A COMPARATIVE STUDY OF THE ENVIRONMENTAL IMPACT OF ONLINE AND OFFLINE MOVIE RENTAL BUSINESSES

by

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Signature of Author

Dedication.
To my supportive parents: Marcelo and Luz Marina.
To my lovely sister: Liza María.
To my beloved wife: Denisa.
To the Department of E-Commerce, Management and Computer Science Faculties at Dalhousie University.
To all the researchers who strive in protecting our planet Earth.

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ABSTRACT

The purpose of this thesis is to assess and compare the energy consumption and carbon footprints of two, online and offline, major movie rental services in Canada. The thesis is divided into two parts that represent two papers that are being published. The comprehensive literature survey provides the state-of-the-art in E-Commerce carbon footprinting with a new categorization framework. The model development and application compares the energy consumption and carbon footprints of the two business models via a systems approach and the Economic Input Output Life Cycle Assessment (EIO-LCA) model and evaluates environmental performances. The portions of the logistics chains that were different in the two business models were analyzed and processes that were common were excluded. Regarding findings, the analyses conclude that the online movie rental service has lower carbon footprint than the offline one. We suggest practical implications for policy makers, government, businesses, and customers in movie rental industry.

LIST OF ABBREVIATIONS AND SYMBOLS USED

B2B	Business to Business
B2C	Business to Consumer
CO_2	Carbon Dioxide
DSS	Decision Support Systems
DVD	Digital Video Disc
E-Commerce	Electronic Commerce
EIO-LCA	Economic Input Output Life Cycle Assessment
ELCA	Environmental Life Cycle Assessment
GHGs	Greenhouse Gases
ICT	Information Communication Technology
IT	Information and Technology
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
MJ	Mega Joules
ppm	parts per million
SLCA	Social Life Cycle Assessment
TJ	Tera Joules

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CHAPTER 1: INTRODUCTION

This thesis contains two papers, recently presented at international conferences and accepted for publication in recognized journals. This dissertation format is permitted by Dalhousie University.

1.1 Significance of Sustainability

The temperature of the Earth has increased rapidly since the Industrial Revolution in the middle of the eighteenth century. There is significant evidence that this increase was caused especially by deforestation and the burning of fossil fuels (Hansen et al., 2008; Mann and Jones, 2003; McMichael and Woodruff, 2004). According to many, the change has been influenced by orbital and planetary motion and by emissions of Green House Gases (GHGs) that are exceeding the normal. As a result, the atmosphere of our planet has gotten warmer (Hansen et al., 2008; Mann and Jones, 2003; McMichael and Woodruff, 2004).

Approximately two hundred fifty years ago, our planet had 275 ppm of CO_2 in the atmosphere. In contrast the atmosphere now indicates 385 ppm of CO_2 (Hansen et al., 2008). To continue at this increasing pace, in other words if the planet has more CO_2 every day, humans put to risk living in this planet. Therefore, it is vital for humans to reduce CO_2 emissions by adapting their habits not only as consumers and but also as suppliers of goods and services to reach a greener economy. We need to ensure eco-efficiency and eco-efficacy by having more online businesses, for instance. To conclude, the research reported in this thesis is important because it provides an analysis of two major online and offline businesses in Canada. According to one source, movie rental services belong to entertainment and to the top three important household items ranked by Canadians (Robertson, 2008).

1.2 Importance of Information and Technology

The usage of Information and Technology (IT) has expanded in the twentieth century, especially after the commercial inception of the Internet that emerged in 1988 (Castells, 2001; Turban et al., 2008). Nowadays, almost every household and business has access to the Internet. Consequently, people ought to use the unique opportunity to exploit the Internet infrastructure and capabilities to join the common effort to minimize the effects of greenhouse gases, known as the greenhouse effect. Thus, by living “green” and by creating efficient business models, people can reach sustainability. In the current information age, new business models with a value proposition, which will be both competitive and efficient, can be deployed. Indeed, the Internet plays a major role in today’s digital integration. Clearly, the Internet has become the infrastructure of choice for E-Commerce, in contrast to traditional commerce, because it offers businesses an easier and low cost way to connect with customers and other businesses. Moreover, the

Internet contributes to cost efficiency (Laudon and Laudon, 2007). To conclude, companies ought to integrate IT into their business operations and processes (to have more online businesses) to reach environmental and efficient cost goals.

1.3 E-Commerce and Sustainability

Several experts have argued that E-Commerce, which is defined as the buying and selling of products and services by businesses and consumers by IT, in particular the Internet, can help realize sustainable progress for humans and the environment (Haag et al., 2006; The Climate Group, 2008). However, such statements generally lack the support of scientific research, which is considered a disadvantage of E-Commerce. Another disadvantage of E-Commerce is that client orders, amount of bought and returned items, electronic waste, airfreight transportation, and consumption of minerals for Internet infrastructure will increase in terms of emissions of GHGs. Nevertheless, others believe that E-Commerce has more benefits than disadvantages, such as decreases in paper consumption, fuel consumption, and transportation flow and the fact that the size of real estate usage will be reduced (Leahy, 2000).

Due to the increase of Internet access and usage in households and companies, E-Commerce has grown rapidly in recent years. In 2008, Canada reported 28 million Internet users (Internet World Stats, 2009). There are several reasons why Internet users, online consumers, exploit the Internet. According one source, one of the most used online services refers to movie rental service (Robertson, 2008). Consequently, Canada spent US$12 million in online movie rental services in 2006. This fact resulted in a prediction that by 2011, this number will rise to US$285 million (Pricewaterhouse Coopers LLP, 2007). In conclusion, movie rental services should realize that customers are changing from traditional to online ones.

Due to the importance of the Internet and online movie rental, the research reported in this thesis explores the environmental effects of two major online and offline movie rental services in Canada in relation to greenhouse carbon dioxide (CO_2) equivalent emissions and energy consumption. The study will include investigation of business activities such as transportation, power used in storage warehouses, and the amount of packaging that are crucial for business operations. Hence, the Economic Input Output Life Cycle Assessment Approach (EIO-LCA) will be used to examine the impact of the offline and online movie rental services items on the environment via usage of common criteria (Hendrickson, Lave and Matthews, 2006).

The EIO-LCA was chosen in this thesis because according to the Carnegie Mellon University Green Design Institute, the EIO-LCA method "estimates the materials and energy resources required for, and the environmental emissions resulting from, activities in our economy. It is one technique for performing a life cycle assessment, an evaluation of the environmental impacts of a product or process over its entire life cycle. The method uses information about industry transactions - purchases of materials by one industry from other industries, and the information about direct environmental emissions of industries, to estimate the total emissions throughout the supply chain" (Carnegie Mellon University Green Design Institute, n.d., para. 1). To conclude, the EIO-LCA will be a decisive criterion for the evaluation of the traditional versus online movie rental service in this thesis study.

1.4 Past Studies

Quantitative and qualitative frameworks and decision models are necessary to evaluate the sustainability of various human endeavors (Ahmad, 1997; Ben-Daya and Rahim, 2003). Some researchers have already suggested such models and frameworks for assessing sustainability. For instance, there exists the standard model of "sustainability assessment" that is often referred to as the "triple bottom line" in the industry. This one is also known as the "3-pillars of sustainability" (Klöpffer, 2008). The triple bottom line can be explained as an assessment model of the sustainability triad consisting of the environmental, economic, and social aspects (Klöpffer, 2008). This sustainability assessment model is a whole life cycle analysis (from cradle to grave) for goods, services, processes, and systems. The first of the triad is ascertained by the Environmental Life Cycle Assessment (ELCA); the second by the Life Cycle Costing (LCC); and the last aspect by the Social Life Cycle Assessment (SLCA) (Klöpffer, 2008). Firstly, the ELCA is a method to address environmental impacts of product, which refers to both goods and services, in its life cycle. Secondly, the LCC includes costs of a product incurred in its life cycle. Thirdly, the SLCA assesses social and socio-economic impacts that may directly affect stakeholders positively or negatively throughout the product life cycle (Emblemsvåg, J., 2003; UNEP, 2009).

In addition, one of the ways to reach sustainability has already been proposed frequently and it is through the potential reduction in carbon emissions within E-Commerce. However, in spite of all proposals offered by E-Commerce in reducing carbon emissions, we need to be aware of fundamental factors such as transportation, packaging, and real estate usage before we make a final decision on whether or not the carbon footprint created by E-Commerce is smaller than the one of the traditional commerce model.

Regarding these factors, past research towards gauging the carbon footprint of various E-Commerce activities illustrated the environmental impacts of E-Commerce with regard to selling and buying books and DVDs online. Researchers explored the scenario between Amazon.com and Federal Express on the delivery of more than quarter of a million copies of a popular fiction book to customers in the USA (Matthews, Hendrickson and Lave, 2000). Others explained the economic and environmental effects in generic scenarios for E-Commerce versus conventional retailing for best-selling books. The inquiry found that certain important parameters such as shipping distances, return rates, or shopping allocations are decisive for one of the two methods (online and offline) to be more environment-friendly and cost-efficient. The researchers concluded that the E-Commerce version is more environment-friendly and cost-efficient (Matthews and Hendrickson).

Other scholars designed generic scenarios to compare the environmental impacts and monetary costs between the retail logistics and E-Commerce for a best-selling book. Despite several variables (shipping distances, shopping allocations, return rates, type of delivery), the authors stated that E-Commerce is more cost-efficient and environment-friendly than the traditional retail logistics, considering unsold book returns. They also found that where a book is not returned, both delivery methods have the same costs (Matthews, Hendrickson and Soh, 2001a, 2001b). To conclude, the inquiries mentioned above prove that E-Commerce is a better version than offline model in terms of cost and sustainability.

Some researchers analyzed the environmental impacts of E-Commerce versus traditional retail for desktop computers. For example, they reflected on two scenarios in the United States. The first scenario was Business to Consumer (B2C) and the second an integrated scenario with Business to Business (B2B) and B2C through the usage of web services. The authors applied the environmental life cycle analysis of the product and suggested that resources, energy, and environmental burdens depend on the type of transportation used for distribution, especially in the B2C scenario. They also stated that if B2C is combined with B2B, the transportation type is not as crucial to achieve positive results (Caudill et al., 2000).

Some experts studied E-Commerce in relation to grocery shopping. One contrasted traditional versus electronic grocery shopping by focusing on B2C E-Commerce (Cairns, 1999). Other compared the economic and environmental effects of e-grocery home delivery models with the conventional delivery system in Lund, Sweden, pointing that the E-Commerce model is more efficient than the traditional model (Li, 2000).

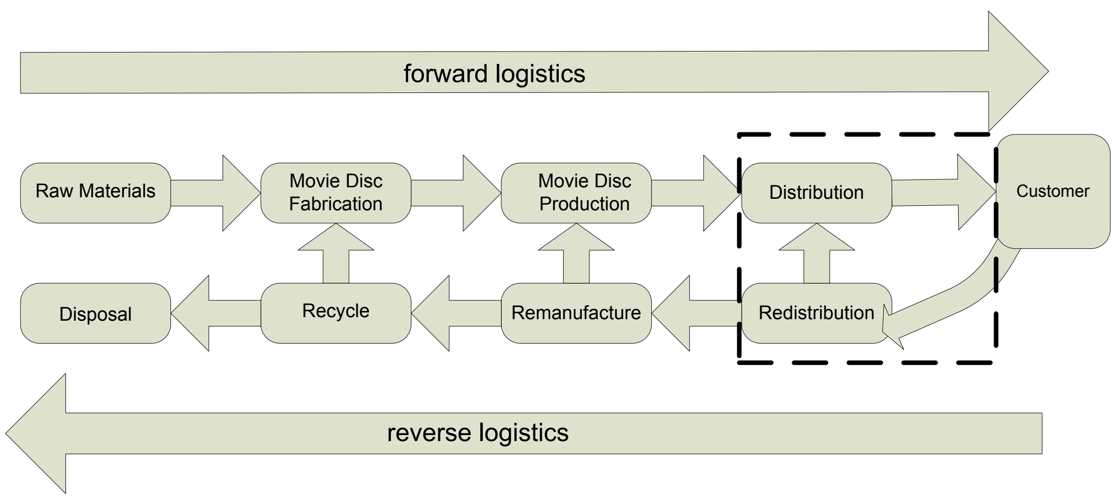
Lastly, one study focused on a comparative assessment of energy, environmental, and economic impacts of offline and online DVD rental services via using process-based and input-output life-cycle assessment methods. The picture of their analysis takes into account a customer situated in Ann Arbor, Michigan, USA. The results illustrated that the E-Commerce option has a better performance than the traditional DVD rental service in terms of energy, environmental emissions, and economic standpoints (Sivaraman et al., 2007).

1.5 Scope and Limitations of the Thesis

The main aim of the thesis is assessment and comparison of the energy consumption and carbon footprints of two major movie rental services models in Canada: an online movie rental service and offline or traditional (brick and mortar) movie rental service. For the research, the functional unit of all deliveries is three high-density (HD) optical discs or movie discs (DVD and Blu-ray format) that will be called a Value Package herein; as a matter of fact, a customer rents on average the amount of three movie discs per visit (Sivaraman et al., 2007).

This inquiry includes portions of the logistics chains that were different between traditional and E-Commerce movie rental services. From the analysis, the study removed common processes for both distribution channels (offline and online). The study considered that transportation is realized by first class post using truck freighting, and it exploited the Economic Input Output Life Cycle Assessment model (EIO-LCA). The EIO-LCA shows the environmental effects of operations of renting movie discs. The EIO-LCA set aside emissions from private vehicles; however, the thesis inquiry included them, as these emissions are necessary for calculations.

