

A Critical Interrogation of e-Waste Management in Canada: Evaluating Performance of Environmental Management Systems

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Electronic waste or E-waste is one of the main sources of harmful toxic pollutants (polyvinyl chlorides, polychlorinated biphenyls, lead and mercury). E-waste also represents a potent source of valuable metals such as gold, silver, palladium, and copper. As such, the end-of-life management of consumed ICT goods presents a multifaceted site for scholarly research. We developed an empirical method of performance evaluation and conducted a comprehensive assessment of Canadian e-waste management practices and discourse. Although Canada has environmental regulations on e-waste, we find that some Canadian e-waste management companies espouse a discourse of corporate responsibility that is contradicted by actual practice.

INTRODUCTION

The production of information communication technology (ICT) and electrical and electronic equipment (EEE), including eventual disposal as waste electrical and electronic equipment (WEEE), represents a significant source of environmental pollution and energy use (CO₂ production). Accounting for one percent of Canada's waste, WEEE already contributes 70% of heavy metals poisoning in the waste stream (McKerlie et al., 2005). In addition to its toxic content and ubiquity, WEEE represents a potent and readily available source of valuable metals – if processed in advanced materials recycling facilities (Barba-Gutierrez et al., 2008; GeSI, 2008; Hischer et al., 2005; McLaren et al., 1999; Socolof et al., 2005). According to Industry sources the electronics industry is believed to use (as a fraction of global annual metal supply to produce new ICT/EEE goods each year) up to a full nine percent of the world's supply of gold, 36% of tin, 25% of cobalt, and 15% of palladium – and hence, it could make good business sense for industry to increase the use of recycled materials in the production cycle (GeSI, 2008). Despite this, one of the main preconditions – as consistently observed in the literature – for establishing sound environmental management practices is that political will and environmental regulation is required (CCME, 2009; C.D. Howe Institute, 2010; CIELAP, 2008; Cui & Zhang, 2008; EnvironmentCanada, 2004; Kang & Schoenung, 2005; Khetriwal et al., 2005; Khetriwal et al., 2007; Widmer et al., 2005;). The

lack of environmental law and regulations, particularly in developing nations, has been cited as a limiting factor preventing proper management of WEEE (Fraige et al., 2011).

Meanwhile, the effectiveness of environmental regulations (regarding e-waste management) in developed nations has not yet been subjected to critical research and scrutiny. In many nations, e-waste management systems have been implemented through the Extended Producer Responsibility (EPR) policy framework (Lee et al., 2000; Liu et al., 2006; McKerlie et al., 2005; Nnorom & Osibanjo, 2008b; Wagner, 2009). EPR programs provide a mechanism for ICT/EEE producer companies to establish e-waste management systems offering WEEE recycling services within a particular province or jurisdiction; and such systems generally implement a shared fiscal responsibility with consumers, and often include some form of pricing signals to promote better product design (McKerlie et al., 2005). As WEEE is itself a tradable commodity, it represents lucrative business opportunity for unregulated operators (Geyer & Doctori Blass, 2010; Hicks et al., 2005; Nnorom & Osibanjo, 2008a). In nations where effective environmental law and regulation does not exist, WEEE may be processed using crude recycling techniques (Huo et al., 2007; Deng et al., 2006; Leung et al., 2007; Li et al., 2007; Wong et al., 2007; Yu et al., 2006). As such, e-waste management is caught up in international (yet highly regionalized) trade networks facilitating the breakdown of WEEE into its component parts and materials – representing an unregulated value chain of end-of-life ICT goods as global inequity continues to be strewn from rich nations to the less developed (Lepawsky & McNabb, 2009).

Managing the social and environmental impacts of WEEE occurs on the precondition that either industry or both government and industry partners agree to confront the issue. Canadian e-waste management systems have been designed, and are managed by foundations owned by technology companies. Little is known about how technology companies use discourse to shape our collective decision-making processes (Cukier et al., 2009). This is a subtle argument that may be routinely overlooked. We use Swales and Rogers (1995) to give example of a study that includes a rigorous discourse analysis method. After comprehensively reviewing a large corpus of corporate mission statements for American companies, Swales and Rogers then conducted an in-depth contextual analysis of the mission statements of two well-known companies. While statements of the two companies shared rhetorical and linguistic similarities, further contextual analysis revealed stark differences in the communicative purposes and likely intent of the two original statements. Crucially, any differentiation of corporate value or culture remained indistinguishable from the vantage of the first (textual) reading (Swales & Rogers, 1995). They demonstrate the power of text; and suggest that any textual analysis that excludes context may ultimately lead to incomplete and possibly suspect results.

