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Examining Responsibility for Environmental Harm: Public Discourse and E-Waste Management Systems in a Developed Nation

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EXAMINING RESPONSIBILITY FOR ENVIRONMENTAL HARM: PUBLIC DISCOURSE AND E-WASTE MANAGEMENT SYSTEMS IN A DEVELOPED NATION

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Abstract

Canadian e-waste management practices have not yet achieved high levels of environmental performance. Our methodology is based on information systems research, organization studies, and critical theory. We find evidence that – absent of strong environmental regulations – management systems designed by industry may become based on contradictory notions of responsibility (corporate, social, environmental, legal, fiscal). We posit that if such contradictions exist, the system will lack coherence, and will ultimately be unable to achieve high levels of environmental performance. Using a mixed-methods research design including critical discourse analysis and two-stage least squares regression – we offer an empirical method of environmental impact measurement – and, we conduct a comprehensive assessment of e-waste management practices in Canada in order to adequately observe and measure actual environmental benefit as impact on per capita CO_2. Comments are provided with implications for further management and academic research.

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1 Introduction

1.1 Green information systems

Green information systems (hereafter, IS) is a nascent topic of scholarship that crosses the domains of organization studies, information systems research, among others. In Jenkin, Webster and McShane (2010) a multilevel framework is developed to examine issues of sustainability from the perspective of organization studies; however, notably, their framework does not extend to social systems level of analysis. While recognizing this gap, Jenkin et al. depict the availability of literature examining societal levels impacts as sparse, and acknowledge the critical need for green IS research at the societal level (Jenkin, Webster, & McShane, 2010). Measuring environmental impacts is presented as a chief research challenge; and a call is put out for good research into green IS built on empirical research methods(Jenkin, Webster, & McShane, 2010).

In Melville (2010), the principal thesis is put forth that IS research can lead to important contributions to our knowledge of complex problems involving information, organizations, and the natural environment. According to Melville, information systems innovation has a crucial role to play in supporting environmental sustainability at both the organization and social levels; however many approaches to environmental sustainability do not incorporate IS perspectives (Melville, 2010). Melville sets out a research agenda, providing a comprehensive assessment of the theoretical terrain ahead. A full discussion of his article can be found in section 2.1.

This present study is based on one of Melville's recommendations regarding the life-cycle analysis of information communication technology (ICT) goods. Citing the ubiquity, short product life-span, and toxic materials content of ICT goods, a life-cycle analysis (LCA) is recommended as a relevant and useful research method – one that may provide research findings that ultimately improves our knowledge about sustainability. A full literature search on this topic is presented in chapter 2. Briefly, the LCA method measures the life-time deleterious environmental impacts of ICT goods – throughout the entire product life-cycle, inclusive of the entire value chain from extraction industries and manufacturing, to retail, through consumption, and ultimately inclusive of end-of-life (e.g. landfill, incineration, export, or domestic e-waste recycling).

In the literature, LCA is often combined with other models such as materials flow analysis (MFA) in order to extrapolate these product-level findings to estimate the total environmental impact of these systems. Notably, McLaren, Wright, Parkinson and Jackson (1999) use energy as a first-order indicator to measure the environmental performance of cell-phone recycling systems in Sweden and the United Kingdom. They affirm that the LCA model has high relevance to regulatory or industrial decision-making (McLaren, Wright, Parkinson, & Jackson, 1999). In Hischier, Wager, and Gauglhofer (2005), LCA and MFA are combined and used to estimate the total environmental impact of e-waste management systems across a variety of impact categories, including CO_2 emissions. The Hischier et al. study demonstates that e-waste management systems are generally good from an environmental perspective (Hischier, Wager, & Gauglhofer, 2005).

As reviewed in the literature search (chapter 2), we find broad application of the LCA method in professional and academic literatures on e-waste management. Nonetheless, the LCA method is inherently product-centric and requires additional methods to extrapolate findings in order to estimate a systems' total environmental impact. When extrapolated to the level of social systems analysis, the LCA method may inadequately represent actual impacts; as warranted by Barba-Gutierrez, Adenso-Diaz and Hopp's discusison of transportation costs(Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008).

Anticipating the argument that we have developed in chapters 3 and 4, environmental sustainability depends on a shared responsibility whose degree of coherence may be hidden from positivist research methods. Thus, we shift our analysis from the product-centric LCA method; and develop an empirical method of environmental impact measurement that we believe represents an important methodological contribution to IS research on environmental sustainability.

In Melville (2010), a relevant theoretical framework is provided; belief-action-outcome (BAO), shown in Figure A-2. The BAO framework tells us that the sustainability behaviour of social systems will be impacted by what its members believe, and how they act. To understand and fully evaluate environmental or financial performance outcomes – for instance, of e-waste management systems – we must evaluate both cognitive states regarding sustainability and actual actions undertaken by organizations or individuals as part of sustainability practices or processes (Melville, 2010). We will use this framework to assist in the selection of an appropriate research design and strategy, as outlined in chapter 4.

Using the BAO framework to focus in on e-waste management systems in Canada, we intend to demonstate that in the absence of strong environmental regulations, attempts by industry to address environmental responsibility may result in systems that are unable to achieve high levels of environment performance, and whose design is based on incoherent notions of responsibility (corporate, social, environmental, legal, fiscal).

1.2 Organization of the thesis

This thesis is divided into eight chapters. This chapter describes the critical intention of the research, and introduces the research topic chosen for study.

The second chapter provides a full review of scholarly literature and professional reports on e-waste management. In many instances the extant literature recognizes the linkages between e-waste systems and per capita CO_2. The methods commonly found in academic and professional practice alike are life-cycle analysis and materials flow analysis; both are discussed in chapter 2. Often these two methods

are combined and used to measure the performance of e-waste management systems; refer to section 2.2.1. Additionally, we introduce the BAO framework (Figure A-2) and use this theoretical framework to identify connections among the topics being researched.

Chapter 3 articulates the research problem and situates the study within the domain of information systems research for environmental sustainability. Hypotheses are then identified for testing.

Chapter 4 discusses the research methodology and design. The research is to be understood from the perspective of information systems research. The first half of the fourth chapter provides a literature survey on appropriate research methodologies. Given the social nature of our study (as will be described in chapter 3), it has been deemed necessary to use two research methods. The remainder of the fourth chapter sets out a fitting research strategy for this and argues for the particular design choices made.

The results from the first method are presented in chapter 5; results from the second method in chapter 6. In chapter 7, a full analysis is provided on the research topic in light of the findings from both research methods. The thesis concludes with consideration for future research, and a specification of the study's (intended) contribution academic and management research and practice.

Chapter 8 contains the appendices and includes all figures with the prefix Figure A-*x*.

2 Review of the literature

2.1 Information systems research for environmental sustainability

Environmental sustainability is an expansive topic of research. As of autumn 2011, the Social Sciences Citation Index hosted a total of 1,235 articles that included the text "Environmental Sustainability", spanning over one hundred different domains of academic research. Although the topic of environmental sustainability has received limited coverage in information system research, several leading researchers have developed comprehensive frameworks for information systems research into environmental sustainability(Melville, 2010; Dedrick, 2010; Jenkin, Webster, & McShane, 2010). Articulated by Melville: "[I]nformation systems research can make an important contribution to the knowledge at the nexus of information, organizations, and the natural environment" (Melville, 2010, p. 1). There is general consensus that while the research in this area is yet nascent, IS has a crucial role to play in achieving environmental sustainability.

In Murugesan (2008), the research question of how to mitigate the environmental impact of information technology (hereafter, Green IT) is explored: "Green IT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling" (Murugesan, 2008, pp. 24-25). Although broadly defined, the concept of Green IT is put forth as a relevant and persisting topic for enterprise and strategic management research. A general discussion is offered from the perspective of organizations using strategies to reduce the environmental impact of their IT systems(Murugesan, 2008). In Watson, Boudreau, Chen and Huber (2008) two concepts and research streams are identified: Green IT; and, Green IS. Whereas the former is described in terms similar to Murugesan and limited to energy efficiency of IT systems, Green IS refers "to the design and implementation of information systems that contribute to sustainable business processes" (Watson R. T., Boudreau, Chen, & Huber, 2008, p. 2).

In Dedrick (2010), a synthesis of the existing literature on IS and environmental sustainability is presented. Building on prior research of Watson and Murugesan, Dedrick provides the following

summary: "Green IS refers to the use of information systems to achieve environmental objectives, while Green IT emphasizes reducing the environmental impacts of IT production and use" (Dedrick, 2010, p. 173). While explorative, the Dedrick article discusses Green IS and Green IT from the perspective of corporate management. It is suggested that IS scholarship has a major role to play providing analysis for policymakers and leaders of organizations. However, the quantitative impacts of IT and information communication technology (hereafter, ICT) on the environment must also be addressed.

One way to extrapolate and measure environmental performance of social systems is to measure carbon productivity. In Dewan and Kraemer (2000) evidence is cited that investments in IT capital can be attributed to an increase in total factor productivity of the national economy; for instance, an anecdotal example is given where a transportation company could lower CO_2 emissions through the use of IT by optimizing the transportation routes used (Dedrick, 2010). Further research is needed to support these assertions. Jenkin, Webster, and McShane (2010) offer a multilevel researcher framework to guide research on Green IT/IS research and to connect this scholarship with "the more well-established environmental sustainability literatures in management, environmental psychology, and social marketing" (Jenkin, Webster, & McShane, 2010, p. 2). To this stated end Jenkin et al. conducted an in-depth literature search and a total of 20 scholarly articles and 18 conference and working papers were selected, of which about one quarter based on strong theoretical grounding. An iterative, reflexive reading and coding process supported the development of a multilevel research framework(Jenkin, Webster, & McShane, 2010). Four main components were identified: environmental sustainability motivating forces; environmental sustainability initiatives; environmental orientation; and, environmental impacts. As can be clearly observed, Jenkin et al. focus on impacts within organizations and do not include social systems' impacts.

In Watson et al. (2010) IS is recognized as the single most important force that has led productivity improvements over the past half century(Watson, Boudreau, & Chen, Information systems and environmentally sustainable development: energy informatics and new directions for the IS community, 2010). Watson et al. call for descriptive, explanatory, and predictive research on IS and

environmental sustainability; holding an underlying assumption that IS research can reduce energy consumption. Their principle hypothesis is that a new subfield of IS on energy informatics is warranted; the core idea summarized as: 'Energy + Information < Energy'(Watson, Boudreau, & Chen, Information systems and environmentally sustainable development: energy informatics and new directions for the IS community, 2010). The use of IS to reduce energy impacts is a crucial research aim.

Melville (2010) sets forth a research agenda to open a new discourse on IS innovation for environmental sustainability. Taking a comprehensive search strategy, Melville conducted a literature search of the five leading IS and operations research journals over the period of eight years including 2000-2007. A total of 35 articles were selected for analysis; ultimately revealing three principal topics(Melville, 2010). The first group examines the antecedents that promote or inhibit the adoption of sustainable business practices. The second group examines the relationship between sustainability practices and organizational or environmental performance measures. The third group examines the topic of the sustainability of supply chains. Having characterized the scope and research topics already covered in the literature, Melville develops a theoretical framework - belief-action-outcome (BAO) shown in Figure A-2(in the appendices) - to explain the underlying micro and macro processes impacting sustainability performance of social systems or organizations.

The BAO framework enables the IS research community to identify the linkages between societal and organizational beliefs and actions regarding sustainability. It includes three factors: individual and organizational beliefs or cognitive states about the environment; those actions enacted as part of sustainability practices or processes; and, the outcome or behaviour of social systems or organizations with respect to environmental sustainability (Melville, 2010). With respect to the present study, the BAO framework provides theoretical backing for the necessary claim that the beliefs and actions of social actors directly impact the performance outcomes and efficiency of e-waste management systems in Canada (link 3, Figure A-2). The application of this framework to the present study will be discussed further in section 4.5.1.

2.2 E-WASTE MANAGEMENT IN THE LITERATURE

2.2.1 MODELS TO CALCULATE E-WASTE FLOW VOLUME AND ENVIRONMENTAL IMPACT

Life-cycle analysis(hereafter, LCA) is a commonly used method within the literature on e-waste. As of autumn 2011, the Social Sciences Citation Index contains at total of 3,126 articles that mention this method. In the majority of publications on the topic of e-waste management, LCA analysis is conducted using proprietary software called SimaPro, versions 5.0, 6.0, and 7.0. Barba-Gutierrez, Adenso-Diaz, and Hopp (2008) provide a clear description for the technique: "[A] process for assessing the consumption of resources, environmental impacts and waste generation associated with the entire life cycle of a product, process or activity, encompassing (1) extracting and processing raw materials, (2) manufacturing, transportation and distribution (3) use, reuse, maintenance and (4) recycling and final disposal" (Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008, p. 484).Hence, the LCA method can accurately measure the full life-time impacts at each product phase as described. These studies provide a crucial scientific foundation on which to build subsequent research claims.

Measuring the environmental impacts of a given product (such as a mobile cellular phone) is a first step. The second step is to determine the volumes of such devices that are generated. Matthews et al. (1997) provide a basic model that uses sales data to estimate e-waste flow volumes. The model demonstrates the life cycle of PCs as a flow process from owner, to storage or reuse (e.g. PC donated to charity), with disposal to landfill as final end-point (Matthews, McMichael, Hendrickson, & Hart, 1997). This model understands recycling in terms of reuse and does not allow for precious metals recovery.

In McLaren et al. (1999) a LCA study in conducted on a pilot cell phone 'take-back' scheme in Sweden and the United Kingdom. The researchers develop two models: a static model, and; a time-series model that allows for more dynamic predictive capability. McLaren et al. (1999) combine LCA with additional methods to accurately quantify the volume and total impact of e-waste in terms of environmental costs associated with various policy decisions. Importantly, McLaren et al. use energy as a first-order indicator (as energy avoided due to e-waste management); and thus, demonstrate that outputs of e-

waste management systems have a positive net impact in energy equivalents (McLaren, Wright, Parkinson, & Jackson, 1999).

The results of the static model in McLaren et al. demonstrates a 'snap-shot' of the energy balance of a cell phone that has been recovered via a pilot 'take-back' program in operation at the time. They consider three product types: i) products on the market prior to 1992; ii) products released onto the market between 1992 and 1994; and, iii) products released onto the market between 1995 and 1996. The majority of the lifetime energy impacts all occur during raw materials extraction and product manufacturing – prior to the device ever being turned on by an end-user. Of particular relevance is the year of product production. McLaren et al. (1999) explain how the total environmental impact of a particular ICT good – a cellular phone – has actually decreased as product innovations have resulted in smaller, lighter devices that contain increasingly smaller amounts of recoverable metals potential (McLaren, Wright, Parkinson, & Jackson, 1999). Despite the declining incremental benefits of product recovery, collections, and recycling, McLaren et al. find cell phone take-back programs are generally positive in effect; and, if described in terms of energy consumption – e-waste management systems have generally positive benefits from an environmental perspective (McLaren, Wright, Parkinson, & Jackson, 1999).

Isaacs, Gupta and Boon (2000) provide a similar research design to McLaren et al. (1999). Modeling the life cycle of personal computers (PCs), the researchers explore our topic from the perspective of a net-cost function as incurred by the recycling processor. Based on the assumptions held by the researchers at the time, PC recycling was found to be unprofitable: no direct economic incentive to recycle was found(Isaacs, Gupta, & Boon, 2000). Nonetheless, the methodology deployed by Isaacs et al. makes no allowance for the presence of an Extended Producer Responsibility (EPR) framework and associated 'product stewardship' fees. In the case of Canada, and many other jurisdictions, modifications would be required of this net-cost function to allow wider applicability. Potentially, e-waste collections and recycling does generate economic value. However, additional research would be required to demonstrate *when* it is profitable and for *whom*.

Macauley, Palmer and Shih (2003) provide the earliest study into e-waste management found in the Social Sciences Citation Index. This study aims to measure the environmental costs and benefits associated with the end-of-life management of a particular product, cathode ray tube (CRT) computer monitors. CRT monitors contain lead and other heavy metals that could be released to the human and social environment if not properly disposed of. Their study estimates the frequency of end-of-life disposal options chosen for computer monitors. Using the assumption a lowest cost option will always be selected, the researchers conducted a simulation in which they construct a Monte Carlo simulation using a sample of 2000 members.

An important question of the research is whether, at the end of its useful life, will a CRT monitor will be recycled or discarded to landfill? The CRT monitor contains no precious metals; moreover, it contains heavy metals that can be costly to extract and offer low marginal value in a secondary materials market. This means that the private recycling of CRT monitors has a high net cost. The research is based on a rigorous LCA analyses, and suggests that absent of strong regulations, few used monitors will be recycled. Furthermore, they further suggest that health effects or cost of incineration of CRT monitors (about $1/unit, only if incinerated, or negligible if disposed in modern landfill facility) has been met by $20/unit estimated cost of a complete ban on monitor landfill and incineration; whereas the cost of an incineration-only ban would be $3/unit (Macauley, Palmer, & Shih, 2003).

Socolof, Overly and Geibig (2005) provide a rigorous comparative environmental impact study on computer monitor technologies - liquid crystal display (LCD), and previous generation cathode ray tube (CRT) monitors. A total of twenty environmental impact categories are considered. In the case of CRT, 73% of overall life cycle energy impacts falls under the category of energy used to product CRT glass (Socolof, Overly, & Geibig, 2005). The LCA model represents a comprehensive inventory of the total environmental impacts associated with CRT and LCD monitors. Primary data was collected from over 25 companies, representing 14 distinct processes over 13 years, and secondary data from 21 processes. All this data was then entered into proprietary software that conducted the LCA

assessment; the net energy impact (expressed in CO_2 equivalents) of the CRT monitor is considerably higher than the LCD monitor (Socolof, Overly, & Geibig, 2005).

In Hischier et al. (2005) the research question of whether e-waste recycling makes sense from an environmental perspective is explored in greater detail. To answer this question, from the perspective of Switzerland, the researchers combine two approaches – material flow analysis (MFA), and LCA. The material flow analysis provides empirical data quantifying the volume of e-waste flows in the studied context; whereas, the life-cycle analysis accurately characterizes environmental impacts attributable to e-waste. By combing these two methods, systems' performance of e-waste management can be measured.

The Hischier et al. (2005) study is based on actual country data over the period of one-year and finds there are clear advantages to e-waste management from an environmental impact perspective (Hischier, Wager, & Gauglhofer, 2005). The findings are based on Switzerland – wherein effective environmental regulations exist on e-waste management. As shown in Figure A-3, the Swiss take-back program is a highly orchestrated e-waste management operation that is built on government and industry collaboration and effective environmental regulations. Switzerland is shown to have positive energy balance associated with its e-waste management practices (Hischier, Wager, & Gauglhofer, 2005).

In Barba-Gutierrez et al. (2008) the question of whether and when the environmental impact of e-waste collections is higher than the impact of non-collection is examined. Their study is built on the Hischier et al. (2005) method, modifying it to broaden its applicability. They find that distance travelled to transport the e-waste is highly relevant. Modifications were made to allow the model to apply in *any* country, and the definition of e-waste was expanded to include a variety of discrete goods (PCs, mobile cell phones). Barba-Gutierrez et al. deliver a strong message – if not properly specified, these LCA-based studies may lead to inconsistent findings; especially wherein distance travelled in e-waste collections and management exceeds a particular threshold (Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008).

In Kang and Schoenung (2006) the infrastructural needs to manage e-waste within the state of California are examined. To estimate the quantities of e-waste that is generated, Kang and Schoenung use both historic data and projected estimates. Assumptions were made about end-of-life *choices* made by the owners of e-waste: 75% storage (for an average two years); 15% Recycle; 7% Landfill; 3% Reuse – for an average two years, and then potentially into storage for another two years(Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006). The materials flow of e-waste is a function of user choices, and is shown in Figure A-4.

Kang and Schoenung estimate that by 2013, recycling will cost California 1.7 times greater than in 2005 – over a period of 8 years(Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006).Following rigorous analysis of e-waste management in practice and the literature, Kang and Schoenung identify four factors upon which e-waste management systems depend: i) laws and regulations are required to encourage e-waste recycling; ii) accurate estimates of e-waste generated; iii) facilities infrastructure to recycle e-waste; and, iv) secondary materials markets (Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006).

2.2.2 Critical studies into e-waste management

E-waste management can be understood as part of a larger global conversation on sustainability and managing environmental harm. The hypothesis of a 'pollution haven' is relevant to our analysis. Described by Lepawsky and McNabb, the pollution haven hypothesis is "the proposition that pollution-intensive economic activity will tend to migrate to those jurisdictions where costs related to environmental regulation are lowest" (Lepawsky & McNabb, 2009, p. 4). Although the physical e-waste streams can be exported global environmental impacts remain regardless of which countr(y/ies) e-waste ultimately is recycled in. Lepawsky and McNabb map out the international trade in e-waste and show a systematic relationship between net trade in e-waste and GDP per capita. As a nation's GDP per capita decreases, the likelihood increases that the country will be a net importer of e-waste; wherein e-waste is measured by proxy using the COMTRADE database with a dataset of 200 countries or territories

over a six-year period(Lepawsky & McNabb, 2009). As shown in Figure A-5, Asia is the dominant recipient of e-waste.

There are significant trade patterns occurring within and between developing countries. Lepawsky and McNabb (2009) demonstrate that e-waste flows are highly regionalized; presenting a far richer and more complex picture of e-waste than is explained by pollution haven hypothesis. There is a consistent flow of e-waste from developed to developing countries, but this is only a partial explanation. While the dominant narrative of rich countries dumping on the poor is not technically untrue, it does not sufficiently identify or call to account the full issue (Lepawsky & McNabb, 2009). It is problematic to conceive of e-waste management simply as an end-point in a linear flow of production, consumption, and final disposal (Lepawsky & McNabb, 2009). The pollution haven hypothesis is supported by the findings of Lepawsky and McNabb; however, also critically suggest the pollution haven hypothesis contains empirical and conceptual limitations. Namely, the hypothesis of a pollution haven obscures the realities of a global value chain of e-waste traffic and trade (Lepawsky & McNabb, 2009).

In Saint (2008) the impact of public discourses on waste management practices in the developed world are explored. The two primary discourses examined are modernity and neo-liberalism. Using a critical discourse analysis method, Saint shows these two discourses to both be based on an absurd belief an end to resource scarcity(Saint, 2008). Dominant discourses (of modernity and neo-liberalism) are shown to be rich sources of evidence on the power of corporations to maintain the 'status-quo' or 'business-as-usual'(Saint, 2008). To explain their relevance, both discourses require discussion.

In the words of Jüergin Habermas and critical geographer, David Harvey:

> "[T]he *project* of modernity came into focus during the eighteenth century. That project amounted to an extraordinary intellectual effort on the part of Enlightenment thinkers 'to develop objective science, universal morality and law, and autonomous art according to their inner logic.' The idea was to use the accumulation of knowledge generated by many individuals working freely and creatively for the pursuit of human emancipation and the enrichment of daily life. The scientific domination of nature promised freedom from

> scarcity, want, and the arbitrariness of natural calamity" (Harvey, The Condition of Postmodernity, 1990, p. 12).

The dominion of nature (human or otherwise) is a key theme. However, one must be intensely careful when attributing causality to matters of discourse and social reality. For the purpose of explaining the relevance of discourse to our present study, a few additional illustrations are warranted. This will be accomplished through a selective and purposive citation. When contemplating social life under advanced late capitalism, we are everywhere confronted with a concept of material agency – understood as the ability to control and bring nature under command. The dominion of nature is one of the key discursive characteristics common to neo-liberal and modernist thinking. However, it is difficult to fathom the full magnitude of the *social* consequence of this thought. To illustrate this present conundrum, we can take Heidegger's account of 'modern technology':

> "Historians and social scientists define 'modern technology' as the application of power machinery to production. They locate its beginnings in eighteenth England, where large coal deposits provide a source of energy for the production of steam, which in turn propels machinery in textile and other mills. But already at this relatively primitive stage of development the nexus of events becomes so complicated that nobody can neatly separate cause from effect or even establish the customary hierarchy of causes. Everything is jumbled together into inscrutable 'factors' – revolutionary discoveries in the natural sciences, detection and extraction of energy resources, invention of mechanical devices and chemical processes, availability of investment capital, improved means of transportation and communication, land enclosures, mechanization of agriculture, concentration of unskilled labor; a happy combination of this-worldly and other-worldly incentives – and the age of modern technology is off and running before anyone can catch their breath and raise a question" (Heidegger, 1993, p. 308).

The above passage raises fundamental issues regarding the representation of nature and material agency. It suggests that social reality is imbued with additional characteristics that are unevenly understood, and whose presence can often be observed. The topic has been examined by many scholars and philosophers, from a multitude of vantages. Critical geographer David Harvey provides the following succinct depiction of present-day social reality:

> "How can we characterize the general form of the corporate state as a mode of socio-political organization? It appears as a relatively tightknit, hierarchically ordered structure of interlocking institutions – political, administrative, legal, financial,

> military, and the like - which transmits information downwards and 'instructs' individuals and groups down the hierarchy as to what behaviors are appropriate for the survival of society as a whole" (Harvey, The Spaces of Capital, 2001, p. 31).

One has to be careful when applying and interpreting grand social theories. The introduction of David Harvey (Harvey, The Condition of Postmodernity, 1990; Harvey, The Spaces of Capital, 2001) and now Manuel Castells (Castells, The Rise of the Network Society, 1996; Castells, The Power of Identity, 1997) is intended to encapsulate and re-present those commonly held understandings regarding discourses of modernity and neo-liberalism. On the topic of the latter, Castells provides the following commentary:

> "[N]eo-liberalism ...quickly established a new ideological hegemony. In the early 1990s it came to constitute what Ignacio Ramonet labelled as *'la pensée unique'* ('the only thinking'). While the actual ideological debate was considerably richer, on the surface it did appear as if political establishments around the world had adopted a common intellectual ground: an intellectual current not necessarily inspired by Von Hayek and Fukuyama, but certainly tributary of Adam Smith and Stuart Mill. In this context, free markets were expected to operate economic and institutional miracles, particularly when coupled with the new technological wonders promised by futurologists" (Castells, The Rise of the Network Society, 1996, pp. 143-144).

The ideology of neo-liberalism can only be seen against this backdrop of modernity. However, and again, one must tread carefully when discussing matters of ideology. It would not be valid to put loose parenthesis around either term. As Castells stated above, considerably rich debate persists under the surface. Nonetheless, a clear and consistent narrative is demonstrably present on these topics regarding private enterprise and the free market.

Saint (2008) suggests private enterprises have greatly influenced the legal status of what constitutes waste management practices. First, we must recognize that technology companies and corporations have huge marketing budgets that; as Saint argues, have these corporations taking control of the environmental debate - and ultimately controlling the legal definition of environmental crime (Saint, 2008). Second, corporations are bureaucracies - an organizational structure associated with modernity - and this in turn leads to decisions being made solely on a cost-effectiveness basis (Saint, 2008). How these discourses impact social systems is a complex

topic. According to Saint, in the hands of bureaucratic private enterprise, environmental harm is systematically excluded from consideration. Although recycling options exist in the United States under the current policy and regulatory regime it is more profitable to export e-waste than it is to process it domestically (Saint, 2008).

To summarize the first two factors presented by Saint, the overall effect of neo-liberal policies is "rewarding corporations with a free market and punishing workers and consumers by abolishing state restrictions to big business"; where, in the words of Norm Chomsky, "'[U]nder capitalist conditions – meaning maximisation of short-term gain – you're ultimately going to destroy the environment'" (Saint, 2008, p. 11).

Third, Saint argues that given the above two points, voluntary measures that have corporations 'self policing' their pollution rather than facing strong regulatory regimes must be identified as attempts by industry to avoid heavy regulation (Saint, 2008). Fourth it is through the discourse of individual or shared responsibility that the influence of private enterprise is solidified: "With the corporations in control of the environmental debate, consumers could become 'green' simply by altering their purchasing behaviour, i.e. buying 'green' products from companies that claimed to be 'green'" (Saint, 2008, p. 17).