However, this study leaves out the potential enjoyment and psychological/physiological benefits that come from visiting a movie rental service, choosing a film among many options, and lastly carrying it home. The study considered that the aspect of satisfaction of movie viewers is the same for both online and offline models. Furthermore, the inquiry excludes the aspect of purchasing movies and other goods such as refreshments, and it leaves out the deterioration of movie cases and sleeves, too. The inquiry aims at two stages from the product life cycle, the forward and reverse distribution (Hanafi, Kara and Kaebernick, 2008), which are highlighted in Figure-1.1. As a result, the study focuses on the logistics of moving the movie discs between the two stages of the two business models.



Figure–1.1: Close-loop Supply Chain: Forward and Reverse Logistics for Movie Discs

1.6 Research Objectives

- Provide a comprehensive and integrative literature survey of the state-of-the-art in E-Commerce carbon footprinting.
- Provide a framework for categorizing research in this critical area which is E-Commerce carbon footprinting.
- Compare the carbon footprints of offline and online movie rental services by using a Systems approach.

- Compare the environmental impacts of offline and online movie rental service distribution channels in terms of energy consumption and carbon footprints.
- Identify the critical factors in both (online and offline movie rental) supply chains to improve environmental sustainability.
- Test the hypothesis that online movie rental performs better than offline movie rental in terms of environmental impact and sustainability.
- Provide some promising future research directions.

1.7 Research Methodology

The research methods utilized in this thesis were literature review and quantitative analysis. The literature review on E-Commerce and carbon footprint issue was accompanied with an evaluation discussion of the methodological aspects/gaps. The purpose here was to present the literature survey in E-Commerce and carbon footprint since the inception of the Internet, which is the underlying infrastructure of E-Commerce (Paper 1).

The quantitative analysis of E-Commerce and carbon footprint issue, which is the calculations part of the thesis, was applied via a systems approach perspective, followed by mathematical model development, and later by a model testing of the application in analyzing online and offline movie rental distribution channels. Within a green economy, working in this domain is easily considered to be part of the movement of "Systems Approach" that is one of three competitive approaches today in human and social sciences (Arbnor and Bjerke, 1997). We consider the systems approach throughout the analysis in this work. Arbnor and Bjerke (1997) defined the systems approach as a framework that considers synergy among the components of the system; in other words, not only are the components the sum of the system as a whole, but also they have a relationship with each other. The components cannot be understood in isolation; rather they can be understood in relation to each other and other systems. Based on the similarity with a systems approach, we used EIO-LCA in this research to assess, compare, and identify the environmental impacts. My work also considers public data and a data set of a major online movie rental service company to compare the energy use and carbon footprint associated with delivering movie discs.

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CHAPTER 2: LITERATURE SURVEY

This second chapter, which presents the literature review, is written in the style of a journal paper. The chapter provides a survey of the state of the art in E-Commerce carbon footprinting. The in-depth literature survey informs the research community on previous and present objective and subjective efforts towards evaluating eco-efficiency and eco-efficacy of E-Commerce. Moreover, it categorizes research in this critical domain of E-Commerce carbon footprinting via developing an updated and reusable framework for scholars in this field. In addition, the review shows that the studies in this area are rapidly growing and progressing. The body of literature presented here is significant for academia, government, and corporate policy-makers for making informed decisions regarding sustainability. It also indicates a lack of objective quantitative studies in comparing E-Commerce carbon footprinting of various alternative supply chains for different products and services, so the review suggests that more quantitative inquiries must be undertaken.

PAPER 1

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Audience of this Paper

E-Commerce researchers, business managers, government and corporate policymakers

State-of-the-Art in E-Commerce Carbon Footprinting

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Abstract

This paper provides a survey of the state of the art in E-Commerce carbon footprinting. This comprehensive literature survey informs the research community on past and recent objective and subjective efforts towards measuring eco-efficiency and eco-efficacy of E-Commerce. Moreover, this paper provides a framework for categorizing research in this critical area. We also provide a summary of some very promising future research directions in carbon footprinting of E-Commerce. Our survey corroborates that carbon footprinting is now considered a widely recognized broad framework of gauging eco-efficiency and eco-efficacy of E-Commerce. Furthermore, it informs us that the research in this discipline is fast expanding and evolving. Such a survey in this critical research field is significant for government and corporate policy-makers in formulating informed decisions regarding sustainability. In addition, the research in this domain may be useful to environmentally conscious consumers who want to make informed choices on their consumption habits for reducing their personal carbon footprints.

2.1 Introduction

The growing evidence that the environmental sustainability of our planet is quickly deteriorating due to modern human activities has made the notion of sustainability a major focus of humankind. Nevertheless, the whole of humanity needs to join the common efforts of minimizing greenhouse effects by living “green” and reaching a sustainable existence by creating efficient business models and practices. However, in order to assess the impact of various factors and complex underlying dynamics, we often need some quantitative and qualitative frameworks and models to make objective decisions (Ahmad, 1997; Ben-Daya and Rahim, 2003).

In general, there have been some research efforts where such models and frameworks for assessing sustainability have been proposed. For instance, there is the standard model of sustainability assessment, often referred to in the industry as the Triple Bottom Line (TBL), which expands the focus of governments and businesses from purely financial performance to an integration of social, ecological, and financial performances (Klöpffer, 2008). This sustainability assessment model is a whole life cycle analysis from cradle to grave for products, systems, services, and processes. It is directed at assessing the sustainability triad constituting of the social, ecological, and financial aspects. The first aspect is ascertained by the Social Life Cycle Assessment or SLCA, the second aspect by the Life Cycle Costing or LCC, and the last aspect by the Environmental Life Cycle Assessment or ELCA (Ibid).

Interestingly, the advent of the Information Age has facilitated the development and procurement of exclusively new business models, value propositions, and more efficient organizations (Castells, 2000a, 2000b, 2001, 2004). Indeed, the Internet plays a major part in such a digital integration, providing the infrastructure of choice for E-Commerce. In fact, the Internet offers governments and businesses easier and more efficient means to link with customers and other enterprises. Moreover, the Internet offers the promise for reducing the transaction costs for organizations (Laudon and Laudon, 2007; Brynjolfsson and Smith, 2000). Consequently, E-Commerce holds significant potential for reducing carbon emissions due to its cost-effectiveness to businesses and governments.

Significantly, E-Commerce has frequently been proposed as a means of improving sustainability through the potential reduction in carbon emissions. Nevertheless, despite all promises offered by E-Commerce towards reducing harmful emissions, there are important factors that must be considered prior to making a final decision on whether or not the carbon footprint created by E-Commerce is smaller than that of traditional commerce. In the past, some research has been done towards gauging the carbon footprint of various E-Commerce activities. This paper is intended to provide an extensive and integrative survey of past research efforts in E-Commerce carbon footprinting. We believe that such a literature survey will facilitate future research by providing a good reference on this issue.

The rest of the paper is organized as follows: Section 1 provides some historical perspective on carbon footprinting, Section 2 presents a case for research in E-Commerce carbon footprinting, Section 3 provides an extensive literature survey in this domain, Section 4 tenders some interesting and challenging future research directions and Section 5 concludes the paper with a summary.

2.2 Historical Perspective

Currently, our planet Earth is experiencing its highest average surface temperature for the last 100,000 years. Among other factors, our climate is profoundly affected by emissions of GHGs. Indeed, the amounts of the GHGs in our atmosphere are above the normal, resulting in a warmer planet (McMichael and Woodruff, 2004). As one study informs us, "the Earth has warmed by at least 0.2°C every year during the past 20 years or so – about the same amount by which it has warmed or cooled over the space of a century in the past" (Mann and Jones, 2003). This argumentation of the GHGs started after the first Industrial Revolution around 1750 and resulted primarily from the burning of fossil fuels and clearing of forests (McMichael and Woodruff, 2004).

Before the Industrial Revolution, the air held no more than 275 ppm CO_2 and now it has 385 ppm CO_2 (Hansen et al., 2008). Essentially, the experts stated, "If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted…CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm" (Ibid.). As such, the reduction in GHGs has become an important goal at the global level.

Nevertheless, a new world is taking shape in this beginning of the third millennium. Three major independent processes fundamentally alter our world: the information technology and systems revolution, the financial crisis, and environment-centered social movements. The contemporary society reflects on the consequences of these processes, which are affecting the very existence of humanity in the global village (Castells, 2000a, 2000b, 2001, 2004). Such reflections and considerations are made at international, regional, organizational, and individual levels. Currently several companies in the World exploit technology and thus advocate Green IT by implementing innovation, for instance Accenture, Boston Consulting Group, Capgimini, General Electric, HP, IBM, Infosys, McKinsey, SAP, TCS and PWC (Accenture, 2009; Boston Consulting Group, 2009; Capgimini, 2009; General Electric, 2009; HP, 2009; IBM, 2009; Infosys, 2009; McKinsey, 2009; SAP, 2009; TCS, 2009; PWC, 2009).

For instance, in 1987, the Montreal Protocol focused on reducing ozone depletion caused by anthropogenic emissions like chlorofluorocarbons with some success (UNEP, 2002). However, the importance of carbon dioxide as a major contributor to anthropogenic greenhouse gases (GHGs) cannot be overestimated. In 1997, the United Nations stated the Kyoto Protocol to control the emission of carbon dioxide and the other GHGs of industrialized countries (United Nations, 1997). The Kyoto Protocol came into force in 2005.

Prior to that, in 1996, the ISO 14001 was first published, providing international standards for environmental management systems for any organization (Von Zharen, 1996). Recently, the Intergovernmental Panel on Climate Change (IPCC) stated in its assessment report that "… changes in atmospheric concentrations of GHGs and aerosols, land cover and solar radiation alter the energy balance of the climate system…" and concluded that "… increases in anthropogenic GHG concentrations is very likely to have caused most of the increases in global average temperatures since the mid-20th century" (IPCC, 2007).

In order to gauge the GHG emissions of various human activities in an easy to comprehend and easy to compare fashion, the term carbon footprint has become very popular (Safire, 2008). Several definitions of the term carbon footprint have been put forward. One such definition has evolved out of other definitions of the past decades and defines the carbon footprint as: "… a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (Wiedmann and Minx, 2007).

In this paper, we will rely on the aforementioned description of carbon footprint as a guide for evaluating various research efforts, because of our belief that this definition considers the commonly accepted accounting principles and modeling approaches. Furthermore, we concur that this definition of carbon footprint takes into account most, if not all, direct and indirect harmful emissions, caused by the activities of governments, businesses, organizations, and consumers (Ahmad, 2009). In the next section, we discuss the significance of E-Commerce carbon footprinting in our contemporary world.

2.3 A Case for E-Commerce Carbon Footprinting

With the devastating potential of climate change higher up on the agenda around the world, the carbon footprint is now a buzzword that is extensively employed by the governments, businesses, and consumers around the world. The premise is that once governments and businesses know the magnitude of the carbon footprint of various activities, it is possible to formulate policies and strategies for reducing the overall emissions of GHGs (Ahmad and Bliemel, 2009; Wiedmann and Minx, 2007). Indeed, many in both the public and the corporate sectors have started calling for carbon footprint calculations for products or services provided to them. It is analogous to providing information on ingredients and nutritional contents of food products, as mandated by law in most countries (Ahmad and Bliemel, 2009).

Knowing the carbon footprint of various supply chains should enable businesses to develop policies for promoting green supply chains in order to reduce environmentally devastating effects of GHGs. As mentioned, we believe that a great opportunity is being offered by E-Commerce towards achieving this goal of reducing carbon emissions (Ahmad and Bliemel, 2009). Despite differing views on how to measure the environmental performance, various studies strongly advocate the adoption of eco-efficacy and eco-efficiency for measuring and comparing the ecological performance of various supply chains (Abukhader, 2008; Abukhader and Jönson, 2004a). In short, the premise is that we need to improve eco-efficiency and eco-efficacy in operational activities in order to achieve greener supply chains. By making technical and strategic choices on ecological product design, production processes, scheduling, as well as both forward and reverse e-logistics, we may very well achieve our goal of improving eco-efficiency and eco-efficacy. Once again, achieving this objective requires reliable measurements and comparisons of the carbon footprints for various activities.

As mentioned earlier, a significant development in recent times, which may help improve eco-efficacy, is the emergence of the Internet-based economy (Ahmad and Bliemel, 2009). We are fast moving towards an Internet-based society and the Internet has managed to expand exponentially since its commercial inception in 1988 (Castells, 2001). For instance, in 2006, the worldwide number of the Internet users was 1.2 billion and projected to reach the 2 billion users mark by the year 2012, exhibiting a growth rate between 140 million to 145 million users per year. A growing population, more affordable and faster computers, and increase usage of mobile devices are considered main contributors to this astounding growth in Internet users (Turban et al., 2008). Moreover, it is expected that the digital economy will be attained through economic growth driven by IT and E-Commerce. Based on these trends, the U.S. Department of Commerce began a discussion about the emergence of the digital economy (Henry, Cooke and Montes, 1998; Henry et al., 1999). Consequently, the future of the digital economy and E-Commerce is promising even after considering the effects of the current economic downturn.

The trend is most certainly having shoppers move towards online shopping due to convenience, disintermediation, lower prices, and an ability to do quick comparisons of product prices and features (Forrester, 2008). Indeed, online retailing is growing significantly worldwide. According to a market research company, US online retail reached US$175 billion in 2007 and is projected to grow to US$335 billion by 2012 (Forrester, 2008). Canadian online retail reached US$12.9 billion in 2007 and is projected to grow to US$22.2 billion by 2012 (eMarketer, 2008).

Due to the importance of E-Commerce, various research groups are studying its environmental impact in relation to greenhouse carbon dioxide equivalent emissions caused by transportation, power consumption, and packaging. This survey paper is an attempt to facilitate the research in carbon footprinting of E-Commerce. In the next section, we provide a comprehensive literature survey as well as a framework for classifying research in this area.