The aim of this study is to investigate the impact of e-waste management systems and practices in Canada over the period of 2000-2010. Our main research question is: how and to what extent are Canadian e-waste management practices designed and implemented in the context of global sustainability discourses and goals regarding CO₂ reductions? To investigate this, we present a novel approach RoSI by employing both qualitative and quantitative methods known as critical discourse analysis and two-stage least squares regression. Our study shows that in spite of much effort undertaken at both provincial and federal levels to regulate WEEE in Canada, many of Canada's e-waste management systems are currently operating at lower performance.

EVALUATING DISCOURSE AND PRACTICE IN E-WASTE MANAGEMENT STUDIES

Prior to describing our methodology for performance evaluation in the next section, we modify a theoretical framework from the domain of IS research (Melville, 2010). We use this framework to demonstrate the conceptual difficulty in addressing complex social research problems. The Beliefs-Actions-Outcomes (BAO) framework provides us with three primary vectors to consider: *belief formation*, *action formation*, and *outcome*. The first examines *beliefs* about the environment; the second represents *actions* undertaken as part of sustainability initiatives or systems; and the third encompasses the environmental performance *outcome* that results in an empirically measurable impact on macro-level variables such as per capita CO₂ (Melville, 2010). The BAO framework is a useful framework to group e-

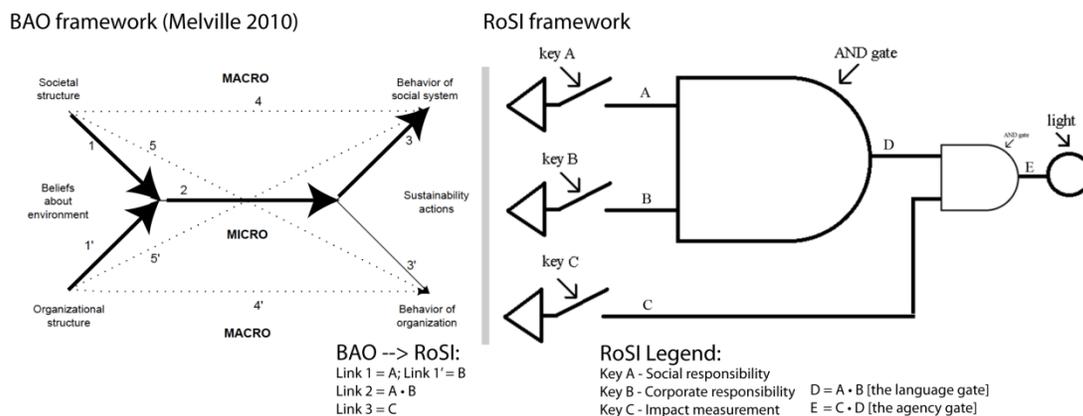
waste management research into three distinct categories. The first variety (focused on *beliefs* and *belief formation*) can be observed in Fraige et al. (2011). Households are one of the major consumers of ICT/EEE, and ultimately are primary generators of WEEE. It was observed that, in Jordan, more than half of the households surveyed knew the term WEEE or e-waste; however, more than three quarters of the households were not aware of proper WEEE disposal options available to them, and even 11% believed (incorrectly) that they could dispose of WEEE by tossing with municipal trash (Fraige et al., 2011). Given that households assume a dual role as consumers of ICT/EEE and generators of WEEE, gauging consumer awareness represents an important contribution to scholarly research on e-waste management.