Considerable evidence exists of 'counter-narratives', of those yet-enchanted with prospects of an end to resource scarcity. The ultimate expression of the pervasiveness of these suspect notions is found in a "discourse evident in the media and the government: that of individualisation of harm, the 'we are all responsible' line, from the most powerless to the most powerful' …The sense of urgency that is inherent in any discourse on environmental harm (apart, obviously, from those that deny the severity of harm, for instance, climate change) effectively stifles any discussion on the topic" (Saint, 2008, p. 23). And thus, discursively, counter-narratives can, in the words of Saint, stifle debate. Additionally, three other powerful counter-narratives are identified. First, climate change does not exist or is not a serious threat. Second, the only solution to climate change is the free market. Third, through actions of individuals (such as re-use of plastic bags and bottles) the planet

will be 'saved' (Saint, 2008). While each counter-narrative is invalid in its own right, each deflects some amount of attention away from the underlying issues.

Saint explains that discourses and discursive practices used by corporations and governments in effect 'control' the legal status and definition of corporate environment harm. Ultimately key discourses of advanced late capitalism (modernity, neo-liberalism) are shown to be incompatible with a mandate of protecting the natural environment (Saint, 2008). Saint does not limit focus to a single incident of study – instead, embarks on an esoteric and widest possible literature search to demonstrate that generally issues such as global warming are placed in the hands of the consumer, rather than corporation(Saint, 2008). The ultimate finding of Saint's critical discourse analysis study is that the modern capitalist system is incompatible with an adequate care of the natural environment – wherein, corporations are able to bypass the stigma of crime entirely by designing their own regulatory and operating environments (Saint, 2008).

In Temanos (2007) a case study is developed into the municipal sustainability planning in resort town, Whistler, British, Columbia. Her study examines waste management discourses, and warns that these discourses are 'used' by local interest groups and institutions to potentially promote a variety of local interest groups and ideologies (Temanos, 2007). Municipalities may be influenced by incoherent notions of economic, social and environmental responsibility, and thus the risk exists that a discourse of sustainability may be 'used' to deflect critique of their actual performance(Temanos, 2007).To test this hypothesis, Temanos conducted a discourse analysis to determine whether such practices exist and if any demonstrable impact on waste management policies could be observed (Temanos, 2007). Temanos' focus is on the term 'responsibility' as it relates to the concerns of municipal governance (e.g. Whistler, B.C.); wherein responsibility is diffused ultimately to individual citizens:

> "[B]ecause of shifting forms of neoliberal governance processes where responsibilities for management of things such as social welfare and environmental protection that were once attributed to the state are now being only from federal to provincial and municipal level of government, but also to NGOs and individual citizens" (Temanos, 2007).

Temanos describes a notion of global citizenship that resonates with Saint (2008): "Under roll-back neoliberalism, personal responsibility is greatly increased since individual citizens are increasingly pushed to be personally responsible consumers of services and participants in new governance processes which seek to replace the role of the welfare state" (Temanos, 2007, p. 18). Temanos builds on critical work of geographer David Harvey to make her point: "The formulation of discourses and the relationship between them are mediated through people. Without individuals working in relation to each other, discourses would not be formed and ideologies would not be created" (Temanos, 2007, p. 23). Thus Temanos examines "the interrelationship of stakeholders in the context of waste management [revealing] some of the ways ideologies surrounding sustainability are created, represented, and changed, and how this shapes and is shaped by individual stakeholders" (Temanos, 2007, p. 15).

2.2.3 Qualitative studies on e-waste management and environmental regulation

Lee, Chang, Wang and Wen (2000) discusses the development of an Extender Producer Responsibility (EPR) program in Taiwan as of July 1997. EPR is the policy framework for e-waste management and will be discussed further in section 2.3. In 1988, a Waste Disposal Act was issued to mandate an EPR system; in 1996 a state-run agency announced its intentions to develop the EPR program, initially accepting only scrap computers. Within less than two years, a formal foundation was established to administer the EPR program in Taiwan. By the end of 1998, the Taiwanese recycling network consisted of more than 400 collection points and three regional storage facilities. As of 2000, the program included six key ICT goods - laptops, monitors, hard drives, power units, circuit boards, and desktop shells (Lee, Chang, Wang, & Wen, 2000).

Hicks, Dietmar and Eugster (2005) offer an exclusive look into the informal sector of end-of-life processing of e-waste in China: "The existence of an extensive informal sector, combined with a lack of environmental awareness among WEEE collectors, recyclers and consumers, are contributing to China's difficulties in developing a financially and environmentally sound recycling and disposal system" (Hicks, Dietmar, & Eugster, 2005, p. 451). The researchers suggest that an extensive informal sector exists in China, but given the lack of environmental regulations lead to difficulties in

achieving environmental and fiscal responsibility(Hicks, Dietmar, & Eugster, 2005).In fact, Hicks et al. demonstrate the capacity of this informal sector to act as a gatekeeper, pre-processing e-waste streams prior to their reaching any officially sanctioned operators. The social and environmental impacts of current recycling practices can be found in section 2.2.4. In the absence of effective environmental regulation, most business models employ primitive recycling techniques. The Hicks et al. (2005) study clearly demonstrates that, absent of strong environmental regulations, e-waste will be processed using particularly environmentally destructive methods.

Kang and Schoenung (2005) provide an overview of infrastructure and technology options for e-waste recycling within the United States. Citing environmental and economic costs of conventional waste disposal methods, Kang and Schoenung identify the great need for e-waste recycling programs and technology (Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005). Recycling e-waste is a complex and multistep and typically manual procedure conducted at a materials retrieval facility (MRF), shown in Figure A-6(Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005). With regard to technical operation, the above findings are equally applicable to the case in Canada.

In McKerlie, Knight and Thorpe (2005) the case of advancing EPR in Canada is discussed in great detail. Many challenges are presented. In Canada jurisdictional responsibility is split between multiple levels of government; there is no effective federal regulations for the nation of Canada; the result has been widely varied provincial product stewards approaches (McKerlie, Knight, & Thorpe, 2005). McKerlie et al. explain how jurisdictional boundaries have impacted waste management practices in Canada They described how Canadian municipalities do not have adequate environmental tools to manage environmental responsibility within the provincial and federal regulatory frameworks in Canada (McKerlie, Knight, & Thorpe, 2005). Moreover, e-waste is expected to rise from one to five percent of Canada's waste streams; at one percent e-waste already contributes to 70 percent of heavy metal contamination in our waste stream (McKerlie, Knight, & Thorpe, 2005). There are significant environmental risk factors associated with e-waste.

The policy framework to manage e-waste and other waste streams is Extended Producer Responsibility (hereafter, EPR). EPR is an important policy tool able to drive pollution prevention efforts and is the topic of several academic studies(McKerlie, Knight, & Thorpe, 2005; Liu, Tanaka, & Matsui, 2006; Wagner, 2009; Nnorom & Osibanjo, 2008). If designed effectively EPR enables producers to reduce the total life cycle impact of their products (McKerlie, Knight, & Thorpe, 2005). There are two purposes to EPR programs: i) to encourage Design for Environment (DfE) practices; and, ii) promote more sustainable materials management. The result of having producers assume all cost and responsibility for the end-of-life disposal is, in the ideal case, a feedback loop of pricing signals wherein products may get redesigned and thus decrease total impact.

Reducing environmental impacts through product design initiatives can be a result of e-waste management programs. But according to McKerlie et al., product design initiatives are only furthered in the case of full product stewardship. There are key differences between shared and full approaches. With the exception of British Columbia which has 'full product stewardship' legislation, EPR in Canada in practice has developed as a shared responsibility (McKerlie, Knight, & Thorpe, 2005).In fact, e-waste EPR programs in Canada typically follow a 'full product stewardship' model and thus do not operate through municipal waste collections.

The case study of Maine, USA is discussed in Wagner (2009); where, in 2004, the state legislature adopted an EPR-based e-waste law. Maine implemented a shared responsibility program that includes municipalities and curbside collection programs (Wagner, 2009). This collaborative approach was necessary to make the system free (or very low cost) for public use. Additional survey research is provided that suggests that 60% of Maine residents are willing to pay US$2 per items and 25% are willing to pay $5; whereas, (based on 2002 state-wide survey data) in Florida, 64% are unwilling to pay any fee at all (Wagner, 2009).

Khetriwal, Kraeuchi and Schwaninger (2005) provides a comparison of e-waste management in both Switzerland and India. In the context of their study, Switzerland is seen as an exemplar of e-waste management - with over ten years experience in this area (Khetriwal, Kraeuchi, & Schwaninger, 2005).

The researchers acknowledge that e-waste is a lucrative business opportunity(Khetriwal, Kraeuchi, & Schwaninger, 2005).Based on thorough qualitative analysis of e-waste management practices in both Switzerland and India, the researchers suggest four-fold criteria for further analysis: i) quantify the per capita generation of e-waste; ii) assess the employment potential; iii) understand the occupational hazards; and, iv) quantify toxic emissions.(Khetriwal, Kraeuchi, & Schwaninger, 2005).

In Khetriwal, Kraeuchi and Widmer (2007) e-waste specific EPR programs are examined. The Swiss EPR program for e-waste is an organized system with well-established roles and actors(Khetriwal, Kraeuchi, & Widmer, 2007). The materials and cost flows are depicted in Figure A-7, and the 'social actors' of the Swiss e-waste management system are numerated (Khetriwal, Kraeuchi, & Widmer, 2007). While the authors clearly state no single model exists to do EPR, the case of e-waste management in Switzerland is imbued with lessons and crucial insights that could be relevant to other developed nations, such as Canada. Several advantages of the Switzerland case are noted; notably effective systems were already in place prior to legislation being established – and thus a highly efficient and cooperative systems was possible (Khetriwal, Kraeuchi, & Widmer, 2007).Moreover, the Swiss EPR program is designed in a manner that does not place any cost on the municipal government; moreover, fees paid by consumers are subject to market forces(Khetriwal, Kraeuchi, & Widmer, 2007).

One major research problem of e-waste management is the topic of 'reverse logistics'. In Geyer and Van Wassenhove (2000), design and operating decisions are discussed with direct reference to the performance of e-waste management systems. In their 2010 publication, Geyer and Doctori Blass reveal a global value chain for e-waste update the 2000 study – demonstrate that particularly in the case of cell phones, there exists a thriving second-hand market for these devices(Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010).One implication of this is a greater propensity for product reuse, and hence a longer effective 'product life'. Geyer and Doctori Blass (2010) note that although some programs are voluntary and environmentally motivated, such programs are an exception. Geyer and Doctori Blass demonstrate that absent of strong environmental regulations, profit is the main driver of e-waste management systems (Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010).

The recycling of e-waste is the next eventual step down the end-of-life ICT goods value chain. Geyer and Doctori Blass (2010) attribute about 70% of the recycling revenues to the gold contained in the handsets, while cell phone recycling is basically copper recycling – from a mass perspective(Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010). Furthermore, as illustrated in Figure A-8, through production innovation and design both the mass of the phone and its required precious metal contents have been reduced. The results of these factors impact greatly on the profitability of cell phone recycling(Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010). Instructively, Geyer and Doctori Blass (2010) claim that cell phone recycling is best characterized as an off-shoot of a thriving market for second-hand cellular phones (Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010).

An unknown amount of global trade in e-waste is driven by re-use and not simply disposal. It is a relevant and persisting research question to determine how much reuse occurs from international trade in e-waste. Nnorom and Osibanjo (2008) explore the conditions for e-waste management 'on the ground' in Nigeria in order to demonstrate the environmental and health impacts faced by the country. In the absence of environmental regulations, Nigeria has become home to an informal sector using primitive techniques(Nnorom & Osibanjo, 2008). Other sources that suggest as much as three quarters of these donations were not usable(Nnorom & Osibanjo, 2008).

Oteng-Ababio (2010) explores e-waste management in Ghana, a similar country to Nigeria with regards to lacking effective environmental regulations. This study employed a purposive sampling technique to collect a comprehensive dataset from which the glean insight. Currently e-waste management in Ghana consists of three potential stages: i) repair and reuse; ii) disposal in municipal landfill; and, iii) crude recycling using primitive techniques.

In Kahhat and Williams (2009), the case of Peru is examined. The researchers found evidence to suggest that in Peru, official trade in used computers does result in reuse. Nonetheless, they acknowledge that a high value tax (VAT) of 19% creates an economic incentive for firms to participate

in unofficial and black market trade (Kahhat & Williams, Product or waste? Importation and end-of-Life processing of computers in Peru, 2009).

2.2.4 Scientific and lab studies on health and pollution impacts of e-waste

In 2006 and 2007 a number of scientific studies were published on the topic of environmental and social health impacts associated with the primitive e-waste recycling techniques used in Guiyu, China. Representing a total of 28 villages spread across a total area of 52 km^2, Guiyu has a resident population of 132,000 and an additional migrant worker population of 100,000 (Huo, et al., 2007). In Huo et al. (2007) the researchers looked for evidence of impacts from e-waste recycling activities on the children in the region. Samples from a total of 226 children under the ages of 6 were collected. There were 165 children selected from Guiyu, and 61 children in a control group from the neighbouring Chendian. Statistical analysis demonstrated an apparent correlation between the number of e-waste workshops and elevated blood levels of lead (BLL) in the children living in the region. Of the children living in Guiyu, 81.8% had BLLs in excess of a given safety threshold, compared to 37% of the children living in a neighbouring town (Huo, et al., 2007).

In Yu et al. (2006) the concentration, distribution, profile and possible sources of soil contaminants in Guiyu was investigated. Specifically, the researchers were looking for evidence of polycyclic aromatic hydrocarbons (PAHs) which are often caused by incomplete combustion – in this case, thought to be associated with the open burning of e-waste due to the primitive recycling techniques used in Guiyu, China(Yu, Gao, Wu, Zhang, Cheung, & Wong, 2006).

Similarly, Leung, Luksemburg, Wong and Wong (2007) conducted research on surface soils and combusted residue at e-waste facilities in this same region. In their findings, the primitive recycling techniques are causing the release of persistent toxic substances or dioxins. The toxic concentrations of soil at the acid leaching site where printed circuit boards were processed were observed at levels over 930 times greater than the control site (Leung, Luksemburg, Wong, & Wong, 2007). Based on the collected evidence, the researchers postulate that the open dumping and burning of e-waste is likely a major component of global inventory of dioxins. Similarly, in Wong, Wu,

Duzgoren-Aydin, Aydin and Wong (2006) river sediments in Guiyu were examined for contamination. Serious levels of contaminants of cadmium, copper, nickel, lead, and zinc were found in samples collected from the local rivers Nanyang River (Wong, Wu, Duzgoren-Aydin, Aydin, & Wong, 2007).

Focusing on air pollutants, Li, Yu, Sheng, Fu and Peng (2007) find evidence of severe levels of dioxins in the atmosphere of Guiyu. In fact, the researchers claimed that the levels of dioxins in the ambient air of Guiyu are the highest documented values ever recorded in the world (Li, Yu, Sheng, Fu, & Peng, 2007). The researchers also measured the impact on adults and children living or working in Guiyu. Where the World Health Organization (WHO 1998) threshold for PCDD/F (dioxin) tolerable intake is 1-4 pg of W-TEQ kg^{-1} day^{-1}, inhabitants of Guiyu are shown to take in 15 to 56 times the WHO 1998 recommended limit. Moreover, neighbouring city, Chendian, located nine kilometres away from Guiyu was also shown to have dioxin levels that were higher than common urban areas across the world (Li, Yu, Sheng, Fu, & Peng, 2007). Prior to this study, Deng et al. (2006) attempted to establish the levels of priority polycyclic aromatic hydrocarbons (PAHs) and heavy metal concentrations in the ambient air surrounding Guiyu. The levels recorded exceeded those of Ghangzhou, one of China's most polluted cities. Furthermore, it was demonstrated that all of the toxic levels were attributed to the primitive recycling techniques used to process e-waste in the region (Deng, Louie, Liu, Bi, Fu, & Wong, 2006).

Within the developed world, modern recycling techniques are used. If e-waste is disposed in a modern facility, the environmental impacts may differ greatly. In Williams et al. (2008) the emissions of toxins from landfill disposal and the impact on workers and surrounding social environments are measured. Samples were taken from over 200 municipal landfill sites and then tested for heavy metals. Instructively, the analysis undertaken by these researchers suggest that minimal risk exists that toxic materials could leach if computers are recycled in modern facilities (Williams, Kahhat, Allenby, Kavazanjian, Kim, & Xu, 2008).

2.2.5 Issues raised by the literature

These are four articles that raise challenges to this present study and its design. First, Socolof et al. (2005) demonstrate that LCA can assess energy and global warming related categories, but also should include chronic public health toxicity, e.g. heavy metals and other pollutions. However, in our study we have excluded all impacts other than per capita CO_2. This decision has been made due to limitations of scope. Second, McKerlie et al. (2006) raise the importance of heavy metal in Canadian waste streams. They cite that although e-waste currently comprises only one percent of the waste, it already contributes to 70% of heavy metals in waste stream in Canada. Again, although there are 800+ possible impacts and 20 major impact categories, due to limitations of scope our analysis has been focused on CO_2.

Third, Hischier et al. (2005), and fourth, Barba-Gutierrez et al. (2008) both specifically state that transportation (in terms of distance travelled) is key factor in determining the environmental benefit of e-waste management systems. Transportation has not been included by our study. The rationale for this decision is that our analysis is on the macro or social level, and does not adequately examine the micro or organizational level where distance travelled to drop-off e-waste could be properly embedded in the model. Given that our study does not observe the micro or organizational level, it was not deemed adequate to introduce transportation into the model at this time; we will recommend this for future research.

2.3 Environmental regulations and e-waste management in practice

2.3.1 Environmental regulations and e-waste policy in Canada

This section examines environmental regulations and policy that regard e-waste management in Canada to provide a complete discussion of these topics as it relates to the research problem in this study. For the purposes of this present study, in addition to exploring environmental regulation it is also necessary to provide a relevant synopsis of the practice of e-waste management. This section will thereby review the positions and public statements of relevant organizational bodies relevant to the

practice of e-waste management in Canada. Analysis also extends to the discourse of practitioners in this field; namely, a series of conferences on EPR held in Canada. International organizations such as Organization for Economic Co-operation and Development (OECD) and United Nations (UN), including their United Nations Environment Programme (UNEP) are also included in this discussion of e-waste management in practice. The objective of this section is to present an objective and thorough discussion of environmental regulations and e-waste management practices in Canada.

The Canadian Council of Ministers of the Environment (CCME) is an intergovernmental forum, led by ministers, for collective action on environmental issues with national or international concern (CCME, 2011). In June 2004, CCME endorsed and released a report entitled: 'Canada-wide principles for electronics product stewardship.' The report identified e-waste management as a rapidly emerging and major public policy issue with both global and domestic relevance; also encouraged is cooperation on a regional or national level in the development of e-waste programs with the stated objective to promote consistency across jurisdictions, especially with respect to which products should be included in stewardship programs across Canada (Canadian Council of Ministers of the Environment, 2005). In 2009, CCME released a Canada-wide Action Plan (hereafter, CAP) for EPR that includes policies and commitments for government action on the adoption of EPR, and identifies priority products(CCME, 2009). EPR is defined as:

> "[A] policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle. EPR shifts responsibility upstream in the product life cycle to the producer and away from municipalities. As a policy approach it provides incentives to producers to incorporate environmental considerations in the design of their products" (CCME, 2009, p. i).

The approach prescribed by CCME is described as harmonized in that it promotes a common approach. However it is also noted that implementation falls under the provincial jurisdictional authorities (CCME, 2009). No formal coordinating mechanism exists to deliver this outcome and leadership has not been championed by the federal government. The 2009 action plan recognizes this discrepancy, and recommends additional regulatory and policy measures are required:

> "In a complex and competitive national and global business market signals to producers from a relatively small market like Canada may not be strong enough alone to influence new environmentally conscious product design and supply chain management. The environmental objectives of EPR may therefore need to be supported and reinforced by other measures, such as: eco-labelling; restrictions on toxic substances; recycled content standards and regulations; green procurement policies; environmental performance/voluntary agreements and a variety of other potential standards, bans, guidelines and educational tools" (CCME, 2009, p. iv).

The CAP articulates a framework to implement EPR across Canada, and uses the promise of having industry potentially set their own regulations:

> "It commits jurisdictions to work towards developing and regulating the development of EPR programs for implementation and operation by industry stewards, and includes a list of priority products for action within six years of the plan's adoption and a secondary list of products for action within, eight years. The identification of specific product categories and specific products with timetables for program implementation is designed to give producers and their organizations the necessary signals to start considering their EPR program options knowing that regulations governing their products could be adopted" (CCME, 2009, p. 6).

The overarching goals and principles of CCME's CAP are to reduce environmental impacts, maximize environmental benefits, increase producer responsibility and promote design for environment initiatives (CCME, 2009). In a comprehensive report on the topic, CCME provide an overview of key program elements that should be considered in EPR program development but which may or may not be addressed by EPR regulations (CCME, 2009). Crucially the CCME recognize that these voluntary efforts may ultimately be insufficient. CCME clearly identify the need for additional reinforcement mechanisms to ensure high levels of environmental performance (CCME, 2009). Unfortunately no such measures have been championed by the federal government of Canada.

The social actors active in Canadian e-waste management presented in Figure A-9. The organizational body that administers these systems in Canada is the producer responsibility organization (PRO). A PRO is an industry led organizational body that works in collaboration with appropriate government bodies in order to develop an EPR/e-waste program. As has been shown, the incentive is that industry gets to design the regulations which may subsequently be adopted by government. In their CAP, CCME

specify a variety of parameters for EPR program design (CCME, 2009). CCME provides a framework for EPR program development, including the following defining features: scope and products coverage, responsibilities, stewardship plan, training and education, performance measures, targets, design for environment, appropriate fees, audits, competition, and public consultation (CCME, 2009). With respect to product redesign and DfE, CCME state:

> "The objective of the design process is to produce a product that is least damaging to the environment while balancing other relevant considerations, such as function, technical requirements, quality, performance and safety. Producers and PROs should undertake research and implement environmental design improvements for products collected and managed by the EPR program" (CCME, 2009, p. 29).

EPR is an established policy framework for Canadian waste management practices. This is evidenced by numerous background papers and conference proceedings on EPR in Canada, presented by Environment Canada (Environment Canada, 2004; Environment Canada, 2002; Marbek Resource Consultants, 2006).

In 2001 OECD published a guidance manual on EPR for governments in which the global issue of solid waste management is described in great detail. Defined by OECD, the two most important design issues of EPR are allocating responsibility and determining who the producer is (OECD, 2001). Citing the growing global volume of solid waste, OECD explains that EPR can be used to treat of products during a post-consumer stage (e.g. recycling), but also can be an important policy tool to reduce waste generation overall. OECD explains that EPR programs, when designed appropriately, can create pricing signals that enable producers to internalize and ultimately lessen the environmental externalities associated with final disposal of waste products (OECD, 2001).

The history and status of EPR in Canada and the United States is the topic of a book chapter by Sheehan and Spiegelman (2005). EPR is presented as a policy tool that shifts all or part of the responsibility to manage end-of-life products back to the manufacturers or producers of the product, as opposed to conventional waste management authorities such as municipalities (Sheehan & Spiegelman, 2005). Municipal recycling programs across both U.S. and Canada expanded rapidly in the late 1980s and early 1990s; however, problems developed and it became apparent that municipal governments lacked appropriate tools to manage certain waste streams, such as hazardous wastes (Sheehan & Spiegelman,

2005). The example of British Columbia is cited as following an 'ideal' where costs and responsibility for waste management are shifted from government and taxpayers towards industry and consumers (Sheehan & Spiegelman, 2005).

Programs to manage e-waste have now been enacted in several provinces – British Columbia (since August 2007), Alberta (October 2004), Saskatchewan (February 2007), Ontario (April 2009), Nova Scotia (November 2007), Prince Edward Island (July 2010). Manitoba does not yet have an e-waste program in place, but environmental regulations came into effect in 2010. Prince Edward Island has had e-waste regulations on the books since 1998 however e-waste collections within the province did not begin until July 2010. Additionally, it has been common for amendments to be made to these regulations; Nova Scotia (2007), Alberta (2007), Saskatchewan (2009), and British Columbia (2011). The social actors of e-waste management industry in Canada are shown in Figure A-10.

2.3.2 Impact of Canadian e-waste management practices on CO_2 emissions

A comprehensive consultants' report – Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions – was submitted October 31, 2005 to Environment Canada and Natural Resources Canada, authored by ICF Consulting of Toronto, Canada. The report describes waste-related mitigation as cost-effective and a significant opportunity for potential reductions in energy use (ICF Consulting, 2005). The report attempts to quantify from a LCA perspective emission factors that are associated with solid waste practices of Canadians (residential, and industrial, commercial, and institutional);and uses LCA methodology to calculate the net impact to GHG emissions and sinks in Canada due to solid waste management practices; included are CO_2, CH_4, NO, PFCs or inorganic carbons (ICF Consulting, 2005). The focus of our current study is to evaluate the impact on CO_2 emissions of Canadian e-waste management – itself a subset of solid waste management, denoted in Figure A-11as 'Recycling'.

March 2006 a National Resources Canada (NRCan) report was published, with subcontracted assistance from Statistics Canada, Recycling Council of Alberta, and two private consulting firms. Two goals are cited: quantifying the volume of recyclable materials currently disposed of in Canada; and,

estimating the potential for GHG reductions(NRCan, 2006). In 2011, the government of Canada (GC) and Recycling Council of Ontario (RCO) released a report titled: Measuring energy savings and greenhouse gas (GHG) emission reductions benefits resulting from recycling in Canada. The report explains that waste management systems associated with particular waste streams can lead to net reductions in total energy use, and also lessened air and water pollution (Government of Canada, 2011).

United Nations Environment Programme (UNEP) published a 2009 report titled: 'Recycling – From E-waste to Resources'. UNEP describes the e-waste treatment processes as having two key objectives: i) removing toxic materials; or, ii) separating out all main recyclable materials such as glass, plastics, metals; and although both are desirable, often only one is chosen (UNEP, 2009). However, in concert with the prior literature scan, e-waste management must be understood as being embedded in what Lepawsky and McNabb (2009) term, moral geographies:

> "Modern electronics can contain up to 60 different elements; many are valuable, some are hazardous and some are both. The most complex mix of substances is usually present in the printed wiring boards (PWBs). In its entity electrical and electronic equipment is a major consumer of many precious and special metals and therefore an important contributor to the world's demand for metals. Despite all legislative efforts to establish a circular flow economy in the developed countries/EU, the majority of valuable resources today are lost. Several causes can be identified: firstly, insufficient collection efforts; secondly, partly inappropriate recycling technologies; thirdly, and above all large and often illegal exports streams of ewaste into regions with no or inappropriate recycling infrastructures in place. Large emissions of hazardous substances are associated with this" (UNEP, 2009, pp. 253-254).

United Nations Environment Programme (UNEP) published a 2010 report titled: 'Waste and Climate Change: Global Trends and Strategy Framework'. Waste management is presented as an important issue with global policy implications. UNEP claims that although the whole waste management sector contributes 3-5% of global CO_2 emissions, it is uniquely positioned to achieve major CO_2 abatements through advanced materials recycling (UNEP, 2010). UNEP suggests the actual magnitude and net energy impact of waste management practices is difficult to measure due to inaccuracies in emissions models and lacking data available on worldwide waste streams and their management (UNEP, 2010).

It is important to note that e-waste is described by Environment Canada as a shared responsibility - with federal, provincial, municipal all having roles to play in setting regulations(VanderPol, 2007). In chapter 6, much attention will be given to the various delineations of and articulations of responsibility found in practice. Responsibility for e-waste management is not clearly or authoritatively defined in Canada. The federal government of Canada does have an e-waste policy, and as of 2010, and all its end-of-life electronics equipment now recycled in verified facilities. However, little evidence exists of substantial, national leadership and political will on matters of the environment in Canada. This can be clearly illustrated with the October 2011 report from the Office of the Auditor General of Canada on behalf of the Commissioner of the Environment and Sustainability Development to the House of Commons.