2.4 Literature Survey

There is a fast growing body of literature in this domain appearing in various journals, proceedings, and other knowledge repositories. However, the diverse perspectives and scattered locations of this literature mean that there is a growing need for an integrative literature survey that will guide researchers working on expanding the current literature.

In addition to an integrative literature survey, there is a need for classifying and cataloging the current diverse literature. In this regard, Abukhader and Jönson (2003) provide one classification framework in a seminal study. However, the scheme is more appropriate for a rich and large body of literature in spite of all its attributes. As such, it may not be suitable to the current body of relatively modest, albeit rapidly expanding, research. Consequently, we deem that a simpler categorization of research in this area is more suitable to the current body of literature. Indeed, the two dominant streams of research, namely qualitative and quantitative, provide suitable categorization guides. In the following subsections, we provide a survey of existing literature with this notion in perspective.

2.4.1 Qualitative Studies

Qualitative studies bear the character of largely subjective comparisons of carbon footprints in various E-Commerce activities. Among the various qualitative studies, some examine the theoretical and conceptual levels of the relationship between information society, sustainable development, and technology issues (Jokinen, Malaska and Kaivo-oja, 1998). Other studies advocate the need for quantifying the environmental footprint of the ICT systems on products and operations (Shah et al., 2009). One study reflected on a critical survey on the topic E-Commerce and environment. In that study, researchers attempted to define E-Commerce and classify the environmental effects, and eventually suggested a framework for future investigation (Abukhader and Jönson, 2003).

In recent times, there have been some studies on economic and environmental benefits of the Internet, which is the underlying infrastructure for E-Commerce. For instance, some inquires studied environmental and social aspects of E-Commerce (Rejeski, 2002; Türk, 2003). In addition, other studies considered the economic impacts of E-Commerce in their research (Yi and Thomas, 2006). One piece of literature listed several research papers that dealt with the environmental impact of e-business and Information Communication Technology (ICT) (Yi and Thomas, 2007). Rejeski (1999) analyzed the environmental effects of E-Commerce in society and discussed the lack of regulations in E-Commerce at that time.

Such trends as the use of environmental regulations, policies, environmental literacy, and Eco-friendly "bots or robots" were pointed out as positive signs (Sarkis, Meade and Talluri, 2002). Such bots are artificial intelligence programs designed to find on the Internet, especially in E-Commerce sites, the most useful mixture of environmental aspects and price for any merchandise or service. In this regard, several experts searched the environmental effects of the forward and reverse cycle for e-logistics (Ibid.).

Some researchers reflected on the opportunities for the ICT industry to reach sustainability. It can be done by using: a) smart motor systems by optimizing motors and industrial automation; b) smart logistics by efficient transportation and storage; c) smart buildings by improving design, automation and management; d) smart grids by optimizing the monitoring and management of electricity grids, and integrating ICT systems into the energy Internet (The Climate Group, 2008).

Cohen (1999) predicted ten Internet trends that were likely to become green practices and policies on the Internet to reach an ecologically sustainable society. Those are: "Mass customization" for eco-efficiency, marketing by pixels instead of packages, dematerialization of products, the de-mailing of America, letting the modem do the driving, closing the loop on-line, green bot.com, reusing materials through on-line auctions, adding information to products for environmental efficiency, and globalization E-Commerce. Another research study investigated the environmental effects of the Internet Economy that were caused by IT infrastructure, Internet use, and its rebound effects (Fichter, 2001). One researcher analyzed the environmental effects of E-Commerce by using past works and by conducting interviews at seven British companies. It concluded with a recommendation that the businesses should consider the environmental aspects such as energy, transportation, carbon trading, and green products (Hurst, 2001). Similarly, others suggested that E-Commerce oriented businesses should pay attention to the resources that are used by logistics, inventory, and distribution (Thornton and Ferrone, 2001).

Naturally, researchers have been exploring the relation between the environmental effects of E-Commerce and logistics industry (Hultkrantz and Lumsden, 2001). Some reported on positive influences of E-Commerce on sustainability of distribution systems (Hesse, 2002). Consequently, important environmental and political strategies were suggested to achieve a sustainable society by reducing CO_2 emissions and energy consumption by increasing the IT and E-Commerce usage (Fichter, 2001). In addition, not only were the energy and economic effects of E-Commerce analyzed, but also some business strategies were recommended in order to achieve sustainable development (Fichter, 2002). Moreover, several past studies were cited to support the argument that E-Commerce was inherently neither friendly nor hostile to the environment. Thus here is no determinism regarding environmental impacts of E-Commerce.

Peng, Li and Zhang (2005) described a conceptual model followed by the discussion on positive and negative environmental effects of E-Commerce. Energy and resource savings were listed as positive impacts of E-Commerce; nevertheless, it was pointed out that E-Commerce also has its negative effects on the environment (Ibid.). Sui and Rejeski (2002) commented on another categorization of positive influences called the three D's - Dematerialization, Decarbonization and Demobilization. Also they stressed the significance of environmental policies in the information age (Sui and Rejeski, 2002).

Some researchers dealt with the financial and environmental effects of inventory management as well as the tradeoff between transportation and warehousing in a logistic network scenario (Matthews, Hendrickson and Lave, 2002). The analysis summed up that reductions in energy usage, resources, and environmental emissions will be achieved by applying the E-Commerce model, which considers centralized inventory and shipping services (Ibid.). Other researchers concluded that, in logistics and transportation, concrete local contributions such as consumer habits, delivery modes, and population density contribute to distribution efficiency (Jönson, Orremo and Wallin, 2000; Davis, 2000; Koomey, 2000; Türk, 2003; Williams, 1999).

Romm (2002) outlined the impacts in the Internet Economy of facilities, production, transportation, energy consumption, etc., along with the environmental and economic effects of the Internet Economy itself in the USA. Furthermore, it was argued that the reduction in energy intensity is related to the growth of IT and Internet Economy, which increased efficiency in the processes and required less energy than traditional methods. In short, it was argued that the Internet Economy is more likely to be more environment-friendly, cost-efficient, and energy-efficient than the traditional economy (Romm, 2002; Romm, Rosenfeld and Herrmann, 1999).

Abukhader examined the environmental implications of E-Commerce in a collection of four journal papers. This first paper is a literature review of the works that have been undertaken in the field of E-Commerce and environment as well as a framework for classifying future studies (Abukhader, 2003). Subsequently a two-dimensional environmental assessment model for green E-Commerce supply chains is proposed (Abukhader and Jönson, 2004a). Furthermore, the adoption of the eco-efficacy approach as a complement to the eco-efficiency is proposed in order to examine the environmental consequences of E-Commerce. This proposal has its roots in the use of tools of efficiency and effectiveness for measuring the performance in a supply chain management system (Abukhader, 2008). Subsequently, the effects of logistics and supply chain management on the environment are explored from the sustainability perspective (Abukhader and Jönson, 2004b). In this regard, Amato-McCoy (2009) provided the analysis to reach sustainability via ecological E-Commerce through a comparison of trends in various metrics/indicators. In Table–2.1, we summarize a list of some important qualitative studies in E-Commerce carbon footprinting.

Table–2.1: E-Commerce versus Carbon Footprinting: Qualitative Studies

Qualitative Studies on E-Commerce Carbon Footprinting
Abukhader, 2003, 2008; Abukhader and Jönson, 2003, 2004a, 2004b; Ahmad, 2009; Ahmad and Bliemel, 2009; Amato-McCoy, 2009; Brynjolfsson and Smith, 2000; Cohen, 1999; Davis, 2000; Fichter, 2001, 2002; Henry, Cooke and Montes, 1998; Henry et al., 1999; Hesse, 2002; Hulkrantz and Lumsden, 2001; Hurst, 2001; Jokinen, Malaska and Kaivo-oja, 1998; Jönson, Orremo and Wallin, 2000; Keeney, 1999; Klöpffer, 2008; Koomey, 2000; Matthews, Hendrickson and Lave, 2002; Peng, Li and Zhang, 2005; Rejeski, 1999, 2002; Romm, 2002; Romm, Rosenfeld and Herrmann, 1999; Sarkis, Meade and Talluri, 2002; Shah et al., 2009; Sui and Rejeski, 2002; Thornton and Ferrone, 2001; The Climate Group, 2008; Türk, 2003; Williams, 1999; Yi and Thomas, 2006, 2007

2.4.2 Quantitative Studies

Quantitative studies provide numerical figures and calculations for carbon footprints. A detailed study of enquiry in the quantitative field demonstrates that the research in this area can be divided into three broad categories; namely, products, services, and tools. In the following we provide the survey of research in various product and service areas.

2.4.2.1 Books/DVDs

Some researchers explained the environmental effects of E-Commerce in regards to selling and buying books and DVDs. Matthews, Hendrickson and Lave (2000) compared

Amazon.com's and Federal Express E-Commerce's supply chain efficiency while delivering about a quarter of a million copies of a popular fiction book to customers in the USA. Matthews and Hendrickson (2001) explained the economic and environmental impacts in generic scenarios for E-Commerce and traditional retailing for a single commodity; namely, a best-selling book. The inquiry identified certain important determinants and drivers of environment-friendliness and cost-efficiency such as shipping distances, return rates, or shopping allocations. It was concluded that the E-Commerce method is more environment-friendly and cost-efficient compared to traditional retailing (Matthews and Hendrickson, 2001).

In another study, a generic scenario was created to compare the environmental impacts and monetary costs between the retail logistics and E-Commerce for a best-selling book. After considering several variables such as shipping distances, shopping allocations, return rates, unsold book returns, type of delivery, etc. the researchers concluded that E-Commerce was more cost-efficient and eco-efficient than traditional retailing. Nevertheless, it was shown that where a book is not returned, both delivery methods seemed to have comparable costs (Matthews, Hendrickson and Soh, 2001a, 2001b). To conclude, several papers were upgraded and restated (Hendrickson, Lave and Matthews, 2006; Matthews, Hendrickson and Soh, 2001a, 2001b).

Matthews et al. (2002) explained the financial and ecological impacts of traditional retailing and online retailing of books (single commodity) in generic scenarios for the USA and Japan. This study exploited two life cycle assessment models and hence compared the online versus offline retailing logistic systems. The result of the analysis was that the energy and cost efficiency of the systems depend on the conditions of the implementations, especially the transport modes, shipping distances, population density, packaging, number of items per order, return rates, or shopping purchase allocations used by suppliers and consumers (Matthews et al., 2002).

Reichling and Otto (2002) elucidated the environmental impacts of e-retailing versus Traditional retailing for a book purchasing scenario. They observed that the environmental effects are correlated with the customer's method of commute. Williams (2002) compared online and offline retail for books in Japan and showed that E-Commerce has a slightly bigger carbon footprint than traditional retailing due to the need for additional packing. Moreover, it was pointed out that the energy use in bookstores is comparable to the energy used at home when a consumer makes an online purchase (Williams, 2002). It was concluded that such important factors as transport modes, shipping distances, population density, packaging, number of items per order, return rates, or shopping purchase allocations used by suppliers and consumers, etc. have impact on the energy and cost efficiency of the systems (Williams, 2002).

Williams and Tagami (2003) studied the environmental impacts of E-Commerce and the traditional retailing based on energy consumption for the Japanese book market. One study searched for a design and evaluation of a sustainable networked delivery system for books in the USA. For this inquiry, they compared the emissions and energy consumption of three book delivery systems, which are the Sustainable Networked

Delivery (SND), the Traditional Networked Delivery (TND), and the E-Commerce Networked Delivery (END). It concluded that the best option is the SND system, which is a combination of E-Commerce system and pickup points or hybrid B2C book delivery (Kim et al., 2008, 2009).

Xu et al. (2009) used an Agent Based Modeling (ABM) technique to work on the market dynamics and environmental effects of buying books under certain logistic systems. Based on the energy and emission savings, it was confirmed that the use of a combination of E-Commerce and pickup points was a better option (Kim et al., 2008, 2009). Others commented about dematerialization caused by digital media and associated hardware regarding digital music delivery and concluded that digital formats do not beneficially contribute to dematerialization, largely due to increases in hardware (Hogg and Jackson, 2008).

2.4.2.2 Computers and Accessories

Caudill et al. (2000) analyzed the environmental impact of E-Commerce versus Traditional retail for desktop computers. They reflected on two scenarios, the B2C scenario and an integrated B2B and B2C scenario through the use of web services. They applied the environmental life cycle analysis of the product to compare the two business models in the two scenarios. It was suggested that resources, energy, and environmental burdens depend on the type of transportation used for distribution, especially in B2C scenario. However, if B2C is combined with B2B, the transportation type is not so crucial to have positive results (Caudill et al., 2000).

Other investigators explored ways to optimize an E-Commerce supply chain of desktop computers by employing fuzzy logic decision theory (Luo, Wirojanagud and Caudill, 2001). Others compared the energy consumption of e-retailing and Traditional retailing of personal computers in Netherlands. Using a life cycle analysis it concluded that the energy use per article sold by the online reseller consumes less energy (Reijnders and Hoogeveen, 2001).

Gay et al. (2005) elucidated the environmental impacts of E-Commerce with regards to Traditional retailing of personal computers in the USA. They recommended using more than one life cycle assessment software for the environmental analysis. The study demonstrated that E-Commerce was more environmentally beneficial to the world than the traditional method of purchasing and delivery (Ibid.). Weber et al. (2008) compared the energy consumption and carbon dioxide emission of E-Commerce and traditional retail. The unit of study was a flash memory and it exploited a data set from Buy.com in the USA.

2.4.2.3 Groceries

Several researchers studied E-Commerce in relation to grocery shopping. For instance, Cairns (1999) contrasted Traditional versus electronic grocery shopping by focusing on B2C E-Commerce, whereas Li (2000) compared the economic and environmental effects of e-grocery home delivery models with the conventional delivery system in Lund, Sweden, indicating that the E-Commerce model seemed to be more efficient than the traditional model.

