



Distortional Bullwhip Effects on carriers

Michael A. Haughton *

School of Business & Economics, Wilfrid Laurier University, Waterloo, Ontario, Canada N2L 3C5

ARTICLE INFO

Article history:

Received 10 September 2007
Received in revised form 2 May 2008
Accepted 24 June 2008

Keywords:

Bullwhip effect
Simulation
Supply chain
Inventory replenishment policy

ABSTRACT

This paper analyzes the Bullwhip Effect (BWE) problem from the (carriers') viewpoint. The analysis explores how retailer's limited capability to forecast end-customer demand and their sub-optimal replenishment policies distort service demand signals to carriers. The consequent unnecessary increases in carriers' capacity costs and operational instability are quantified for a context of pronounced seasonality. The paper finds that carriers unable to adjust transportation capacity to seasonal changes can incur costs of nearly five times what is possible with maximum forecasting capabilities and prudent replenishment policies. Another major finding is that replenishment policy is superior to forecasting capability in reducing BWE-related costs.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

The "Bullwhip Effect" (BWE) describes how distorted end-customer demand fluctuations create disproportionately larger demand fluctuations by successive echelons further back in the supply chain (from wholesalers back to distributors and finally back to manufacturers). The BWE has been extensively studied to yield insights on how each echelon is affected by the distorted retail orders. Undesirable BWE outcomes such as ballooning inventories throughout the supply chain are well established in the widely recognized works of Lee et al. (1997a,b) as well as in studies such as Bhaskaran (1998). Empirical data on the volatility of production schedules vis-à-vis the relative stability of customer demands confirm the reality of the BWE (e.g., Siems (2005)). However, while there has been much research on BWE problems for the various supply chain echelons that make, store, and trade merchandise, little attention has been paid to the impact on an intermediary function between these echelons: the carrier (freight transport/delivery) function. In a similar vein, although inventory models are well studied and refined to aid inventory replenishment decisions in operations such as retail stores, rigorous analysis of the potential challenges these decisions create for carriers is absent from the scientific literature. Yet, these challenges are certainly a concern for the service providers (carriers). For example, Stiles (2005) has observed that shippers making 11 h demand changes such as requesting large deliveries to satisfy sales promotion and renegeing on delivery requests create resource allocation inefficiencies for carriers by complicating and destabilizing their capacity plans.

The aim of this paper is to move beyond qualitative discussion and quantify these inefficiencies. This will extend formal analysis of the BWE to cover the transportation provider perspective. More specifically, the analysis depicts how the demand-distorting actions of retailers impact the capacity costs and operational instability of carriers making deliveries from the upstream suppliers (shippers) to the retailers (consignees). A related goal of the paper is to depict how these impacts of distorted demands for transportation service might be attenuated or mitigated by (a) the timing and magnitude of delivery requests by shippers to carriers and (b) the retailers' capability to forecast end-customer demands. To provide a point of

* Tel.: +1 519 884 1970x6205; fax: +1 519 884 0201.

E-mail address: mhaughton@wlu.ca

reference for examining the impact of capacity flexibility, baseline findings are presented for the standard service provider context where a carrier invests in the capacity required to meet peak demand. This context, which is characterized by limited ability to make short-term capacity adjustments, will be contrasted with the impacts if carriers have some flexibility to quickly add and reduce capacity instead of having to make heavier financial outlays to acquire permanent staff and purchase vehicles. The quantitative findings provide a basis for contending that, in the presence of seasonal demands, retailers' replenishment policies as well as capacity flexibility are more influential than forecasting accuracy in mitigating the adverse impacts on carriers. The material that clarifies the findings as well as that assertion appears in Section 5 of the paper, and is preceded by, in order of appearance in the paper, a literature overview (next section), discussion of the study's supply chain context (Section 3), and its methodology (Section 4). Section 6 contains the summary and conclusions.