Commissioner Scott Vaughan describes his role as Parliament's watchdog that monitors the federal government and its handling of its commitments on sustainable development and the environment. The discussion that follows in his 2011 report is unflattering and suggests that the federal government of Canada has done little to close key information gaps that would assist in better environmental pollution management action and policy.

The report delivers scathing conclusions:

> "Since the early 1990s, the federal government has made a number of different commitments to tackle climate change. However, the start-and-stop pattern of federal program planning has given inconsistent signals to industry, other levels of government, and Canadians about the consistency and predictability of the federal government's approach to reduce greenhouse gas emissions. Our audit shows that Canada is not on track to meet its commitments under the Kyoto Protocol to reduce greenhouse gas emissions. This is not new. However, the federal government has made new international and national commitments to reduce greenhouse gas emissions, which include commitments set out under the Copenhagen Accord, the 2010 Federal Sustainable Strategy, and the Cancun action plan. All of these establish a commitment to achieving a 17 percent reduction, from the 2005 levels, in greenhouse gases by 2020. It is unclear whether the federal government will be able to achieve these new reduction targets until a coherent system is in place that has clear objectives, timelines, interim targets, and expectations with key partners. The government will also need an overall strategy to coordinate efficient and effective spending of billions of dollars" (Vaughan, 2011, p. 9).

In chapter 1 of the above mentioned report, Commissioner Vaughan examines Canada's climate change plans under the *Kyoto Protocol Implementation Act*. The Kyoto protocol is an international framework on Climate Change, led by the United Nations. In the first chapter of the commissioner's report, there are three key findings. First, the climate change plans produced by Environment Canada are missing key information and hence *are not* in compliance with the act. Second, Canada is not going to meet its emissions target under this act. The existing data suggests in 2008 Canada's CO_2 were 31% higher than the stated Kyoto target. In fact, since the plan's first publication in 2007, expected reductions associated with climate change plans have been reduced by 90% (Vaughan, 2011).

Third, although the federal government has allocated more than $9 billion to implement these climate change measures; there is no sufficient governance structure, nor is there an effective assurance system, financial controls, or performance reporting systems in place (Vaughan, 2011).

The impact of this current policy regime on the nation's environmental pollution management performance can be observed in Figure A-14. Canada is not on track to achieve its commitments under the Kyoto protocol; moreover, appropriate governance and accountability mechanisms do not exist (Vaughan, 2011).

The challenges raised by the Office of the Auditor General of Canada are legitimate and well-founded. They are also consistent with the findings of 2011 report from the Conference Board of Canada which examines the nation's performance on a series of 10 'hot topics'. Canada's performance on the environment and in particular its waste management practices are deteriorated. Municipal solid waste generation has increased steadily since 1980 and remains well above the OECD average; between 1990 and 2008, Canada experienced a 24% increase in total annual GHG emissions; and Canada is ranked in last place out of 17 countries, and receives a 'D' grade for its alarmingly high levels of municipal solid waste it generates (The Conference Board of Canada, 2011).

From the perspective of the present study, and on the authority of the Office of the Auditor General of Canada – and supported by various additional sources, such as Conference Board of Canada research – this pattern of behaviour of the federal government of Canada depicted herein serves as

overwhelming evidence that the Government of Canada provides neither effective national leadership nor consistent political will on matters of the environment. The implications of this will be explored in detail in chapter 5.

2.4 Summary of the literature search

E-waste is a rich source of metals (Cui & Zhang, 2008; Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008); and the output of e-waste management systems can measured in net CO_2 impact (McLaren, Wright, Parkinson, & Jackson, 1999; Socolof, Overly, & Geibig, 2005; Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008). However, to successfully implement e-waste programs and to encourage public use requires an orchestrated effort between various stakeholder groups (McKerlie, Knight, & Thorpe, 2005; Hicks, Dietmar, & Eugster, 2005; Liu, Tanaka, & Matsui, 2006; Kahhat, Kim, Xu, Allenby, Williams, & Zhang, 2008; Wagner, 2009; Oteng-Ababio, 2010; Khetriwal, Kraeuchi, & Widmer, 2007; Khetriwal, Kraeuchi, & Schwaninger, 2005).

Switzerland is often cited as an ideal case where e-waste management systems are efficient, cost effective, and characterized by industry and government collaboration as well as effective environmental regulations (Hischier, Wager, & Gauglhofer, 2005; Khetriwal, Kraeuchi, & Widmer, 2007). In the Switzerland example, a voluntary industry initiative for e-waste management was *already* in place when environmental regulations were enacted in 1998. This is a key fact, and one that could be supplemented with further discussion of an exemplar of industry and government collaboration; documented in Khetriwal et al. (2007). Because specific effort was made to ensure the Swiss e-waste management system promotes competition, that the researcher's claim Switzerland as an exemplar of competitive, economical e-waste management practices in a developed nation (Khetriwal, Kraeuchi, & Widmer, 2007)

As a counter example, poor or non-existent regulations in parts of the developing world encourage crude recycling techniques which are known to cause significant environmental pollution (Hicks,

Dietmar, & Eugster, 2005; Nnorom & Osibanjo, 2008; Huo, et al., 2007; Yu, Gao, Wu, Zhang, Cheung, & Wong, 2006; Leung, Luksemburg, Wong, & Wong, 2007; Li, Yu, Sheng, Fu, & Peng, 2007).

Advanced materials recovery systems such as e-waste management systems are estimated to account for 25% to 40% of annual global metal production; and industry reports cite availability of end-of-life electronics products waste streams from which to recover materials as the primary factor that prevents greater recovery efficiency (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008). Central to our discussion is the concept of net energy impact of e-waste management practices from a systems' perspective. Metals obtained from advanced materials recovery systems can displace demand for virginal resource extraction as e-waste is a rich source of metals (Cui & Zhang, 2008; Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008); hence, there are substantial energy savings that are attributable to e-waste management practices – if conducted in modern recycling facilities, as are found in Canada(McLaren, Wright, Parkinson, & Jackson, 1999; Socolof, Overly, & Geibig, 2005; Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008; Government of Canada, 2011; Hischier, Wager, & Gauglhofer, 2005).

Based on the literature search provided in this chapter, success of e-waste management systems is believed to rely on four factors: i) effective laws and regulations; ii) quantify e-waste flows in short and long term; iii) modern recycling facilities and infrastructure; and, iv) secondary materials markets (Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006). Evidenced by numerous consultants' reports and PROs reports, sufficient treatment facility infrastructure exists and e-waste quantities are readily known (CSR, RIS International Ltd.,MacViro Consultants Inc. & Jack Mintz & Associates Inc., 2005). Evidenced by 2008 GeSI report cited above, sufficient after markets exist for the materials recovered (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008).

Yet, EPR/e-waste programs in Canada have not been met with strong environmental regulations. As shown in Figure A-9, environmental regulations on e-waste do exist in many Canadian jurisdictions. Programs to manage e-waste have now been enacted in several provinces – British Columbia (since August 2007), Alberta (October 2004), Saskatchewan (February 2007), Ontario (April 2009), Nova Scotia (November 2007), Prince Edward Island (July 2010). Although Manitoba does not yet have an e-waste program in place, its environmental regulations came into effect in 2010. Provincial schemes are a constitutional dictate in Canada; and thus uniformity cannot be a viable political option. Nevertheless, as evidenced by the preceding section, no financial controls or performance measurement and reporting systems have been put into place to support or drive these efforts nationally.

Please refer to Table 1 for a summary of relevant claims from the literature search:

Table 1 Table of relevant claims from the literature

Relevant research claims	Source
Information systems research has an important contribution to make to environmental sustainability	(Melville, 2010)
Life-cycle analysis of IT hardware (e-waste) is a salient topic for information systems research	(Melville, 2010)
The Belief-Action-Outcome framework is a theoretical framework to understand the relationship between public discourse and general public beliefs about sustainability, action and public use of e-waste systems, and outcome of these systems as contribution to per capita CO_2	(Melville, 2010) in Figure A-2
E-waste is not an end-point in a linear system of production, consumption and product disposal	(Lepawsky & McNabb, 2009)
International trade in e-waste exists, and is highly regionalized	(Lepawsky & McNabb, 2009)
The dominant discourses of environmental NGOs on the topic of e-waste are inconsistent (e.g. pollution haven hypothesis is insufficient)	(Lepawsky & McNabb, 2009)
Substantial volumes of e-waste is exported to the developing world, especially Asia	(Lepawsky & McNabb, 2009) in Figure A-5
E-waste has economic value	(Lepawsky & McNabb, 2009)

Relevant research claims	Source
A thriving market for cellphone resale exists in many countries, and is primarily motivated by profit (based on primary data from US and UK)	(Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010)
In the developing world (notably China) crude recycling techniques are used to process e-waste	(Hicks, Dietmar, & Eugster, 2005; Nnorom & Osibanjo, 2008)
Crude recycling techniques lead to serious environmental harm	(Yu, Gao, Wu, Zhang, Cheung, & Wong, 2006; Huo, et al., 2007; Wong, Wu, Duzgoren-Aydin, Aydin, & Wong, 2007; Deng, Louie, Liu, Bi, Fu, & Wong, 2006; Li, Yu, Sheng, Fu, & Peng, 2007)
Advanced materials recovery from e-waste can displace demand for virginal resource extraction	(Cui & Zhang, 2008; Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008; Government of Canada, 2011)
Secondary markets exist for metals and materials recovered from materials	(Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008)
Recycling e-waste has a positive impact in CO_2 emission reductions, if done so in modern recycling facilities (e.g. not crude recycling techniques)	(McLaren, Wright, Parkinson, & Jackson, 1999; Socolof, Overly, & Geibig, 2005; Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008; Hischier, Wager, & Gauglhofer, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008; Government of Canada, 2011)

Relevant research claims	Source
Discourses of modernity and neo-liberalism are relevant to our understanding of waste management practices; responsibility for environmental harm is systematically diffused or diluted	(Saint, 2008)
EPR/e-waste systems depend on four factors: i) laws and regulations are required to encourage e-waste recycling; ii) accurate estimates of e-waste generated; iii) facilities infrastructure to recycle e-waste; and, iv) secondary materials markets	(Kang &Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006)
EPR/e-waste can be an effective policy framework	(McKerlie, Knight, & Thorpe, 2005; Lee, Chang, Wang, & Wen, 2000; Liu, Tanaka, & Matsui, 2006; Wagner, 2009; Nnorom & Osibanjo, 2008)

3 The research problem

In his 2010 publication in MIS Quarterly, Melville sets out a research agenda to explore information systems innovation for environmental sustainability. His principal hypothesis is that "information systems research can make an important contribution to knowledge at the nexus of information, organizations, and the natural environment" (Melville, 2010, p. 1). The topic carries relevance for both academic and professional research practitioners. It is a broad, yet nascent topic of scholarly research.

The belief-action-outcome (BAO) framework – developed by Melville to 'galvanize' IS research on information systems research on sustainability – is shown in Figure A-2 in the appendices. It provides the theoretical backing to explore research questions that intersect information systems research, organization studies, and environmental sustainability. There are three factors to this framework: beliefs or cognitive states regarding sustainability; actions of individuals or organizations enacted as part of sustainability practices or processes; and, performance outcomes in terms of environmental impact or financial cost at either societal or organizational level(Melville, 2010).

Our argument – which we develop further in chapter 4 – is the construct of environmental sustainability depends on a shared responsibility whose degree of coherence may be indecipherable to positivist methods alone. Hence, in this research we will conduct a descriptive and explorative analysis in order to open new dialogue and contribute to information systems research on environment sustainability. Our research adopts a novel approach that uses an IS perspective to evaluate e-waste management and environmental pollution management performance in Canada. The focus of this study is the net impact of e-waste management systems on per capita CO_2 in the developed nation of Canada. To our knowledge no academic study has to date conducted a critical evaluation of a nation's performance in achieving CO_2 emission reductions through e-waste management systems.

As has been described in chapter 2, and as depicted in Figure A-9, Canada has a modest e-waste management capacity in various stages of operation in a number of provinces. Each province is represented by its own regulation. With the exception of Atlantic Canada wherein one organization operates across two provinces, all other jurisdictions have a singular system which may or may not share operational efficiencies and processes across jurisdictional boundaries. The organizations that manage e-waste in the provinces are the industry funded organizations (IFO) or producer responsibility organizations (PRO); as depicted in Figure A-10.

Ultimately we aim to evaluate the environmental performance of Canadian e-waste management systems. Importantly, this study is not designed to offer a rich policy and in-depth financial analyses of the regulatory environment in Canada. Instead, we adopt the modest approach as ask whether incoherent notions of environmental responsibility can be observed in the public communications of key industry and governmental stakeholders representing e-waste management in Canada – most notably, the audited annual reports of all PROs.

Given our stated research aims and intended purposes, we put forth two key hypotheses for testing:

> H1: Absent of strong environmental regulations across the country, e-waste management systems designed by industry may become based on contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility
>
> H2: Systems that exhibit contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility will be unable to achieve high levels of environmental performance

These first two hypotheses will be tested using a combination of critical discourse analysis and two-stage least squares regression modeling. We use two research methods to examine the status and efficiency of e-waste management in Canada.

The next two hypotheses will be explored using a statistical method called Two-Stage Least Squares (2SLS).

> H3: An increase in e-waste/ICT index performance is negatively correlated with per capita CO_2

H4: The presence of EPR/e-waste regulation (as a % of regions/populations with legislation versus those without) will be negatively correlated with per capita CO_2

Finally, we must introduce three additional hypotheses related to the Two-Stage Least Squares (2SLS) model used in method 2:

H5: An increased level of GDP per capita in the long run will lead to a reduction in per capita CO_2

H6: An increased level of urbanization is positively correlated with pollution as measured in per capita CO_2

H7: An increased level of energy consumption per capita is positively correlated with per capita CO_2

Please refer to section 4.4.2 for a complete discussion of our second method, and rationale for H5, H6, H7.

Please refer to sections 4.5.*x* for a full and systematic account of how this research has been conducted.

4 Research design and approach

4.1 Introduction

The research in this thesis analyzes e-waste management from a social sciences point of view; where it is argued that e-waste management is a moral problem and a complex multifaceted phenomenon that crosses legal, economic, environmental, political, cultural, and organizational boundaries. This chapter describes the objectives of our study and provides rationale for the chosen research method. In particular, an information system research approach has been adopted. This research purpose is two-fold:i) to measure the environmental performance of e-waste management systems in a developed nation; and, ii) to surface and reveal empirical observations wherein contradictory notions of responsibility (corporate, social, environmental, fiscal, legal) persist.

As presented in Howcroft and Trauth (2004), important challenges to information systems research will unavoidably be encountered; and often the solution is the inclusion of additional social factors for analysis. This may ultimately lead to richer analysis (Ngwenyama & Lee, 1997). In this chapter we defend the research design choices made and document the systematic manner in which this study has been completed. We adopt a critical theory paradigm and combine two research methodologies: one quantitative, one qualitative. The quantitative method uses Two-Stage Least Squares (2SLS) regression to provide empirical grounds for evaluating the efficiency of e-waste management systems in Canada, measured as impact on per capita CO_2 and in terms relative to usage of ICT goods on an annual basis. Qualitative analysis uses critical discourse analysis (CDA)and an examination of how responsibility for e-waste management is discursively framed in Canada.

We believe that the combined results of these two methods will yield findings that adequately capture the 'problem' of this research study. Additionally, using two methods allows us to triangulate our findings and to ensure a greater robustness and degree of internal consistency for the study.

4.2 Research on e-waste management

4.2.1 Quantitative approaches

There are four types of quantitative research approaches common to this topic. First, there are studies that build a statistical model in order to estimate the volume of material product flow (e-waste) that is generated. These models provide crucial information that is required in order to quantify and evaluate the efficiency of e-waste management systems in terms of total product throughput. Second, there are life-cycle analysis (LCA) studies which allow researchers to estimate the total lifetime impact for a given ICT product category such as a cell phone or computer monitor. Third, there are hybrid studies (similar to this study's first method) wherein both LCA and MFA approaches are combined. Fourth, there are site studies using scientific lab and field analysis techniques to measure environmental and social health impacts of air, soil, and water of regions in the vicinity of e-waste processing and recycling operations.

4.2.2 Qualitative approaches

As presented in chapter 2, e-waste management represents relatively new terrain for scholars. Current research covers a variety of topics and perspectives. Some studies have focused on the second-hand markets that are associated with ICT goods reuse (e.g. cell phone resellers). Some studies explore the technical nature of metallurgical recovery(Havlik, Orac, Petranikova, & Miskufova, Hydrometallurgical treatment of used printed circuit boards after thermal treatment, 2011; Havlik, Orac, Petranikova, Miskufova, Kukurugya, & Takacova, Leaching of copper and tin from used printed circuit boards after thermal treatment, 2010; Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005). Another group of studies explore whether trade in used computers results in reuse(Kahhat & Williams, Product or waste? Importation and end-of-Life processing of computers in Peru, 2009). Many studies focus on policy instruments such as the Extended Producer Responsibility program on which e-waste management in Canada is based(McKerlie, Knight, & Thorpe, 2005). Additionally of note, Lepansky and McNabb (2009) offer a critical study and reveal limitations in the generally observed narratives surrounding e-waste from a global policy and

environmental or social advocacy perspective. These research studies are crucial for efforts to establish an adequate space for dialogue on e-waste and environmental pollution management.

4.3 Methodological requirements for this study

A research problem must be matched with an appropriate research strategy. This approach requires the use of critical studies and critical theory. Orlikowski and Baroudi, describe how critical studies enables us to reveal structural contradictions inherent to social systems that are believed to be the source of alienating and restrictive contradictions (Orlikowski & Baroudi, 1991). Stahl describes CDA's purpose as opening up dialogue by exposing ideologies and presenting better arguments (Stahl, 2006). From the perspective of this study, the researcher aims to open discourse on environmental harm and its management within a developed nation – from the perspective of information systems research and with implications for management research and practice.

The research in this thesis falls under the critical theory paradigm, and adopts critical realism for its ontology. The critical theory paradigm has been selected precisely because it enables us to, as Blaikie suggests, to describe social crises and also to recognize how such crises can be resolved (Blaikie, 2000). Critical realism has been adopted for instrumental reasons as well. Critical realism enables the researcher to observe social reality that would otherwise be unobservable to non-critical methods. Social reality includes not only of events (which are experienced) but also includes events that occur (even if not directly experienced); and is also composed of structures and mechanisms – which we believe ultimately produce these events(Blaikie, 2000).Norman Fairclough explains this key distinction of the real and the actual:

> "Critical realists assume a 'stratified ontology', which sees processes/events and structures as different strata of social reality with different properties. A distinction is drawn between the 'real', the 'actual', and the 'empirical': the 'real' is the domain of structures with their associated 'causal powers'; the 'actual' is the domain of events and processes; the 'empirical' is the part of the real and the actual that is experienced by social actors"(Fairclough, Peripheral vision, 2005, p. 922)

From the perspective of this present study, e-waste management is a real process/structure *and* it has actual systems yields of which we measure their impact on per capita CO_2 across a ten year panel dataset of Canadian data, 2000-2010. Quantitative methods are able to measure the actual (method 2).Qualitative analysis is required to surface and reveal 'real' impacts that would not readily present to quantitative methods alone. Method 2 can tell us the contribution of e-waste systems to per capita CO_2, but qualitative methods are required to further describe what the measured performance *means* from the perspective of a developed nation and its e-waste management practices.

4.4 Mixed-methods research design

4.4.1 Critical discourse analysis

In Saint (2008) the stated research task was to examine the legality of corporate environmental harm as framed in public discourse. This was accomplished with critical discourse analysis (CDA) as a research method. The selection of this research method is not arbitrary. Often CDA is used to investigate social inequality and can involve working alongside disenfranchised groups; e.g. a CDA study could give voice to those who suffer directly from environmental pollution. However, CDA is a robust method with several practical and appropriate applications - as Saint explains:

> "A critical discourse analysis does not necessarily require a specific group that the researcher, out of empathy or pity, feels s/he should protect and defend. Instead, the researcher should identify location or embodiment of power as target for criticism - in [Saint's] case, the corporations who commit harms, and the governments who protect, in some cases justify, these actions" (Saint, 2008, p. 6).

Whereas Saint (2008) uses a CDA method based on a qualitative and open-ended literature search process, the CDA method in this present study is based on an empirical CDA technique developed in Cukier, Ngwenyama, Bauer and Middleton (2009). The CDA method used in this study relies heavily upon the social theory of Jürgen Habermas, and his theory of communicative action (hereafter, TCA).

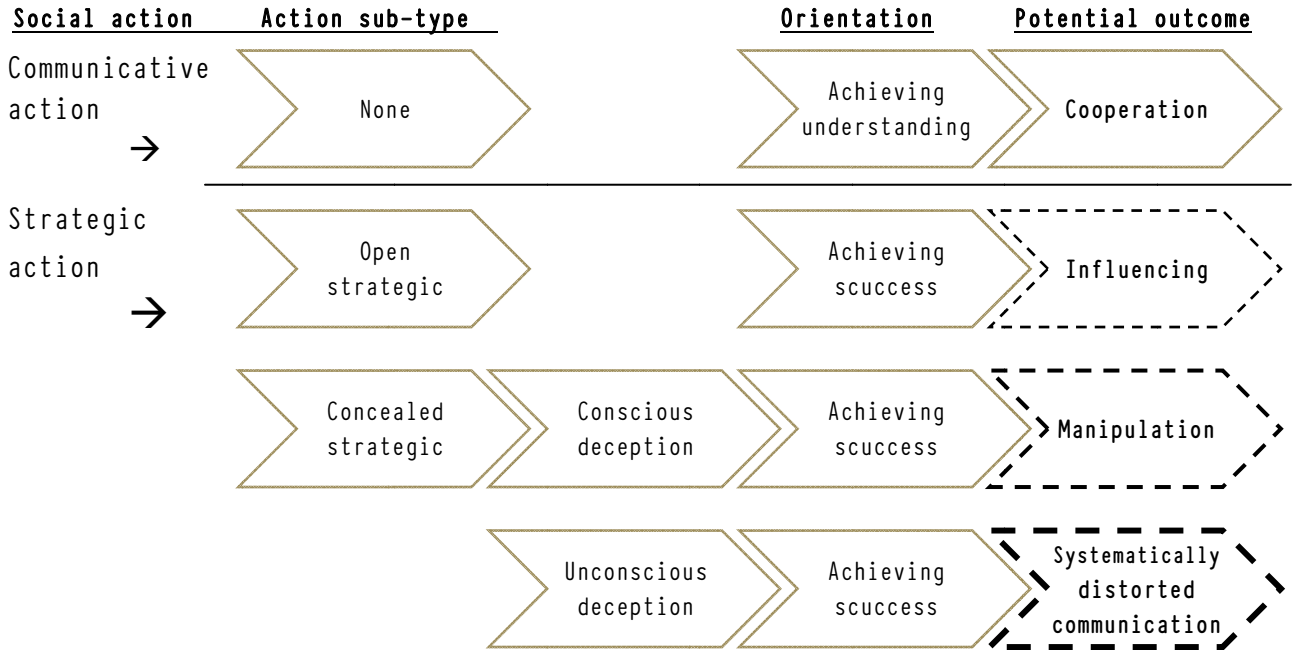
To understand TCA from the perspective of IS research, Klein and Huynh describe the value of discourse analysis as suspending ordinary communication, allowing a meta-level reflection over on

what was said (Klein & Huynh, The critical social theory of Jürgen Habermas and its implications for IS research, 2004).At its core, TCA asks the researcher to empirically assess the authenticity of speech acts. As can be seen in Figure 1, communicative action can lead to shared understandings and cooperation. However, this outcome is not assured. Manipulation and distorted communications may lead to outcomes that are not based on cooperation (Cukier, Ngwenyama, Bauer, & Middleton, 2009).

As a research method, there is no established and singular means to conduct CDA. As a research method CDA critically investigates social inequality and involves analysis of how language is used in practice, to observe how social inequity becomes represented or legitimized by discourses and language use (Wodak R. , What CDA is about, 2001).

Figure 1 Communicative and strategic action and distorted communication

Source: (Cukier, Ngwenyama, Bauer, & Middleton, 2009)



In Cukier et al. (2009) a CDA method based on Habermas' TCA is proposed. Their intention is to extend the "critical reflection and debate on the impact of systematically distorted communication about technology in the public sphere" (Cukier, Ngwenyama, Bauer, & Middleton, 2009, p. 175). One of the

objectives of this present study is to examine whether technology companies and governments have distorted the public discourse on e-waste and to determine whether responsibility to manage environmental harm is lessened through this discourse. This is accomplished through an analysis of language and written documents, hereafter referred to as speech acts. Speech acts that are 'communicative action' promote cooperation and are oriented towards achieving an understanding that is shared. If the intended outcome of a speech act is to influence or manipulate, then 'strategic action' is employed instead.

From the perspective of the receiver of the communication, it may be unclear whether the action is communicative or strategic. Following Habermas' TCA, a genuine communication would not include any manipulation or abuses. However, this cannot be taken for granted. Through systematic analysis of speech elements in discourse it is possible to reveal the presence or absence of communication distortions:

> "A central theoretical foundation of this research is Habermas' theory of communication action, which focuses on implications of speech and proposes general normative standards for communication. Habermas also places particular emphasis on the importance of the public sphere in a democratic society, critiquing the role of media and other actors in shaping public discourse"(Cukier, Ngwenyama, Bauer, & Middleton, 2009, p. 175).

Following the Cukier method for CDA discourse must be interrogated from the perspective of each of the four validity claims of TCA. A communication (in the form of a 'text' – e.g. speech transcript, news release, annual report) can be parsed, and have its statements systematically tested against the four validity claims, shown in Figure 2. If the communication does not pass all validity claims, then empirical evidence will be produced that may point to distortions or inconsistencies in the discourse.

The first claim, comprehensibility, asks whether a communication is expressed clearly in plain language. Comprehensibility violations result from incomplete messages and also from information overload or strategies of excessive language use (Cukier, Ngwenyama, Bauer, & Middleton, 2009). The second claim is truth, which establishes the factual correctness of a statement. To determine this one must appropriately contextualize the communication. This objective is to obtain consolidated

understanding of specific texts in the discourse; wherein argumentation structure is also evaluated against defensibility (Cukier, Ngwenyama, Bauer, & Middleton, 2009).

Figure 2 Categories of analysis for Habermasian CDA

Source: (Cukier, Ngwenyama, Bauer, & Middleton, 2009)

Comprehensibility

Criteria for ideal communication	Potential distortion	Validity test	Speech elements to analyze
What is said is audible (or legible) and intelligible.	Confusion	Is the communication sufficiently intelligible? Is the communication complete? Is the level of detail too burdensome for the readers or hearers?	Completeness of physical representations; Syntactic and semantic rules

Truth

Criteria for ideal communication	Potential distortion	Validity test	Speech elements to analyze
The propositional content of what is said is factual or true.	Misrepresentation	Is evidence and reasoning provided sufficient?	Argumentation

Sincerity

Criteria for ideal communication	Potential distortion	Validity test	Speech elements to analyze
The speaker is honest (or sincere) in what she says.	False assurance	Is what is said consistent with how it is said?	Connotative language; hyperbole; metaphors; jargon

Legitimacy

Criteria for ideal communication	Potential distortion	Validity test	Speech elements to analyze
What the speaker says (and hence does) is right or appropriate in the light of existing norms or values.	Illegitimacy	Are competing 'logics' (e.g. Stakeholders) equally represented?	Use of 'experts' and 'authorities'; silences

The third claim, sincerity, examines whether correspondence exists between what is said consistent, and with what is meant (Cukier, Ngwenyama, Bauer, & Middleton, 2009). To address this claim, one must examine what kind of language is used (e.g. connotative; overly technical; emotionally-laden) and whether the language reveals inconsistencies between what the speech or communication says versus what the actual actions of the speaker are. The fourth claim is legitimacy. For a communication to be legitimate it must be in accordance with relevant social norms and values – for instance, regarding who is considered an expert, or whose opinions get represented, and whether any dissenting voices are excluded (Cukier, Ngwenyama, Bauer, & Middleton, 2009).

