European Journal of Operational Research 239 (2014) 744–755

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Decision Support

Environmental implications for online retailing

Janice E. Carrillo [a,*], Asoo J. Vakharia [a], Ruoxuan Wang [b]

[a] Department of Information Systems and Operations Management, Warrington College of Business Administration, University of Florida, Gainesville, FL 32611-7169, United States
[b] Management Information Systems, College of Business Administration, San Diego State University, San Diego, CA 92182-8234, United States

ARTICLE INFO

Article history:
Received 22 May 2013
Accepted 26 May 2014
Available online 12 June 2014

Keywords:
Retailing
Pricing
Environment
e-Commerce
Dual channel

ABSTRACT

Recent press has highlighted the environmental benefits associated with online shopping, such as emissions savings from individual drivers, economies of scale in package delivery, and decreased inventories. We formulate a dual channel model for a retailer who has access to both online and traditional market outlets to analyze the impact of customer environmental sensitivity on its supply. In particular, we analyze stocking decisions for each channel incorporating price dependent demand, customer preference/utility for online channels, and channel related costs. We compare and contrast results from both deterministic and stochastic models, and utilize numerical examples to illustrate the implications of industry specific factors on these decisions. Finally, we compare and contrast the findings for disparate industries, such as electronics, books and groceries.

1. Motivation

The environmental benefits associated with online shopping, such as emissions savings from individual drivers, economies of scale in package delivery, and decreased inventories, are well documented. Weber et al. (2008) performed a case study for buy.com comparing the environmental impact of e-commerce vs. a traditional retailer for the purchase and delivery of a flash drive. A key finding of this study is that the total energy usage for a traditional retailer is higher than that typically associated with e-commerce delivery. The main factors driving this result are the distance that the customer has to drive to buy the item via a traditional retailer (on average they drive 14 miles for a round trip), and the consumer fuel economy (assumed to be 22 miles/gallon from the US EPA). The authors also note the limitations of these results. For instance, if express air shipping is chosen as the delivery method by the customer, then the carbon emissions for both modes (i.e. e-commerce and traditional retailer) are roughly comparable.

Moreover, consumer awareness concerning the environmental impact associated with particular product choices is growing. A 2010 article appearing in the Wall Street Journal summarizes the results of a poll which finds that 17% of U.S. consumers and 23% of European consumers are willing to pay more for environmentally friendly products (O'Connell, 2010). These numbers have increased significantly over the past year. Consequently, major retailers such as Wal Mart are undertaking initiatives to include environmental information on labels along with pricing information. To start the process of gathering more environmental information from suppliers, Wal Mart will require its suppliers to answer questions concerning energy costs and emissions, material efficiency, natural resources, and ethical workforce concerns (Bustillo, 2009). According to O'Connell (2010), the percentage of advertisements in major magazines making "green claims" has also grown. However, many vendors have overstated the environmental properties of their goods (a practice commonly referred to as "greenwashing") such that the Federal Trade Commission has taken actions against these claims.

Internet companies are undertaking initiatives to highlight the environmental choices to consumers when they purchase goods via the internet. For example, Amazon.com has received a patent on "environmentally conscious electronic transactions," (Engleman, 2010). Their goal is to distinguish the environmental impact between different shipping methods, and to specifically market this service to consumers who are willing to pay more for delivery methods which have a lower environmental impact. Engleman (2010) also notes that, "These shipping options could cost more, and entail a longer wait for a package, but presumably Amazon sees a potential market for this." Examples of such environmental shipping practices include the use of hybrid vehicles, minimization of packaging materials, and efficient truck utilization techniques.

Many retail firms are grappling with the issue of how to best manage dual distribution channels for their goods as demand via internet channel grows. To illustrate, the U.K. retailer Tesco

* Corresponding author. Tel.: +1 (352) 392 5858; fax: +1 (352) 392 5438.
E-mail addresses: jc@ufl.edu (J.E. Carrillo), asoov@ufl.edu (A.J. Vakharia), ruoxuan.wang@sdsu.edu (R. Wang).

http://dx.doi.org/10.1016/j.ejor.2014.05.038
0377-2217/

established a home delivery service in 2000 and advertised their new internet channel with the slogan, "You shop. We drop." (Anonymous, 2006). While other retailers may fear that there is a conflict between these two important channels, Tesco embraced the complementarities between the new and old channels while concurrently continuing to expand its traditional bricks-and-mortar stores. In contrast, Webvan tried to establish a single online channel to deliver groceries by investing in large warehouses and inventory management systems (Spurgeon, 2001). Unfortunately, they went bankrupt due to a lack of customers willing to pay a higher premium for their service. Therefore, primary concerns of dual channel distribution include supply chain costs, customer service, and pricing.