Among examples of the second approach (*actions*) and (*action formation*) is provided in McKerlie et al.'s (2005) evaluation of Canada's implementation of the EPR policy framework. In Canada jurisdictional responsibility is split between multiple levels of government. As mentioned by (McKerlie et al., 2005) there is no effective federal WEEE regulations and this has resulted in a range of different stewardship approaches across the various provinces. They explain how jurisdictional boundaries have impacted waste management practices in Canada; and the fact that Canadian municipalities have limited tools and funding to successfully reduce levels of waste generated in Canada. Nonetheless, in Canada e-waste management is under provincial jurisdiction. The identification of these constraints provides insight into the *action formation* and boundary conditions facing industry and government stakeholders. The third approach can be seen in the work of Green IS scholars, notably in Dedrick (2010), Melville (2010), Watson et al. (2010), and Hilty and Ruddy (2010). Research from this third domain builds upon the argument that ICT and systems innovation will play a pivotal role in generating social impact and environmental performance that affects macro-level variables, such as per capita CO₂. Nonetheless, it is problematic to speak of *outcome* without also calculating the vectors that preceded it. It is with the above stated intentions that we develop, in the next section, a new methodology of empirical systems impact measurement.

The Rubric of Systems Impact (RoSI)

To accommodate this inherent uncertainty between text and context, between discourse and practice, as found in this study, we have proposed a dialectical method from science studies and have applied it directly to the management sciences. We have taken Melville's BAO framework and have re-interpreted it using the lens of 'the mangle'¹ – Andrew Pickering's work on human and material agency (Pickering, 1993). The result, shown in FIGURE 1, is our rubric of systems impact (RoSI) framework. We have replaced Melville's previous link 2 (*actions*) with the 'actual' system that is now in operation (*agency gate*, C•D); and have regrouped the domains of *belief formation* and *action formation* under the label 'human agency' and subjected them to discourse analysis (*language gate*, A•B).

FIGURE 1
RUBRIC OF SYSTEMS IMPACT (ROSI) FRAMEWORK; EXTENSION OF MELVILLE, 2010



We posit performance of environmental management systems (such as e-waste management systems) is itself a construct that is best represented as a circuit that passes through two gates. To pass the first (language gate) members of the social system must generally accept the discourse of responsibility (key A), as it relates to e-waste management and behavioural expectations of the public in general (e.g. Fraige et al., 2010); and – as we will argue in this study – technology companies must present a coherent discourse regarding their corporate responsibility and sustainability practices (key B). Passing the second (agency gate) requires both a coherence of human agency (gate 1 open) and a consistently demonstrable orchestration of material agency (key C), leading to an observable impact on macro-level variables such as per capita CO₂, C•(A•B) or *outcome* as per the BAO framework. Our methodology for impact measurement and the systematic strategy under which this research has been conducted is documented in the following section.

