Modeling coexisting business scenarios with time-series panel data: A dynamics-based segmentation approach

Catarina Sismeiro [a,*], Natalie Mizik [b], Randolph E. Bucklin [c]

[a] *Imperial College Business School, Imperial College, London, United Kingdom*
[b] *Kenan-Flagler School of Business, University of North Carolina, Chapel Hill, United States*
[c] *UCLA Anderson School of Management, United States*

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ABSTRACT

At a given point in time, individual consumers may be in different stages of the product adoption or consumption cycle. As a result, different types of behavioral patterns may coexist within a single product market. Existing segmentation approaches typically do not address long-term dynamics in customer response and do not adequately capture this phenomenon. We develop an approach for modeling the coexistence of multiple dynamic behavioral patterns (business scenarios) within a single product market. We apply this approach to physician panel data on drug prescriptions and direct-to-physician promotions. We find markedly different responses across physician segments. For firms that track customer-level marketing activity and sales over time, market segmentation based on dynamic scenarios can provide a new tool for efficient targeting. The proposed approach is straightforward to implement and is scalable to very large samples and continuous testing.

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1. Introduction

The concept of business scenarios in the context of time-series modeling was first discussed by Dekimpe and Hanssens (1999). In their study, the authors presented four possible alternative scenarios for a given market (Fig. 1): "business as usual" (in which both performance and marketing variables are stationary), "escalation" (in which only the marketing variables are evolving), "hysteresis" (in which only the performance measure is evolving), and "evolving business practice" (with evolving performance and marketing variables). Depending which scenario is detected in the market under analysis, alternative formulations for vector autoregressive models would be appropriate, which, when estimated, lead to different strategic conclusions.

In this paper, we propose that, due to differences in customers and firm behavior, multiple business scenarios may coexist within a single product market. Just as products, industries, and markets may be at different stages of their life cycles, individual consumers may be at different stages of their consumption life cycles and may be subject to targeted marketing actions that differ significantly (in terms of intensity and scope) from those aimed at other consumers. Several prominent theories provide support for such a phenomenon. For example, new product diffusion and adoption theories rely on the existence of distinct consumer

segments that learn about and adopt the product at different points in time (Bass, 1969; Rogers, 2003). Firms have access to a broad set of tools to customize marketing actions at the individual level in terms of intensity, message, and even the medium used.

Despite the likely coexistence of multiple business scenarios in a market, the modeling of distinct dynamic consumer responses and dynamic firm behavior has not been incorporated into existing segmentation methodologies. With this paper, we develop and illustrate an approach that uses time-series panel data to investigate whether different dynamic business scenarios might exist concurrently across a firm's customer base and what the data imply strategically. If these business scenarios do coexist, some customers (or segments) might present the firm with "business as usual," while others present the perils of "escalation" or the opportunities of "hysteresis" or "coevolution" scenarios. To study this phenomenon, we relax the common, though typically implicit, assumption that the time-series properties of the data are uniform across panelists.