2. Literature overview and extensions

Several studies have undertaken the combined tasks of (a) estimating the supply chain inefficiencies and costs resulting from the BWE and (b) assessing strategies to mitigate the BWE. Mitigating strategies have been based on work to deepen understanding of the potential causes of the BWE, including behavioral causes (e.g., [Sterman \(1989\)](#) and [Croson and Donohue \(2003\)](#)). These studies have all focused on the supply chain members that, at one point or another own inventory (either in finished or unfinished state) that is ultimately made available to the end-customer. As such, inventory-related costs such as holding and shortage costs have dominated the analyses with no explicit treatment of the unnecessary costs incurred by the transportation intermediary. For example, [Bhaskaran \(1998\)](#), in a simulation study based on General Motors Corporation, noted that distorted demand information (in the form of inaccurate forecasts) leads to high average inventory for manufacturers. Also, [Metters \(1997\)](#) found that removal of distortions caused solely by forecast errors can increase chain-wide (system) profitability by 5–10% while removal of distortions due to upstream amplification of downstream demand variations can yield a 10–20% increase. Similar results concerning the avoidable costs of distorted information appear in [Chen et al. \(2000a,b\)](#), [Zhao et al. \(2002\)](#), and [Chatfield et al. \(2004\)](#). Corroborating results also appear in, for example, [Warburton \(2004\)](#), who showed that it is possible to analytically determine the BWE's inventory impacts in a supply chain. Existing findings also cover the impact of inventory replenishment policies (e.g., [Kelle and Milne \(1999\)](#)). [Baganha and Cohen \(1998\)](#) also demonstrate the BWE dampening effect of inventory.

These studies are illustrative of the almost exclusive focus of the BWE literature on product supply chains. The earliest of the few BWE studies on services ([Anderson and Morrice, 2000](#)) was a behavioral experiment in which MBA students simulated the processing of mortgage applications. The findings showed that, along the application processing (supply) chain, upstream access to true downstream information on the applications dampened the BWE, and thus led to more cost-effective capacity plans. In that experiment, the sole capacity resource was labour so capacity adjustments involved only period-to-period hiring and firing (the costs for which were part of the BWE costs in their paper). The work by [Akkermans and Vos \(2003\)](#) was also motivated by the intuitive observation that the BWE peculiarities caused by the intangibility of services require analysis and remedies that cannot simply be replicas of what one sees in manufacturing. In their study of a US telecommunications company using case research methods, Akkermans and Vos note, for example, that "*countermeasures that work by way of inventory do not apply*". In two subsequent studies, [Anderson, Morrice, and Lundeen \(2005, 2006\)](#) build on the initial work of [Anderson and Morrice \(2000\)](#) with simulation and analytical results to further clarify the heightened relevance of capacity as the focus of analysis in non-manufacturing supply chains. These works sought insights that might apply to a broad range of services by modeling serial supply chains involving two stages and three or more stages ([Anderson et al. \(2005, 2006\)](#), respectively) in which the generic entity "workload" is what each stage processes.

Notable in the experimental contexts by Anderson and colleagues (e.g., [Anderson et al. \(2005\)](#)) is that capacity adjustments are limited adding or subtracting workers. However, for the case of transportation, capacity adjustments are not simply about staff size changes. Fleet size adjustments – typically involving capital investments by the carrier – must also be considered. This is a defining feature of the present paper's extension of the BWE literature on services. A second important feature is that the well documented problem of driver shortage (e.g., [Kilcarr \(2005\)](#)) might reduce flexibility in staff-related capacity adjustments since carriers may be reluctant to lay off drivers and risk being unable to rehire them. Therefore, the BWE costs for some carriers will be more in terms of costs that are inelastic with respect to short-term demand fluctuations; i.e., costs that are irreversible in the short term. In other words, hiring a driver and acquiring a vehicle create fixed financial commitments – salaries and capital asset investments – lasting multiple periods beyond the hiring/acquisition date.

Given that transportation is an intermediary service activity that is directly influenced by a product supply chain, it is quite surprising that, heretofore, no BWE study on service providers address carriers. Specifically, it is a logical inference that a supply chain's product owners are not the only ones adversely affected by what authors such as [Caplin \(1985\)](#) demonstrate as a tendency for replenishment orders to be more volatile than end-customer demand. This reflects obvious knowledge gaps in the literature concerning the magnitude of the adverse effects on carriers and how shippers' replenishment policies influence those effects. In addition to addressing replenishment policy as a source of influence on carriers' BWE, this study also tackles one of the issues cited in [Anderson et al. \(2006\)](#) as deserving attention in future research on service sector BWE: forecasting. In particular, this study depicts how forecasting capability at the retail level of a two-echelon supply chain influences the magnitude of the BWE incurred by the carrier.

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات