Computational Statistics and Data Analysis 56 (2012) 3055–3069

Contents lists available at SciVerse ScienceDirect

Computational Statistics and Data Analysis

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

Modeling dynamic effects of promotion on interpurchase times

Dennis Fok*, Richard Paap, Philip Hans Franses

Econometric Institute, Erasmus School of Economics, Erasmus University Rotterdam, P.O. Box 1738, NL-3000 DR Rotterdam, The Netherlands

ARTICLE INFO

Article history:
Available online 5 April 2012

Keywords:
Dynamic duration model
Time-varying covariates
Error-correction model
Unobserved heterogeneity

ABSTRACT

Dynamic effects of marketing-mix variables on interpurchase times can be analyzed in the context of a duration model. Specifically, this can be done by extending the accelerated failure-time model with an autoregressive structure. An important feature of the model is that it allows for different long-run and short-run effects of marketing-mix variables on interpurchase times. The error-correction specification of the model contains parameters which measure the direct effect of a temporary change in a marketing-mix variable on interpurchase times and parameters which measure the long-run (cumulative) effect of a temporary change in a marketing-mix variable on current and future interpurchase times. As marketing efforts usually change during the spells, time-varying covariates are explicitly dealt with. Heterogeneity of individual behavior is allowed for through a mixture approach. An empirical analysis of purchases in three different categories reveals, for some segments of households, that the short-run effects of marketing-mix variables are significantly different from the long-run effects. The decay in the effect of changes in marketing-mix variables over time is larger in categories with large interpurchase times, and price has the largest long-run effect for the perishable product. Finally, ignoring dynamic effects leads to erroneous results about the effectiveness of marketing instruments.

1. Introduction

For marketing managers it is important to understand the dynamic effects of marketing-mix variables like promotion and advertising on marketing performance measures such as sales, market shares and profitability. Particularly, it is relevant to understand the long-run effects of marketing efforts, as this knowledge can, for example, lead to more efficient marketing strategies. In the end, brand managers and retailers are interested in the net (cumulative) effect of a promotion. Examples of recent studies that address this issue are Mela et al. (1997), Dekimpe et al. (1999), Jedidi et al. (1999), Paap and Franses (2000) and Fok et al. (2006) to mention just a few. The literature contains two different approaches. One approach tries to capture the (long-run) effects of marketing instruments on, for example, the price elasticity (Mela et al., 1997; Jedidi et al., 1999). Dynamics are then incorporated through the future responses to marketing instruments. The second approach, which is also considered in the present paper, focuses on dynamic effects in behavior (Dekimpe et al., 1999; Paap and Franses, 2000; Fok et al., 2006).

We address the issue of measuring the long-run and short-run impact of marketing-mix variables on interpurchase times. The theoretical and empirical analysis of purchase-timing behavior of households has received considerable attention in the past and in recent years. The analysis of interpurchase timing can give interesting insights into household behavior. Purchase timing can be especially informative to learn about inventory management and consumption rates. In fact the purchase timing and the volume bought are the only two measures related to inventory that are usually available. Furthermore, we can study purchase acceleration and stock piling using interpurchase timing. Blattberg et al. (1981) show under stringent

* Corresponding author. Tel.: +31 10 4081333; fax: +31 10 4089162.
E-mail addresses: dfok@ese.eur.nl (D. Fok), paap@ese.eur.nl (R. Paap), franses@ese.eur.nl (P.H. Franses).

0167-9473/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.csda.2012.03.022

conditions that promotions lead to purchase acceleration. Empirical evidence for this behavior can be found in Gupta (1988) and Helsen and Schmittlein (1992) among others, although, for example, Neslin et al. (1985) report that promotions were less likely to accelerate purchase times. A review of interpurchase time modeling before 1990 can be found in Jain and Vilcassim (1991, Table 1).

More recently, researchers have focused on using hazard functions to analyze the effect of promotions on interpurchase times; see among others Helsen and Schmittlein (1992, 1993), Jain and Vilcassim (1991), Vilcassim and Jain (1991), Gönül and Srinivasan (1993a), Chintagunta and Prasad (1998), Vakratsas and Bass (2002) and Seetharaman (2004). The last five studies also incorporate unobserved household heterogeneity.