Our approach allows us to effectively identify distinct dynamic patterns at an individual level and to investigate the differences in response dynamics across customers. It consists of two steps. In the first step, we test for the order of integration in the data using unit-root tests at the disaggregate level. We conduct two sets of unit-root tests, one for the outcome variable and one for the marketing covariates. Then, using the test results, we assign individuals to one of four groups. In the second step, we specify an appropriate panel vector autoregressive model (PVAR) for each group, and we estimate
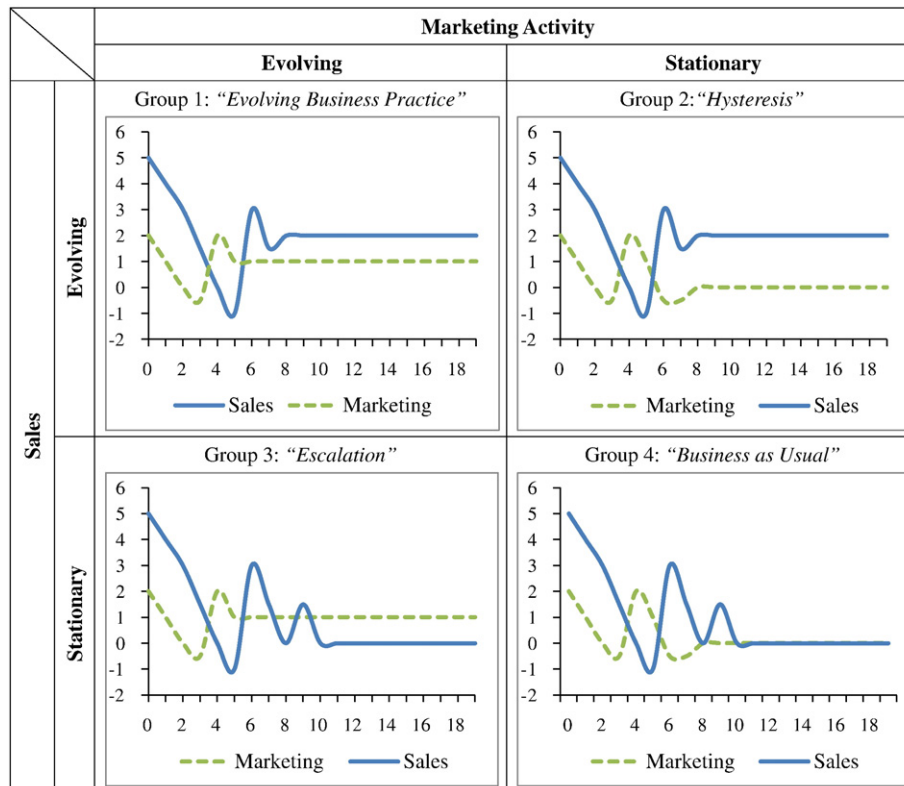
Legend: This figure presents stylized examples of "own" impulse response functions (IRFs) for sales and marketing efforts. A sales IRF represents the impact of a sales shock in period zero on future sales. The marketing IRF represents the impact of a marketing shock in period zero on future marketing effort. When the IRFs converge to zero, the series are stationary; IRFs converging to a non-zero value mean that the series are non-stationary (i.e., a unit root is present). We note that although there might be a relation between the two series (e.g., the evolving behavior of sales could be due to the evolving behavior of marketing), the first-stage classification into business scenarios does not require such cause-effect relationships. This classification is important for the second-stage modeling phase because the specification of the VAR models depends on the stationary or evolving nature of the series.

Fig. 1. The four basic business scenarios—stylized examples of impulse response functions.

separate PVAR models to investigate potential differences in response dynamics across groups.

To test our approach, we use individual physician-level time-series panel data on prescribing and direct-to-physician promotion (DTP) from a pharmaceutical prescription drug market. Differences across doctors in age, experience, practice size and type, risk aversion and adoption timing could lead to differences in the level of time-series integration for individual prescribing (i.e., prescription data series might be evolving or stationary depending on these factors). Different levels of marketing activity targeted by pharmaceutical companies across physicians can also give rise to evolution versus stationarity of DTP activity at the individual level. Thus, different dynamic business scenarios might be present across physicians.

Empirically, we find that multiple dynamic scenarios coexist within a single drug market, each with markedly different response magnitudes and patterns. We assess the performance of the proposed method relative to alternative segmentation approaches and present evidence that common segmentation variables used by the industry fail to detect meaningful response differences across groups. Tests using cross-sectional and longitudinal holdout samples support the superiority of the proposed dynamic business scenario-based segmentation, which produces not only better in-sample fit but also better out-of-sample fit. Hence, we believe that the proposed segmentation approach provides a useful new tool for enhancing the productivity of marketing resources through better targeting at the individual level.

2. Motivation

In markets where sales and/or marketing activity may be evolving, econometricians have emphasized the importance of handling potential nonstationarity in time-series data. These "persistence modeling" methods (1) employ unit-root tests to ascertain the stationary versus evolving nature of the data and (2) estimate appropriate vector autoregressive (VAR) models given the integration level of the data to assess the market dynamics and long-run effects. The application of VAR-based persistence models to marketing data has yielded key insights about dynamic response in a series of studies conducted on aggregate-level data (e.g., Dekimpe & Hanssens, 1995, 1999; Bronnenberg, Mahajan, & Vanhonacker, 2000; Pauwels, Hanssens, & Siddarth, 2002; Horváth & Franses, 2003). Dekimpe and Hanssens (1999), for example, have demonstrated how time-series methods applied to aggregate historical data can identify different dynamic business scenarios: business as usual, escalation, hysteresis, and evolving business practice (or coevolution). Implications for return on marketing spending, marketing strategy, and profitability can differ dramatically across these scenarios. The possibility that different dynamic business scenarios may coexist within a single market, however, has not been examined.

Another branch of marketing science has extensively studied disaggregate-level data in consumer panels, based largely on UPC scanner data for packaged goods. This stream has emphasized the study of short-run response to marketing activity across individual