Persson et al. (2001) reported the design of an energy-efficient and environment-friendly distribution network system for e-grocery in Stockholm in Sweden. Punakivi and Holmström (2001) also dealt with grocery shopping online. Siikavirta et al. (2003) explored the economic and environmental effects of e-grocery home delivery models, showing it as a more environmentally friendly model in comparison to the conventional delivery system in Helsinki, Finland. Tehrani and Karbassi (2005) assessed the energy consumption and environmental impacts of e-grocery and conventional model for Tehran, Iran. Once again, the outcomes showed that the E-Commerce version was more environment-friendly and energy-efficient than the traditional model.

2.4.2.4 Advertising

Some researchers described a model to estimate emissions and energy consumption in order to deliver either online advertising or a given amount of information to an online user. The model assesses the energy use and data flows of the equipment inside the Internet Backbone, WAN (Wide Area Network), businesses' LAN (Local Area Network), PTN (Public Telephone Network), Cell sites, and excludes home network equipment, personal computers and wireless devices (Taylor and Koomey, 2008).

2.4.2.5 DVD Rental

A study focused on a comparative assessment of energy, environmental, and economic impacts of online and offline DVD rental services. The analysis was performed using process-based and input-output life-cycle assessment methods. The data illustrated that the E-Commerce option has a better performance in terms of energy, environmental, and economic standpoints than the traditional DVD rental service (Sivaraman et al., 2007).

2.4.2.6 Information Delivery

Some researchers compared the environmental effects of two wireless technologies applications with their traditional versions for which they could substitute. The first comparison was between reading newspapers content by using a Personal Digital Assistant (PDA) against the hardcopy version of a newspaper. The second was wireless teleconferencing versus business travel. Having applied a life-cycle assessment, the data demonstrated that both wireless technologies produce lower emissions than the conventional technologies (Toffel and Horvath, 2004).

2.4.2.7 Carbon Footprint Calculators

Recently consumers have started to become more conscious about their carbon footprint by using online carbon footprint calculators. One investigator reported several carbon footprints calculators in use on the web at this moment (Dodge, 2008). Others compared various carbon footprint calculators, and concluded that although these calculators can estimate the personal carbon footprint, there is a lack of consistency between them, as much as several metric tons per annum per individual, and suggest that developers achieve standardization of this assessment tool. Clearly, there is a need for more formal and elaborate quantitative models for this purpose (Padgett et al., 2008). In Table 2.2, we summarize a list of some important quantitative studies in E-Commerce carbon footprinting.

Table–2.2: E-Commerce versus Carbon Footprinting: Quantitative Studies

Qualitative Studies on E-Commerce Carbon Footprinting		
Products		
Books/DVDs	**Computer and Accessories**	**Groceries**
Hendrickson, Lave and Matthews, 2006; Hogg and Jackson, 2008; Kim et al., 2008, 2009; Matthews and Hendrickson, 2001; Matthews, Hendrickson and Lave, 2000; Matthews, Hendrickson and Soh, 2001a, 2001b; Matthews et al., 2002; Reichling and Otto, 2002;Williams, 2002; Williams and Tagami, 2003; Xu et al., 2009	Caudill, et al. 2000; Gay et al., 2005; Luo, Wirojanagud and Caudill, 2001; Reijnders and Hoogeveen, 2001; Weber et al., 2008	Cairns, 1999; Li, 2000; Persson et al., 2001; Punakivi and Holmström, 2001; Siikavirta et al., 2003; Tehrani and Karbassi, 2005
Services		
Advertising	**DVD Rental**	**Information Delivery**
Taylor and Koomey, 2008	Sivaraman, et al., 2007	Toffel and Horvath, 2004
Tools		
Carbon Footprint Calculators		
Dodge, 2008; Padgett et al., 2008		

2.5 Future Research Directions

In order to advance the research in carbon footprinting, identification of some of the critical aspects of supply chains for appraisal and modeling would be essential. Clearly, there are some aspects of supply chains that cannot be meaningfully identified as critical or non-critical based only on the available scientific data. Consequently, some qualitative approaches would be helpful in identifying those aspects of the supply chains that are critical to achieving the environmental sustainability objective. Once critical aspects of both E-commerce and traditional supply chains are identified, quantitative approaches would be required to model those aspects in the form of reliable, reusable, and extendable mathematical models and formulae (Ahmad, 2009). More specifically, it would require extensive mathematical modeling of complex, non-linear, interdependent supply chain dynamics (Ahmad, 1997). Such quantitative model would be beneficial in developing effective, interactive, and adaptive decision support systems for policymakers, business managers, and researchers (Ahmad, 2009).

The existing research in this domain has largely dealt with assessing carbon footprinting for such products as books, DVDs, groceries, electronics (computers), etc. as well as such services as printing, advertising, and DVD rental. In future, we suggest an increased focus on carbon footprint of various services, such as pharmaceutical services and online education. In addition, there is a need to assess the cost of various potentially adverse social implications of E-Commerce, such as reduced social interaction, reduced physical work, etc. (Ahmad, 2009). Moreover, there is a need for extending the existing carbon footprinting calculators to create usable and effective Decision Support Systems (DSS). Various integrated decision models for E-Commerce supply chains may prove useful in developing such DSS. Indeed, such DSS have been effective in various complex interdisciplinary problem solutions and the promise of using DSS in this complex domain cannot be overemphasized (Ahmad et al., 2008).

Furthermore, the intricate interdependency of complementary and substitute products and services mean that no meaningful carbon footprint assessment can be done by focusing on merely a single product or service in isolation. There is a need to also take an integrative look at the supply chains of complementary and substitute products as well as product families. Naturally, there is growing need for developing integrated quantitative decision models (Ahmad, 1997; Ben-Daya and Rahim, 1999; Ben-Daya and Rahim, 2003).

We would like to emphasize that the scope and complexity of these research directions would require significant support from governments, regulatory bodies, and research institutions. Furthermore, it would require interdisciplinary research teams with skills in such diverse domains as operations research, management sciences, supply chain management, marketing, environmental management, social sciences, strategy and policy, etc. As suggested earlier, an integrative systems approach to such a broad-ranging problem is needed (Ahmad, Safayeni and Ahmad, 2008). For instance, the carbon footprint of the entire communications and computing infrastructure developed to enable high-speed data transfer including end-user computers, servers, routers, and communications channels are ignored in past studies on E-Commerce carbon footprinting. Nevertheless, the true life cycle analysis should take into account the environmental impact of environmental impact of the entire enabling and supporting infrastructure of E-Commerce.

2.6 Summary

This paper provides an extensive literature review of significant contributions to the research in carbon footprinting of E-Commerce. It not only complements the past literatures surveys in this critical research area but also classifies the relevant literature in two broad categories, namely quantitative and qualitative studies. Within the quantitative category, we have further categorized literature based on products, services, or tools considered for measuring carbon footprinting in those papers. Consequently, this review not only brings an innovation in terms of its scope but also contributes to the research on E-Commerce and carbon footprinting through updating the relevant information.

Moreover, the classification framework presented in this paper may prove useful for future literature surveys. We have also provided some novel and interesting future research directions. This paper will be useful to government and corporate policy-makers as well as environmentally conscious consumers. We believe that this paper contributes significantly to the existing literature by providing a useful resource to all those interested in using or pursuing the research in this area.

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CHAPTER 3: MODEL DEVELOPMENT AND IMPLEMENTATION

The third chapter presents the model development and implementations in the industry of movie rental services to compare the energy consumption and carbon footprints of the two business models using a systems approach and the Economic Input Output Life Cycle Assessment (EIO-LCA) model and assess environmental performances. Here we explain assumptions, parameters, variables, calculations of comparative costs of logistics, environmental, comparative, and relative impacts of online and offline movie rental services implemented in this research.

3.1 Model Development

The model development is derived from a systems approach perspective because we used EIO-LCA that is based on the framework that reflects synergy among parts of the whole system. According to Arbnor and Bjerke (1997), in the systems approach the parts coexist and can be understood only in the relationships among each other. Therefore, we implemented this approach because we gathered data for combining the relations among components on the business distribution channels. Moreover, in the presented model development, we used the Environmental Life Cycle Assessment (ELCA) and considered the ISO 14000. These are the core of the International Environmental Standards assessment tools (Abukhader, 2003).

3.1.1 Assumptions

In our calculations, used to compare online and offline movie rental service to assess carbon footprinting, we assumed the functional unit of deliveries to be a high-density (HD) optical disc or movie disc, which is DVD or Blu-ray format; however, in the implementations, which are in the following section, for practical reasons we used three movie discs. The functional unit can be customized according to the number of movie discs. Regarding money value in the analysis, one currency must be used. Moreover, to make the presented model work, adjustment of currency value must be made to the year of the database of the EIO-LCA.

Within the offline model (Figure 3.1), we assumed that the procedure of renting a movie is as follows: The movie discs in cases are in the headquarters from where they are shipped to movie rental stores across a whole country by first class mail. For simplicity direct shipment from the headquarters to the movie rental stores is considered (a distribution center is excluded). Then, customers drive their cars from homes to a movie rental store where they rent a movie. Afterward they drive back home. After watching the movie, customers drive their cars to the movie rental store to return it.

Within the online model (Figure 3.2), we assumed that the procedure of renting a movie is as follows: Customers browse an online movie rental store's website, choose a movie (or movies), and finally rent it (or them). When customers click on "order button" to rent a movie, they send a request to the online company's data center (headquarters). The center accepts orders and ships the movie discs in sleeves through first class mail to a local distribution point that is the nearest one to a customer's home address. The movie discs are then taken to a post office nearest to a customer's home address, and the movie discs are delivered by a postman who walks the last mile, which is considered as a distance from a movie rental store or post office to a customer's home. After watching the movie, a customer returns the movie disc (or discs) in household to the postman, who walks the last mile to the nearest post office. Later, the movie discs are shipped through first class mail from the post office to a local distribution center. There, the movie discs are stored until the next renter's online order happens.

To make this model work, removal of some aspects of renting movies is necessary. These are the part of the retail activity of movie rental stores that includes buying movies, drinks, and refreshments; the aspect of satisfaction of movie renters, which comes when they search and rent movies, because it is identical for both business models; the aspect of watching movies itself since the energy consumption is the same for both business models; the aspect of the manufacture stage of movie discs since it is the same for online and offline models; the aspect of lights (incandescent lamps) and air conditioning/space heating because they are not a necessity for renting movies online; and lastly the aspect of damage of movie disc cases and their replacement for sleeves.

3.1.2 Parameters

Amount of Economic Activity in the sector (\$) = I $(0 \leq I \leq +\infty)$

Distances from Headquarters to Movie Stores (km) = D_i

Distances from Headquarters to Regional Distribution Centers (km) = D_j

Distances from Regional Distribution Centers to Movie Stores (km) = D_k

Average round trip distance between Customer's home and Movie Store (Km) = D_{CM}

Production cost per Movie Discs (\$) = C_{MD}

Movie Disc Case Price (\$) = P_{MDCase}

Movie Disc Sleeve Price (\$) = $P_{MDSleeve}$

Truck Transportation Price (\$/ton*km) = P_T

Movie Disc weight (Kg) = W_{MD}

Movie Disc Case weight (Kg) = W_{MDCase}

Movie Disc Sleeve weight (Kg) = $W_{MDSleeve}$

Total Number of Movie Stores across the nation of the major Offline Movie Rental = n

Total Number of Regional Distribution Centers across the nation of the major Online Movie Rental = m

Total Number of Movie Rental Businesses across the nation (including Stores and Distribution Centers) = l

Percentage of passenger cars in passenger fleet (%) = P_{cars}

Percentage of light trucks in passenger fleet (%) = P_{trucks}

Energy Impact per kilometer for passenger car (MJ/km) = E_{Ecar}

Energy Impact per kilometer for light truck (MJ/km) = E_{Etruck}

Energy Impact for placing an order at the movie rental website (MJ/MB) = E_{Eweb}

Carbon Footprinting Impact per kilometer for passenger car (g/km) = E_{CFcar}

Carbon Footprinting Impact per kilometer for light truck (g/km) = $E_{CFtruck}$

Carbon Footprint impact of online ordering (metric Ton) = C_{Fweb}

Trucking sector Energy Impact (TJ) = E_{truck}

Real Estate sector Energy Impact (TJ) = E_{RS}

Plastic packaging sector Energy Impact (TJ) = E_{pk}

Power generation and supply sector Energy Impact (TJ) = E_{power}

Trucking sector Carbon Footprinting Impact (metric Ton) = C_{Ftruck}

Real Estate sector Carbon Footprinting Impact (metric Ton) = C_{FRS}

Plastic packaging sector Carbon Footprinting Impact (metric Ton) = C_{Fpk}

Power generation and supply sector Carbon Footprinting Impact (metric Ton) = C_{Fpower}

3.1.3 Variables

The following variables are involved in calculations.