Dynamic models for duration data are relatively scarce, although one might expect strong dynamic effects in practice. The latter may especially be the case in marketing data. Available evidence for stock piling and purchase acceleration directly translates into dependences across consecutive interpurchase times. For example, a promotion may shorten the present interpurchase time, while it likely lengthens future interpurchase times due to stock piling. For financial data the Autoregressive Conditional Duration [ACD] model of Engle and Russell (1998) and the Stochastic Conditional Duration [SCD] model of Bauwens and Veredas (2004) are available. Both of these models build on the accelerated lifetime model. However, in neither of the two models it is possible to include time-varying covariates. Furthermore, the models do not allow for a clear separation of short-run versus long-run effects. Finally, the estimation of the parameters in the SCD model can be very demanding, see, for example, Strickland et al. (2006) and Bauwens and Galli (2009).

An example of a study in marketing that explicitly incorporates dynamic structures in purchase timing is Allenby et al. (1999). In that paper, dynamics in interpurchase times of financial products are modeled by lagged interpurchase times, but again no explicit separation of long-run from short-run effects of covariates is pursued. As we believe that short-run and long-run effects might differ substantially, especially in fast moving consumer goods, we aim to contribute to the literature by putting forward a dynamic model for interpurchase times that does allow for different long-run and short-run effects. The model extends the familiar accelerated failure-time model by including lagged interpurchase times as well as lagged covariates. Rewriting this model as an Error Correction Model [ECM] allows us to distinguish the long-run from the short-run effects, see Hendry et al. (1984) and Fok et al. (2006) for a recent application in marketing.

The values of covariates, like price and promotion, are likely to change during interpurchase spells. In many (marketing) applications of duration models, it is assumed that covariates remain constant during spells, which is perhaps imposed for convenience. In contrast, in this paper we follow a similar approach as Gupta (1991), that is, we allow for time-varying covariates in the hazard specification. Additionally, many studies have emphasized the relevance of unobserved household heterogeneity, and that it should be taken into account when analyzing purchase behavior. Therefore, we accommodate for unobserved differences across households by a latent class approach. In many studies, unobserved heterogeneity is incorporated using a mixed proportional hazard model, where one introduces a stochastic multiplicative factor to the hazard specification, see Lancaster (1979) and see Gönül and Srinivasan (1993a) for an application in marketing. This however restricts the heterogeneity to the baseline purchase rate. In this paper we also allow for different effects of the covariates including the marketing mix on the interpurchase times, see also Vakratsas and Bass (2002) for a similar approach. Indeed, such heterogeneity may be especially relevant for modeling dynamics in purchase timing. For example, the population may contain households with very different dynamic purchase timing patterns.

In sum, we propose a dynamic model for interpurchase time, with possibly differing short-run and long-run effects of covariates, which incorporates unobserved heterogeneity and also takes care of time-varying covariates in between purchases. Hence, in this paper we only take a partial approach where we focus on interpurchase times. To more formally analyze stock piling and the consumption rate we of course also would need to describe the dynamic patterns in purchase quantity, see, for example, Böckenholt (1999). A longer interpurchase time may imply that households have a larger stock but it may also be the case that households have a lower consumption rate. As purchase quantity and interpurchase times are correlated, the ultimate challenge to analyze stock piling will be to combine both measures in a bivariate dynamic model. In this paper we take a step in this direction by adding a dynamic model for interpurchase times to the literature. As we only consider interpurchase times, we cannot generalize the effects of promotions on interpurchase times to the effects of promotions on stock piling and/or consumption rate.

The outline of our paper is as follows. In Section 2, we discuss our dynamic duration model. We show how the accelerated failure-time model can be extended to allow for time-varying covariates and possibly differing long-run and short-run effects of marketing variables. We discuss in detail how one can interpret the parameters and estimate them using maximum likelihood [ML]. In Section 3, we apply our model to purchases in three distinct categories of frequently purchased consumption goods, that is liquid laundry detergent, catsup and yogurt. One of our main empirical findings is that, for some household segments, the short-run effects of marketing mix variables are significantly different from zero, while the long-run effects are not. Neglecting dynamic effects can even lead to the wrong conclusions about the effectiveness of marketing instruments. We show that the model can be used by managers to evaluate marketing strategies. In Section 4, we conclude our paper with a discussion of the main results and with suggestions for further research topics.

2. A dynamic model for interpurchase times

In this section we put forward our dynamic model for interpurchase times, which enables a separate evaluation of long-run and short-run effects of covariates, such as promotion and other marketing-mix variables. In Section 2.1, we present