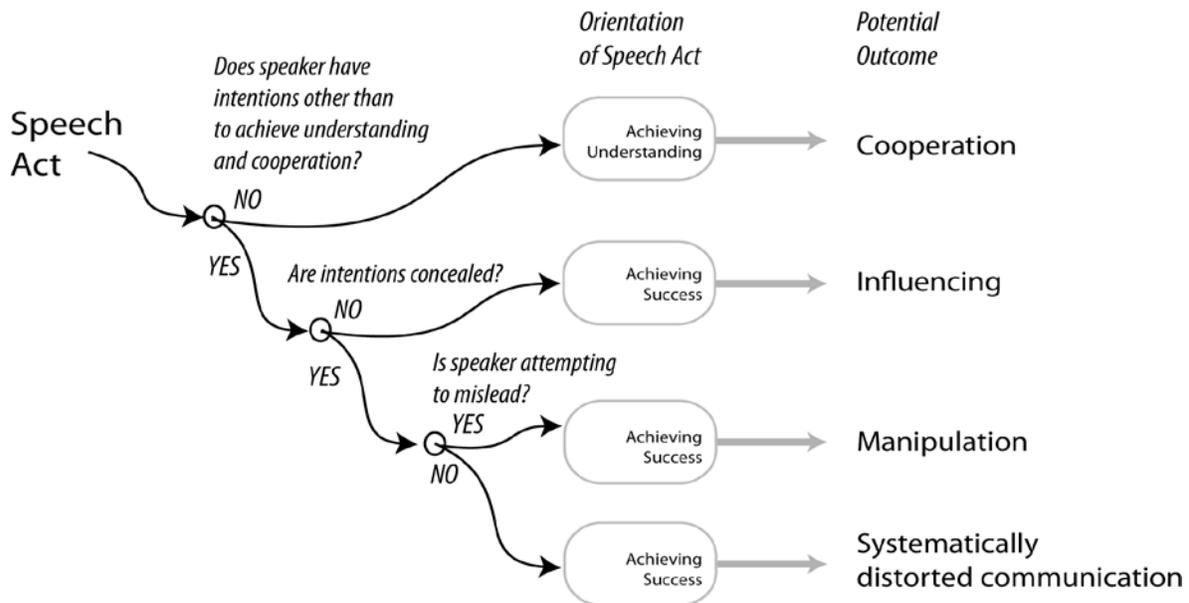
METHODS AND MATERIALS

We bring information systems (IS) research perspectives to the literature on e-waste management. Our principal thesis is that systems performance depends on coherence of discourse and practice. Our analysis suggests that when a company is not coherent in how it ‘uses’ responsibility in its annual reports and other public communications, the associated e-waste management system will be unable to achieve high levels of performance. These assertions are tested using two research methods: critical discourse analysis (hereafter, CDA) and two-stage least squares regression (2SLS). In the preceding section we presented our RoSI framework (FIGURE 1), and described environmental performance of management systems as a construct that can be understood as a circuit that passes through two gates: the language gate, and agency gate. We now describe the empirical methodology and mixed-methods design that we have used in this study as it relates to these two logical gates.

Critical Discourse Analysis and the Language Gate

To pass the language gate we argue that Canadian e-waste management discourse and practices should not contain contradictions regarding corporate responsibility and sustainability practices. We have used CDA in this study to surface and reveal any uses of strategic communication (FIGURE 2). Stahl (2006) describes CDA’s purpose as opening up dialogue by exposing ideologies and presenting better arguments. The CDA method in this present study is based on an empirical CDA technique developed in Cukier et al. (2009), which is based on the social theory of Jürgen Habermas, and his theory of communicative action (TCA). At its core, TCA asks the researcher to empirically assess the authenticity of speech acts. As can be seen in FIGURE 2, communicative action can lead to shared understandings and cooperation. However, this outcome is not assured. As noted by Cukier et al. (2009) distorted communications may lead to outcomes that are not based on cooperation and mutual understanding. 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, 2001). However, there is no established and singular means to conduct CDA.

FIGURE 2
COMMUNICATIVE AND STRATEGIC ACTION AND DISTORTED COMMUNICATION



Adapted from Cukier et al. (2009)

One of the objectives of this study is to examine whether technology companies and to some extent the existing laws and regulations have distorted the public discourse on e-waste and to determine whether responsibility to manage WEEE (consumed ICT goods) is lessened through this discourse. This is accomplished through an analysis of language and written documents 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. We argue that discourse must be interrogated from the perspective of each of the four validity claims of TCA. To do so requires us to systematically interrogate each communication (in the form of a ‘text’ – e.g. speech transcript, news release, annual report) testing lines of text against the four validity claims (comprehensibility, truth, sincerity and, legitimacy). If the speech act does not pass all four validity claims, additional contextual analysis will be conducted. 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. 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 and to evaluate the defensibility of argumentation structures used. The third claim, sincerity, examines the kind of language used (e.g. connotative; overly technical; emotionally-laden) and determines whether language use choices reveal inconsistencies between what the speech act 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, or in the inclusion or exclusion of dissenting voices. 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.

DATA COLLECTIONS AND ANALYSIS

Critical Discourse Analysis

The CDA method used in this study can be described in four highly iterative steps. In step 1, we defined the corpus of data to be analyzed. In this study, we limit our search to publicly available documents. As such we employed a targeted CDA approach and focus on the annual reports and public communications of relevant industry organizations, including 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 search with the following parameter: e-waste WEEE “e-waste management” 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]”. The same search was repeated for the national industry body: +pdf +“Electronic Product Stewardship Canada”. We then reviewed the results on the order prioritized by the search algorithm. Except in instances where insufficient results were returned, generally at a minimum we reviewed top 250 results in which 105 relevant documents were selected. 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 Adobe PDF format. Additionally we supplemented the corpus with documents from industry, government, and other relevant advisory bodies. Appendix A lists the source organizations and the number of articles used in our study. As noted above, a total of 105 relevant articles were selected; and each article was then assigned an identification code EM1-EM105. The process became highly iterative upon completion of step 1.

In step 2, content is analyzed and coded. Validity claims were used to identify relevant empirical observations. Speech acts were then examined for the types of arguments made, their frequency, or any other relevant patterns or characteristics. Each source was first imported as Adobe PDF documents into NVivo software, and was then coded twice using the following categories: (a) statements regarding the advantages and disadvantages of e-waste management; (b) terms used to describe e-waste management systems - adjectives, metaphors, associative language; (c) experts and spokespeople for e-waste management in Canada; (d) specialized language or jargon; and, (e) statements regarding responsibility and legitimacy of e-waste systems. Data was also coded for source organization. In step 3 a textual reproduction of all empirical observations were then extracted to Excel as a table. All selected statements were each read individually – and were also read several additional times as part of a series of table sorts (by category, source organization). In step 3 all speech acts were analyzed for meaning. Each statement was tested against the four validity claims. Additional search processes were then undertaken to find empirical evidence that would refute the statements’ validity. An additional (final) reading was then undertaken; themes were identified; and all statements were grouped (where warranted) by similarity/theme. Upon adequate completion of steps 2 and 3, the findings are then related in step 4 as an Excel table containing a total of 149 statements, inclusive of 17 statements that failed one or more validity tests.

Two-Stage Least Squares Regression

The regression method used in this method is Two-Stage Least Squares (2SLS). With respect to the present study, we examine the relationship between Canada’s CO₂ 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 CO₂ per capita for Canada. Two independent variables of interest are: ICTEWASTE - a ratio of e-waste recycled to index of ICT usage; and, REGULATION – a ratio of jurisdictions with e-waste regulations to provinces without. By using 2SLS and introducing additional control variables, we are able to triangulate and observe statistical relationships that exist in the data between the control variables and CO₂PC. An 11 year panel dataset was used, including years 1999-2010. Additionally, the following control variables are included in our regression analysis warranted by prior literature review: 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.

Secondary data in the form of annual reports from e-waste companies, consultants' reports submitted to the government, academic publications, and industry publications was obtained. It was necessary to determine what actual capacity exists for e-waste processing within Canada. How much of the e-waste generated in Canada is actually recycled? 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 & Recycling Council of Ontario, 2000; NRCan, 2011; PHA Consulting Associates, 2006; RIS International Ltd., 2003; CSR, RIS International Ltd., MacViro Consultants Inc. & Jack Mintz & Associates Inc., 2005; Waste Diversion Ontario, 2005). Following the literature review, the following regression model (equation 1) was applied on panel data:

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

Where the subscripts refer to year (*t*); α_0 is a constant, α_1 through α_5 are variable coefficients and ε is the error term. We assume that the index of *co2pc* depends on *ictewaste*, *regulation* and a number of control variables, which, according to previous literature, may be related to CO₂ emissions. Among the control variables we include GDP per capita (*GDPP*), the level of energy consumption due to increased GDP per capita (*gdpenerg*) and the percentage of the urban population (*urban*). 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.

EVALUATING THE LANGUAGE GATE

We have evaluated the truth, sincerity, legitimacy, and comprehensibility of speech acts regarding Canadian e-waste management. When a speech act was found to be strategic (FIGURE 2), further analysis of the statement was undertaken. We have used CDA to produce descriptive analysis to depict the e-waste management systems and practices in place across Canada. We have conducted a rigorous process of discourse analysis, and have systematically revealed statements that fail one or more validity claim. In this section we will present some examples from our analysis. The first validity claim is truthfulness. The primary claims made in the public sphere regarding EPR/e-waste systems are consistent with those depictions observed in the extant literature. There is wide consensus on the benefits of e-waste management. It can displace demand for virgin 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 or market opportunity (EM02, EM56). Negative aspects of e-waste management systems are limited (see Appendix A to cross-reference EM to source).

On balance there is little disagreement over the benefits and operational realities of EPR/e-waste systems in Canada. Despite this, some strategic speech acts were observed. For instance, Electronics

Products Stewardship 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’. 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. 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. Furthermore, SWEEP claims that the current e-waste regime in Canada is ‘no longer sustainable’ (EM100). No adequate evidence is provided for this claim.