Number of Movie Discs = $N_{MD} = \frac{I}{C_{MD}}$ (1)

Number of Trips to Movie Store from Household = $N_{MSH} = N_{MD}$ (2)

3.1.4 Comparative Costs of Logistics for Offline versus Online Movie Rental

Number of Movie Discs to each Movie Store (N_{MDn}) is calculated using equation (1) and parameter n

$$N_{MDn} = \frac{N_{MD}}{n} \tag{3}$$

Number of Movie Discs to each Regional Distribution Center (N_{MDm}) is calculated using equation (1) and parameter m

$$N_{MDm} = \frac{N_{MD}}{m} \tag{4}$$

The following Table–3.1 displays the total number of two major Movie Rental Services across a nation in a number and a percentage

Table–3.1: Operations Centers of the Two Major Movie Rental Services

Type of Movie Rental Services	Locations in a nation	
	Number	Percentage
Offline Movie Rental Stores	n	$\frac{n}{l} \times 00\%$
Online Movie Rental Distribution Centers	m	$\frac{m}{l} \times 00\%$

Packaging cost of Offline Movie Rental (P_{OFF}) is calculated using equation (1) and parameter P_{MDCase}

$$P_{OFF} = P_{MDCase} \times N_{MD} \tag{5}$$

Bulk truck shipments cost to Movie Store from the Offline movie rental Headquarters (S_{HQMS}) are calculated from equation (3) and parameters W_{MDCase} , W_{MD} , P_T and D_i

$$S_{HQMS} = \left(N_{MDn} \times \frac{W_{MDCase} + W_{MD}}{1000} \times P_T \right) \sum_{1}^{n} D_i \tag{6}$$

Packaging cost Online Movie Rental (P_{ON}) is calculated from equation (1) and parameter $P_{MDSleeve}$

$$P_{ON} = P_{MDSleeve} \times N_{MD} \tag{7}$$

Bulk truck shipments cost to regional Distribution Centers from the Online movie rental Headquarters (S_{HQDC}) are calculated from equations (3), (4) and parameters $W_{MDSleeve}$, W_{MD}, P_T, D_j and D_k

$$S_{HQDC} = \left(\frac{W_{MDSleeve} + W_{MD}}{1000} \times P_T \right) \left(N_{MDm} \sum_{j=1}^{m-1} D_j + 2N_{MDn} \sum_{k=1}^{n} D_k \right) \qquad (8)$$

The following Table–3.2 displays the costs associated with packaging and bulk truck shipments to movie rental stores or distribution centers for Offline and Online movie rental modes. It considers the equations (5), (6), (7) and (8).

Table–3.2: Comparative Costs of Logistics in Offline and Online Movie Rental Services

Item	**Offline movie rental**	**Online movie rental**
Packaging	P_{OFF}	P_{ON}
Bulk truck Shipments to movie store or distribution center	S_{HQMS}	S_{HQDC}
Total	$P_{OFF} + S_{HQMS}$	$P_{ON} + S_{HQDC}$

3.1.5 Environmental Impacts to Movie Rental Stores in Passenger Vehicles

Energy Impact for round trip distance between Customer's home and Movie Store for passenger car (E_{Ercar}) is calculated from parameters D_{CM} and E_{Ecar}

$$E_{Ercar} = D_{CM} \times E_{Ecar} \qquad (9)$$

Energy Impact for round trip distance between Customer's home and Movie Store for light truck ($E_{Ertruck}$) is calculated from parameters D_{CM} and E_{Etruck}

$$E_{Ertruck} = D_{CM} \times E_{Etruck} \qquad (10)$$

Total Energy use impact from trips to Movie Stores from Household (T_{Etrips}) is calculated from equations (1), (9), (10) and parameters P_{Cars} and P_{Trucks}

$$T_{Etrips} = \frac{N_{MD} \times E_{Ercar} \times P_{Cars} + N_{MD} \times E_{Ertruck} \times P_{Trucks}}{1* 0^6} \qquad (11)$$

Carbon Footprinting Impact for round trip distance between Customer's home and Movie Store for passenger car (E_{CFrcar}) is calculated from parameter E_{CFcar}

$$E_{CFrcar} = D_{CM} \times E_{CFcar} \qquad (12)$$

Carbon Footprinting Impact for round trip distance between Customer's home and Movie Store for light truck ($E_{CFrtruck}$) is calculated from parameter $E_{CFtruck}$

$$E_{CFrtruck} = D_{CM} \times E_{CFtruck} \tag{13}$$

Total Carbon Footprinting impact of trips to Movie Stores from Household ($T_{CFtrips}$) is calculated from equations (1), (12), (13) and parameters P_{Cars} and P_{Trucks}

$$T_{CFtrips} = \frac{N_{MD} \times E_{CFrcar} \times P_{Cars} + N_{MD} \times E_{CFrtruck} \times P_{Trucks}}{1*\ 0^3} \tag{14}$$

The following Table 3.3 organizes the impacts of round-trips to movie rental stores in passenger vehicles. It considers the equations (9), (10), (11), (12), (13), (14) and the parameters E_{Ecar}, E_{Etruck}, E_{CFcar} and $E_{CFtruck}$

Table–3.3: Environmental Impacts of Round-trips to Movie Rental Stores in Passenger Vehicles

Type of environmental impact	Impact per kilometer (passenger car)	Impact per kilometer (light truck)	Impact for round trips (passenger car)	Impact for round trips (light truck)	Total impact of trips to Movie Stores from Household
Energy use	E_{Ecar}	E_{Etruck}	E_{Ercar}	$E_{Ertruck}$	T_{Etrips}
Carbon Footprinting	E_{CFcar}	$E_{CFtruck}$	E_{CFrcar}	$E_{CFrtruck}$	$T_{CFtrips}$

The next Table 3.4 categorizes the Energy and Carbon Footprinting parameters associated with the Amount of Economic Activity (I) for the Trucking, Real Estate, Plastic packaging, and Power generation and supply sectors.

It considers the parameters E_{truck}, E_{RS}, E_{pk}, E_{power}, C_{Ftruck}, C_{FRS}, C_{Fpk} and C_{Fpower}

Table–3.4: Environmental Impacts of the Amount of Economic Activity in the Movie Rental Services Industry

Impact	Trucking sector	Real Estate sector	Plastic Packaging sector	Power generation and supply sector
Energy	E_{truck}	E_{RS}	E_{pk}	E_{power}
Carbon Footprinting	C_{Ftruck}	C_{FRS}	C_{Fpk}	C_{Fpower}

3.1.6 Comparative Impacts for Offline and Online Movie Rental Services

Trucking Energy Impact of Offline movie rental (E_{TOFF}) is calculated from equation (6) and parameter E_{truck}

$$E_{TOFF} = \frac{S_{HQMS}}{1*10^6} E_{truck} \tag{15}$$

Real Estate Energy Impact of Offline movie rental (E_{RSOFF}) is calculated from parameter E_{RS}

$$E_{RSOFF} = \frac{n}{l} \times E_{RS} \tag{16}$$

Packaging Energy Impact of Offline movie rental (E_{pkOFF}) is calculated from equation (5) and parameter E_{pk}

$$E_{pkOFF} = \frac{P_{OFF}}{1*10^6} E_{pk} \tag{17}$$

Power Generation and Supply Energy Impact of Offline movie rental ($E_{powerOFF}$) is calculated from parameter E_{power}

$$E_{powerOFF} = \frac{n}{l} \times E_{power} \tag{18}$$

Passenger trips Energy Impact of Offline movie rental (E_{ptOFF}) is calculated from equation (11)

$$E_{ptOFF} = T_{Etrips} \tag{19}$$

Total Energy Impact of Offline movie rental (E_{OFF}) is calculated from equations (15), (16), (17), (18) and (19)

$$E_{OFF} = E_{TOFF} + E_{RSOFF} + E_{pkOFF} + E_{powerOFF} + E_{ptOFF} \tag{20}$$

Trucking Carbon Footprinting Impact of Offline movie rental (C_{FTOFF}) is calculated from equation (5) and parameter C_{Ftruck}

$$C_{FTOFF} = \frac{S_{HQMS}}{1*10^6} C_{Ftruck} \tag{21}$$

Real Estate Carbon Footprinting Impact of Offline movie rental (C_{FRSOFF}) is calculated from parameter C_{FRS}

$$C_{FRSOFF} = \frac{n}{l} \times C_{FRS} \tag{22}$$

Packaging Carbon Footprinting Impact of Offline movie rental (C_{FpkOFF}) is calculated from equation (5) and parameter C_{Fpk}

$$C_{FpkOFF} = \frac{P_{OFF}}{1\times 10^{6}} C_{Fpk} \tag{23}$$

Power Generation and Supply Carbon Footprinting Impact of Offline movie rental ($C_{FpowerOFF}$) is calculated from parameter C_{Fpower}

$$C_{FpowerOFF} = \frac{n}{l} \times C_{Fpower} \tag{24}$$

Passenger trips Carbon Footprinting Impact of Offline movie rental (C_{FptOFF}) is calculated from equation (14)

$$C_{FptOFF} = \frac{T_{CFtrips}}{1 * 10^{3}} \tag{25}$$

Total Carbon Footprinting Impact of Offline movie rental (C_{FOFF}) is calculated from equations (21), (22), (23), (24) and (25)

$$C_{FOFF} = C_{FTOFF} + C_{FRSOFF} + C_{FpkOFF} + C_{FpowerOFF} + C_{FptOFF} \tag{26}$$

Trucking Energy Impact of Online movie rental (E_{TON}) is calculated from equation (8) and parameter E_{truck}

$$E_{TON} = \frac{S_{HQDC}}{1 * 10^{6}} E_{truck} \tag{27}$$

Real Estate Energy Impact of Online movie rental (E_{RSON}) is calculated from equation (16) and parameter E_{RS}

$$E_{RSON} = \frac{n}{l} \times E_{RS} \tag{28}$$

Packaging Energy Impact of Online movie rental (E_{pkON}) is calculated from equation (7) and parameter E_{pk}

$$E_{pkON} = \frac{P_{ON}}{1 * 10^{6}} E_{pk} \tag{29}$$

Power Generation and Supply Energy Impact of Online movie rental ($E_{powerON}$) is calculated from parameter E_{power}

$$E_{powerON} = \frac{n}{l} \times E_{power} \tag{30}$$

Internet Energy Impact of Online movie rental (E_{ION}) is calculated from equation (1) and parameter E_{Eweb}

$$E_{ION} = \frac{N_{MD}}{10^6} E_{Eweb} \quad (31)$$

Total Energy Impact of Online movie rental (E_{ON}) is calculated from equations (27), (28), (29), (30) and (31)

$$E_{ON} = E_{TON} + E_{RSON} + E_{pkON} + E_{powerON} + E_{ION} \quad (32)$$

Trucking Carbon Footprinting Impact of Online movie rental (C_{FTON}) is calculated from equation (8) and parameter C_{Ftruck}

$$C_{FTON} = \frac{S_{HQDC}}{10^6} C_{Ftruck} \quad (33)$$

Real Estate Carbon Footprinting Impact of Online movie rental (C_{FRSON}) is calculated from the equation parameter C_{FRS}

$$C_{FRSON} = \frac{n}{l} \times C_{FRS} \quad (34)$$

Packaging Carbon Footprinting Impact of Online movie rental (C_{FpkON}) is calculated from equation (7) and the parameter C_{Fpk}

$$C_{FpkON} = \frac{P_{ON}}{10^6} C_{Fpk} \quad (35)$$

Power Generation and Supply Carbon Footprinting Impact of Online movie rental ($C_{FpowerON}$) is calculated from parameter C_{Fpower}

$$C_{FpowerON} = \frac{n}{l} \times C_{Fpower} \quad (36)$$

Internet Carbon Footprinting Impact of Online movie rental (C_{FION}) is calculated from equation (1) and the parameters C_{Fweb}

$$C_{FION} = N_{MD} \times C_{Fweb} \quad (37)$$

Total Carbon Footprinting Impact of Online video rental (C_{FON}) is calculated from equations (33), (34), (35), (36) and (37)

$$C_{FON} = C_{FTON} + C_{FRSON} + C_{FpkON} + C_{FpowerON} + C_{FION} \quad (38)$$

The following Table 3.5 shows the Energy and Carbon Footprinting impacts of the Offline and Online distribution channels. It considers the impacts of applying the equations from (15) to (38).

Table–3.5: Comparative Environmental Impacts of Offline and Online Movie Rental Services

	Item	Energy (TJ)	Carbon Footprinting (metric Ton)
Traditional movie rental	Trucking	E_{TOFF}	C_{FTOFF}
	Real Estate	E_{RSOFF}	C_{FRSOFF}
	Packaging	E_{pkOFF}	C_{FpkOFF}
	Power Generation and Supply	$E_{powerOFF}$	$C_{FpowerOFF}$
	Passenger trips	E_{ptOFF}	C_{FptOFF}
	Total	E_{OFF}	C_{FOFF}
E-Commerce	Trucking	E_{TON}	C_{FTON}
	Real Estate	E_{RSON}	C_{FRSON}
	Packaging	E_{pkON}	C_{FpkON}
	Power Generation and Supply	$E_{powerON}$	$C_{FpowerON}$
	Internet	E_{ION}	C_{FION}
	Total	E_{ON}	C_{FON}

3.1.7 Relative Impacts of Movie Rental Services Methods

Energy Difference between Offline and Online movie rental (ΔE) is calculated using equations (20) and (32)

$$\Delta E = E_{OFF} - E_{ON} \tag{39}$$

Energy Percentage Difference between online and offline movie rental ($\%E$) is calculated using equations (20) and (39)

$$\%E = \frac{\Delta E}{E_{OFF}} 100\% \tag{40}$$

Carbon Footprinting Difference between online and offline movie rental services (ΔC) is calculated using equations (26) and (38)

$$\Delta C = C_{FOFF} - C_{FON} \tag{41}$$

Carbon Footprinting Percentage Difference between online and offline movie rental ($\%C$) is calculated using equations (26) and (41)

$$\%C = \frac{\Delta C}{C_{FOFF}} 100\% \tag{42}$$

The following Table 3.6 presents the difference between Offline and Online distribution channels for Movie Disc rental businesses. It uses the equations from (39) to (42)

Table–3.6: Relative Environmental Impacts of Movie Rental Services Methods

	Energy (TJ)	**Carbon Footprinting (metric Ton)**
Difference between Traditional and E-Commerce	Δ '	Δ '
% Difference	$\%E$	$\%C$

3.1.8 Relative Impacts of Traditional and E-Commerce Logistics, per Movie Disc

Relative Energy Impact per Movie Disc of Offline movie rental (E_{MDOFF}) is calculated using equations (1) and (20)

$$E_{MDOFF} = * \; 0^{6} \frac{E_{OFF}}{N_{MD}} \quad (43)$$

Relative Energy Impact per Movie Disc of Online movie rental (E_{MDON}) is calculated using equations (1) and (32)

$$E_{MDON} = * \; 0^{6} \frac{E_{ON}}{N_{MD}} \quad (44)$$

Relative Carbon Footprinting Impact per Movie Disc of Offline movie rental (C_{FMDOFF}) is calculated using equations (1) and (26)

$$C_{FMDOFF} = * \; 0^{3} \frac{C_{FOFF}}{N_{MD}} \quad (45)$$

Relative Carbon Footprinting Impact per Movie Disc of Online movie rental (C_{FMDON}) is calculated using equations (1) and (38)

$$C_{FMDON} = * \; 0^{3} \frac{C_{FON}}{N_{MD}} \quad (46)$$

The following Table 3.7 shows environmental differences regarding Energy and Carbon Footprinting between Offline and Online distribution channels. It uses the equations from (43) to (46)

Table–3.7: Relative Environmental Impacts of Traditional and E-Commerce Logistics per Movie Disc

Impacts	**Traditional**	**E-Commerce**
Energy (MJ)	E_{MDOFF}	E_{MDON}
Carbon Footprinting (Kg)	C_{FMDOFF}	C_{FMDON}

3.2 Model Implementation

The following section presents the model deployment, written in the style of a journal paper. The section contains an introduction into the topic of the movie rental service industry in relation to E-Commerce carbon footprinting and sustainability, scope of this research, analysis with outcomes, comparison frameworks, logistics of online and offline business models, comparative costs and environmental impacts, and finally future research directions. The whole section focuses on contrasting the carbon footprints of online and offline business models via using a systems approach. Furthermore, it contains two figures that illustrate the transportation chain depicting the real estate transitions within the offline movie rental service model in the first figure and the online model in the second figure.