The output of this method is a set of empirical observations that reveal any inconsistencies between speech and action with respect to e-waste management in Canada. These observations will be reviewed in the final chapter, and combined with the findings of method 2.

4.4.2 Two-stage least squares regression analysis

The regression method used in this method is Two-Stage Least Squares (2SLS). Generally this method will be chosen if inadequate data conditions exist to support linear regression models (e.g. OLS – Ordinary Least Squares). OLS is a powerful quantitative method that allows a researcher to predict unknown parameters in a linear regression. In OLS there are two variables of importance: i) independent or explanatory variable; and, ii) dependent variables. OLS allows the researcher to determine whether empirically and statistically supported relationships exist in the data under investigation. A simple example involves relating the height of individuals to their weight. If data can be collected on a random group of people, OLS could tell us whether we can effectively estimate the weight (dependent variable) of a person belonging to this group if we only know their height (explanatory variable).

OLS works well in cases where the independent (explanatory) variables are exogenous (e.g. fully independent of the descriptive variables) and no multicollinearity exists. Multicollinearity occurs when additional variables exist having a significant impact on the predictor variables (e.g. dependent variables). These conditions cannot always be satisfied in practice. For instance, a common

example is the case of what the causal effect of smoking is on general health. A person's health and their status as a smoker are likely to causally affect one another in various multicollinear ways.

In a commonly cited example, researchers use Two-Stage Least Squares (2SLS) to observe statistical patterns *through an additional regression step* that uses the tax rates on tobacco products as a control variable. Because taxes on a product are not in themselves going to have health effects, those effects observed by the regression model can be explained by collinearity. Thus, tobacco taxes are an instrumental variable; it is correlated with smoking but is not directly correlated with health *except through its affect on smoking*. If such variables can be found, 2SLS regression is a consistent method that will allow analysis of data situations not suitable for OLS.

With respect to the present study, we examine the relationship between Canada's CO_2 emissions per capita and an 11 year panel dataset of actual values of e-waste recycled per capita across Canada (measured as a percentage of total available stock of ICT goods consumed in the same year).

Our dependent variable of interest is:

- CO2PC – the level of CO_2 per capita for Canada

Two independent variables of interest are:

- ICTEWASTE – a ratio of e-waste recycled to index of ICT usage
- REGULATION – a ratio of jurisdictions with e-waste regulations to provinces without

These variables are exogenous to CO2PC along with other variables as depicted in equation (1). By using 2SLS and introducing additional control variables, we are able to triangulate and observe if statistical relationships exist in the data – if such a relationship exists, between the control variables and CO2PC. In order to evaluate these relationships, the following control variables are included in our regression analysis based on our literature search:

- GDPP – gross domestic product (GDP) per capita

- URBAN – the level of urbanization (by region/province)
- GDPENERGY – the increased level of energy consumption due to increased GDP per capita

In addition to test the relationship between the growth of GDPP and its impact on CO_2 emission variable GDP3 – cubic value of GDP per capita, was separately included in our regression analysis to investigate the EKC assumption.

As presented in chapter 3, there are five hypotheses that will be evaluated using the above described method and variables. Each hypothesis must now be reviewed, with clear explanation given for its inclusion in the study.

> H3: An increase in ICT/e-waste index performance is negatively correlated with per capita CO_2

The ICT/e-waste index is the ratio of recycled ICT machinery and equipment (e.g. laptops, computers, cell phones, switchers, routers, cables, television sets) to an index of ICT usage, calculated annually from Canadian data. We expect that a higher value of this index is positively correlated to the reduction of CO_2. As discussed in chapter 2, recycling e-waste has a positive impact in CO_2 emission reductions, if done so in modern recycling facilities (e.g. not crude recycling techniques) (McLaren, Wright, Parkinson, & Jackson, 1999; Socolof, Overly, & Geibig, 2005; Barba-Gutierrez, Adenso-Diaz, & Hopp, 2008; Hischier, Wager, & Gauglhofer, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008; Government of Canada, 2011).

Canadian e-waste stewards operate using environmentally sound and managed facilities. Thus we would expect that an improvement in the ratio of e-waste recycled to ICT goods consumed over an annualized reporting period should lead to CO_2 emission reductions as warranted by the literature.

Our first hypothesis will thereby be interpreted as a measure of system efficiency. A strong statistical performance of this variable would suggest that Canadian e-waste management practices and strong, well-designed, and effectively designed.

> H4: The presence of EPR/e-waste regulation (as ratio of jurisdictions with legislation versus those without) will be negatively correlated with per capita CO_2

E-waste programs exist in several provinces across Canada however no national coverage is in place. Hence, availability of e-waste programs across Canada is uneven. We introduce the variable REGULATION as percentage of total population in provinces with regulations in place versus those without. In years prior to the establishment of provincial e-waste programs, this variable would equal 0. If programs were established in all Canadian provinces and territories, it would equal 1. The actual value for this is calculated on a yearly basis as the ratio of Canadians living in provinces that have e-waste programs to those living without (e.g. in Yukon, Northwest Territories).

It is expected for the second hypothesis that per capita CO_2 will be decreased as more e-waste regulations become available across the country. However it is anticipated that REGULATON may lag behind the ICTEWASTE performance measure. Environmental regulations are necessary, but not sufficient condition to ensure e-waste gets responsibly recycled in Canada. As shown in Figure A-9, there is often a period of one to three years from when regulations are legislated to when a suitable industry steward organization gets formed and approved. Thus, we would anticipate that a stronger and more primary interaction will be observed between CO2PC and ICTEWASTE; and a potentially a weaker relationship between CO2PC and REGULATION. However, if we do observe a strong performance on this measure, it would be evidence that Canadian regulations *are* effective at achieving EPR/e-waste performance. In the case of weak performance, however, our ten-year panel dataset may have too few data-points to observe the impact of weak regulations.

> H5: An increased level of GDP per capita in the long run will lead to a reduction in per capita CO_2

According to the environmental Kuznets curve (EKC) hypothesis, the pollution levels including CO_2 initially increase with economic development as measured by Gross Domestic Product (GDP) but subsequently decreases after development and income have reached a certain threshold. In fact, the relationship between GDP per capita and CO_2, and in particular the cubic value of GDP per capita, derives from a variety of effects that occur as economic activity increases (Grossman & Krueger, 1995; Cole, 2003; Wier, Lenzen, Munksgaard, & Smed, 2001; Schmalensee, Stoker, & Judson, 1998; Chow, Kopp, & Portney, 2003). The extreme form of this EKC argument would have adverse environmental

impacts decoupled from economic activity, and offset through technical innovations and efficiency gains.

The environmental Kuznets curve (EKC), shown in Figure A-1 – illustrates the pervasiveness of the promised belief in the end of resource scarcity: "The EKC is named for Kuznets (1955) who hypothesized that income inequality first rises and then falls as economic development proceeds. The EKC concept emerged in the early 1990s with Grossman and Krueger's (1991) pathbreaking study of the potential impacts of NAFTA and the concept's popularization through the 1992 World Bank Development Report" (Stern, 2004, p. 1419). EKC is the empirical corollary to neo-liberalist and modernist dreams discussed in section 2.2.2. If only EKC is achieved, the end of resource scarcity can be reined in.

In Grossman and Krueger (1995) the concept is drafted:

> "Exhaustible and renewable natural resources serve as inputs into the production of many goods and services. If the composition of output and the methods of production were immutable, then damage to the environment would be inextricably linked to the scale of global economic activity. But substantial evidence suggests that development gives rise to a structural transformation in what an economy produces ...And societies have shown remarkable ingenuity in harnessing new technologies to conserve scarce resources. In principle, the forces leading to change in the composition and techniques of production may be sufficiently strong to more than offset the adverse effects of increased economic activity on the environment" (Grossman & Krueger, 1995, pp. 353-4).

The EKC concept is now pervasive in the literature. In Schmalensee, Stoker and Judson (1998) global CO_2 emissions from 1950-2050 are examined. Evidence is considered that supports EKC: "[F]or highly developed countries (here the United States and Japan) the growth of per-capita CO_2 emissions with per-capita GDP flattens and may even reverse at higher levels of economic development. This latter pattern, referred to as an 'inverted U' relation, has been noted by other researchers for various air pollutants" (Schmalensee, Stoker, & Judson, 1998, p. 15). However, it remains speculative whether the historic patterns observed in select developed nations carry any explanatory power for developed nations looking to 'leap-frog' into an advanced, developed state.

A substantial and growing body of research refutes the EKC hypothesis. In Chow et al. (2003) the topic of energy resources and global development is examined. An attempt is made to quantify the economic and environmental consequences associated with our global energy system (Chow, Kopp, & Portney, 2003). Some alarming facts are presented. A comparison of energy consumption in developed and developing nations is conducted across five end-use sectors: agriculture, commercial and public services, industry, residential, and transportation. Results showed developed nations consume more energy per capita in all the above sectors – and consume more energy in each by a factor of 3 to 14 times (Chow, Kopp, & Portney, 2003). According to Chow et al., "[t]hese relationships between wealth and energy consumption suggest that as a country becomes richer, its people tend to consume substantially more energy" (Chow, Kopp, & Portney, 2003, p. 1529).

Moreover, Wier et al. (2001) use Danish data to reveal the impact of household characteristics on per capita CO_2:

> "Our study shows that different family types have different CO_2 requirements. These differences are primarily due to differences in household expenditure, the type accommodation, urbanity and age. More specifically we found that energy and CO_2 requirements are positively correlated with household expenditure" (Wier, Lenzen, Munksgaard, & Smed, 2001, p. 265).

Substantial evidence suggests that income per capita (or other related measures, such as household expenditure) is positively correlated with energy consumption. EKC is generally *not* supported by these studies. In Cole (2003) the linkages are examined between EKC and the pollution haven hypothesis (see section 2.2.2). Using a panel dataset for the period 1980-1997 on a sample of OECD countries, Cole estimated EKC for each country (Cole, 2003). The results of the analysis are actually in support of the EKC hypothesis:

> "[A]ll of the air and water indicators, except VOC and CO, exhibit an inverted U-shaped relationship with per capita income. ...The results therefore provide no evidence of an N-shaped relationship between per capita income and emissions and thus emissions do no appear to rise again at high-income levels. ...It would therefore appear that structural changes within the economy are at least partly responsible for the decline in emissions experienced at higher income levels" (Cole, 2003, p. 77).

In Cole (2003) additional research is conducted to demonstrate that the EKC analysis captures pollution haven effects which also contribute to CO_2 abatement. An argument is put forth that if the pollution haven hypothesis holds EKC may actually be demonstrating 'pollution haven' effects(Cole, 2003). Essentially countries with high income levels can afford to export their 'dirty' manufacturing industries, and in turn import the products from developing economies without (directly) experiencing the associated pollution effects. No conclusive evidence is provided by Cole that would affirm or refute the pollution haven or EKC hypothesis.

In summary, although enchanting -Stern (2004) argues the EKC hypothesis is ultimately unfounded and typically based on weak econometric analysis (Stern, 2004). He finds that sulphur emissions in many OECD nations have been reduced substantially over past decades on a per capita basis – in concert with EKC; but correlation is not causation (Stern, 2004). From an econometric perspective, income per capita may have some impact on reducing total environmental pollution through technology and process innovations, however the benefits therein have been grossly overestimated: "It seems that structural factors on both the input and output side do play a role in modifying the gross scale effect though they are mostly less influential than time-related effects. The income elasticity of emissions is likely to be less than one – but not negative in wealthy countries as proposed by the EKC hypothesis" (Stern, 2004, p. 1435). Despite these empirical findings confirming the insufficiency of the EKC hypothesis the underlying notion is yet pervasive.

Given the relevance of the EKC hypothesis – and its ultimate lack of foundation – we include the fifth hypothesis to test our model. We would anticipate that our research will find EKC to offer explanatory power in the exclusionary sense that we do not expect H5 to be accepted.

> H6: An increased level of urbanization is positively correlated with pollution as measured in per capita CO_2

The sixth hypothesis suggests that per capita pollution is higher as more people live in urban settings. This can at first appear as counter intuitive. Certainly, evidence exists that those living in rural homes will consume more direct energy (e.g. to heat their homes) compared to urban dwellings (Wier, Lenzen, Munksgaard, & Smed, 2001). However, there is a growing body of literature on urban

carbon emissions that show high levels of pollution is correlated with urbanity. In Dhakal (2010), some alarming figures are discussed. Based in 2006 data, the CO_2 emissions from urban energy use in the United States comprised 80% of the country's primary energy demand; and these figures are expected to rise (Dhakal, 2010).

Dhakal further states that energy consumption of urban centres can be calculated using two different methods. First, the direct energy consumed can be quantified; and, second, the embedded energy must be calculated including both direct energy consumption and total impact that includes a full life-cycle accounting from production to consumption, and inclusive of end-of-life management(Dhakal, 2010). According to Dhakal, the policy community has adopted carbon emission reporting requirements that include embedded emissions. We will include URBAN as a control variable to increase the consistency and reliability of the model.

> H7: An increased level of energy consumption per capita is positively correlated with per capita CO_2

The fifth hypothesis is well supported in the literature. Although energy consumption can be supplied by various energy sources, all sources include CO_2 impacts (Chow, Kopp, & Portney, 2003).

Moreover, one cannot isolate or decouple carbon emissions from global economic growth (Schmalensee, Stoker, & Judson, 1998). Thus we introduce these as control variables – warranted by a substantial body of literature on the association between urbanization, pollution, and CO_2 emissions.

4.5 Research strategy

4.5.1 Examining responsibility for environmental harm

Using Melville's BAO framework (Figure A-2), we know that the actions of individuals in a social or organizational setting are impacted by the beliefs they hold about the environment (Melville, 2010). The link between beliefs about environment and resultant social action is not well understood. Warranted by Cukier et al. (2009) and Saint (2008), we believe that beliefs are influenced by public

discourse. In chapters 1 and3, the researcher explained the purpose of this study – to examine discourse and action on e-waste in Canada. The researcher used the models and methods demonstrated in chapter 2 to devise an appropriate research strategy.

Building on the argument we anticipated in chapters 1 and 3, the construct of environmental responsibility depends on a shared responsibility. We posit that environmental performance of e-waste management systems ultimately depend upon its degree of coherence – that is, if systems become based on contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility, it will lack both coherence and be unable to achieve efficient system performance.

To support our analysis, we have adopted two research questions from Temanos to guide our analysis (Temanos, 2007):

> Q1: In what way are the notions of environmental, economic and social responsibility implicated in the design and implementation of e-waste management programs across Canada?
>
> Q2: How and to what extent are Canadian e-waste management practices designed and implemented in the context of global sustainability discourses and goals regarding CO_2 reductions?

We first examine whether there is consistency between what is said about the responsibility to manage e-waste (BELIEFS), and what constitutes e-waste management in actual practice (ACTION); and finally we measure actual performance (OUTCOME). Our critical intention is to expose distortions in the public discourse and official communications on e-waste management. By bringing incoherent notions of sustainability to the surface, empirical observation may be discovered – and ultimately may lend itself to additional analysis and interpolation.

Using the BAO framework (Figure A-2), we first use critical discourse analysis (CDA) to examine the cognitive states regarding responsibility as held by key stakeholders. CDA will also be used to evaluate the coherence of reported actions and to surface and reveal any inconsistencies in reported or observed actions.

We will then use two-stage least squares regression (hereafter, 2SLS) to evaluate the combined environmental performance of Canadian e-waste management systems – as measured as contribution to per capita CO_2.

This research adopts a mixed method approach. First, Two-Stage Least Squares (2SLS) regression analysis is used to construct an index of e-waste/ICT for Canada – in order to measure the efficiency of e-waste management systems across the country. A second method is used – critical discourse analysis (CDA) – to surface and reveal if inconsistencies exist in the public sphere. It was decided that both CDA and regression analysis were necessary to support this study and adequately interrogate the phenomena being researched.

The researcher first came up with the general research question of *How to measure the sustainability performance of a developed nation?* After a cursory literature scan, the focus of e-waste management was then selected for this study. As is now presented in chapter 2, strong evidence exists to support the claim that substantial volumes of CO_2 emission reductions are achievable through e-waste management systems. At the original initial stage, a thorough literature review was completed in order to identify all relevant theoretical frameworks. Several models were found in the literature to estimate e-waste volumes and associated impacts. It was then possible to obtain supporting data to quantify the materials content of e-waste and ultimately express the outputs of e-waste management as a contribution to per capita CO_2.

By combining 2SLS regression with CDA as described above, this study will conduct a critical assessment of e-waste management practices in the developed nation of Canada. Staying within the scope of this study it is then possible to provide further descriptive analysis on the relevance of the findings with respect to both management research and practice, policy work, and future information systems research for environmental sustainability.

4.5.2 Unit of analysis

The unit of analysis selected for this study is the developed nation of Canada. Our intention is to measure national performance of e-waste management systems as contribution to per capita CO_2. To

accomplish this data was collected on a regional basis (where possible) and then extrapolated to the national level. From the perspective of method 2, there is no inter-organizational or in-depth financial analysis of individual e-waste programs. However, from the perspective of method 1 we examine statements from numerous regional operators (IFO/PRO as shown in Figure A-10). All findings will be extrapolated to and interpreted from the perspective of e-waste management systems in a developed nation and per capita CO_2.

4.5.3 Critical discourse analysis – data collections and analysis

CDA, as based on Cukier et al., requires a sophisticated and iterative data collection and analysis strategy. It is based on four underlying steps which will now be discussed. The underlying focus of this present study is to examine public discourses regarding waste management and the topic of environmental harm; using the Cukier CDA method we intend to surface and reveal all relevant claims made by social actors in Canadian e-waste management at the macro and social systems level. In step 1, the corpus of data to be analyzed is defined. A purposive, but comprehensive selection of texts is necessary(Cukier, Ngwenyama, Bauer, & Middleton, 2009).

We limit our search to publicly available documents. Additionally, we do not include media or lobby group sources; as we believe e-waste management in Canada is not itself a contentious enough issue to warrant such analysis. *(Alternatively, such analysis would likely be warranted in the case of climate change in the United States where analysis of the media space would potentially reveal an array of interest groups.)* Moreover, it is not feasible to isolate e-waste management practices from broader discourse on climate action.

We employ a targeted CDA approach and focus on the annual reports and public communications of relevant industry organizations, and relevant governmental and non-governmental advisory bodies.

An intensive search process was undertaken to support this study. Empirical data was collected by searching the Internet using Google.com search with the following parameter: +"e-waste management" +Canada; +"e-waste" +Canada. This query was then subsequently repeated using the names of the provinces and territories. A targeted search strategy was then used to discover all relevant reports

published by industry: +pdf +"[name of PRO]. As shown in Figure A-10 there are six official producer responsibility organizations (PRO) in Canada. The same search was repeated for the national industry body: +pdf +"Electronic Product Stewardship Canada".

The researcher individually reviewed the results on the order prioritized by the search algorithm. Except in instances where insufficient results were returned, generally at a minimum the researcher reviewed the first 25 pages of results (top 250). Associated websites of these organizations were also included using a manual process. In instances where relevant content was found on websites, the content was printed to a pdf document and included in the analysis. Additionally we supplemented the corpus with documents from industry, government, governmental, and other relevant advisory bodies.

Figure A-15 lists the source organizations and the number of articles used in our study. A total of 105 relevant articles were selected; and each article was then assigned an identification code EM1 through EM105.The process becomes highly iterative with following steps 2 and 3.

In step 2, content is analyzed and coded. The desired outcome of this step is to use the validity claims to identify relevant empirical observations; and to examine the types of arguments made, their frequency, etc.(Cukier, Ngwenyama, Bauer, & Middleton, 2009).Each source was coded twice for the following: i) statements regarding the advantages and disadvantages of e-waste management; ii) terms used to describe e-waste management systems - adjectives, metaphors, associative language; iii) experts and spokespeople for e-waste management in Canada; iv) specialized language or jargon; and, v) statements regarding responsibility and legitimacy of e-waste systems. This analysis will be conducted using NVivo 9.0 software.

In step 3, empirical observations will then be extracted to Excel as a table. All selected statements will be individually read, and analyzed for meaning; each statement being tested against each validity claim for additional empirical evidence that would refute the statements' validity (Cukier, Ngwenyama, Bauer, & Middleton, 2009).

Upon adequate completion of steps 2 and 3, the findings are then related in step 4.

Please refer to Figure A-16 for an index of texts included in the corpus.

4.5.4 Two-stage least squares – data collection and analysis

The researcher was able to obtain various secondary data in the form of annual reports from e-waste stewardship associations, consultants' reports submitted to the government, academic publications, and industry publications. Having the benefit of multiple sources to calibrate our model, it was possible to greatly improve the accuracy of findings obtained by this method. It was necessary to determine what *actual* capacity exists for e-waste processing within Canada. How much of the e-waste that is generated in Canada is actually *recycled* in Canada? This information was obtainable using target search strategies and found in publicly accessible reports.

ICT variable is a composite index obtained from ITU and UNDP dataset covering the following main ICT components:

- Residential phone lines per 100 households
- Internet users per 100 inhabitants
- TV equipped households per 100 households
- Internet hosts per 1,000 inhabitants
- Internet users per 100 inhabitants
- Number of PCs per 100 inhabitants
- Digital lines/mainlines four main components: Fixed telephone lines, mobile cell

Data for GDP per capita, Urbanization index, CO2 emission and the Canadian energy consumption was obtained from UNDP dataset.

The regulation index was obtained from Heritage Foundation.

E-waste data in Canada was collected from multiple sources including: (Government of Canada, 2011; NRCan, 2006; Waste Diversion Ontario, 2005; ICF Consulting, 2005; CSR, RIS International Ltd.,MacViro

Consultants Inc. & Jack Mintz & Associates Inc., 2005; RIS International Ltd., 2003; PHA Consulting Associates, 2006).

Following the literature review the following regression model was applied on panel data:

$$co2pc_t = \alpha_0 + \alpha_1 ictewaste_t + \alpha_2 gdpp_t + \alpha_3 regulation_t + \alpha_4 gdpenerg_t + \alpha_5 urban_t + \varepsilon_t \quad (1)$$

Where subscript t is referred to time period, α_0 is constant, α_1 through α_5 are variable coefficients and ε_t is error term. We assume that the variation of the level of CO_2 per capita ($co2pc$) is a function of the index of ICT per e-waste ($ictewaste$), the degree of environmental regulation (*regulation*) and other control variables such as GDP per capita ($gdpp$), the level of urbanization (*urban*) and the increased level of energy consumption due to increased GDP per capita ($gdpenergy$). In other words our endogenous variable is ($co2pc$) while other valuables are our exogenous variables.

In this study we used Stata software version 9.1 to test the above equations. We used 2SLS structural regression analysis to estimate the above equation. Given the relatively small sample size found in our study, it was necessary to use the Stata software 2SLS regression with an option called 'small' which is designed for small panel data sets that accompany the scale of this study.

To test multicollinearity among variables the Variance Inflation Factor (VIF) was estimated. Our panel's VIF shows a value of 1.94 which is far from the severe multicollinearity value of 30. In addition the model's R-squared value is estimated at 0.4939.

4.5.5 Validity of the data

The 2SLS regression method is considered a consistent method for statistical prediction in cases where data multillinearity exists. The dataset used in this study was based on panel data over the period of 11 years; tracked across several distinct regions (provinces) and aggregated to provide nation-wide prediction of e-waste systems impact on per capita CO_2 in Canada, as described in this chapter. From a numbers perspective, our dataset is small. The results described in chapter 5 are

robust, but the data lacks fine granularity. It is important that we do not over emphasize the findings of the first method. Nonetheless, we believe that our 2SLS findings are consistent and reliable; and are wholly adequate to the research task and strategy as elaborated in this chapter.

The first method must also be interpreted with obvious parenthesis. This CDA method allows us to discern whether distortions are present in the discourse surrounding e-waste in Canada. We must acknowledge that the scope of our second method does not adequately capture the municipal and regional characteristics of e-waste systems. In method 2, system performance is measured from the perspective of Canada as a nation; however actual reality occurs at a finer granularity – which we do not represent in this study through either method. Nonetheless, in our first method we will look evidence of performance claims and may observe differences in the behaviour of the various individual e-waste management systems across Canada.

The internal validity of our method 1 CDA findings should not be in dispute, given the above qualifications. The imposition of Habermas' validity claims upon the corpus set for analysis expectedly will filter out those statements which do not pass for communicative actions. If strategic actions are detected then an empirical trace route will remain, and subsequently will be subject to additional analysis. Those cases which are speculated to represent evidence of distortions or diffusion in the discourse will be set aside for elaboration in chapter 5.

This method is empirical and systematic, and it is our opinion that it will produce valid findings – to be read within the scope defined in this overall section, 4.5.

4.6 Criticism of chosen method

A mixed methods research design must clearly demonstrate how its methods are aligned and both necessary. With respect to the present study, we believe this to be the case.

Method 1examines the language and public discourse on e-waste and identifies any distortions or manipulations present. Method 2 provides us with a measurement of the actual performance of e-waste

systems in Canada. Both methods are deemed necessary to capture a full depiction of the phenomena being researched.

We do not extend our analysis into an inter-organizational and in-depth analysis of provincial stewardship models. We provide descriptive analysis based on the public statements regarding the various business models for EPR/e-waste adopted across Canada. Additionally, we do not (in any way) incorporate the informal sector and Canadian e-waste entrepreneurs into our analysis. We also exclude municipalities which may also be collecting e-waste.

The critical intention of this study is to better understand how moral and environmental issues are framed in absence of clear directives for their management. We argue this design is clearly aligned with the chosen research problem.

5 Critical discourse analysis – method 1

5.1 Introduction to CDA

The CDA method used in this study relies heavily upon the social theory of Jürgen Habermas, and his theory of communicative action. Please refer to section 4.4.1 for a background discussion of this method. We now search for empirical evidence of communication distortions or abuses in the public discourse found on the topic of e-waste management in Canada. The theoretical framework used in this CDA study will be elaborated in the following section. In the sections 5.3.*x* evidence of distortions will be systematically analyzed. In section 5.4, additional analysis is provided to support our speculations and descriptions of the empirical observations. Finally, a table and discussion of key findings is presented in section 5.5.

Chapter 7 will conclude our analysis with a synthesis and discussion of the combined findings from research methods, 2SLS and CDA.

5.2 Theoretical framework for CDA

Our approach to CDA is built upon the Frankfurt School scholars, and directly inspired by Habermas' Theory of Communicative Action (TCA), shown in Figure 2 (page 47) – and brilliantly operationalized as a CDA method in Cukier et al. (2009). Please refer to section 4.4.1 for a full discussion of this method.

The framework is used to evaluate the truth, sincerity, legitimacy, and comprehensibility of speech acts and textual statements regarding e-waste in the public sphere. If a statement is shown to be false, insincere, lacking legitimacy, or is incomprehensible, the statement may be an attempt to manipulate or distort communications – as illustrated in Figure 1 (page 45). If a communication is shown to be strategic, an empirical analysis of the claim will then be systematically undertaken. This approach allows us to surface and reveal characteristics of e-waste management in Canada as they are observed and defined in practice. Ultimately we are interested in assessing e-waste system

performance and to provide descriptive analysis that accurately depicts the EPR/e-waste programs across Canada. Although our analysis does not fully capture how responsibility has come to be solidified in organizational form, it will surface and reveal an adequate volume of empirical observations. We can then construct an argument that describes how responsibility is observed in use.

This method enables us to now conduct a targeted search to uncover, and evaluate empirical evidence; and particularly in those statements that fail the validity test.

The table below provides some examples illustrating how validity claims were critically examined and tested. Elaboration on these findings can be found in the section that follows.