The second validity claim is that of sincerity. Sincerity implies congruity between that which is said, what is actually meant; 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 (Cukier et al., 2009). 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). 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). In a 2008 report from GeSI’s Climate Group (EM02), the broad topic of ICT for environmental sustainability is examined (e-Sustainability, 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 a foreword to the report, CEO of the GeSI Climate Group emphasizes the 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” (GeSI, 2008, p. 8).

While the above statements may be true, it may also be considered a distorted communication (see FIGURE 2). While response and action are warranted on the climate change issue, it is equally important that we respond correctly. 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, the fact is that the Ontario EPR stewards as ‘monopsony purchasers of waste services’ (EM104). This program does not promote competition in Ontario (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). 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 sincerity of this claim remains in doubt.

The third claim is legitimacy. As has already been cited, concern has been consistently raised over the practices of Ontario steward, OES (EM43, EM104, EM27). 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, serious legitimacy concerns are raised by these observations. The fourth claim is comprehensibility. Failures on the validity of comprehensibility test, are typically in the form of incomplete communications. We observed one possible (mis)use of 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 communicate the risk of export and ultimate disposal through crude recycling techniques as would reasonably occur in the absence of an adequate EPR/e-waste program.

Evaluating the Agency Gate

FIGURE 3 shows the results of 2SLS regression analysis with a confidence of 95%. This shows our variable for e-waste management system performance (ICTEWASTE) having a negative correlation with per capita CO₂. This means that Canadian e-waste management practices on the whole appear to reduce CO₂ emissions, but this impact in Canada is not yet 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 these findings are perhaps consistent. The impact of current efforts to manage e-waste in Canada is not making (as of 2010) a difference of any statistical significance. In the case of Canada, the presence of EPR/e-waste regulation is negatively correlated with per capita CO₂. Nonetheless, variable regulation is only significant at 90% level ($P > |t| = 0.084$). While this shows a positive impact of environmental regulations in reducing CO₂ emissions, however, Canada needs a stronger environmental regulation regime for responsible management of ICT goods across and beyond its borders.

FIGURE3
3 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						
gdpp1	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: gdpp1 regulation gdpenerg ictewaste urban

DISCUSSION

Using the RoSI framework to focus in on e-waste management systems in Canada, our study demonstrate that despite the presence of environmental regulations, attempts by industry to address their responsibility (in at least one instance) has resulted in systems whose design is based on incoherent or contradictory uses of the construct ‘corporate responsibility’. To determine this, we used the RoSI framework (FIGURE 1) and conducted two separate analyses. The first test (language gate) was not passed. Neither was the second (agency gate). There are several general observations made during this study. We have provided these with references to both literature and articles used in CDA (Appendix A, EM1-105). 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). EPR can be an effective policy framework to deal with e-waste (EM20, EM23, EM43, EM56, EM104; McKerlie, Knight, & Thorpe, 2005; Liu et al., 2006; Lee et al., 2000; Nnorom & Osibanjo, 2008b; Wagner, 2009). EPR/e-waste systems can be equitable and efficient, EM20, EM23, EM43, EM104 (CIELAP, 2008; CCME, 2009). 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; CIELAP, 2008; EnvironmentCanada, 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; Government of Canada, 2011). 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. Note, these values constitute key A in our RoSI framework (FIGURE 1). Ontario currently achieves the lowest value of (total) e-waste collected per capita at 3.63kg. Incredibly, Manitoba has demonstrated the strongest performance on this measure at 10.5kg (with the exception of Alberta, the country’s first and longest operating steward). Based on all above analysis, we find that in particular, Ontario steward, does not perform efficiently compared to other provinces in Canada.

Our argument is based on the use of discourse analysis. The relevance of discourse analysis to policy and management studies is taken up in Hilding-Rydevic and Akerskog (2011). They examine the

implementation of Swedish local spatial planning policy in conjunction with the European Union's 'Strategic Environmental Assessment Directive' (SEA). This is conducted using hermeneutic and content analysis techniques wherein elements of discourse are systemically examined (Hilding-Rydevik & Akerskog, 2011). Ultimately the researchers demonstrate that structural contradictions persist in both the discourse and practice associated with Sweden's local spatial planning and land-use policy. It is clearly demonstrated that the SEA discourse does not adequately address how local land-use planners are to achieve SEA benefits through the use of existing sets of policies, practices, and resources; specifically a consistent presentation that no extra costs would follow from this implementation is clearly suspect (Hilding-Rydevik & Akerskog, 2011). The scholars offer our first basic standpoint: *how* a discourse – surrounding any concrete problem – gets articulated, ultimately impacts the practices of those implementing the solutions; hence, if planning is insufficient in both scale and scope, implementation will necessarily be hindered (Hilding-Rydevik & Akerskog, 2011). We believe our study demonstrates a parallel finding. Thus, and this is our second and final basic standpoint: if the relationship between discourse and practice contains structural contradictions, the effectiveness of any associated systems and practices will necessarily be lessened.