Moreover, it highlights the difference between the two movie rental distribution channels in Canada. The section informs that the investigation of environmental impacts of both business models was performed via employing multiple evaluation criteria. Outcomes of the analyses indicate that the E-Commerce version is more environment-friendly than the conventional version. To conclude, the quantitative analyses and outcomes present future steps that policy makers, businesses, consumers, and government should take in order to trim the environmental impact of movie rental services.

PAPER 2

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Online versus Offline Movie Rental: A Comparative Study of Carbon Footprints

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Abstract

Purpose – This paper focuses on comparing the energy consumption and carbon footprints of two major movie rental service models: offline or traditional (brick and mortar) and online or E-Commerce movie rental services.

Design/methodology/approach – For this study the Life Cycle Assessment (LCA) approach was selected, the functional unit of all deliveries is renting three movie discs at one time, which are high-density (HD) optical discs (with DVD or Blu-ray format). The research was conducted in Canada. We used data received from a major movie rental service company. In this study we exclude processes that are common to the two distribution channels (offline and online). We analyzed the portions of the logistics chains that differed between traditional movie rental service and E-Commerce version, such as movie disc delivery. We used the Economic Input Output Life Cycle Assessment (EIO-LCA) model to measure and compare the offline and online movie rental services and their environmental performances regarding energy consumption and carbon footprint.

Findings – Our analyses indicate that the online movie rental service has a lower carbon footprint and energy consumption regarding real estate, packaging, transportation and power consumption compared to the offline version.

Practical implications – We provide future steps that policy makers, government, businesses and consumers should take in order to make informed decisions and thus reduce the environmental impact of movie rental services.

Originality/Value – Our paper will thus contribute to the previous studies in this domain and enhance the understanding the carbon footprinting of movie rental services by employing data procured from major offline and online movie rental services in Canada. Moreover our study is robust compared to the previous studies because it exploited data directly from a major movie rental service company.

Paper type Research Paper.

3.2.1 Introduction

The increasingly cogent evidence that the environmental sustainability of our planet is rapidly deteriorating due to human actions has made the concept of sustainability a key focus of humankind. Nonetheless, in order to assess the impact of various factors and complex underlying dynamics on sustainability, we often need some quantitative and qualitative frameworks and models to make objective decisions (Velásquez, Ahmad and Bliemel, 2009; Velásquez, 2003). This paper employs quantitative approaches to compare the environmental impact of online and offline movie disc rental services.

In order to achieve as much eco-efficiency and eco-efficacy as possible in the modern business environment, the companies must continuously employ innovative processes to bring positive changes in the “triple bottom line” (Velásquez, Ahmad and Bliemel, 2009). In the current information age, it is possible to create new business models, value propositions, and more efficient and competitive firms. Based on the available technology infrastructure, an organization is able to communicate with its internal and external stakeholders in a seamless flow of information, and the Internet plays a major role in this digital integration. Indeed, the Internet has become the infrastructure of choice for E-Commerce because it offers businesses an easier and low cost way to link with customers and other businesses. Moreover, it is the Internet that helps companies to reduce their transaction costs (Laudon and Laudon, 2007). Indeed, it has been argued by many researchers and practitioners that the Internet and E-Commerce can help in realizing a sustainable development for human beings and the environment (The Climate Group, 2008). However, such arguments lack scientific evidence in most cases.

Nevertheless, the trend is most certainly having shoppers move towards online shopping. Indeed, online retailing is growing tremendously worldwide. For instance, US online retail reached US$175 billion in 2007 and is projected to grow to US$335 billion by 2012 (Forrester, 2008). Similarly, Canadian online retail reached US$12.9 billion in 2007 and is projected to grow to US$22.2 billion by 2012 (eMarketer, 2008). Moreover, the online services in Canada are growing rapidly; the amount of US$12 million was spent in online movie rental service in Canada in 2006. By 2011 the number is expected to surpass US$285 million (Pricewaterhouse Coopers LLP, 2007).

There are various underlying causes for such a strong trend towards online retailing. For instance, it has been argued that the “Web channel has been relatively successful because it is a destination for consumers to find low prices and it is perceived to be more convenient than shopping in stores” (Forrester, 2008). Based on the USA experiences, the growth of online shopping and services is driven by two major factors: first, by the growing rate of fast Internet connections which allow more interaction and faster buying process for the online customers; and second, for the extensive and effective marketing strategies used specially by some of the larger online corporations (Punkett Research, 2009).

In the worldwide ranking, Canada belongs to the top 15 in Internet usage (Computer Industry Almanac Inc., 2007). In 2008, Canada had 28 million Internet users, which is almost two-thirds of all Canadians (Internet World Stats, 2009). Considering the current economic crisis, the last three household items from the list of ten that Canadians would cut are the home Internet, movie rentals, and cell phone. However, the first seven that they will cut to their budget are big ticket events, Movie going, DVD buying, magazine subscription, cable/satellite TV extras, video game buying, and home phone. These results, from a survey conducted by Solutions Research Group in Canada and the USA, showed that during a recession households prioritize, almost like heating and water, the relative new services of home Internet, movie rentals and cell phone (Robertson, 2008). One of the reasons why people keep the Internet and cell phone is that our current society is getting into the connectivity era, where being connected with the world is a priority.

Also the movie rentals are linked to the Internet since they receive requests for orders Online. The movie rentals have for a long time been an effective alternative, based on price and quality, to the movie theater and a complement to the TV standard package. Although movie rental services are of a high priority in customers' consumption basket, there is only one inquiry, which is found in the latest literature survey within the scope of E-Commerce and carbon footprinting (Velásquez, Ahmad and Bliemel, 2009). That study concentrated on a comparative assessment of energy, environmental, and economic impacts of offline and online DVD rental services through using process-based and input-output life-cycle assessment (LCA) methods. The scenario of their analysis takes into account a specific customer situated in Ann Arbor, Michigan, USA. The stages of their product life cycle analysis considered DVD production, DVD distribution, DVD usage, and DVD redistribution within comparison of the two major movie rental businesses in the USA. The functional unit was renting three DVDs at one time. The results illustrated that the E-Commerce option has a better performance in terms of energy, environmental, and economic standpoints than the traditional DVD rental service (Sivaraman et al., 2007).

Our paper differs from the study of Sivaraman et al. in several important ways. Firstly, in our analysis we excluded factors such as the usage of lights (incandescent lamps) and air conditioning/space heating, because they are not a necessity for renting movies online. On the contrary, the analysis of Sivaraman and colleagues (2007) considered those unnecessary factors. Secondly, our examination put aside the aspect of actual watching a movie, which is rented, because it does not have an influence on energy consumption; in other words the energy consumption is the same for both online and offline movie rental businesses. Thirdly, the calculations of Sivaraman and colleagues (2007) are slightly restricted since they consider orders of only one, two, and three DVDs at once. On the contrary, our calculations take into account a possibility of ordering more than three DVDs and hence are not restricted to the number of orders a customer makes. Fourthly, the calculations of Sivaraman and colleagues (2007) used only one route between the customer's home and movie rental services (movie store, and distribution center) that they applied in their analysis. In their analysis, routes of other clients and movie rental stores were derived from that single route. In contrast to their theoretical model, our practical model includes all possible routes based on the distribution networks of the two major movie rental services. Fifthly, Sivaraman and colleagues (2007) included the manufacture stage of a movie disc, but we excluded it because this datum is unnecessary, since both online and offline major movie rental services use movie disc manufactured in the same way. Next, we used the term movie disc to identify a high-density (HD) optical disc with DVD and also Blu-ray format. Sivaraman and colleagues (2007) used the term DVD only, since at that time Blu-ray was not so common. Hence, our study is significant because it extends the previous body of literature with its updated information. Lastly, our study, compared to that of Sivaraman and colleagues (2007), is more robust because it exploited data directly from a major movie rental service. Also, there is a difference in geography: our study takes place in Canada while Sivaraman and colleagues' study (2007) took place in the USA. To conclude, our paper is vital since it contributes with its findings to the community of researchers in this area.

In our analysis a sleeve of the movie disc is made of polypropylene while in the analysis of Sivaraman and colleagues (2007) it is made of paper. Consequently, the results of our study and Sivaraman and colleagues (2007) are different also due to packaging (different sleeve material). Moreover, in the E-Commerce distribution network the outcomes of the bodies of works differ because Sivaraman and colleagues (2007) measured the packaging weight of cases and sleeves for movie discs, while we measured the packaging weight only of sleeves. To conclude, this influenced the findings for the whole packaging transportation, and also this explains how our study differs from Sivaraman and colleagues (2007).

The rest of the paper is organized as follows: Section 2 presents the study scope and boundary description; Section 3 reports carbon footprinting comparison between the online and offline movie rental services with results and discussions; Section 4 provides some interesting and challenging future research directions; and Section 5 concludes the paper.

3.2.2 Scope of the Research

The aim of this study is to assess and compare the energy consumption and carbon footprinting of two major movie rental services models: online movie rental service and offline or traditional (brick and mortar) movie rental service. For this study, the functional unit of all deliveries is three high-density (HD) optical discs or movie discs (with DVD or Blu-ray format), and we will name it Value Package herein, due to the fact that a customer rents on average the amount of three movie discs per visit (Sivaraman et al., 2007).

In this study we analyzed the segments of logistics chains that differed between traditional movie rental service and E-Commerce version. We will exclude processes that are the same for the two movie rental modes (offline and online). We assumed that all the transportation is done by first class post using truck freighting. We used the Economic Input Output Life Cycle Assessment model (EIO-LCA) to assess and compare the carbon footprinting and energy consumption of the offline and online movie rental services. The EIO-LCA will depict the environmental impacts of the process of renting movie discs.

We excluded enjoyment which arises from going to the movie rental, browsing for the movie discs, and finally renting it, since we assumed that satisfaction of spectators is identical for both online and offline movie rental services. We set aside also the retail part of the movie rental store which is buying movies, snacks, and beverages. We put aside also the replacement of movie disc cases and sleeves in case of damage.

We show a conceptualization of the offline and online movie rental services models in Figures 3.1 and 3.2. Figure 3.1 visually illustrates the transportation chain containing the real estate transitions within the offline movie rental service model. The movie discs begin at the headquarters from where they are assumed to be shipped across Canada by first class mail to each movie rental store. The movie discs sit in the movie rental store (for the sake of simplicity we assume that the movie discs are shipped directly to the movie rental store, without passing a distribution center). Later customers travel by car from their homes to the movie rental store to choose and pick up the movies and then travel home. After watching the movies the customers return the Value Package (three movies) to the movie rental store by car and then go home.

Figure 3.2 shows the diagram of the transportation chain for E-Commerce movie rental model. In the E-Commerce model, the movie discs start at the headquarters/main distribution center and are delivered to a regional distribution center by first class mail. This figure demonstrates the process of renting the movies and thus the link between headquarters and consumer. The process starts when the customer browses for the movies in the E-Commerce company website and sends the request (online order) of the movie discs to the online company's data center (headquarters). It accepts an order and ships the Value Package via first class mail to the regional distribution which is the closest to the customer's home address. The Value Package, along with other Value Packages, is then taken to the closest post office to the individual homes and the last mile (distance from movie store/postal office to the customer) is completed on foot by a postman. The returning process starts when the postman picks up the Value Package from the household and walks the last mile to the closest post office. Later the Value Package is shipped by first class mail to the regional distribution center. In the regional distribution center, the movie discs are stocked until the next customer's request occurs.

3.2.3 Analysis and Results

We compared two stages from the product life cycle: forward and reverse distributions (Hanafi, Kara and Kaebernick, 2008). Consequently, we can concentrate on the logistic of moving the movie discs from the main distribution center/headquarters to a customer's home. Since emissions from private vehicles were excluded from the EIO-LCA and these calculations were necessary for our analysis, we included them.