Table2 Illustration of empirical analysis of validity claims

Example of Claim	Source	Claim	Criteria	Evidence of Distortion	Source
Environmental handling fee (EHF) ensures electronics products get recycled responsibly in Canada	EM04	Truth	Falsehood	EHF fee funds the program. The act of paying the fee does not ensure that this particular product will be recycled responsibly in Canada	
Harmonization would not impact day-to-day operations of stewards	EM100	Truth	Falsehood	This is a loaded issue. Evidence exists that some stewards may be avoiding harmonization; there is no reason to assume there is considerable similarity between these business models	EM22, EM43, EM104
Green products are 'not only better for the environment, but they also appeal to consumers due to better performance, reduced costs and overall convenience'	EM30	Truth	Falsehood	No supporting data is provided for these arbitrary claims; the association of convenience with 'green' is certainly unfounded	
Alberta Recycling is committed to achieving the most effective program	EM10	Sincerity	Is connotative language consistent with meaning?	Yet Alberta Recycling annual reports include no discussion of harmonization; no evaluation of benefits or costs of harmonization	EM10, EM11, EM35

Example of Claim	Source	Claim	Criteria	Evidence of Distortion	Source
Climate change is the greatest challenge of the century; but we cannot solve it alone	EM02	Sincerity	Does text illicit an emotional response	Although not untrue, these narratives promote a diffused, individual responsibility; provides an excuse for failure or lowered expectations *becaus*e of the complexity of these issues	EM02
Atlantic Canada steward, ACES describes itself as 'Powered up, with energy to share'	EM13	Sincerity	Hyperbole or jargon		
Ontario steward, OES says it creates 7 jobs for every 1,000 tonnes of e-waste recycled	EM75	Sincerity	Does text illicit an emotional response?	Ontario EPR stewards as 'monopsony purchasers of waste services'; provincial e-waste program does not promote competition; comment in OES plan 'Generally, the Ontario program has been the most difficult. Our company belongs to the other four provincial programs, and dealing with their program is extremely simple compared to OES'	EM43, EM104, EM27
Ontario steward, OES warns the cost of a data breach is $7.2 million	EM75	Sincerity	Does text illicit an emotional response?	The $7.2 million figure is based on U.S. corporate data breach, not SME clients to which the advertisement is targeted	EM75
Ontario steward, OES warns: 'The only way therefore to protect your customers from identity theft, shield your corporation from liability, and protect the environment is by ensuring the proper disposal of e-waste'	EM75	Truth	Falsehood	This is simply untrue	

Example of Claim	Source	Claim	Criteria	Evidence of Distortion	Source
Ontario steward, OES says it conducted a public consultation	EM66, EM27	Legitimacy	Who is marginalize -d or excluded?	Legitimacy is challenged because of the poor attempt by OES to solicit feedback; majority of public dialogue consisted of one-way communications	EM66, EM67, EM70, EM71, EM73
Canadian Council of Ministers of the Environment (CCME) recommends a harmonized approach to EPR/e-waste systems in Canada	EM104, EM23, EM47	Sincerity	False assurance	CCME recommends this outcome, but it has no authority or regulatory power to implement; recognizes that political will is required on this issue	EM23, EM38, EM44, EM104
Saskatchewan steward, SWEEP describes the current e-waste regime in Canada as 'no longer sustainable'	EM100	Legitimacy	Are there undisclosed interests?	No adequate evidence is provided for this claim	

5.3 Empirical analysis of validity claims

5.3.1 Empirical analysis of truth claims

E-waste management systems are inclusive of several technologies and systems. As described in section 2.2.2, e-waste management is a moral problem and a complex multifaceted phenomenon that crosses legal, economic, environmental, political, cultural, and organizational boundaries. Assessing e-waste *as a system* requires an examination of the costs and benefits that are understood to follow from having an e-waste management system in place – particularly from the perspective of a developed nation, and specifically with direct reference to Canada.

The primary claims made in the public sphere regarding EPR/e-waste systems are consistent with those depictions observed in the literature search presented in chapter 2. There is wide consensus on the benefits of e-waste management. It can displace demand for virginal resource extraction (EM04, EM43, EM56, EM86, EM91); decrease the impacts of production through design for environment, e.g. reduced

packaging, increased recyclable content, reduced toxicity (EM20, EM43); increase diversion rates from landfill and reduced disposal via export (EM04, EM23, EM29, EM32); protect information security (EM29, EM75). It is also claimed to be an important business/market opportunity (EM02, EM56)

Negative aspects of e-waste management systems are limited. In the developed world where modern recycling facilities exist, generally positive aspects are associated with this technology as evidenced by chapter 2 and the positive empirical observations above. Nonetheless, several threats to systems effectiveness and efficiency were identified during the CDA search. There is no guarantee that a given EPR/e-waste program will remain consistent with the above mentioned positive characteristics. High upfront costs may be required to ensure that the program is designed appropriately (EM43). If jurisdictional boundaries exist, as is the case across Canada, this may lead to inconsistencies in implementation and negatively impact systems efficiency (EM43). EPR/e-waste programs can be equitable, efficient, and competitive – but only if designed to be so (EM20). There are several references to the importance of design in minimizing potential for anti-competitive practices (EM20, EM23, EM43, EM104). Nearly all sources recognize that government leadership and political will are required to achieve an efficient, equitable e-waste management system (EM02, EM23, EM30, EM32, EM38, EM56). However, no statements were found to suggest sufficient political will exists across Canada. Numerous organizations have specifically called for increased federal commitment and action on these issues (EM44, EM56, EM103). Such empirical observations are well supported by the literature, notably sections 2.3.*x*.

On balance there is little disagreement over the benefits and operational realities of EPR/e-waste systems in Canada. Despite this, some discrepancies were observed and a total of 5 statements did not pass the validity test of truthfulness.

EPS Canada – the national organizational body that represents the interests of corporations in Canada's electronics industry – claims that "'greener' products are not only better for the environment, but they also appeal to consumers due to better performance, reduced costs and overall convenience" (EM30). No evidence is provided to support these arbitrary claims; for instance, there

is no clear linkage between convenience and 'green'. As will be discussed further in section 5.3.2, such statements promote a diffused responsibility wherein e-waste management conveniently becomes *everybody's* problem. The interpretation as such of these arguments is in agreement with the literature search in chapter 2 – and specifically the arguments of Saint (2008). It is critical to differentiate between e-waste as everybody's responsibility in the true sense that *we are feel*the brunt of environmental harm; as opposed to the more sincere and also true reading wherein e-waste is the responsibility of the technology company that produced the device, (arguably also) the retail corporation that brought the product to market, and certainly also the consumer who purchases the ICT good, and potentially inclusive of all subsequent users – as in the case of second-hand markets (Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010).

Ontario steward, OES claims that Ontario small businesses can prevent a serious and costly data breach, but *only if* they work with OES to implement an enterprise e-waste management plan (e.g. recycle their old computers with OES). They make the unfounded claim that '[t]he only way therefore to protect your customers from identity theft, shield your corporation from liability, and protect the environment is by ensuring the proper disposal of e-waste' (EM75). While proper disposal of e-waste is important to protecting information security (EM29, EM75), information security as a practice cannot be reduced to e-waste management – certainly numerous other threats to information security exist that spans the entire lifespan of ICT equipment, including end-of-life e-waste management.

Saskatchewan steward, SWEEP claims that a change to a nationalized system 'should have minimal impact on the day-to-day operations of the program' (EM100). The truthfulness of this claim is in dispute because substantial evidence exists to suggest that provincial stewards are not all operating using the same business model. This will be discussed further in section 5.4.2. Furthermore, SWEEP claims that the current e-waste regime in Canada is 'no longer sustainable' (EM100). No adequate evidence is provided for this claim. Moreover, as will be shown in section 5.4.2, this statement clearly promotes the organizational agenda of SWEEP towards harmonization.

British Columbia steward, ESABC makes the claim that the environmental handling fee (EHF) paid at point of purchase by consumers of electronics *ensures* that products get recycled in a responsible manner and within Canada; e.g. prevents disposal via export (EM04). Although this statement is perhaps not insincere, it certainly is not true. The EHF fee is the funding mechanism for the program, but the payment of a single product fee on a particular product in no way ensures that the product will eventually get recycled responsibly within Canada. In itself, this observation does not appear to support or cause any clear distortion in the public sphere. At worst it is an unclear communication. Crucially it we can ascribe meaning to a single observation by recognizing the context in which it is observed; an analysis of the context in this case found no evidence of distortion.

5.3.2 Empirical analysis of sincerity claims

Described by Cukier et al. (2009), sincerity implies congruity between that which is said, what is actually meant (Cukier, Ngwenyama, Bauer, & Middleton, 2009). Another illustration of insincerity can be observed in the use of hyperbole, imagery, or metaphor – which despite the apparent untruth and insincerity – can have a reinforcing effect on certain perspectives in the public sphere. Predominantly positive language is found in descriptions of EPR/e-waste. The annual reports and business plan documents of provincial e-waste stewards use language such as efficient, consistent, streamlined, transparent, greater accountability (EM13); further invest, strive for better, important work, pioneering outreach (EM48); proud, hard-work, commitment, efficient, cost-effective, convenient, environmentally and socially responsible (EM04); level playing field, no cross subsidization, environmental improvement, efficiency improvements, increased harmonization; focused on equitable, efficient and effective system (EM100); committed, open, transparent, integrity, respect, professionalism, partnership, cooperation (EM100).

Although positive language is characteristic of the public discourse on e-waste, there are a number of statements that do not pass Habermas' second validity test of sincerity. Responsibility for e-waste is widely recognized as a shared responsibility (EM03, EM32, EM56); however as described in chapter 2, responsibility for EPR/e-waste systems should include consumers, producers, and generally, should not extend to the municipality or other levels of government. Typically, the responsibility of

government is to set adequate environmental regulations. As a policy framework, extended producer responsibility (EPR) is intended as a means to transfer responsibility *from* government to producers (EM38).

Despite the ideal and intended limits to responsibility legislated through EPR/e-waste programs, there is a wide range of actual outcomes that may occur in practice – from equitable and efficient (EM20, EM38, EM43, EM56) to anti-competitive (EM43, EM104) and characterized as monopsony (EM43). This will be further discussed in section 5.4.2.

From the perspective of sincerity, responsibility is a highly connotative word. Often the expressed meaning extends far beyond the ideal or intended limits for e-waste management – as set in practice and widely accepted as described throughout chapter 2. As observed by Saint (2008), and discussed in section 2.2.2, a counter-narrative exists that responsibility to manage environmental harm is *everybody's* responsibility – effectively making it nobodies' direct responsibility. This is a powerful narrative that can be used to obfuscate and diffuse responsibility (Saint, 2008). This type of connotative language is pervasive, and several instances were observed. The most blatant use was found in a report published by the non-profit international organization, Global e-Sustainability Initiative (GeSI).

In a 2008 report from GeSI's Climate Group (EM02), the broad topic of ICT for environmental sustainability is examined (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008). The focus of the report is to understand the contribution of ICT to enabling the 'low carbon economy in the information age'. While GeSI is a highly credible and reputable organization, evidence is found that promotes a diffused responsibility as described above. In no way do we refute the authenticity or completeness of GeSI's commitment to these issues; but we do wish to draw attention to the language used in this following example – if only to demonstrate the pervasiveness and power of counter-narratives as described by Saint (2008) and discussed in 2.2.2.

In a foreword to the report, CEO of the GeSI Climate Group employs a highly connotative and imagery-laden depiction of the great environmental and social challenges now facing us as citizens of a global society:

> "Putting a man on the moon was one of the greatest technological challenges of the 20th century. In the 21st century we face an even greater test – tackling climate change. In contrast to the space race, the solutions required today must encompass us all. This is not just about one man walking on the moon, but about 7 or 8 billion people, the population of 2020, living low carbon lifestyles in harmony with our climate" (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008, p. 8).

While the above statement is not untrue, it imposes a sentiment that we all have a responsibility and role to bear in bringing this sustainable future to fruition. Again, while not untrue, such assertions (in themselves) do not fairly or sincerely acknowledge the highly politicized nature of social reality. Moreover, the trouble with such depictions is they presume anything is possible if we all commit to the precondition that we all work together: "Putting a man on the moon was once thought impossible. The next 'giant leap for mankind' is within our reach, but only if we act now" (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008, p. 8). There is logical consistency here. Such statements may be true – but they may also be evidence of systematically distorted communications (see Figure 1, page 45).

While response and action are warranted on the climate change issue, it is equally important that we respond *correctly*. We can thus refer back to our second hypothesis which has been refuted in section 0, and the poor response of variable REGULATION on per capita CO_2. A strong response that is not guided by strong environmental regulations may be counter-productive.

On this topic, GeSI has conducted strong research and their Smart2020 report champions thorough and innovative solutions to tackle this great challenge. Nevertheless, these narratives of common responsibility provide an excuse for failure and may lead to lowered expectations *because* of the complexity of these issues. Not only must we act now, but all key partners must act in concert: "If we are to better use ICT technology to move away from existing energy-intensive work habits and lifestyles, we need government policy innovations, incentives for companies and the active

participation of consumers" (Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008, p. 3). This is no recipe for success – it is not warranted to make assertions requiring fantasy preconditions.

While it is important to be honest and pragmatic when describing the challenges ahead and to remain realistic about what is required – it is of greater and more primary importance to champion solutions *in spite of* this stated complexity. In the case of GeSI's Smart2020 report – in the context of their organization and its aims – these above statement certainly pass the sincerity test. Yet, of particular note to this illustration (EM02) is the great uncertainty between that of honest, sincere and constructive communication, versus systematically distorted communications – e.g. by recognizing we are all implicated in the problem does not by itself address the climate change problem. Arguably, the GeSI Smart2020 report does directly address the problem – this statement is not insincere. Nonetheless, this is an important illustration.

An example where positive imagery can effectively divert attention away from issues of a more critical nature can be found with Ontario steward, OES (EM75). A claim is made that 7 jobs are created for every 1,000 tonnes of e-waste recycled in Ontario. While the truth of this statement is not at issue, its sincerity certainly is. As will be discussed in section 5.4, numerous sources draw attention to inconsistencies in the operations at OES. Notable examples are provided below.

An organization that describes itself as 'an independent, not-for-profit professional research and educational institute committed to environmental law and policy analysis and reform' (EM56) characterizes Ontario EPR stewards as 'monopsony purchasers of waste services' (EM104). They also state that the provincial EPR/e-waste program in Ontario does not promote competition (EM104). Moreover, in the comments section of an OES program plan, working concerns were raised against OES – 'Generally, the Ontario program has been the most difficult. Our company belongs to the other four provincial programs, and dealing with their program is extremely simple compared to OES' (EM27). Another independent body claims the Ontario case is troublesome 'as stewards set the targets themselves with review by [Waste Diversion Ontario] and approval by the ministry' (EM43). Certainly

anecdotal and inconclusive at this level of analysis, consistent concern has been raised over the business model employed by OES. The 7x job multiplier cited by OES carries positive connotation; additional analysis would be required to determine if other stewards across Canada achieve higher levels of job creation. In light of the above reflections, the validity and sincerity of this claim remains in doubt.

Alberta steward, Alberta Recycling testifies that it 'strive[s] to provide the most effective environmental stewardship programs possible' (EM10). As will be presented in section 5.4.2, Alberta Recycling is not publicly engaged in the harmonization efforts that other provincial stewards (SWEEP, ACES, ESABC, soon Green Manitoba) are promoting. OES and Alberta Recycling are generally excluded from all discussion of harmonization, and potential efficiency gains therein. Nonetheless, as will be shown in section 5.4.3, Alberta Recycling has achieved very high public awareness ratings and no direct evidence was found that otherwise disputes their commitment as stated above. It is curious that Alberta Recycling does not publicly examine the benefits and potential efficiencies or pitfalls associated with harmonization. Nonetheless, Alberta Recycling is Canada's first e-waste steward – and at this level of analysis insufficient evidence exists to warrant a strong claim of insincerity against Alberta Recycling.

As discussed in section 2.3.1, Canadian Council of Ministers of the Environment (CCME) is the governmental body that has been vocal on the topic of e-waste management in Canada. CCME identifies and provides consistent thought leadership on key environmental issues that are of national or intragovernmental importance; on topics such as air, coordinated environmental management, soil, waste management, and water. This is a singular voice representing governmental values on the environment, inclusive of all Ministers of Environment from the federal and all provincial and territorial governments across Canada. CCME boasts how they enjoy 'the comparative advantage of undertaking work that no one else can do, or work to which it can provide a unique contribution or is particularly suited' (EM105).

CCME clearly recommend a consistent, harmonized approach (harmonization will be discussed further in section 5.4.2). A Canada-wide Action Plan is published in 2009 providing guidance for industry as EPR programs are being implemented, and are now well established as the policy framework for waste management issues across Canada (EM23). In 2004, CCME released a position paper for EPR/e-waste stewardship that established 12 principles to characterize EPR/e-waste and promote consistency across all Canadian jurisdictions. CCME states it is 'widely recognized that legislative/regulatory initiatives are required to establish a level playing field for industry in the management of e-waste'; while their plan acknowledges this, it offers no enforcement/compliance mechanisms (EM47).

Nearly all sources recognize that government leadership and political will are required to achieve an efficient, equitable e-waste management system (EM02, EM23, EM30, EM32, EM38, EM56). However, no statements were found to suggest sufficient political will exists across Canada. This is well supported by sections 2.3.*x*. Furthermore, numerous organizations have called for increased federal commitment and action on these issues (EM44, EM56, EM103). Environment Canada describes the responsibility to manage e-waste in Canada as a shared responsibility - federal, provincial, municipal all have role to play in setting regulations (EM103). Moreover, comments made at a national EPR conference also support this with key recommendations: i) coordinate a national approach allowing for regional differences; ii) establish industry-government partnerships to lead establishment of EPR programs, sector specific (EM44).

While CCME represents all ministers of the environment across Canada, they are apparently not representative of the values of the Federal Minister of Environment, or federal government of Canada. These observations are not enough to challenge the sincerity or legitimacy of CCME's commitment to good environmental management. As with the discussion of GeSI's Smart2020 report (EM02), in the case of problems that require moral leadership and orchestrated political will, care must be taken when preparing recommendations. If in situations where accompanying political will is known to be absent, to propose recommendations that implicitly assumes support is a serious challenge to the credibility and sincerity of these communications.

5.3.3 Empirical analysis of legitimacy claims

An examination of legitimacy is primarily concerned with representation and whether the concerns of all interested social actors are given fair coverage. Are any legitimate voices excluded? Are any illegitimate voices included in the discourse? Given our analysis and research design takes Canada as its focus and does not include an in-depth evaluation of e-waste steward organizations, we are careful to set appropriate scope for the following findings. Based on our purposive search strategy as described in section 4.5.3, we have only included public statements (such as annual reports and business development plans from all relevant organizations). Nonetheless, there is one organization whose claims do not pass Habermas' third test, legitimacy.

As has already been cited, concern has been consistently raised over the practices of Ontario steward, OES (EM43, EM104, EM27). Although our analysis is limited in scope and includes only publicly available materials, clear violations to the principle of legitimacy can be observed in OES documents (EM66, EM67, EM70, EM71, EM73). At issue is the validity of the public consultation process during the design and implementation of the OES program plan. Based on reports published by OES (notably, EM27), consultation with the general public consisted of numerous one-way communications – background paper posted on website, additional website communications, press releases, e-newsletter, notices sent to a total of 11 community or industry groups.

One additional meeting was reportedly held with representatives from selected NGOs in a second round, discussing a revised program plan: 17 people were invited; 4 attended this meeting. This is the stated entirety of OES's public consultation process, as presented in EM27 – and cited elsewhere, EM66, EM67, EM70, EM71, EM73. Due to the non-representative sample size and general lack of any degree of public consultation, serious legitimacy concerns are raised by these observations. While broad conclusions are not warranted due to the limited scope of this study, even at this level of analysis we are able to observe and empirically articulate where potential distortions exist in the public sphere and in e-waste management practices across Canada.

5.3.4 Empirical analysis of comprehensibility claims

Failures on Habermas' fourth validity test, comprehensibility, are typically in the form of incomplete messages, specialized methods, or even information overload (Cukier, Ngwenyama, Bauer, & Middleton, 2009). According to Cukier et al., comprehensibility can be evaluated in many ways - but at the most basic level this requires that the texts strictly adhere to semantic and syntactic rules(Cukier, Ngwenyama, Bauer, & Middleton, 2009). Based on this definition we found little evidence of violations to this claim. Nonetheless, there was one statement of note that included specialized language - wherein a typical reader would not realize they have received an incomplete message.

The policy of the federal government of Canada now ensures safe and environmentally sound disposal of all its electronics equipment (EM31). However, this policy did not come into effect until 2010. Prior to this time, an attempt would be made to recycle through provincial EPR/e-waste programs (if they existed) or by donation to recognized charities - but 'E-waste that cannot be reused and does not qualify for provincial programs can be recycled via the national standing offer for recycling services' (EM29).

The national standing offer for recycling services ultimately means that prior to 2010 the Government of Canada could not assure that its own e-waste was responsibly recycled. Substantial attention is given to proper packaging etiquette, but the fact that federal e-waste being carefully packaged for potential export was obscured by the use of specialized language - national standing offer for recycling services (EM31). Certainly EM29 and EM31 are truthful, sincere, and legitimate. But its comprehensibility is violated because, to the average or typical reader, the words 'national standing offer' in no way communicates the risk of export and ultimate disposal through crude recycling techniques as could reasonably occur in the absence of an adequate EPR/e-waste program.

5.4 Impact and diffusion of discourse

5.4.1 On stated research questions

As described in section 4.5.1, we are examining responsibility for environmental harm and use Melville's BAO framework (Figure A-2) and CDA as a research methodology in order to evaluate the coherence of public discourse on e-waste management with respect to contradictory notions of responsibility (corporate, social, environmental, fiscal, legal).

We have adopted two research questions from Temanos' to lead our analysis:

> Q1: In what way are the notions of environmental, economic and social responsibility implicated in the design and implementation of e-waste management programs across Canada?
>
> Q2: How and to what extent are Canadian e-waste management practices designed and implemented in the context of global sustainability discourses and goals regarding CO_2 reductions?

Our first question draws our attention to statements regarding responsibility as framed by and understood within the context of EPR/e-waste program design and implementation in Canada. Notions of responsibility may contain references or elements of various discourses of responsibility – environmental, economic, and social.

Our analysis does not engage in a detailed financial analysis, but we do encounter references to economic responsibility in the texts. This responsibility is clearly observed in (EM38) where the value of $25 billion is presented as the opportunity cost from materials that would not be recycled due to the current regime efficiency – over the next two decades (EM23). E-waste is also considered an important business/market opportunity (EM02, EM56).

Environmental responsibility is often included in most statements regarding EPR/e-waste systems. It can displace demand for virginal resource extraction (EM04, EM43, EM56, EM86, EM91); decrease the impacts of production through design for environment, e.g. reduced packaging, increased recyclable

content, reduced toxicity (EM20, EM43). These efforts have considerable environmental impacts, as discussed in chapter 2.

Social responsibility includes the moral responsibility to reduce disposal of e-waste via export (EM04, EM23, EM29, EM32). It is also understood with reference to protecting information security (EM29, EM75). Social responsibility also is stated to require a system that is equitable and efficient (EM20, EM23, EM43, EM104).

Our study did not examine media and news coverage of EPR/e-waste and instead took public communications and published reports from key stakeholders, as described in section 4.5.3. Nonetheless, several distortions were observed at our set level of analysis.

The primary distortion involves extending the notion of responsibility to limits that exceed the scope of care defined by the extant literature. Four forms of responsibility are described in practice (EM104). They are: i) financial responsibility; ii) physical responsibility; iii) informative responsibility; iv) liability. CCME recognizes these four and suggests all are relevant and necessary (EM23). Primary responsibility for waste management belongs to the municipality; but municipalities lack the tools to satisfactorily manage e-waste (EM23). Environment Canada states that all three levels of Canadian government (municipal, provincial, federal) have role to play in setting regulations to manage e-waste (EM103). Furthermore, EPR/e-waste as a policy approach is intended to transfer responsibility (all four types) from government to producers (and consumers).

Substantial evidence states that effective political will is required to achieve an efficient, equitable e-waste management system (EM02, EM23, EM30, EM32, EM38, EM56). Moreover, numerous organizations have specifically called for increased federal commitment and action on these issues (EM44, EM56, EM103).

From the perspective of our first research question, we have found clear evidence of disparate notions of environmental, economic, and social responsibility through the discourse on e-waste

management in Canada. Moreover, this is compounded by the 'we are all responsible' line discussed by Saint (2008) and examined in section 5.3.2.

The second question reverses the scope and asks whether Canadian discourse on EPR/e-waste systems resonates with global discourses of sustainability? Canadian e-waste practices are built upon the EPR policy framework. This is a globally accepted and well established means of implementing solid waste management systems (EM20, EM23, EM43, EM56, EM104). Thus at the macro or social level, discourse on e-waste management clearly resonates with similar efforts in the context of global sustainability.

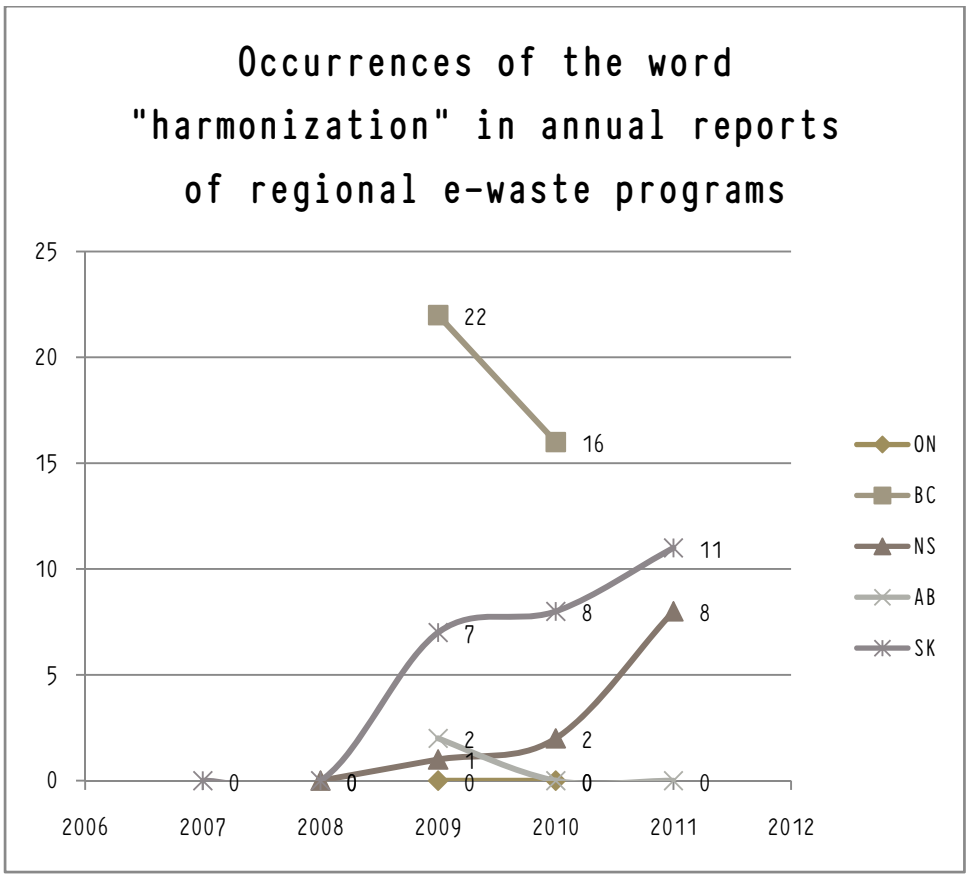
Our analysis now focuses on the public communications and audited annual reports of e-waste management industry organizations across Canada.

5.4.2 On statements regarding harmonization

Discourse on Canadian e-waste management practices is often characterized by the driving principle of harmonization. Described in section 2.3.1 and analyzed in 5.3.2 – speaking on behalf of all Canadian Ministers of Environment, including all provincial and territorial ministers and the federal Minister of Environment – CCME sets out an action plan for Canadian waste management (EM104). As a discourse, harmonization represents an approach described as: providing 'a level playing field for applying EPR initiatives across the country' (EM23); strategic (EM51); focused on 'equitable, efficient, and effective system' (EM100); and linked with transparency (EM38).