CONCLUSIONS

The discourse on e-waste management in Canada requires efforts at all levels (corporate, social, environmental, legal, and fiscal). While all Canadian e-waste stewards currently not exhibit in their full potential performance, the case of Ontario steward, Ontario Electronics Stewardship is particularly unsatisfactory. Based on the findings from our CDA method (language gate), we predicted these low performance ratings. Based on the findings from our 2SLS regression (agency gate), we have further demonstrated that performance and systems impact of Canadian e-waste management systems are not (as of 2010) contributing in a satisfactory way to per capita CO₂ reduction. We believe that this result helps promote a better understanding of the construct of corporate responsibility. If structural contradictions exist between the discourse of corporate responsibility and actual sustainability practice, we posit the associated system will be unable to achieve high levels of environmental performance. The findings of both methods support this presentation. Our findings demonstrate the value of mixed-methods approach, discourse analysis, and critical methodologies for use in the evaluation of environmental systems' performance. In sum, planning and good design matters when implementing systems that involve multiple social actors (such as e-waste management systems). Coherence of discourse and practice is a necessary condition of any system that is able to consistently achieve high levels of environmental performance.

ENDNOTE

1. In his 1993 publication, Andrew Pickering offers a view of science as an emergent field of human and material agency. He articulates two postulates for a *real-time* theory of scientific knowledge production. First, the academy must learn to accommodate temporally emergent phenomena. Second, the de-centering of the human in the process of scientific innovation must be reconciled. Pickering's argument is that traditional research methods have proven insufficient to render a real-time account of scientific practice (Pickering, 1993).

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APPENDIX A

SOURCES OF EMPIRICAL MATERIALS INCLUDED IN THE STUDY

Commentary from Canadian Research Institutes: C.D .Howe Institute(EM43); Carlisle Institute(EM38); CIELAP(EM56); Conference Board of Canada(EM65).

Global voices: Basel Action Network(EM21,EM78); United Nations(EM32); United Nations Environment Programme (EM06).

Government and governmental: Canadian Council of Ministers of the Environment(EM23,EM46,EM47); Environment Canada(EM20,EM44); Federal Government(EM29,EM31,EM41,EM86); Canadian Border Services Agency(EM93,EM94);

Environmental Regulations: Alberta(EM07); British Columbia(EM88); Manitoba(EM01); Nova Scotia(EM89); Ontario(EM74); Saskatchewan(EM34,EM58); Prince Edward Island(EM33)

Industry Stewards: Atlantic Canada Electronics Stewardship(EM12,EM13,EM14,EM15,EM16); Alberta Recycling(EM05;EM08; EM09; EM10; EM11; EM19; EM22; EM24; EM25; EM26; EM35); Green Manitoba(EM18,EM40,EM52,EM54,EM55,EM63); Electronics Products Stewardship Canada(EM30,EM50,EM53,EM76);

Electronics Stewardship Association of British Columbia(EM03,EM04,EM42,EM48,EM49,EM51); Ontario Electronics Stewardship(EM27,EM28,EM57,EM66,EM67,EM68,EM69,EM70,EM71,EM72,EM73,EM75); Saskatchewan WEEE Program(EM95,EM96,EM97,EM98,EM99).

Qualified recycling vendors: eCycle(EM36); GEEP(EM59); Recycle Logic(EM87); SCRI(EM92).

Other: Inter Group Consulting(EM77); Information Technology Association of Canada(EM61); Global Sustainability Initiative(EM02,EM91); International Telecommunication Union (EM64); Northwest Product Stewardship Council(EM79)

Not referenced: EM17, EM37, EM39, EM45, EM60, EM62, EM80, EM81, EM82, EM83, EM84, EM85, EM90