The EIO-LCA method is a linear model that must link monetary values with physical units, and that performs better for higher values. As a result, in our analysis we consider $1.2 million of economic activity, or roughly 166,667 Value Packages, at an assumed production cost of $2.4 per movie disc (Alibaba, 2009). For the traditional model we consider the shipping of 423 Value Packages to each movie rental store (approximately

394 movie stores across Canada of the major movie rental company) (YellowPages, 2009) which are shown in Figure 3.1. For the E-Commerce model we consider the shipping to be 41,667 Value Packages to each of one of the three regional distribution centers (YellowPages, 2009). The remaining 41,667 Value Packages stay at the main distribution center, as can be seen in Figure 3.2. Moreover our analysis considers a total of 2,517 movie rental stores (including distribution centers) across Canada (YellowPages, 2009).

According to our finding from the measurement, each movie disc case made of polypropylene weighs 85g, a single movie disc weighs 18g, and each movie disc sleeve made of polypropylene weighs 2.8g. Furthermore, we use the addresses of the movie stores listed in the phone book to measure the distances between movie stores, headquarters, and distribution centers (YellowPages, 2009). We used a Geographic Information System (GIS) software product to measure these distances.

3.2.3.1 Offline Movie Rental Logistics

The traditional method of movie rental service, where the movie discs are rented through movie rental stores, can be depicted as a series of transport segments among the firm and relevant facilities, which is illustrated in Figure 3.1.

Movie discs are transported from the headquarters in Toronto to the movie rental stores, and a customer rents a movie disc and takes it home. In addition there is a return link for returning a movie disc. In this study we assume that all transportation is performed by truck within the traditional distribution network. For our calculations we used the truck transportation price of $0.19/ton*km (Bureau of Transportation Statistics, 2009).We used the distances between the headquarters and the movie rental stores previously measured by GIS from the addresses collected from the phone book (YellowPages, 2009). For our analysis we consider only a round-trip distance of 8 kilometers according to a previous study by Hendrickson and colleagues (2006). This assumption takes into account that a customer's journey might have other visits on the way.

All these movie discs are transported through the logistic network shown in Figure 3.1. Each movie disc is transported into its movie disc case, which costs $0.38 per unit (Blankmedia, 2009). Therefore the sum of the packaging in offline movie rental services is $190,805.56 (Table–3.9).

In additional to the EIO-LCA method, our analysis takes into account the environmental impacts of the automotive trips made by customers to movie rental stores to rent movie discs. We consider for an average passenger car the fuel economy to be 34.62 kmpg (energy to be 3.8 MJ/km), and carbon footprint Impact to be 258.3 g/km (U.S. Environmental Protection Agency, 2000). For an average light truck, we use the fuel economy to be 27.69 kmpg (energy to be 4.8 MJ/km), and carbon footprint impact to be 324.29 g/km (U.S. Environmental Protection Agency, 2000).

In Canada, a weighted average of the environmental impacts caused by passenger cars and light trucks can be counted in the passenger fleet respectively 57% and 43% (Natural Resources Canada, 2007). The environmental impacts of an average trip to the movie rental store are shown in Table 3.8.

We ignore returns from the movie rental stores to the headquarters, which means movie discs remain in a movie rental store, and hence wait for the next customer who rents them. All calculations are adjusted to 2002 US dollar values because the EIO-LCA Canadian and USA model's database dates at that year.

Table–3.8: Energy and Carbon Footprinting Impacts of Round-trips to Movie Rental Stores in Passenger Vehicles

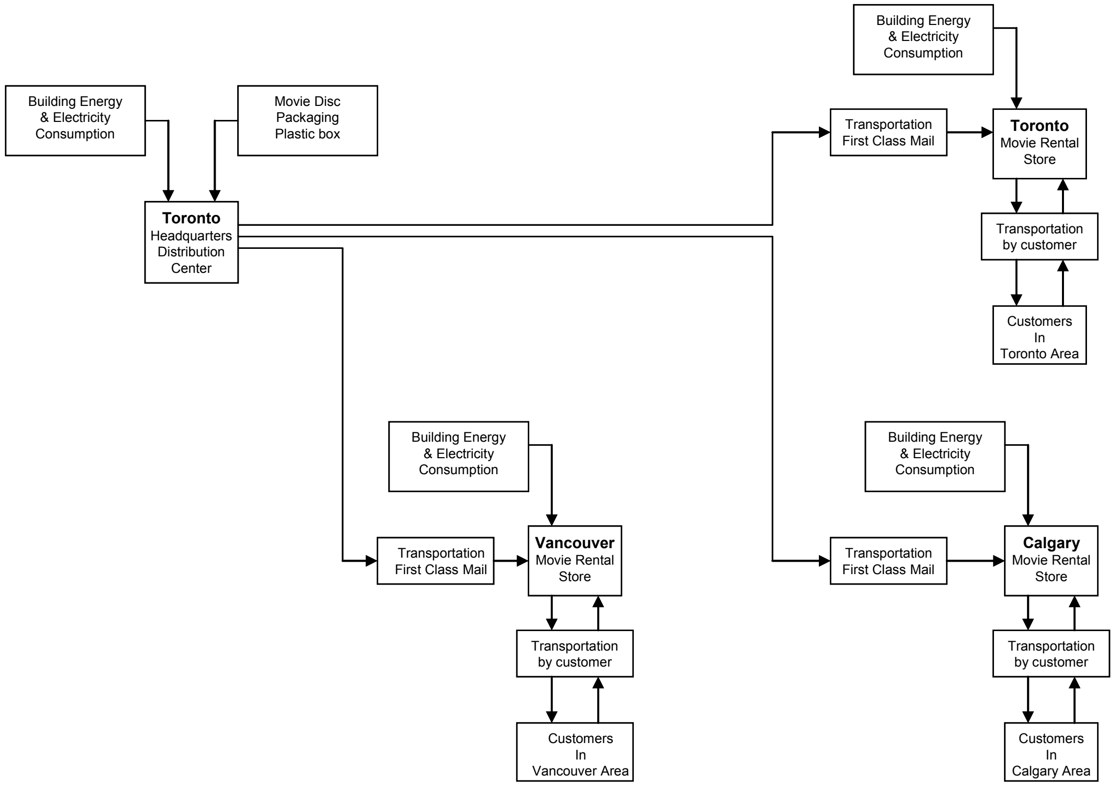
Type of environmental impact	Impact per km (passenger car)	Impact per km (light truck)	Impact for 8 km round trip (passenger car)	Impact for 8 km round trip (light truck)	Total impact for 166,667 trips (57% cars, 43% light trucks)
Energy use	3.8 MJ/km	4.8 MJ/km	30.50 MJ	38.14 MJ	5.63 TJ
Carbon Footprinting	258.30 g/km [a]	324.29 g/km [a]	2,066.40 g	2,594.32 g	382,234.27 Kg

Source: U.S. Environmental Protection Agency, 2000 [a]

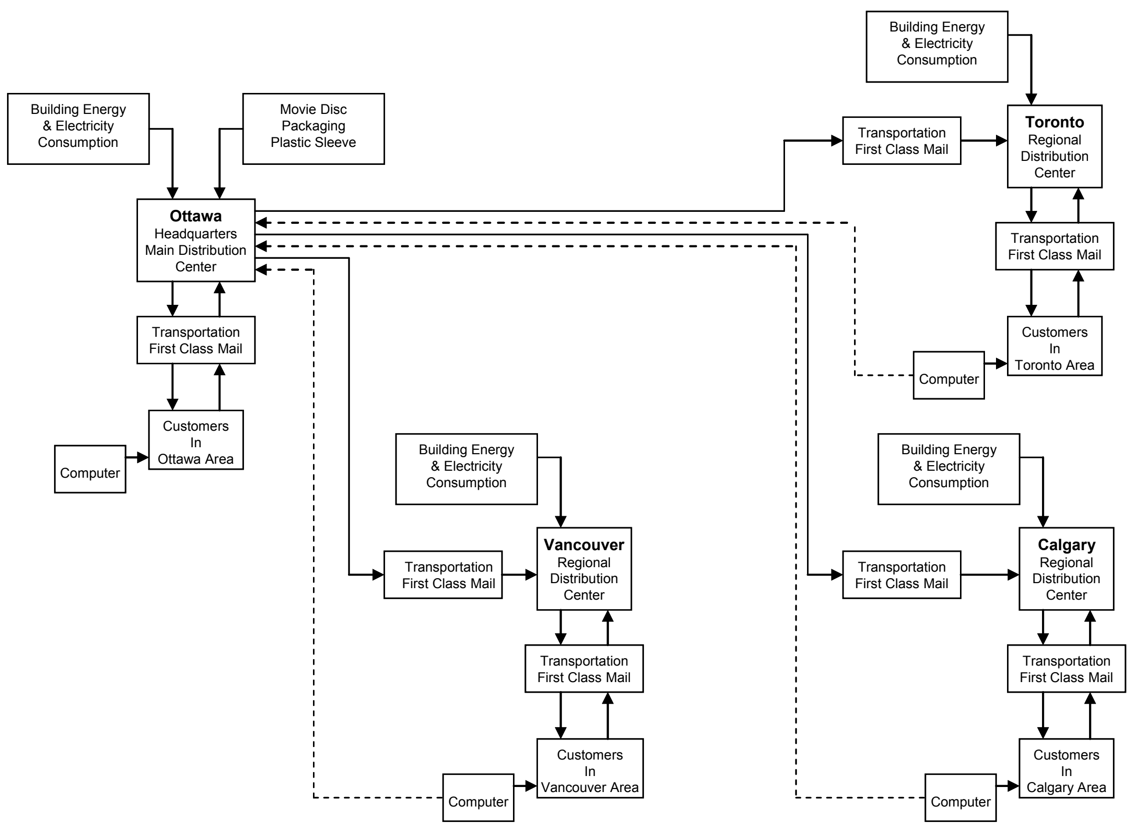
3.2.3.2 Online Movie Rental Logistics

We supposed that the E-Commerce model of renting a movie disc (a movie disc is promoted and purchased online) has fewer segments; however, it includes truck transportation from the E-Commerce headquarters in Ottawa to the regional distribution centers in Calgary, Toronto, and Vancouver (Figure 3.2). We assumed that the movie discs are shipped from the headquarters to the company's regional distribution centers via truck. We considered in our analysis the distances from the headquarters to the regional distribution centers and from them to the postal office nearest to the movie rental store. We further assumed that from the postal office a postman delivers the movie discs to the customer's home which is a round trip of 8 kilometers (the same distance done by car). Past studies have shown that an average mailman walked 35 kilometers (22 miles) per day (Unknown, 1964), which is approximately three times more than a present-day mailman. Current source shows that a postman walks in average 10 Km per day (CCNMatthews, 2007).

All the movie discs in the E-Commerce model are transported by the logistics network of Figure 3.2. Each movie disc is transported into its movie disc sleeve whose cost per unit is $0.1. Thus the total cost of packaging for the online movie rental is $47,701.39, which is shown in Table 3.9 (Sleevetown, 2009). Previous studies show that a person spends between 15 to 30 minutes ordering online. We consider the extreme case, where it takes 30 minutes for a client to place an order in the website and 1MB data usage with an energy consumption estimated for 2 MJ and carbon footprint impact of 3.02E-5 metric Ton (including desktop computer usage and manufacturing factor, Internet infrastructure, headquarters' data center) (Weber et al., 2008).



Figure–3.1: Offline Movie Rental Service Flow Diagram



Figure–3.2: Online Movie Rental Service Flow Diagram

3.2.3.3 Comparative Costs of Online and Offline Movie Rental Logistics

We make the comparison of costs for the two logistics networks; a truck transportation price of $0.19/ton*km was assumed for our calculations (Bureau of Transportation Statistics, 2009). The shipment of the 166,667 Value Packages in the traditional model is 51.5 metric tons, including 9 metric tons of movie discs and 42.5 metric tons of packaging. The shipment of the 166,667 Value Packages in the E-Commerce model represents the transportation of a total of 10.42 metric tons, including 9 metric tons of movie discs and 1.42 metric tons of packaging. A comparison of these costs is shown in Table–3.9.

Table–3.9: Comparative Estimated Costs of Logistics for Offline versus Online Movie Rental Services

Item	Offline Movie Rental	Online Movie Rental
Plastic Packaging	$190,805.56	$47,701.39
Bulk truck shipments to Movie store or Regional Distribution Center	$15,892.95	$5,339.40
Total	$206,698.51	$53,040.79

3.2.3.4 Comparative Environmental Impacts

Regarding the environmental consequences, the traditional and the E-Commerce logistics systems involve truck freight. Table 3.10 shows supply chain environmental impacts from the shipment of the 166,667 Value Packages, which are trucking freight, real estate, fuel production, the Internet, and plastic packaging taken from the EIO-LCA model using Canadian industry accounts information from 2002.

Combining the data from Tables 3.8, 3.9, and 3.10, Table 3.11 shows the use of energy and carbon footprinting for trucking freight, real estate, and power generation and supply in the movie rental service industry, and plastic packaging for the offline and online movie rental models. These emissions data are combined with the cost estimates to ascertain the environmental impacts that are illustrated in Tables 3.12.

3.2.4 Future Research Directions

In order to advance the research efforts in carbon footprinting, identification of some of the critical aspects of supply chains for appraisal and modeling would be essential. Clearly there are some aspects of supply chains that cannot be meaningfully identified as critical or non-critical based only on the available scientific data. Consequently, some qualitative approaches would be helpful in identifying those aspects of the supply chains that are critical to achieving the environmental sustainability objective. Once critical aspects of both E-Commerce and traditional supply chains are identified, quantitative approaches would be required to model those aspects in form of reliable, reusable, and extendable mathematical models and formulae (Ahmad, 2009). More specifically, it would require extensive mathematical modeling of complex, non-linear, interdependent supply chain dynamics (Ahmad, 1997). Such a quantitative model would be beneficial in developing effective, interactive, and adaptive decision support systems for policymakers, business managers, and researchers (Ahmad, 2009).