Some additional findings are relevant. Annual reports of Canadian e-waste stewards make frequent reference to this discourse of harmonization. OES co-sponsored an industry consultants' report on program harmonization and possible shared performance metrics to lead to improved efficiency system-wide (EM51). A harmonization office has been established, and stewards from Atlantic Canada, Saskatchewan, and British Columbia (EM77). OES and Alberta Recycling make no reference to these important developments in their annual reports; and, as shown in Figure 3, with the exception of Alberta and Ontario stewards the topic of harmonization is widely discussed.

Figure 3 Occurrences of the word "harmonization"



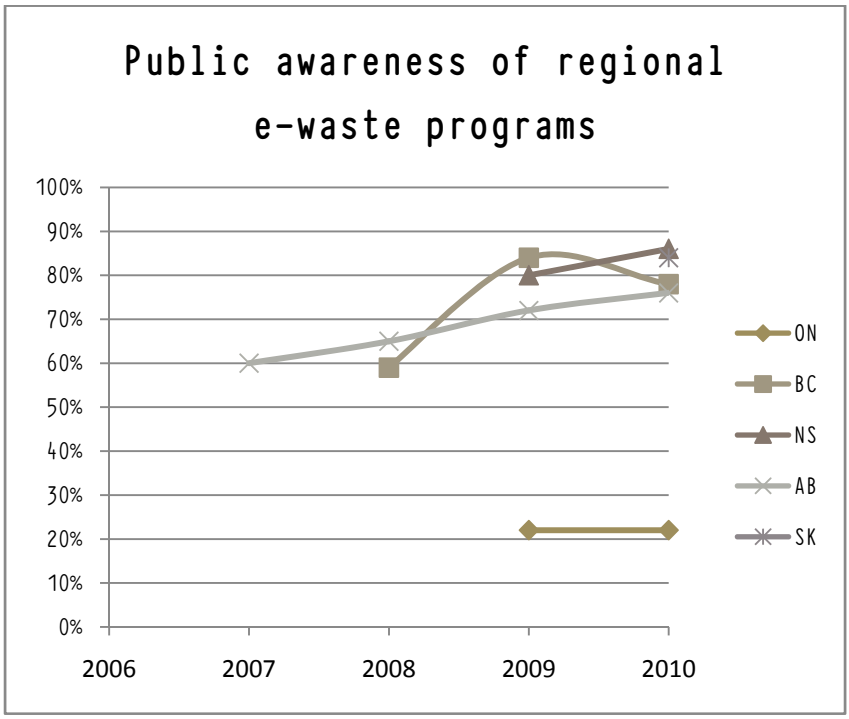
Alberta Recycling briefly mentions harmonization with reference to CCME's recommendation in their 2008-2009 annual report (EM05). No further references were found. Nonetheless, this is Canada's first EPR/e-waste program - and arguably has already established an effective practice. Given the scope of our findings, we cannot speculate further on Alberta Recycling.

Ontario steward, OES on the other hand, reveals a complete story. Given that OES co-sponsored an industry study into harmonization (EM51); has been cited as 'difficult' to work with by its business partners (EM27); and in light of concerns of a lack of competition and transparency (EM27, EM43, EM56, EM104); we cite these claims as a body of evidence that suggests the OES follows a demonstrably unique business model compared to other stewards.

5.4.3 On public awareness of the programs

In method 1 we conduct language analysis in order that we surface and reveal any potential distortions that could help explain – through accurate, descriptive analysis – the results we check against actual performance to be measured in method 2. We rely on method 2 for an empirical measuring of EPR/e-waste system performance.

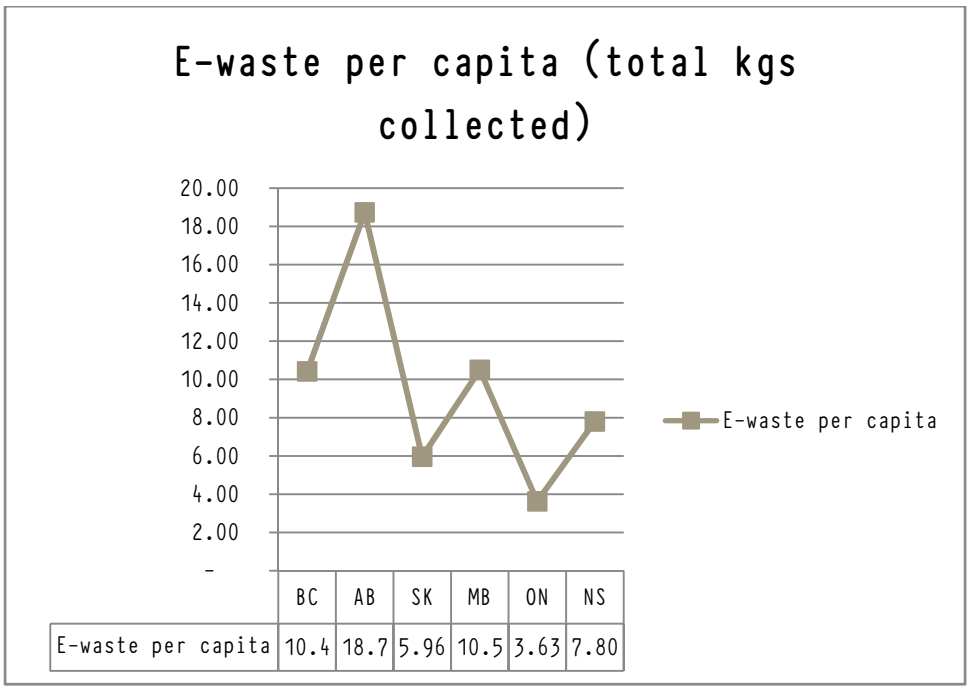
Figure 4 Public awareness of regional e-waste programs



In method 1 we also searched for evidence of performance. Numerous performance indicators are reported in practice. In Figure 4, the public awareness ratings of provincial stewards are shown.

Ontario steward, OES remains at alarmingly low levels. However, all other e-waste stewards are demonstrating strong performance – from the perspective of public awareness, as published in annual reports. Public awareness is an important factor; given at point of purchase the consumer has yet to play the critical (moral/social) role in closing the loop of responsibility, ensuring proper e-waste disposal by Canadian stewards.

Figure 5 E-waste per capita (total kgs collected)



	BC	AB	SK	MB	ON	NS
E-waste per capita	10.4	18.7	5.96	10.5	3.63	7.80

Moreover, as shown in Figure 5, Ontario currently achieves the lowest value of e-waste collected per capita. Notably, Alberta has a demonstrably stronger performance – however, this data is based on lifetime collections; given Alberta has been in operation for about twice the number of years on average, this value is not unexpected. Incredibly, Manitoba – which does not have an official e-waste program in place – has demonstrated the strongest performance on this measure (with the exception of Alberta). Figure 5 is cited as additional evidence that, on the whole, e-waste management practices in Canada are not particularly effective or exemplary.

Based on all above analysis, we find that in particular, Ontario steward, OES is a poor model. At the current level of analysis, we are strong in this claim.

5.5 Summary of method 1 findings – CDA

As articulated in chapter 3, e-waste management requires effective laws and regulations (Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006). Considerable evidence presented in this chapter all suggests strongly

and consistently that Canada lacks the federal political will to instil effective environmental regulations for e-waste management. Please refer to Table 3 for key research findings thus far in the study.

Table 3 Key research findings from method 1

Relevant research claims	Source
Political will is required to achieve an efficient, equitable e-waste management system	EM02, EM23, EM30, EM32, EM38, EM56
EPR/e-waste can be an effective policy framework	EM20, EM23, EM43, EM56, EM104
EPR/e-waste systems can be equitable and efficient	EM20, EM23, EM43, EM104
E-waste displaces demand for virginal resource extraction	EM04, EM43, EM46, EM56, EM86, EM91
There is a moral responsibility to reduce export of e-waste	EM04, EM23, EM29, EM32
Design of EPR/e-waste systems is very important; in particular, to avoid threat of anti-competitive practices	EM20, EM23, EM38, EM43, EM56, EM104
Distortions exist in the public discourse on e-waste management	EM02, EM13, EM04, EM10, EM27, EM30, EM47, EM66, EM75, EM100

On this evidence, we turn to our two key hypotheses:

> H1: Absent of strong environmental regulations across the country, e-waste management systems designed by industry may become based on contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility
>
> H2: Systems that exhibit contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility will be unable to achieve high levels of environmental performance

H1 suggests explicitly that industry-led organizations will not necessarily design coherent systems – if they are not guided by effective laws and regulations. We will determine whether strong environmental regulations exist in Canada using quantitative methods, with method 2 (H4). H2 suggests that actual systems – if they are shown to contain incoherent notions of environmental sustainability and responsibility – will not be able to achieve high levels of environmental performance. Based on

the above analysis, we could tentatively accept H2. However, we will now turn to quantitative methods (H3, H4) before discussing further.

6 Two-Stage Least Squares regression – method 2

6.1 Introduction to 2SLS

The results of this first method will accurately measure actual public use of e-waste disposal systems across Canada. These findings will be quantitative and based on strong empirical methods.

We include a panel of data over a period of 11 years (2000-2010), and thus report on before, during, and after e-waste regulations and EPR programs came into effect across Canada.

Table 4 2SLS regression results

Two-stage least-squares regression

Equation	Obs	Parms	RMSE	"R-sq"	F-Stat	P
co2pc	11	3	.5952633	0.4939	2.28	0.1214
2co2pc	11	2	.705644	0.1872	0.92	0.4194

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
co2pc						
gdppl	5.401176	2.540111	2.13	0.050	-.0129422	10.81529
regulation	-.4927801	.2662541	-1.85	0.084	-1.060287	.0747271
gdpenerg	.075203	.1411753	0.53	0.602	-.225705	.3761111
_cons	-37.97507	25.3405	-1.50	0.155	-91.98707	16.03693
2co2pc						
ictewaste	-.0085377	.0168342	-0.51	0.619	-.0444189	.0273435
urban	.0875549	.2767523	0.32	0.756	-.5023288	.6774386
_cons	10.3678	22.62614	0.46	0.653	-37.85868	58.59427

Endogenous variables: co2pc
Exogenous variables: gdppl regulation gdpenerg ictewaste urban

6.2 Summary of method 2 findings

Table 4 shows the results of 2SLS regression analysis with a confidence of 95%. The hypothetical condition to accept the claims was set to reject any claim if P>|t|>0.05, otherwise the hypothesis is accepted. Please refer to section 4.4.2 for a complete discussion of this method.

We will now review the five hypotheses tested with this method:

H3: An increase in ICT/e-waste index performance is negatively correlated with per capita CO_2

Table 4 shows our variable for EPR/e-waste system performance (ICTEWASTE) having a negative correlation with per capita CO_2. This means that Canadian e-waste management practices on the whole appear to reduce CO_2 emissions, but this impact in Canada is not statistically significant (P>|t|=0.619). This indicates that the EPR/e-waste recycling programs (across Canada on aggregate) are not effective enough. Nonetheless, the direction of the sign is correct (negative) as per our predictions.

Given the newness of these programs (shown in Figure A-9), and warranted by the absence of consistent environmental regulations across all Canadian jurisdictions, these findings are consistent. Thus, we must reject hypothesis H3 with regards to Canadian e-waste performance. The impact of current efforts to manage e-waste in Canada is not making (as of 2010) a difference of any statistical significance.

H4: The presence of EPR/e-waste regulation (as ratio of jurisdictions with legislation versus those without) will be negatively correlated with per capita CO_2

In the case of Canada, the presence of EPR/e-waste regulation is negatively correlated with per capita CO_2. Nonetheless, variable regulation is not statistically significant at 95% level (P>|t|=0.084). Therefore we must reject hypothesis H4 indicating that the Canadian environmental regulation is not strong enough to fulfill its obligations towards an effective and efficient e-waste management program.

Given the apparent absence of federal political will on this matter in Canada (as described in chapter 2, and examined further in chapter 6), this finding is perhaps not alarming. It is believed that regulation leads to provincial or regional EPR/e-waste programs. However, as shown in Figure A-9, having regulations in place does not necessarily mean that industry steward organizations come instantly into operation. For REGULATION to exhibit a strong statistical relationship it is speculated to require ideal conditions as described in chapter 3 with the case of Switzerland. Given that these conditions are not met in Canada, and given the refutation of H3, it is a consistent finding that we must also reject H4.

H5: An increased level of GDP per capita in the long run will lead to a reduction in per capita CO_2

This hypothesis was included to test the EKC hypothesis. As explaining in section 4.4.2, EKC is a controversial claim; it has come under considerable scrutiny (Schmalensee, Stoker, & Judson, 1998; Stern, 2004; Cole, 2003). We have taken a relevant theory (environmental Kuznets curve – EKC) and embedded it in our regression model as a control variable. The above findings are taken as evidence of the strength of our model.

The result of our regression analysis show did not confirm the Kuznets' claim for EKC hypothesis (see Figure A-17 in Appendix). This finding is as expected. Variable GDPP as depicted in table 4 shows a positive sign with regards to co2pc and its p-value is at the critical value of 0.05 indicating its positive impact on increased CO_2 emission. The same is true with regards to cubic GDPP (gdp3). As shown in Figure A-17 (Appendix) the p-value of variable gdp3 shows a value of 0.064indicating its positive impact on increased CO_2 emission. We must reject H5.

H6: An increased level of urbanization is positively correlated with pollution as measured in per capita CO_2

The Canadian urbanization index shows a positive correlation (positive coefficient value) with the increased level of CO_2 emission but this impact is not statistically significant (P>|t|=0.756). This is a consistent and anticipated result. Substantial evidence exists to link levels of urbanization with pollution (Dhakal, 2010). With a p-value of 0.512, we must reject H6. Nonetheless, given the small size of the panel dataset being examined, and given that the sign is in the correct direction (positive), we take this finding as consistent.

H7: An increased level of energy consumption per capita is positively correlated with per capita CO_2

The increased energy consumption in Canada per GDPP – variable (gdpenergy) – shows a positive relationship with the increased level of CO_2 in Canada; however, this impact is not statistically significant. We must reject H7. Nonetheless, given the small size of the panel dataset being

examined, and given that the sign is in the correct direction (positive), we take this finding as consistent.

6.3 Acceptance of the findings

We believe our 2SLS model to be consistent and its findings are accurate. The data covered a total of 11 years; however the first five years are characterized by virtually no regulations on end-of-life electronics product stewardship (shown in Figure A-9). Prior to 2005, e-waste recycling occurred in Canada – but no formal data exists on this in the public sphere. Our data is inconclusive of 2000-2010, and thus captures the lead-in period of program launch and ongoing development.

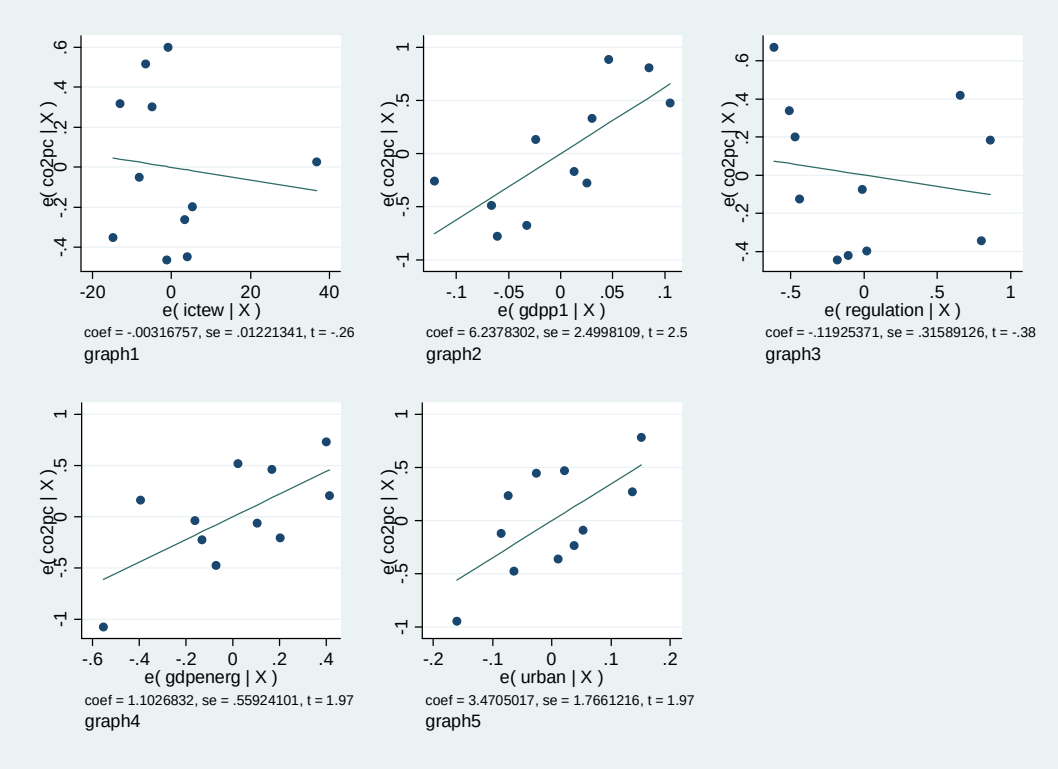
In order to test the validity of our hypothetical model we run a series of normality test against main variables in use as well as our regression error term (residuals). Table 5 displays the partial and semi-partial correlation coefficient of dependent variable (co2pc) with other variables. As indicated the variable GDPP (first order) has a positive impact on the increased level of per capita CO_2 emission and this impact is statistically significant at 95% level.

Table 5 Partial and semi-partial correlations with co2pc

Variable	Partial Corr.	Semipartial Corr.	Partial Corr.^2	Semipartial Corr.^2	Significance Value
ictewaste	-0.5828	-0.3831	0.3397	0.1467	0.1696
gdpp1	0.7673	0.6389	0.5887	0.4082	0.0441
regulation	0.0997	0.0535	0.0099	0.0029	0.8316
gdpenerg	0.6741	0.4874	0.4544	0.2375	0.0968
urban	0.6601	0.4693	0.4358	0.2203	0.1066

In addition Figure 6 below shows scatter plots of independent variables against dependent variable co2pc. As shown in graph1 there is a negative correlation between ICTewaste and variable co2pc. The same relationships exist between variable regulation (graph3) and co2pc. While other variables such as GDPP (graph2), GDPenergy (graph4) and urbanization (graph5) show positive correlations with per capita CO_2 emissions.

Figure 6 Scatter plot of variables



To test the validity of our hypothetical model with regards to the p-values and t-tests as reported by our regression analysis, we checked for normality of residuals to ensure that the error term is not correlated with variables and it is independent and normally distributed (UCLA, 2011). Figure 7 shows the normality test of our model's residuals indicating that error term is normally distributed and therefore we can accept the reported p-values and t-tests.

Finally, Figure 8 shows the spline plots of relations between ICTEWASTE, GDPenergy and per capita CO_2 emission. These graphs are constructed cross variables' median for the period between 2000 and 2010. The plots use the cross medians as knots to fit a cubic spline. As shown in Figure 9, the resulting splines are presented as line plots. Graph 1 and Graph 2 plots were used to demonstrate the non-linear relationships among variables.

Figure 7 Normality test of residuals

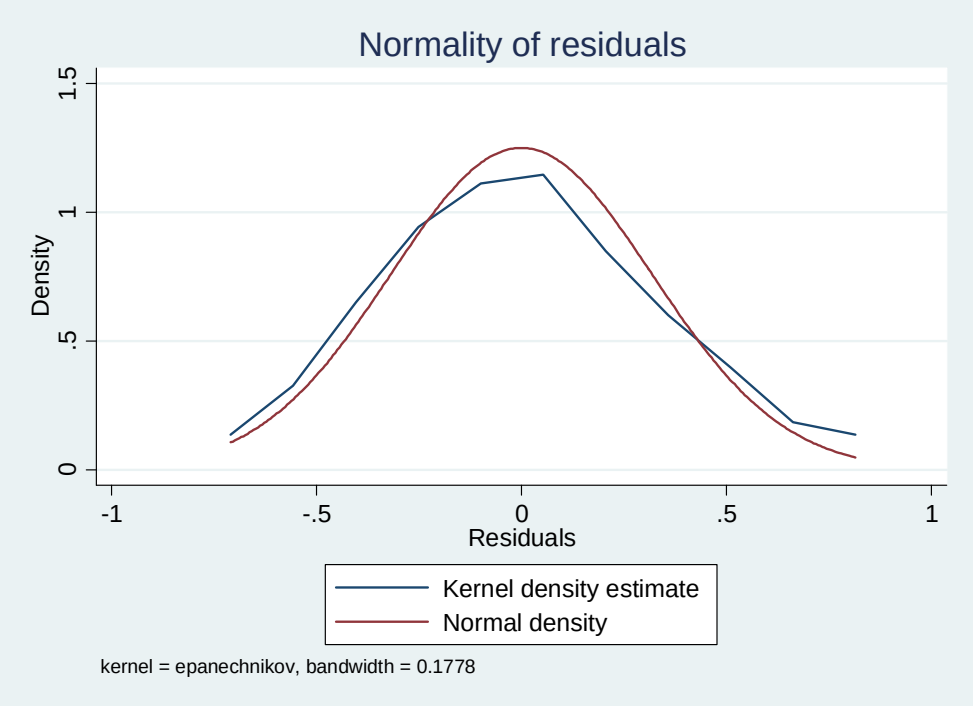
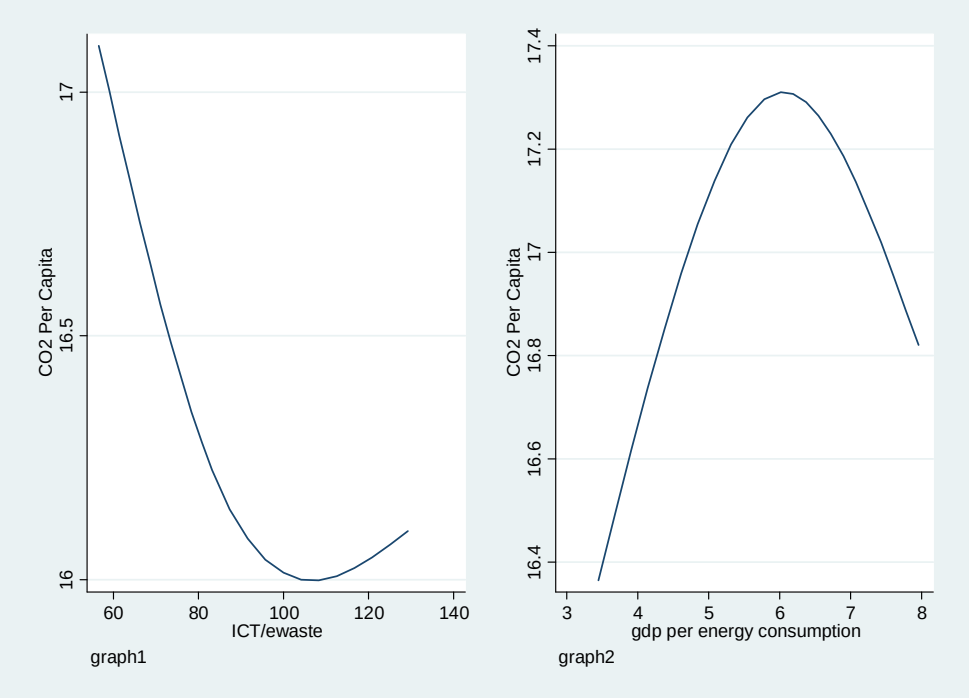


Figure 8 Spline plots of relations between ICT/ewaste, GDPenergy and co2pc



Crucially, with the archival data used in this study being limited to a period 11 years, we do not expect the sample data to portray a complete understanding of the environmental impacts of e-waste management in Canada on reduction of CO_2 emissions. As we know the environmental analysis has by nature a non-linear characteristic. As such it is desirable to consider a longer period of time for such investigation. Unfortunately e-waste data across Canada was not available for periods prior to year 2000. The same limitation of low data availability is true when it comes to e-waste statistics among other developed nations. One option to compensate for the limited dataset for Canada is to expand our analysis to other countries with similar economic, socio-political and environmental settings. In spite of these challenges, this thesis uses the most efficient regression analysis considering the non-linear characteristics of variables, and also uses OLS regression to graphically demonstrate the fitted linear relationships among variables as shown in Figure 6.

6.4 Summary of method 2 findings – 2SLS

In light of the above discussion, we now re-examine our first two key hypotheses:

> H3: An increase in e-waste/ICT index performance is negatively correlated with per capita CO_2

Our analysis did not find sufficient evidence to warrant a strong link between Canada's current e-waste management regime and reductions in per capita CO_2. Nonetheless, it is a generally positive result that our analysis did affirm the correct direction of the sign (negative) of this observed relationship. Based on the data from preliminary years of Canadian e-waste management, the impact of these systems is not statistically significant.

Thus, we take this as evidence that – based on aggregated analysis – none of the provincial EPR/e-waste stewards are demonstrating particularly strong performance.

> H4:The presence of EPR/e-waste regulation (as ratio of jurisdictions with legislation versus those without) will be negatively correlated with per capita CO_2

Our rejection of H4 given the above presentation and discussion of research findings can be taken as adequate evidence that environmental regulations on e-waste management in Canada are not strong enough. In fact, the variable REGULATION shows no statistical relationship (p-value = 0.438) and the direction of the sign is actually positive. We take this as strong evidence that Canadian environmental regulations are not strong.

The implications and descriptive characteristics of these findings will now be supplemented by CDA method in the following chapter. Table 6 provides a summary table of key findings from method 2.

Table 6 Key research findings from method 2

Relevant research claims	Source
Industry EPR/e-waste systems performance (measured as impact on per capita CO_2) is not strong	Rejection of H3
Canadian regulations on EPR/e-waste are not strong enough	Rejection of H4

7 Conclusions

7.1 Overview of the thesis

This thesis is based on a mixed-methods research design, and contains two methods. The thesis has eight chapters. In the first chapter, the scope of the research was defined and the research topic introduced. Chapter 2 provided a full review of scholarly literature and professional reports on e-waste management. Chapter 3 articulated the research problem and situated the study within the domain of information systems research for environmental sustainability; and hypotheses were identified for testing. Chapter 4 discussed the research methodology and design. The results from the first method are presented in chapter 5; results from the second method in chapter 6.

In this chapter, a full analysis is provided on the research topic in light of the findings from both research methods.

7.2 Synthesis of the research findings

Through our examination of responsibility for environmental harm through a discourse study of e-waste management systems in Canada, several empirical observations were revealed to us. Chapter 5 provided supporting descriptive analysis, and the results from method 1. Chapter 6 described the method 2 regression modeling technique that was used to support this claim. Based on this analysis, we rejected both H3 and H4. We found that the contribution of Canada's EPR/e-waste systems to per capita CO_2 is marginal at best. Moreover, strong environmental regulations and political will at the national level were found lacking.

Our study has shown that effective and consistent environmental regulations are not in effect across the country (rejection, H4); the current regime designed, and lead by industry does not contribute strongly to per capita CO_2 (rejection, H3). Crucially, in sections 5.4.x we demonstrated that one of the systems (Ontario's)is based on contradictory notions regarding corporate and environmental

responsibility. Moreover, this particular e-waste management system in Ontario operates at very low levels of environmental performance.

Thus we are able to accept our two key hypotheses:

> H1: Absent of strong environmental regulations across the country, e-waste management systems designed by industry may become based on contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility
>
> H2: Systems that exhibit contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility will be unable to achieve high levels of environmental performance

In next section, we will provide final discussion of our findings.