In this paper, we introduce a stylized single firm model focusing on marketing choices for a dual channel strategy. We explicitly address the environmental implications of each channel to determine appropriate pricing and stocking decisions. Through our analysis, we address the following key research questions:

1. If a retailer has both traditional and online sales channels, how should he/she manage the split between these?
2. Are there circumstances under which a retailer should focus only on online and/or traditional channels?
3. How will consumer behavior evolve in response to these environmental channel concerns?
4. Which factors associated with e-commerce have the most significant impact on the environment?
5. How will policy issues such as a carbon tax impact on the retailer's decision?

The paper is organized as follows. In Section 2, we further discuss the existing body of literature as it relates to our key research questions. In Section 3.1, we introduce and analyze a deterministic model based on price dependent demand functions to determine when a dual strategy is appropriate. We extend this model in Section 3.2 to incorporate demand uncertainty via a newsvendor framework. A numerical analysis that analyzes the impact of various environmental factors on the optimal solutions and profits is included in Section 4. Conclusions and directions for future research are discussed in Section 5.

2. Literature review

2.1. e-Commerce and the environment: empirical literature

Several notable case-based and empirical studies have been published which analyze the environmental effects of e-commerce for specific industries, including electronics, groceries and books. For a more complete description of this literature, see Carrillo, Vakharia, and Wang (2010). As previously mentioned, Weber et al. (2008) utilize monte-carlo simulation techniques to analyze key factors involved in the delivery of a flash drive for buy.com. Fernie, Pfab, and Marchant (2000) survey senior executives currently working in grocery supply chain companies and conclude that some of the top issues that these executives are concerned about for the future included both e-commerce and environmental factors. Siikavirta, Punakivi, Krkkinen, and Linnanen (2002) employ simulation methodologies to analyze green house gas emissions associated with home delivery grocery services. They identify scenarios under which the home delivery service can cut green house gases by up to 87%. Matthews, Hendrickson, and Soh (2001) perform a study of the online book industry to directly analyze the environmental impact of online vs. traditional book retailers. They find that, when there are no returns, both modes have a comparable environmental impact. However, when the remainder rates are significant (they are typically 35% for best-selling books that are not sold at the end of the selling season from the retailer), the environmental impact of the traditional retailer is much worse, as they must stock higher inventories. Our model utilizes the evidence from this body of empirical studies to motivate certain relationships which link environmental factors to consumer decisions concerning channel choice.

2.2. Literature on e-commerce

Agatz, Fleischmann, and van Nunen (2008) offer a detailed overview of both the empirical and analytic literature which addresses e-fulfillment in a multi-channel environment. These authors note that, "One recurrent pattern is the combination of 'bricks-and-clicks', the integration of online sales into a portfolio of multiple alternative distribution channels." They offer numerous examples of retail firms where (a) traditional retailers are adding an online channel and (b) internet retailers are opening physical stores. One of the conclusions that these authors reach is that, "Pricing models for a multi-channel setting appear to be scarce as of yet." Our model directly addresses this shortcoming in the literature. Specifically, we develop optimal pricing and stocking strategies for a multi-channel retailer based on factors such as (a) the consumer's propensity to buy from the online channel, (b) the environmental costs associated with both channels, (c) price sensitivity to demand in both channels, and (c) cross price substitution effects between the channels.

2.2.1. Empirical literature on e-commerce

In his seminal paper, Bakos (2001) offers an overview of the impact of e-commerce on the retailing landscape and summarizes several key issues associated with e-commerce. Factors relevant in our context include increased price competition and differentiation via pricing for goods ordered online. Brynjolfsson and Smith (2000) explore the impact of internet commerce on price by analyzing data from book and CD industries for both traditional and e-commerce channels. These authors find that prices on the internet are significantly lower than those in a traditional retailer even when accounting for taxes, shipping, shopping and transportation costs. Brynjolfsson, Hu, and Rhaman (2009) further characterize the nature of competition between traditional bricks-and-mortar stores and an internet retailer. Their empirical study shows that the competition between these two channels is strongest when the goods are mainstream products that are typically associated with lower search costs. We utilize this literature in motivating our model by incorporating a cross price sensitivity parameter between the channels which reflects the competition between the two channels. Consequently, we can analyze the circumstances under which prices may be lower in a particular channel.

2.2.2. Analytic dual channel models

A body of literature within the operations management area addresses supply chain issues typically associated with dual channel models of distribution. For an overview of these models, see Agatz et al. (2008) and also Cattani, Gilland, Heese, and Swaminathan (2006). In particular, many of these analytic models address the manufacturer's decision concerning the addition of a direct retail channel (i.e. online sales) and sales via a traditional established independent retailer (i.e. bricks-and-mortar). The key decision variables in these models classically include both the wholesale/transfer price between the manufacturer and the retailer and the price offered to customers in both of the channels (Cattani et al., 2006; Chiang, Chhajed, & Hess, 2003; Chiang & Monahan, 2005; Dumrongsiri, Fan, Jain, & Moinzadeh, 2008; Tsay & Agrawal, 2004; Yue & Liu, 2006). These game theoretic models directly address the problem of double marginalization and characterize the circumstances under which the traditional retailer