The existing body of literature in this domain has largely emerged assessing carbon footprinting for such products as books, DVDs, groceries, electronics (computers), etc., as well as such services as printing, advertising, and DVD Rental. For future research, we suggest an increased focus on carbon footprinting of various services, for instance, pharmaceutical services and online education. In addition, there is a need to assess the cost of various potentially adverse social implications of E-Commerce, such as reduced social interaction, reduced physical work, etc. (Ahmad, 2009). Moreover, there is a need for extending the existing carbon footprinting calculators to create usable and effective Decision Support Systems (DSS). Various integrated decision models for E-Commerce supply chains will be vital in developing such DSS. Indeed, such DSS have been effective in various complex interdisciplinary problem solutions and the promise of using DSS in this complex domain cannot be overemphasized (Ahmad et al., 2008).

Furthermore, the intricate interdependency of complementary and substitute products and services mean that no meaningful carbon footprinting assessment can be done by focusing on merely a single product or service in isolation. There is a need to take an integrative look at the supply chains of complementary and substitute products as well as product families, too. Naturally, there is a growing need for developing integrated quantitative decision models (Ahmad, 1997; Ben-Daya and Rahim, 1999, 2003).

We would like to emphasize that the extent and intricacy of these research directions would require major support of governments, businesses, regulatory bodies, and research institutions. Furthermore, it would require interdisciplinary research teams with skills in such diverse domains as operations research, management sciences, supply chain management, marketing, environmental management, social sciences, strategy and policy, etc. (Ahmad, Safayeni and Ahmad, 2008).

3.2.5 Conclusion

Our outcomes indicate significant differences between the movie rental service fulfillment modes more specifically (Tables 3.11, and 3.12). The online or E-Commerce channel has fundamentally less adverse environmental impact in all the common categories compared to the traditional or offline model (Tables 3.11). In Table 3.11, we analyzed the common items of both distribution channels. The offline channel values are higher compared to the online on real estate usage, power, and transportation, which is reasonable based on the number of movie rental stores across Canada. Regarding the packaging item, energy consumption and carbon footprint are higher in the offline because its packaging weighs more (85g) compared to the online packaging (2.8g), which is a consequence of the packaging manufacturing process. About the non-common items in the offline channel, they consume more energy and produce more carbon footprint in comparison to the online.

To conclude, the passenger vehicles trips, real estate, power, and packaging, significantly contribute to energy consumption and an increase of the carbon footprint. By eliminating these trips and movie rental stores, energy consumption and emissions of greenhouse gases are importantly reduced in the E-Commerce model. Our base case analysis suggests that E-Commerce movie rental service has not only a cost advantage but also environmental benefits. Our study confirms the results of the past inquiries of several experts. Moreover, our outcomes are consistent with the findings of Sivaraman and colleagues (2007).

Lastly, for businesses we recommend that the movie rental industry should focus on smart buildings, green transportation, green energy suppliers, and smart supply chains to minimize congestion, consequently reducing energy consumption and carbon footprinting. Moreover, they should utilize the benefit from tax credits and let their customers recognize them as environmental friendly companies.

For policy makers, we recommend the reinforcement of ISO 14000 and environmental policies to reach sustainability in the global business arena.
For government, we recommend creating a long term policy-framework for the movie rental industry, providing targets, regulations and incentives.
For consumers, we recommend considering the environmentally friendly aspect of the movie rental businesses.

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Table–3.10: Energy and Carbon Footprinting Impacts of Economic Activity in the Movie Rental Service Industry

Impact	Trucking	Real Estate of Movie Rental Service Industry	Plastic packaging	Power generation and supply of Movie Rental Service Industry
Energy (TJ)	12	0.068	10.8	3.64
Carbon Footprinting (metric Ton)	845	0.9	629	286

Source: Carnegie Mellon University Green Design Institute

Table–3.11: Comparative Energy and Carbon Footprinting Impacts in Offline and Online Movie Rental Services

	Item	Energy (TJ)	Energy (%) contributions	Carbon Footprinting (metric Ton)	Carbon Footprinting (%) contributions
Traditional movie rental	Trucking	0.16	1.97%	11.26	2.09%
	Real Estate	0.01	0.13%	0.14	0.03%
	Plastic case	1.73	21.34%	100.64	18.67%
	Power generation and supply	0.57	7.04%	44.77	8.31%
	Passenger trips	5.63	69.52%	382.23	70.91%
	Total	**8.10**	**100%**	**539.05**	**100%**
E-Commerce	Trucking	0.05	6.51%	3.78	10.99%
	Real Estate	1.08E-04	0.01%	1.43E-03	0.004%
	Plastic envelope	0.43	52.37%	25.16	73.07%
	Power generation and supply	0.01	0.70%	0.45	1.32%
	Online order	0.33	40.41%	5.03	14.61%
	Total	**0.82**	**100%**	**34.43**	**100%**

Table–3.12: Relative Energy and Carbon Footprinting Impacts of Traditional and E-Commerce Logistics per Movie Disc

Impact	Traditional	E-Commerce
Energy (MJ)	48.60	4.95
Carbon Footprinting (Kg)	3.23	0.21

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CHAPTER 4: CONCLUSION

Conclusion

The purpose of this research was to contrast two major online and offline movie rental services in Canada and to assess the energy consumption and carbon footprints. This chapter summarizes the goals, achievements, and limitations of this study and concludes with future research directions.

4.1 Research Goals

The goals of this research are as follows:

- To study the previous work of E-Commerce in relation to carbon footprint and thus complement a literature survey of the state of the art in E-Commerce carbon footprinting.
- To categorize research in this critical area within E-Commerce carbon footprinting.
- To contrast the carbon footprints of two major offline and online movie rental services by using a systems approach.
- To differentiate the environmental impacts of offline and online movie rental service distribution channels in regards to energy consumption and carbon footprints.
- To recognize the critical factors in both (online and offline movie rental) supply chains in order to reach environmental sustainability.
- To examine the hypothesis that online movie rental functions better than offline movie rental in terms of environmental effect and sustainability.
- To suggest feasible future research orientations.

The next section outlines what we have achieved based on our objectives, observations, analysis, and conclusion. In other words, it summarizes the research achievements.

4.2 Research Achievements

This thesis is significant because it complements past studies in this domain. Besides, the value of the study arises from the important differences between the study of Sivaraman and colleagues (2007) who undertook an inquiry within the same industry as this study we conducted.

First of all, the aspect of the location of the research is new in this study. While the study of Sivaraman and colleagues (2007) took place in the USA, our research took place in Canada. Second, one of the strengthens of our analysis is that it excluded unnecessary factors such as the usage of lights (incandescent lamps) and air conditioning/space heating because they are not relevant for online movie renting. In contrast, Sivaraman and colleagues (2007) used these factors in their analysis. Third, another unnecessary datum is the manufacture stage of a movie disc, and this was included in the paper of Sivaraman and colleagues (2007). On the contrary, our study shows a better understanding of the issue since it excluded this datum in calculations because the process of manufacturing movie discs is identical for both online and offline business models.

Fourth, this investigation excluded the energy consumption while watching a movie since it is identical for both business models. Moreover, one of the weaknesses of the study of Sivaraman and colleagues (2007) is that it is limited in terms of working with one route between a distribution center, movie rental store, and client's home; they calculated other routes with algorithms. On the contrary, our calculations incorporates the context in a better manner and uses the distribution network of the two major movie rental businesses to analyze routes between a distribution center, movie rental stores, and customers' homes. Other limitation of the research of Sivaraman and colleagues (2007) is that they took into consideration renting a maximum of three movies. In this study, however, calculations are not tied to the number of rented movies. Next, this study updates the paper of Sivaraman and colleagues (2007): they consider DVD only, while this study considers present-day movie disc formats that are DVD formats and Blu-ray formats.

Regarding packaging material, in the analysis of Sivaraman and colleagues (2007) sleeves of movie discs of paper were used, while in our analysis sleeves of polypropylene were used. As a result, one of the small differences between these two studies is caused also by different sleeve material, impacting energy consumption and carbon footprint. Regarding the packaging weight, in the study of Sivaraman and colleagues (2007) cases and sleeves were used in the online business model, while in our study only sleeves were used in the online version. Besides differences mentioned above, this research is more robust because calculations were based on information from a major movie rental service. In conclusion, this study adds value with its updated perspective on the issue to the scholars' community in this field. Regarding the outcomes of the study of Sivaraman and colleagues (2007) and this study, there were relatively similar results; small differences in energy consumption and carbon footprint were influenced by the factors mentioned above.

This thesis investigates a substantial literature of significant recent contributions to the research in carbon footprinting of E-Commerce. The newly-designed survey in this thesis shows that carbon footprinting is accepted worldwide as a framework of measuring both the eco-efficiency and the eco-efficacy of E-Commerce. Furthermore, this complemented literature survey, which captures the period from the commercial inception of the Internet until the present, notifies the research community of past and recent objective and subjective efforts towards measuring the eco-efficiency and eco-efficacy of E-Commerce. Hence, through this literature survey we complemented the view on this critical issue combining the previous works with the findings of this research. The literature review sorts the relevant literature into two types: quantitative and qualitative studies. In the qualitative classification, literature is classified according to the products, services, and tools considered for measuring carbon footprinting. In the quantitative classification, the mathematical model for comparing the environmental effects of online and offline movie rental channels is depicted.

The results from the model application indicate important differences between the movie rental service fulfillment modes more concretely; the online or E-Commerce channel has fundamentally less adverse environmental effects in all categories in comparison to the traditional model (as can be seen in Tables 3.11 and 3.12).

4.3 Scope and Limitations

The thesis was intended to assess and contrast the energy consumption and carbon footprints of online and offline movie rental services that are two major ones in Canada. We decided to name three High-Density (HD) optical disc or movie disc a Value Package, which is considered to be the functional unit of all deliveries herein. The reason why we chose the three high-density optical disc or movie disc is that a customer rents on average the amount of three movie discs at once (Sivaraman et al., 2007).

In the analysis of comparison, we excluded the processes that were the same for both the online and offline business supply chains. On the other hand, we included the stages of the logistics chains that were different for the online and offline movie rental services. We used the systems approach; in addition, we used the Economic Input Output Life Cycle Assessment model (EIO-LCA) to ascertain the environmental impacts of both business models. To complement the tool EIO-LCA, we added emissions from private vehicles in the analysis that are put aside in this tool. In this study, we assumed that transportation is performed by first class post using truck freighting.

To conclude, this study did not address the pleasure and health implications of visiting a movie rental service, including choosing a film and bringing it home. Also, this inquiry did not consider the aspect of retail business and the deterioration of movie cases and sleeves. On the other hand, the research focused on the forward and reverse distributions, which are two stages of the product life cycle. (Hanafi, Kara, and Kaebernick, 2008). These are marked in the diagram herein (Figure 1.1). Consequently, the inquiry concentrated on the logistics of moving the movie discs between the two stages of the two business models.

4.4 Recommendations

This thesis is significant for researchers, government, policy makers, businesses, and customers. We suggest that researchers should use information from this thesis to analyze the energy and carbon footprint of products and service within business supply chains. Moreover, we recommend that government designs a policy-framework and hence provides incentives, regulates business operations, and sets goals for the movie rental industry. Furthermore, we propose that policy makers empower ISO 14000 together with environmental policies and thus reach sustainability within present-day businesses. It is beneficial because regardless of size, location or income, any business or organization can be recognized for implementing an effective and efficient environmental management system. For businesses, in particular for the movie rental services, we suggest concentrating on minimizing real estate and transportation and eliminating the need of passenger vehicles trips. Also, the movie rental industry should try to have smart buildings, green transportation, green energy suppliers, and smart supply chains so that customers can notice the environmental care of movie rental services. Via receiving incentives from government, which can be tax credits, the movie rental industry can have positive results in the triple bottom line while applying green practices.

4.5 Future Research

Clearly, fundamental aspects of supply chains for assessment and modeling need to be observed in order to advance research in carbon footprinting. However, situations that cannot be clearly described based on the lack of scientific data do indeed exist. Consequently, qualitative methods would be useful in the specification of factors to gain the environmental sustainability of supply chains. When the factors are specified, quantitative methods would be requested to model the factors within helpful formulae and mathematical models of complex, non-linear, and interdependent supply chain dynamics, in particular. Therefore, policymakers, business managers, and scholars can benefit from such quantitative model to improve efficient, cooperative, and adaptive decision support systems (Ahmad, 1997, 2009).

The present body of literature in this field mainly dealt with evaluating carbon footprinting for items such as books, DVDs, groceries, electronics, etc., along with services like printing, advertising, and DVD rental. We would suggest future examinations of carbon footprinting of pharmaceutical services and online education. In addition, we recommend investigating the cost of decreasing social interaction and physical work that are some of the adverse social implications of E-Commerce. Also, we propose to expand the existing carbon footprinting calculators to create usable and effective Decision Support Systems (DSS) that were valuable in some complex interdisciplinary problem solutions (Ahmad, 2009; Ahmad et al., 2008). DSS would be beneficial for customers in terms of being informed about environmental impacts of goods and services.

Thus, we would like to underline the fact that primary assistance by governments, businesses, regulatory bodies, and research institutions is crucial when implementing the research directions. Also, experts from dissimilar areas such as operations, management, supply chain management, environmental management, marketing, strategy, policy, and social sciences would be necessary to work together and hence join a common effort to reach sustainability (Velasquez et al. 2009, 2010; Ahmad, Safayeni and Ahmad, 2008).

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