Please refer to Table 7 for an overview of relevant research facts and findings:

Table 7 Synthesis of key research findings from both methods and literature

Relevant research claims	Source
Political will is required to achieve an efficient, equitable e-waste management system	EM02, EM23, EM30, EM32, EM38, EM56; (CCME, 2009; C.D. Howe Institute, 2010; CIELAP, 2008; Environment Canada, 2004; Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006)
EPR/e-waste can be an effective policy framework	EM20, EM23, EM43, EM56, EM104; (McKerlie, Knight, & Thorpe, 2005; Lee, Chang, Wang, & Wen, 2000; Liu, Tanaka, & Matsui, 2006; Wagner, 2009; Nnorom & Osibanjo, 2008)
EPR/e-waste systems can be equitable and efficient	EM20, EM23, EM43, EM104; (CIELAP, 2008; CCME, 2009; C.D. Howe Institute, 2010)

Relevant research claims	Source
Design of EPR/e-waste systems is very important; in particular, to avoid threat of anti-competitive practices	EM20, EM23, EM38, EM43, EM56, EM104; (CCME, 2009; C.D. Howe Institute, 2010; CIELAP, 2008; Environment Canada, 2004)
There is a moral responsibility to reduce export of e-waste	EM04, EM23, EM29, EM32; (Lepawsky & McNabb, 2009)
E-waste displaces demand for virginal resource extraction	EM04, EM43, EM46, EM56, EM86, EM91; (Cui & Zhang, 2008; Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005; Global e-Sustainability Initiative & Electronic Industry Citizenship Coalition, 2008; Government of Canada, 2011)
Distortions exist in the public discourse on e-waste management	EM02, EM13, EM04, EM10, EM27, EM30, EM47, EM66, EM75, EM100
E-waste management system established in Ontario is partially based on incoherent notions of environmental sustainability and responsibility (corporate, social, environmental, legal, fiscal)	Affirmation of H1
Industry EPR/e-waste systems performance (measured as impact on per capita CO_2) is not strong	Rejection of H3
Canadian regulations on EPR/e-waste are not strong enough	Rejection of H4

7.3 Summary discussion of the research findings

The results of our second method (notably, Figures 3-5) clearly demonstrate that discourse on e-waste management in Canada is not wholly coherent from the perspective of environmental sustainability and responsibility (corporate, social, environmental, legal, fiscal). While all Canadian e-waste stewards

are shown to currently exhibit poor levels of performance, the case of Ontario steward, OES is particularly alarming.

Moreover, environmental performance of Canadian e-waste management systems has been measured by method 2; and it was not found to be of statistically significant impact.

On this evidence, we turn to our second hypothesis:

> H2: Systems that exhibit contradictory notions of (corporate, social, environmental, fiscal, legal) responsibility will be unable to achieve high levels of environmental performance

In chapter 5, we provisionally accepted H2. Based on the above analysis, and in light of our method 2 quantitative analysis, we can now strongly accept our second hypothesis.

Furthermore, we believe that this result helps promote a better understanding of the construct of environmental sustainability - namely, if incoherent notions of responsibility (corporate, social, environmental, fiscal, legal) are found in organizational discourse - we posit - the associated system will be unable to achieve high levels of environmental performance.

It is also crucial to mention that on December 12, 2011, the federal government of Canada invoked its legal right to withdraw from its international commitments under the Kyoto protocol (CBC News, 2011).

In sum, these findings clearly demonstrate the value of mixed-methods approach and critical methodologies in evaluating the environmental performance of systems - ultimately affirming that *design matters* and coherence in discourse of responsibility is a necessary (although likely not sufficient) condition to obtain systems able to achieve high levels of environmental performance.

7.4 Contributions of the research

There are five principle contributions this research. First, this is among one of the first studies on ICT and e-waste management. Additionally, this is believed to be the first study using a panel dataset of Canadian figures. This study captures an important time period in EPR/e-waste program

development –inclusive of before, during, and after the introduction of programs and regulations occur.

Second, this study is among the few that deploy critical discourse analysis (CDA) as an empirical research method within the research field of environment sustainability and information systems research.

Third, this study has successfully employed a mixed-method research design that uses critical theory in order to highlight some of the practical implications regarding the environmental performance of systems, including but not limited to e-waste management systems. This has allowed the weighing of qualitative analyses within our quantitative analysis of system performance. We believe this to offer an important methodological contribution to this nascent field of IS research for environmental sustainability.

Fourth, given the stated goals of the government of Canada regarding CO_2 performance and emission targets (Kent, 2011) this study sends a clear warning signal that we lack both strong environmental regulations and not all e-waste management systems across the country pass our coherence test. As described in section 2.3.2, Canada is not in a position to reach its stated targets (Vaughan, 2011) and has now requested to withdraw from the Kyoto protocol (CBC News, 2011). Our findings are consistent with these above statements and sources.

Finally, and fifth, this study clearly demonstrates that absent of strong environmental regulations, there is no guarantee that industry will design systems that prioritize environmental performance. This leads to important considerations for policymakers, industry professionals, and academic researchers who are examining pollution management in situations where policy, roles and regulations are not clearly or strongly specified.

7.5 Criticism of the research approach

Our CDA method has been limited to publicly reported statements and reports from key stakeholders. This approach is well calibrated to observe only the most blatant distortions in discourse of

Canadian e-waste management. Nonetheless given the intentions of this method, and its inclusion in a larger mixed-methods research design, we believe this to be a consistent strategy.

Nonetheless, there are a number of relevant criticisms through which the validity of the data may be challenged. We have identified three key concerns that need to be recognized; as well, we will provide directions for future research in the following section in order to expand on these limitations.

First, this study has good horizontal scope (inclusive of the majority of jurisdictions across Canada); however the study is limited in its vertical scope. Based on the inclusion of publicly available data, and given the low number of years of including data-points, we are limited in our scope to interpret or draw conclusions. Nonetheless, given the strong horizontal scope of the study, we have endeavoured to avoid interpretations of the data that focus alternatively on a vertical scope – e.g. our method 2 results measure e-waste systems performance across Canada, however, they do not provide additional analyses with respect to specific jurisdictions. Thus, method 1 was used to supplement this analysis – and to warrant a broader interpretation than would otherwise be possible from a single method study.

Second, given the limited data available for our study, and given that we expect long-term impacts and high variability in data – for instance, given temporal delays due to decision to store device rather than recycle – this data is inherently less reliable on short time span. Nonetheless, based on the inclusion of 11 years panel dataset and the use of actual values from numerous EPR/e-waste systems across Canada, we believe that our analysis is strong and of sufficient validity to warrant the conclusions drawn.

7.6 Comments on future research direction

Based on the above concluding analysis, a number of items have been identified that warrant further consideration. There are five key recommendations for future research on our stated research problem. First, we recommend that the corpus defined for CDA study is expanded to include national media

coverage on e-waste practices, and a sincere attempt to reach an intra-organizational level of analysis – perhaps through the inclusion of surveys of steward organizations as an additional research method.

Second, an in-depth financial analysis of each of the EPR/e-waste systems across Canada should be conducted. It would be interesting to examine what relationship exists between financial performance and environmental performance outcomes.

Third, substantial activity occurs in the informal sector; e-waste entrepreneurs play an important role in understanding system efficiency. However, their impacts are all but hidden from the publicly available data. Additional research methods would be required to include these unrealized inputs.

Fourth, the model needs to be expanded to include all appropriate environmental impact categories – and must especially include heavy metals; as e-waste is already the primary contributor to heavy metal levels in Canada. This impact will only increase as the proportional volume of e-waste generation increases.

Fifth, the quantitative model in method 2 should be expanded to include municipal-level analysis; including distances travelled to recycle e-waste, and a measure of employment generated by these practices.

8 Appendices

Figure A-1 Environmental Kuznets curve for sulfur emissions

Source:(Stern, 2004)

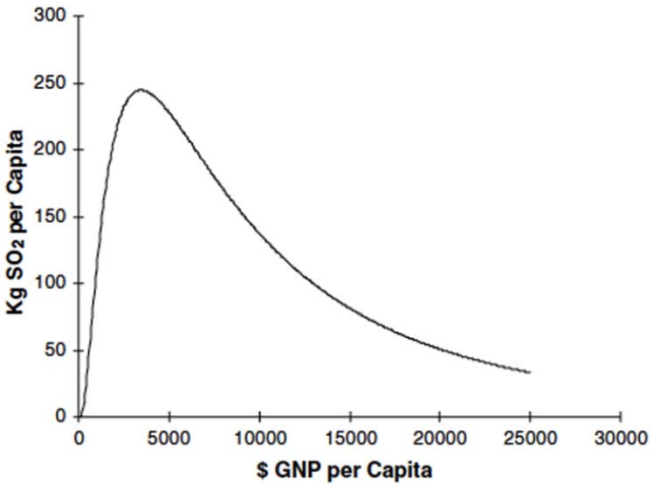


Figure A-2 Belief-action-outcome (BAO) framework for IS research on sustainability

Source: (Melville, 2010)

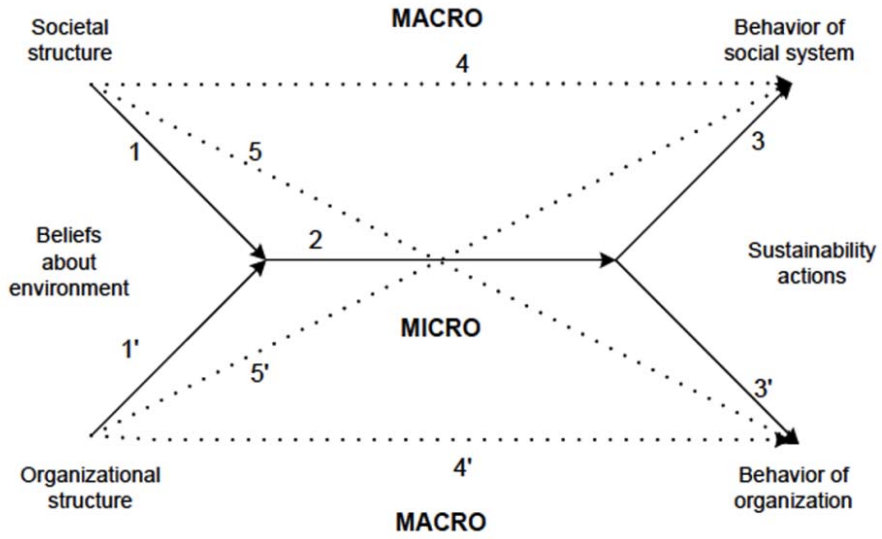
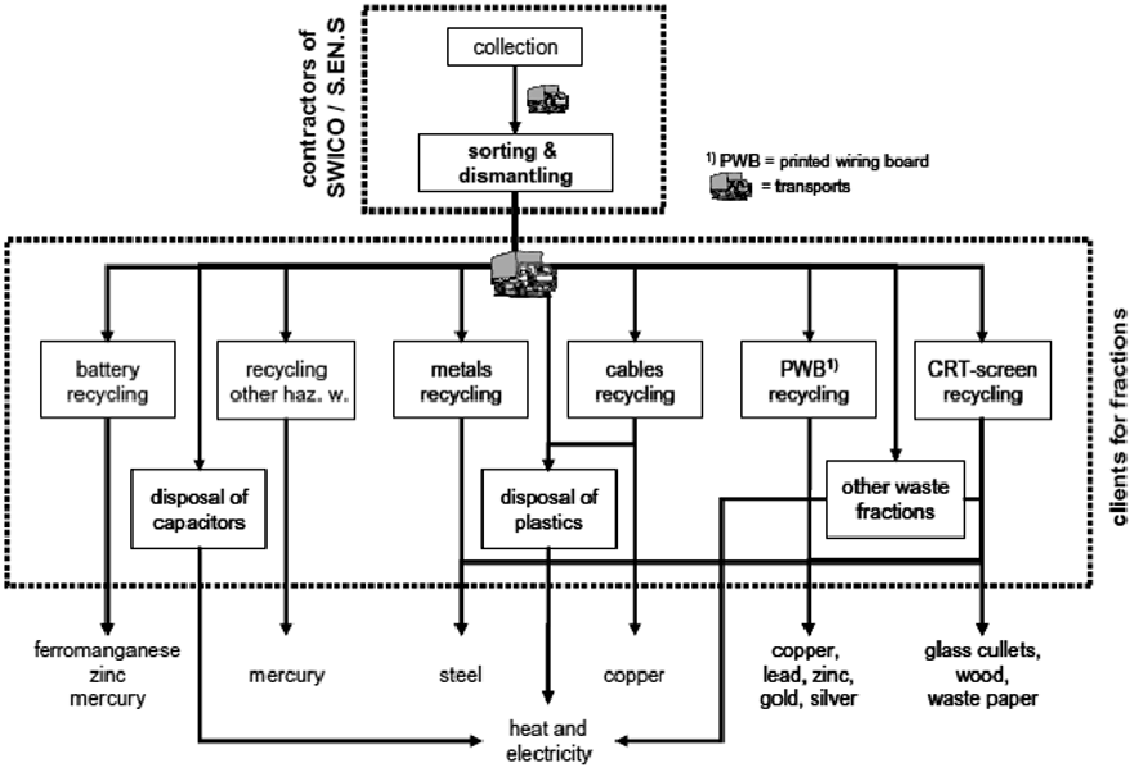


Figure A-3 SWISS TAKE-BACK PROGRAM FOR E-WASTE

Source: (Hischier, Wager, & Gauglhofer, 2005)



System boundaries of the modeled WEEE take-back and recycling systems, including processing steps up to the production of secondary raw materials.

Figure A-4 A TIME-SERIES INFLOW-OUTFLOW MODEL

Source: (Kang & Schoenung, Estimation of future outflows and infrastructure needed to recycle personal computer systems in California, 2006)

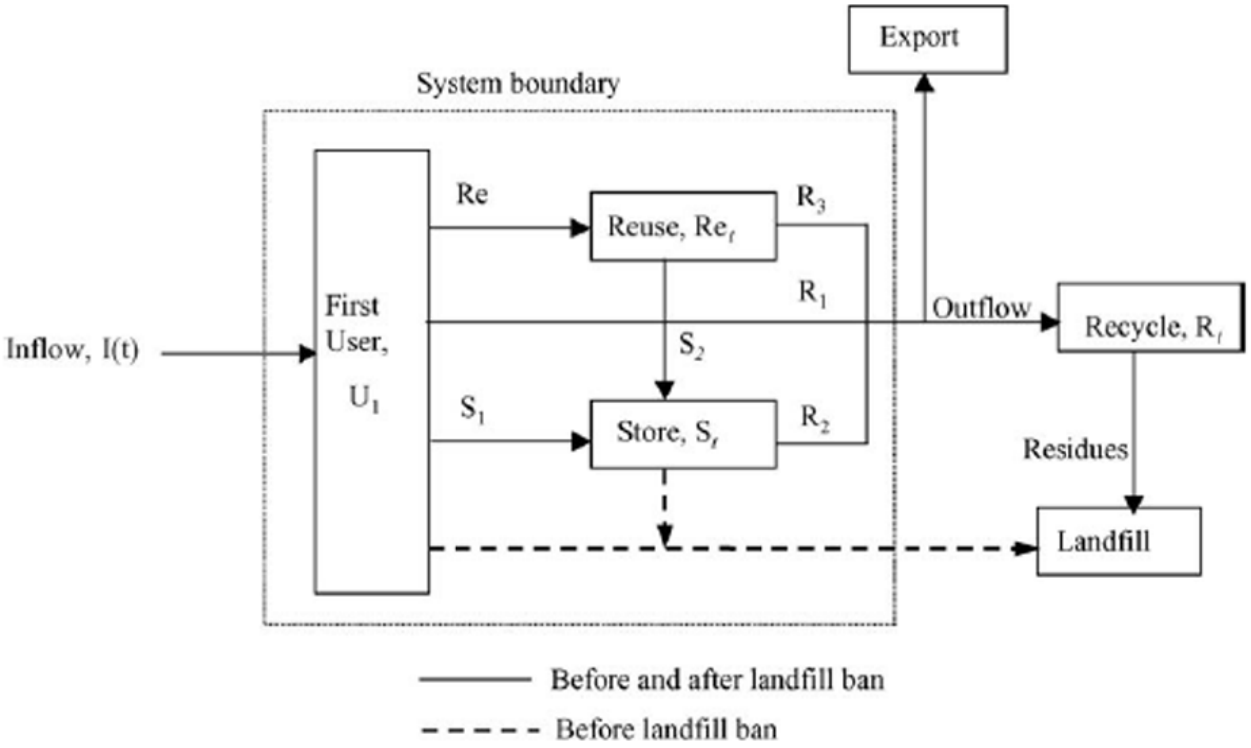
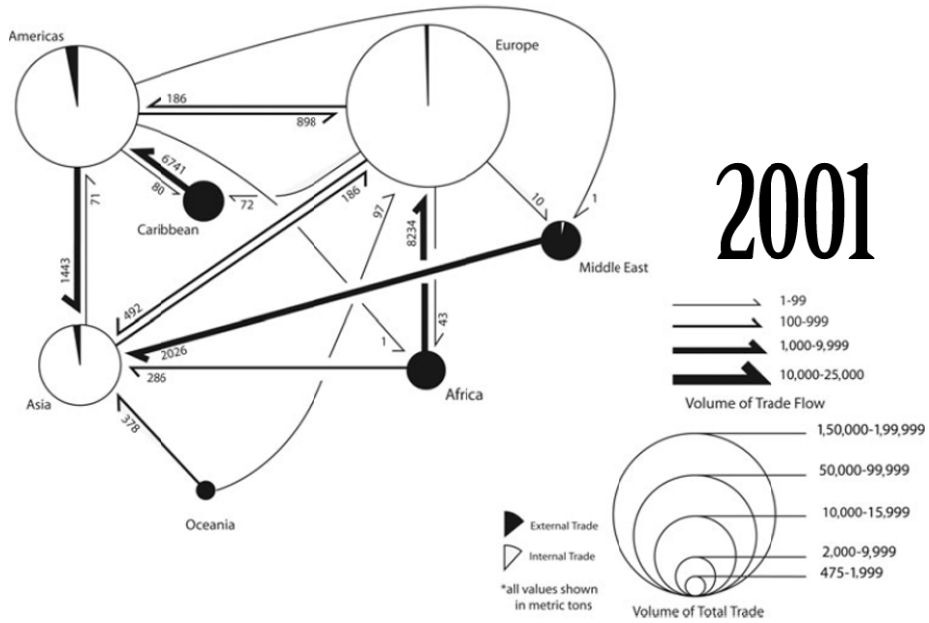


Figure A-5 GLOBAL TRADE IN E-WASTE, ALL VALUES IN METRIC TONNES

Source: (Lepawsky & McNabb, 2009)



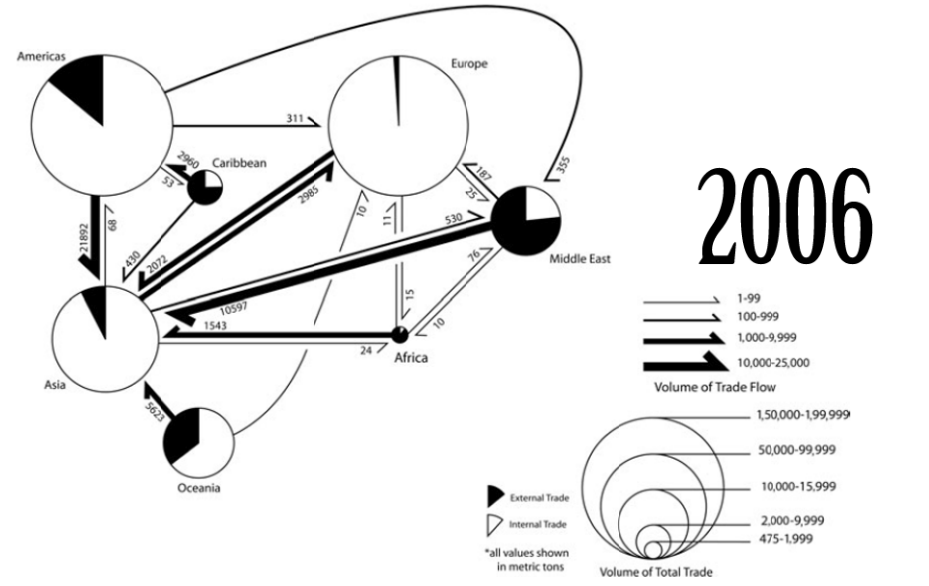


Figure A-6 SIMPLIFIED FLOW DIAGRAM OF THE PROCESS STEPS DURING E-WASTE MATERIAL RECOVERY

Source: (Kang & Schoenung, Electronic waste recycling: A review of US infrastructure and technology options, 2005)

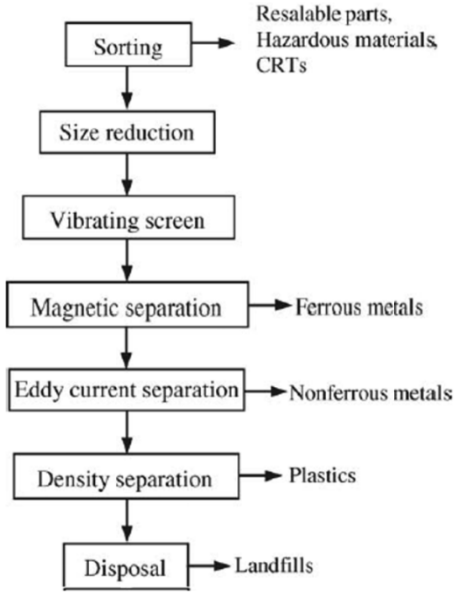
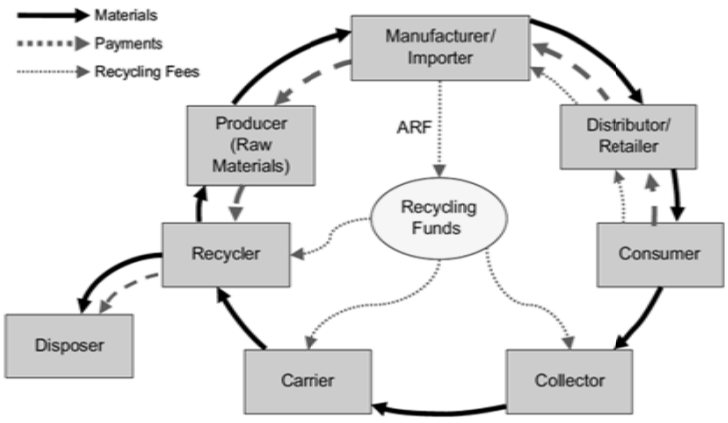


Figure A-7 UNDERSTANDING THE 'SOCIAL ACTORS' OF E-WASTE MANAGEMENT IN SWITZERLAND

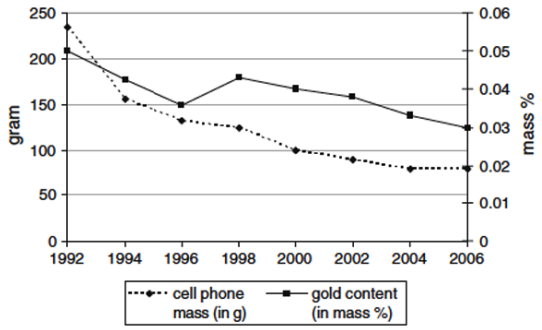
Source: (Khetriwal, Kraeuchi, & Widmer, 2007)



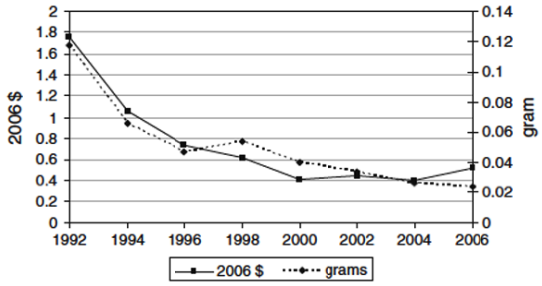
Flow of materials and finances in the Swiss e-waste management system.

Figure A-8 Understanding the value of cell phone e-waste

Source: (Geyer & Doctori Blass, The economics of cell phone reuse and recycling, 2010)

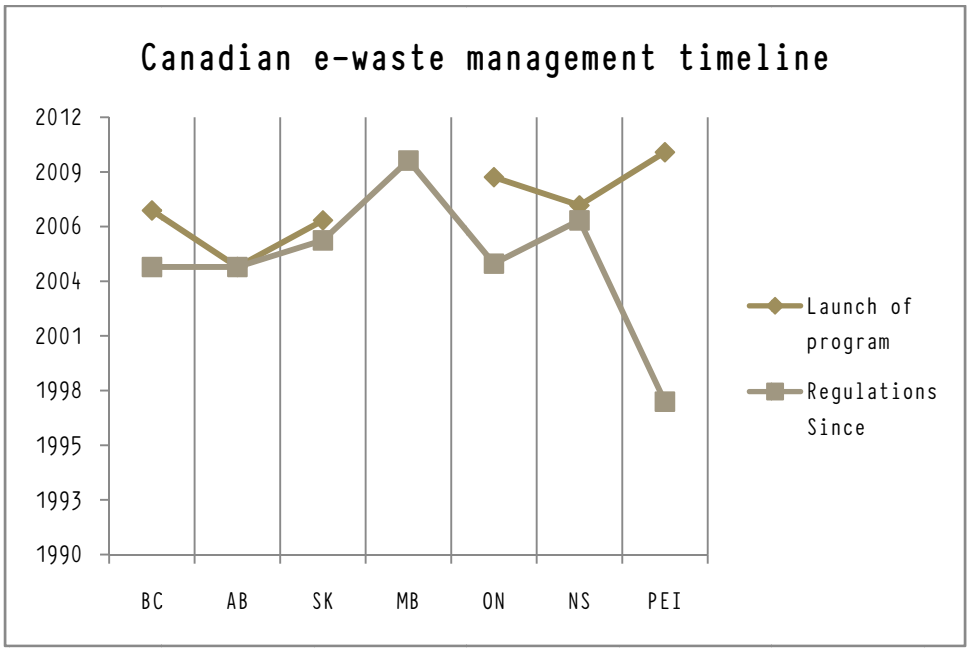


Change in average handset mass and gold content between 1992 and 2006



Declining mass and value of recoverable gold per handset between 1992 and 2006

Figure A-9 Canadian e-waste management timeline



Additional dates of relevance:

2004 – Canadian Council of Ministers of the Environment release: CANADA-WIDE PRINCIPLES FOR ELECTRONICS PRODUCT STEWARDSHIP

2004 – Electronics Product Stewardship Canada, release proposal document: NATIONAL MODEL FOR E-WASTE STEWARDSHIP

2009 – Canadian Council of Ministers of the Environment release: CANADA-WIDE ACTION PLAN FOR EXTENDED PRODUCER RESPONSIBILITY

Figure A-10 Social actors in Canadian e-waste management

EPS Canada – *Industry body to partner and negotiate with government and industry stakeholders to develop an e-waste stewardship across Canada*

Industry Stewards – *Manufacturers, first importers, and brand owners of electronics products*

IFO/PRO Industry Funded Organization, Producer Responsibility Organization – *Not-for-profit industry led organization oversee e-waste management processes within a province or region*

- ✓ ESABC – Electronic Stewardship Assoc. of British Columbia, OES – Ontario Electronics Stewardship, ACES – Atlantic Canada Electronic Stewardship, SWEEP – Saskatchewan WEEE Program, Alberta Recycling, Green Manitoba

Qualified Recycler – *Company that recycles e-waste for materials recovery, designated by IFO/PRO; numerous (10+) companies are operating in conjunction with each regional IFO/PROs across Canada. Often one recycler will operate with multiple IFOs*

Provincial governments – *Draft environmental regulations on e-waste*

Federal government – *No direct responsibility assumed; although a plan now exists to recycle federal e-waste*

Canadian citizens – *If living in vicinity of regional e-waste program, pays fee at point-of-purchase; can then free drop e-waste off at collection stations through each province*

Figure A-11 WASTE MATERIAL AND ENERGY LIFE CYCLE FLOW

Source: (ICF Consulting, 2005)

