Retail trade	89%	2%	8%	0%	100%
29	Air transportation	64%	7%	5%	24%	100%
30	Rail transportation	50%	13%	16%	20%	100%
31	Water transportation	56%	7%	4%	33%	100%
32	Truck transportation	52%	12%	18%	18%	100%
33	Transit and ground passenger transportation	80%	14%	4%	2%	100%
34	Pipeline transportation	67%	17%	7%	9%	100%
35	Other transportation and support activities	58%	10%	11%	21%	100%
36	Warehousing and storage	62%	11%	15%	12%	100%
37	Publishing industries (includes software)	47%	12%	33%	9%	100%
38	Motion picture and sound recording industrie:	71%	7%	4%	19%	100%
39	Broadcasting and telecommunications	73%	11%	10%	6%	100%
40	Information and data processing services	61%	19%	11%	9%	100%
41	Federal Reserve banks, credit intermediation, and related activities	79%	5%	7%	9%	100%
42	Securities, commodity contracts, and investments	77%	6%	4%	12%	100%
43	Insurance carriers and related activities	88%	4%	3%	5%	100%
44	Funds, trusts, and other financial vehicles	98%	1%	0%	1%	100%
45	Real estate	88%	4%	7%	2%	100%
46	Rental and leasing services and lessors of intangible assets	53%	9%	10%	28%	100%
47	Legal services	0%	0%	0%	0%	0%
48	Miscellaneous professional, scientific and technical services	55%	19%	18%	9%	100%
49	Computer systems design and related services	17%	20%	56%	7%	100%
50	Management of companies and enterprises	56%	6%	15%	22%	100%
51	Administrative and support services	67%	14%	12%	6%	100%
52	Waste management and remediation service:	64%	24%	7%	4%	100%
53	Educational services	91%	7%	1%	1%	100%
54	Ambulatory health care services	100%	0%	0%	0%	100%
55	Hospitals and nursing and residential care facilities	99%	1%	0%	0%	100%
56	Social assistance	95%	5%	0%	0%	100%
57	Performing arts, spectator sports, museums, and related activities	83%	7%	6%	4%	100%
58	Amusements, gambling, and recreation industries	96%	2%	1%	0%	100%
59	Accommodation	85%	8%	4%	3%	100%
60	Food services and drinking places	93%	3%	2%	1%	100%
61	Other services, except government	85%	7%	5%	3%	100%
62	Government	20%	78%	1%	1%	100%
	SUM	58%	11%	11%	20%	100%