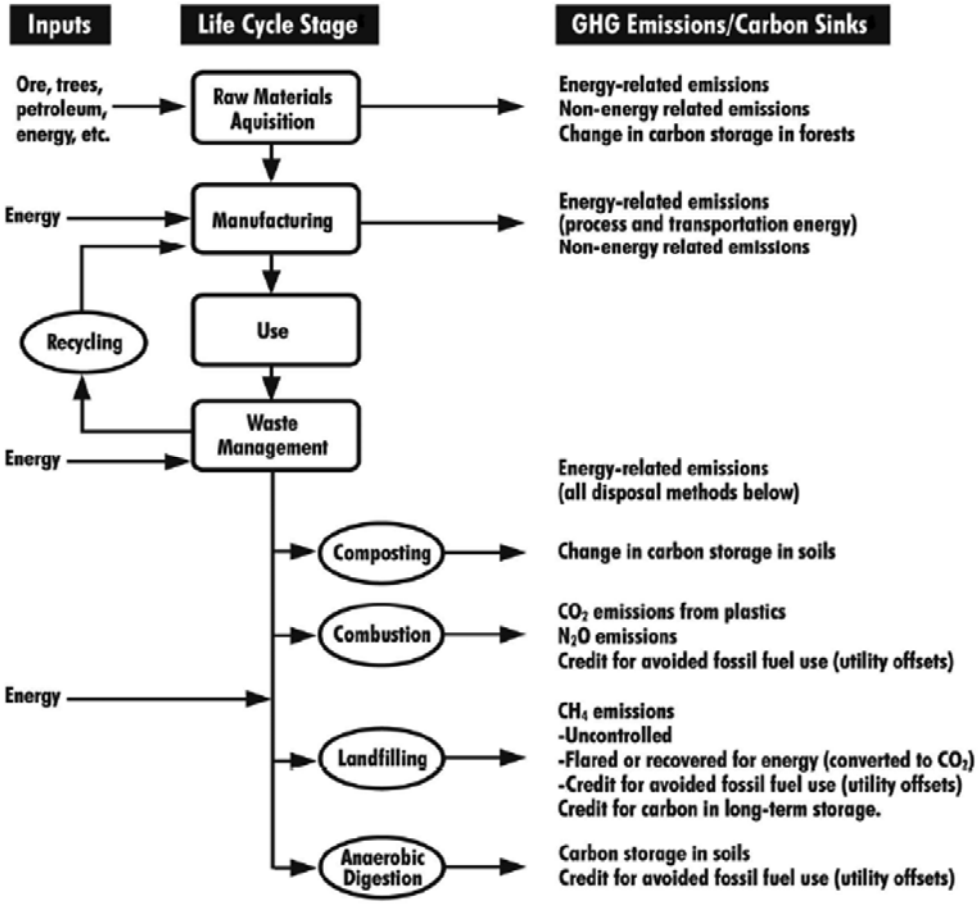


Figure A-12 Federal government of Canada, domestic and international climate change commitments

Source: (Vaughan, 2011)

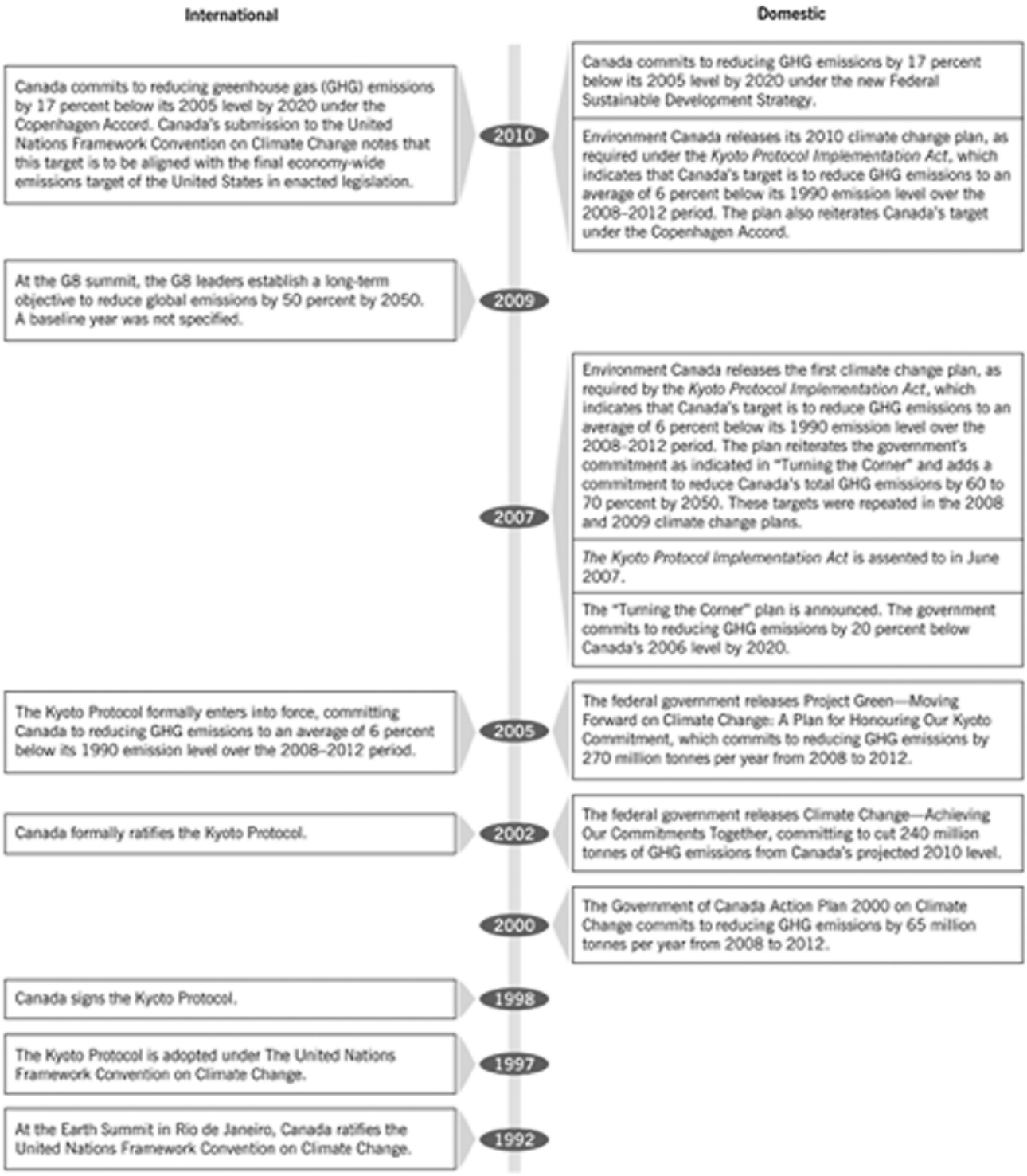
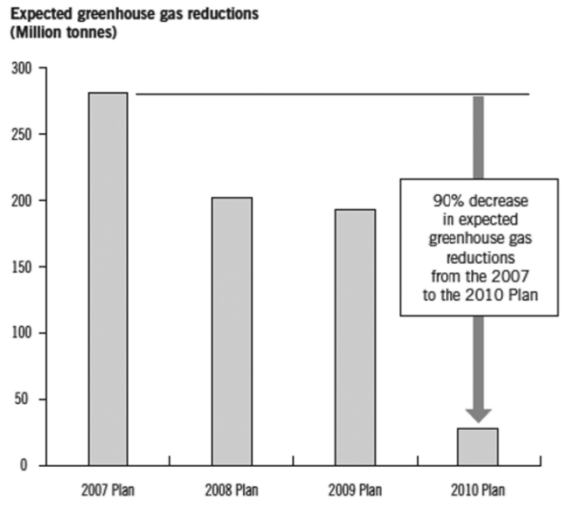


Figure A-13 Canada's climate change action performance

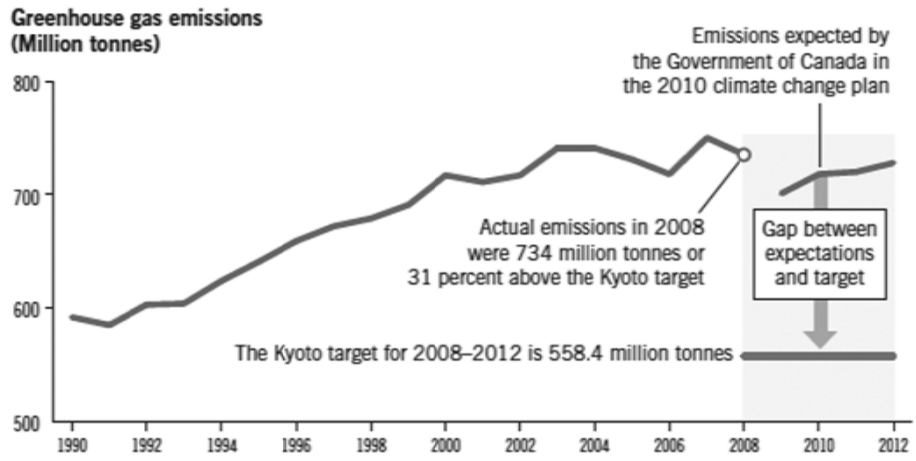
Source: (Vaughan, 2011)



Source: 2007 data calculated by the Office of the Auditor General. Other data is from A Climate Change Plan for the Purposes of the *Kyoto Protocol Implementation Act*, published annually since 2007.

Figure A-14 The gap between expected and actual GHG emission reductions in Canada

Source: (Vaughan, 2011)



Note: Information for 2009 was not available at the time of our audit.

Source: Adapted from Environment Canada's National Inventory Report,1990–2008: Greenhouse Gas Sources and Sinks in Canada (May 2010) and A Climate Change Plan for the Purposes of the *Kyoto Protocol Implementation Act* (May 2010)

Figure A-15 SOURCES OF EMPIRICAL MATERIALS USED IN THE STUDY

Source organization	Number of articles
Government	11
Government of Manitoba	1
Government of Prince Edward Island	1
Government of Nova Scotia	1
Government of Ontario	1
Government of Alberta	1
Government of British Columbia	1
Government of Saskatchewan	2
Federal government	3
Governmental	10
Canadian Border Services Agency	2
Council of Canadian Ministers of the Environment	4
Environment Canada	4
Relevant Canadian organizations	7
C.D. Howe Institute	1
Candian Institute for Environmental Law and Policy	2
Carlisle Institute	1
Conference Board of Canada	1
Northwest Product Stewardshpi Council	1
Product Policy Institute	1
International organizations	8
BAN - Basel Action Network	3
GeSI - Global e-sustainability initiative	2
ITU - International Telecommunications Union	1
UN - United Nations	1
UNEP - United Nations Environment Programme	1
Industry	69
Electronic Stewardship Assoc. of British Columbia	8
Alberta Recycling	17
Atlantic Canada Electronics Stewardship	5
Ontario Electronics Stewardship	15
Certified e-waste recycler company	6
Retail Council of Canada	1
Green Mantoba	6
Electronic Product Stewardship Canada	2
Information Technology Association of Canada	1
Saskatchewan WEEE Program	8
TOTAL	105

Figure A-16 Corpus of texts analyzed in method 1 (CDA)

#	Description	Organization	Category	Web source
EM01	The Waste Reduction and Prevention Act, CCSM c W40	Manitoba - Gov	Environmental Regulations	http://www.canlii.org/en/mb/laws/stat/ccsm-c-w40/latest/ccsm-c-w40.html
EM02	Smart2020 report - Enabling the low carbon economy in the information age	GeSI	Industry Research	http://unapcict.org/ecohub/smart-2020-report-enabling-the-low-carbon-economy-in-the-information-age
EM03	ESABC Bylaws	ESABC	Industry	
EM04	ESABC 2008 Annual Report	ESABC	Industry	http://www.esabc.ca/temp/20121177879/2008 ESABC Annual Report.pdf
EM05	Alberta Recycling 2011/12 - 2013/14 BUSINESS PLAN	Alberta Recycling	Industry	www.albertarecycling.ca/WorkArea/downloadasset.aspx?id=1750
EM06	Strategic Elements in Implementing the 3R Platform	UNEP	Global Research	http://www.unep.or.jp/ietc/spc/3R Strategic Elements.pdf
EM07	ALBERTA REGULATION 94/2004	Alberta - Gov	Environmental Regulations	http://www.canlii.org/en/ab/laws/regu/alta-reg-94-2004/latest/alta-reg-94-2004.html
EM08	Alberta Recycling 2010/11 - 2012/13 BUSINESS PLAN	Alberta Recycling	Industry	www.albertarecycling.ca/WorkArea/downloadasset.aspx?id=1750
EM09	Alberta Recycling Bylaws	Alberta Recycling	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=590
EM10	Alberta Recycling - 2010-2011 Annual Report	Alberta Recycling	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1766
EM11	Alberta Recycling - 2009 - 2010 Annual Report	Alberta Recycling	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1600
EM12	ACES 2008 Annual Report	ACES	Industry	http://www.estewardship.ca/docs/ACES 2008 AR.pdf
EM13	ACES 2011 Annual Report	ACES	Industry	http://www.acestewardship.ca/pdf/annual report/ACES 2011 AR.pdf
EM14	ACES 2011 - OPERATIONAL COSTS & KPI OUTLINE	ACES	Industry	http://www.acestewardship.ca/pdf/annual report/ACES 2011 AR Supplement.pdf
EM15	ACES 2009 Annual Report	ACES	Industry	http://www.estewardship.ca/docs/ACES AR09.pdf
EM16	Press release	ACES	Industry	http://www.acestewardship.ca/pdf/press release/ACES PEI Program Launch-PR-300610.pdf
EM17	REMOVED during step 2			
EM18	Green Manitoba Annual Report 2006/07	Green Manitoba	Industry	http://greenmanitoba.ca/cim/dbf/annual_report_final_sept 07.pdf?im id=400&si id=1001
EM19	Alberta Recycling - 2009/10 - 2011/12 BUSINESS PLAN	Alberta Recycling	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1298
EM20	Background paper from EPR conference, 2004 - Learning from Practice	Environment Canada	Gov Research	http://www.gov.ns.ca/nse/waste/epr/docs/Agenda English.pdf

#	Description	Organization	Category	Web source
EM21	2009 Annual Report	Basel Action Network	Global Research	http://ban.org/library/BAN_AnnualReport_Final_2009.pdf
EM22	Alberta Recycling Bylaws	Alberta Recycling	Industry	www.albertarecycling.ca/WorkArea/downloadasset.aspx?id=588
EM23	CANADA-WIDE ACTION PLAN FOR EXTENDED PRODUCER RESPONSIBILITY	CCME	Government	http://www.ccme.ca/assets/pdf/epr_cap.pdf
EM24	Compliance Audit - April 2009 to March 2010	Alberta Recycling	Industry	http://www.albertarecycling.ca/uploadedFiles/Home/About_Us/Reports/compliance%20assurance%20summary%20final%20report%208%20June%202010.pdf
EM25	Compliance Audit - April 2008 to March 2009	Alberta Recycling	Industry	http://www.albertarecycling.ca/uploadedFiles/Home/About_Us/Reports/compliance%20assurance%20summary%20report%20Apr%2023%202009%20Final.pdf
EM26	Compliance Audit - April 2010 to March 2011	Alberta Recycling	Industry	www.albertarecycling.ca/WorkArea/downloadasset.aspx?id=892
EM27	OES, Business Plan - 2009	OES	Industry	http://www.wdo.ca/files/domain4116/OES%20Final%20Revised%20WEEE%20Program%20Plan_July%2010-09_FINAL%203.pdf
EM28	Press release	OES	Industry	http://www.wdo.ca/files/domain4116/WEEE%20Continuous%20Improvement%20Activities%202010%20Oct%2029%202010.pdf
EM29	Federal Electronic Waste Strategy	Federal Gov	Government	http://www.tpsgc-pwgsc.gc.ca/comm/vedette-features/2010-06-08-00-eng.html
EM30	DfE Report	ESPC	Industry	http://www.wdo.ca/files/domain4116/WEEE%20Continuous%20Improvement%20Activities%202010%20Oct%2029%202010.pdf
EM31	Guideline for the Disposal of Federal Surplus Electronic and Electrical Equipment	Federal Gov	Government	http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/dechets-waste/dechets-waste-eng.html
EM32	Report on environmental and health impacts of economic activity	UN	Global Research	http://www.unctad.org/en/docs/ditcted200512_en.pdf
EM33	ENVIRONMENTAL PROTECTION ACT MATERIALS RECYCLING REGULATIONS	PEI - Gov	Government	http://www.gov.pe.ca/law/regulations/pdf/E&09-15.pdf
EM34	The Waste Reduction and Prevention Act, CCSM c W40	Saskatchewan - Gov	Environmental Regulations	http://www.qp.gov.sk.ca/documents/English/Regulations/Regulations/E10-21R4.pdf
EM35	Alberta Recycling 2008-2009 Annual Report	Alberta Recycling	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1370
EM36	Cdn e-waste recycling company	eCycle	Industry	http://www.albertarecycling.ca/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1370
EM37	REMOVED during step 2			

#	Description	Organization	Category	Web source
EM38	Electronic Waste Management Programs in New Brunswick	Carlisle Institute	Commentary - Cdn Institute	http://www.carlisleinstitute.org/ftp/Electronic%20Waste%20Management%20NB_Final_Oct17_2011.pdf
EM39	REMOVED during step 2			
EM40	Manitoba Product Stewardship Program for End-of-Life Electrical and Electronic Equipment	Green Manitoba	Industry	http://www.interqroup.ca/ewaste/meeesp-draft.pdf
EM41	Government announcement	Federal Gov	Government	http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=2D1DD4CE-B7BA-4DB7-8920-00F90CD81ABF
EM42	ESABC Strategic Business Plan 2011-2013	ESABC	Industry	http://www.esabc.ca/businessplan2011/ESABCBusPlan.pdf
EM43	Lessons from Ontario's Troubled Experiment in Charging for Waste Management	C.D.Howe Institute	Commentary - Cdn Institute	http://www.cdhowe.org/pdf/Commentary_316.pdf
EM44	EPR conference 2004	Environment Canada	Government	http://www.gov.mb.ca/conservation/pollutionprevention/waste/epr_2nd_national.pdf
EM45	REMOVED during step 2			
EM46	EPR conference 2006	CCME	Gov Research	http://www.ccme.ca/assets/pdf/epr_wkshp_rpt_1376_e.pdf
EM47	CANADA-WIDE PRINCIPLES FOR ELECTRONICS PRODUCT STEWARDSHIP	CCME	Government	http://www.ccme.ca/assets/pdf/eps_principles_e.pdf
EM48	ESABC Annual Report 2009	ESABC	Industry	http://www.esabc.ca/cfm/index.cfm?It=100&Id=126&Se=2&Lo=2&AF=Download&AA=100,126&AD=D1f1
EM49	ESABC Bylaws	ESABC	Industry	http://www.esabc.ca/temp/201211730427/ESABC_Bylaws.pdf
EM50	ESABC Program Proposal	EPSC	Industry	http://www.env.gov.bc.ca/epd/recycling/electronics/pdf/ESABC_plan.pdf
EM51	ESABC Annual Report 2010	ESABC	Industry	http://www.esabc.ca/cfm/index.cfm?It=100&Id=137&Se=2&Lo=2&AF=Download&AA=100,137&AD=D1f1
EM52	Green Manitoba - Presentation	Green Manitoba	Industry	http://greenmanitoba.ca/cim/dbf/e-waste_results_07.pdf?im_id=177&si_id=1001
EM53	ESPC National Model for E-waste Stewardship	EPSC	Industry	http://rcbc.bc.ca/files/u3/EPS_Canada_BusinessPlan.pdf
EM54	Green Manitoba - Presentation	Green Manitoba	Industry	http://www.greenmanitoba.ca/cim/dbf/e-waste_roundup_2010-11_depot_presentation_web.pdf?im_id=454&si_id=1001
EM55	Green Manitoba - Press Release	Green Manitoba	Industry	http://www.greenmanitoba.ca/cim/dbf/e-waste_roundup_st.pdf?im_id=349&si_id=1001
EM56	Diverting Waste Electrical and Electronic Equipment in Ontario	CIELAP	Commentary - Cdn Institute	http://www.cielap.org/pdf/EwasteOntario.pdf
EM57	OES, frequently asked questions	OES	Industry	http://www.wdo.ca/files/domain4116/Frequently%20Asked%20Questions%20Oct%2028%202010.pdf

#	Description	Organization	Category	Web source
EM58	The Waste Electronic Equipment Amendment Regulations, 2009	Saskatchewan - Gov	Environmental Regulations	http://www.qp.gov.sk.ca/documents/gazette/part2/2012/G2201202.pdf
EM59	Cdn e-waste recycling company	GEEP	Industry	http://www.geepinc.com/
EM60	REMOVED during step 2			
EM61	National ICT Strategy	ITAC	Industry	http://itac.ca/uploads/pdf/ITAC_09_Review.pdf
EM62	REMOVED during step 2			
EM63	Green Manitoba Manitoba Product Stewardship Program	Green Manitoba	Industry	http://www.gov.mb.ca/conservation/pollutionprevention/waste/pdf/mb_psp_end_e-e_equip.pdf
EM64	Report on global ICT usage	ITU	Industry Research	http://www.itu.int/ITU-D/ict/publications/idi/2010/Material/MIS_2010_without_annex_4-e.pdf
EM65	Report on Environment, Municipal Waste Generation	The Conference Board of Canada	Commentary - Cdn Institute	http://www.conferenceboard.ca/hcp/Details/Environment/municipal-waste-generation.aspx
EM66	OES 2008 Annual Report	OES	Industry	http://www.wdo.ca/files/domain4116/OES%202008%20annual%20report%20with%20financials%20apr%201%20noon.pdf
EM67	OES 2010 Annual Report	OES	Industry	http://www.wdo.ca/files/domain4116/OES%202010%20Annual%20Report%20for%20WDO%20March%2029%202011.pdf
EM68	OES Press Release	OES	Industry	https://www.rco.on.ca/industry_news?news_id=112&view=print
EM69	OES year 1 performance report	OES	Industry	http://www.wdo.ca/files/domain4116/OES%20Year%202%20Performance%20report%20July%207%202011.pdf
EM70	OES year 2 performance report	OES	Industry	http://www.wdo.ca/files/domain4116/OES%20Final%20Revised%20WEEE%20Program%20Plan_July%2010-09_FINAL%203.pdf
EM71	OES year 2 performance report errata	OES	Industry	n/a
EM72	OES Final program plan	OES	Industry	http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@subject/@wastediversion/documents/nativedocs/stdprod_078627.pdf
EM73	OES Final plan appencies	OES	Industry	http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@subject/@wastediversion/documents/nativedocs/stdprod_078628.pdf
EM74	ONTARIO REGULATION 393/04	Ontario - Gov	Environmental Regulations	http://www.e-laws.gov.on.ca/html/source/regs/english/2004/elaws_src_regs_r04393_e.htm
EM75	OES Special Report	OES	Industry	http://www.recycleyourelectronics.ca/office/Library/WhitePapers/OES_Business-Paper-Report_July_15_F.pdf

#	Description	Organization	Category	Web source
EM76	EPSC Presentation	EPSC	Industry	http://www.estewardship.ca/docs/Overview-of-Canadas-Electronics-Stewardship-Programs-August-2011.pdf
EM77	Performance measurement report of OES, ACES, SWEEP, ESABC	InterGroup	Industry	http://www.acestewardship.ca/pdf/Performance_Measurement_Report-2010.pdf
EM78	The EarthECycle Pittsburgh Recycling Scam	Basel Action Network	Global Research	http://www.ban.org/library/PittsburghScam.pdf
EM79	Product Stewardship in Canada - LEGISLATIVE FRAMEWORK OF PROVINCIAL PROGRAMS	Northwest Product Stewardship Council	Industry Research	http://www.productstewardship.net/PDFs/policiesNWPSCCanadianPSPrograms10_09.pdf
EM80	REMOVED during step 2			
EM81	REMOVED during step 2			
EM82	REMOVED during step 2			
EM83	REMOVED during step 2			
EM84	REMOVED during step 2			
EM85	REMOVED during step 2			
EM86	Report on measuring GHG	Federal Gov	Gov Research	https://www.rco.on.ca/uploads/File/projects/completed/GreenhouseGasAndRecycling/RC_Projects-GHG-Fact_Sheet.pdf
EM87	Cdn e-waste recycling company	RecycleLogic	Industry	http://www.recycle-logic.com/
EM88	B.C. Reg. 449/2004 - Environmental Management Act	BC - Gov	Environmental Regulations	http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/449_2004
EM89	Solid Waste-Resource Management Regulations made under Section 102 of the Environment Act	Nova Scotia - Gov	Environmental Regulations	http://www.gov.ns.ca/just/regulations/regs/envsolid.htm
EM90	REMOVED during step 2			
EM91	Social and Environmental Responsibility in Metals Supply to the Electronic Industry	GeSI	Industry Research	http://www.gesi.org/ReportsPublications/tabid/60/Default.aspx
EM92	Cdn e-waste recycling company	SCRI		http://scri.ca/
EM93	Sustainable Development Strategy 2007-2009	CBSA	Government	http://www.cbsa-asfc.gc.ca/agency-agence/reports-rapports/sds-sdd/sds-sdd-07-09-eng.html
EM94	Sustainable Development Strategy 2011-2013	CBSA	Government	http://www.cbsa.gc.ca/agency-agence/reports-rapports/sds-sdd/sds-sdd-11-13-eng.html
EM95	SWEEP Annual Report 2007	SWEEP	Industry	http://www.sweepit.ca/images/stories/documents/sweep_2007_annual_report_final.pdf
EM96	SWEEP Annual Report 2008	SWEEP	Industry	http://www.sweepit.ca/images/stories/sweep_2008_ar_low_res_final.pdf

#	Description	Organization	Category	Web source
EM97	SWEEP Annual Report 2009	SWEEP	Industry	http://www.estewardship.ca/docs/SWEEP%202009%20Annual%20Report.pdf
EM98	SWEEP Annual Report 2010	SWEEP	Industry	http://www.estewardship.ca/docs/SWEEP_2010_Annual_Report.pdf
EM99	SWEEP Annual Report 2011	SWEEP	Industry	http://www.sweepit.ca/images/stories/documents/SWEEP-Annual-Report-2011.pdf
EM100	SWEEP 2011 Strategic Business Plan	SWEEP	Industry	http://www.esabc.ca/businessplan2011/ESABCBusPlan.pdf
EM101	Cdn e-waste recycling company	TechnoTrash	Industry	http://www.technotrash.ca/
EM102	Report on pollution haven	Basel Action Network	Global Research	http://ban.org/library/TheDigitalDump.pdf
EM103	Presentation on e-waste management in Canada	Environment Canada	Gov Research	http://www.gesi.org/ReportsPublications/tabid/60/Default.aspx
EM104	A background paper on the review of the Waste Diversion Act	CIELAP	Commentary - Cdn Institute	http://www.cielap.org/pdf/WDA_BeyondRecycling.pdf
EM105	CCME website	CCME	Government	http://www.ccme.ca/about/businessplan.html

Figure A-17 2SLS Regression Results with GDP3

Two-stage least-squares regression

Equation	Obs	Parms	RMSE	"R-sq"	F-Stat	P
co2pc	11	3	.6099388	0.4686	2.06	0.1490
2co2pc	11	2	.705644	0.1872	0.92	0.4194

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
co2pc						
gdpp3	.0158647	.0079586	1.99	0.065	-.0010987	.032828
regulation	-.4609777	.2676513	-1.72	0.106	-1.031463	.1095075
gdpenerg	.0667409	.1455112	0.46	0.653	-.243409	.3768908
_cons	.2290769	7.876744	0.03	0.977	-16.5598	17.01796
2co2pc						
ictewaste	-.0085377	.0168342	-0.51	0.619	-.0444189	.0273435
urban	.0875549	.2767523	0.32	0.756	-.5023288	.6774386
_cons	10.3678	22.62614	0.46	0.653	-37.85868	58.59427

Endogenous variables: co2pc
Exogenous variables: gdpp3 regulation gdpenerg ictewaste urban

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