{New Method}

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Sibling Rivalry: ESTIMATING CANNIBALIZATION RATES FOR INNOVATIONS

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To evaluate the success of a new product, managers need to determine how much of its new demand is due to cannibalizing the company's other products, rather than drawing from competition or generating primary demand. A new model allows managers to estimate cannibalization effects and to calculate the new product's net demand, which may be considerably less than its total demand. The new methodology is applied to the introduction of the Lexus RX 300 using detailed car transaction data. This case is especially interesting since the Lexus RX 300 was the first crossover SUV, implying that its demand could come from both the SUV and the Luxury Sedan categories. As Lexus was active in both categories, there was a double cannibalization potential. Indeed, demand is shown to originate from different sources and to vary over time. The results contain valuable insights for evaluating and managing brand extensions.

New Products' Potential Cannibalization Effects across Categories

"If anyone is going to cannibalize us, I want it to be us, not a competitor", Steve Jobs announced when first introducing the iPhone. In fact, cannibalization may often be a necessary evil when new products are introduced. Though innovation, the process of bringing new products and services to market, is one of the most important strategies in order to grow, the cannibalization of existing products can moderate the growth effect. To evaluate the success of a new product, managers need a method to gauge not only how much new demand it

generates, but also to what extent this demand comes at the expense of (cannibalizes) their other products. When the extent of cannibalization is ignored, the success of the new product will be overestimated.

Managers practicing category management are typically aware of the cannibalization phenomenon but are not clear on how to quantify the size of the cannibalization risk. This problem is exacerbated when companies operating in multiple categories introduce radical, pioneering innovations. A radical innovation is difficult to assign to a particular category a priori, and it is unclear

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{ Box 1 }

MODEL OVERVIEW

The model applied here observes changes in base sales of incumbent brands and categories. “Base sales” are defined as the expected sales level when all marketing instruments are at their average levels and when all short-run fluctuations have settled. The duration of the data interval is in weeks.

Sales change for focal new model (at time t) =
 + change in demand for other models within same brand and category
 + change in demand for other brands within category
 + change in demand for other models within same brand in other categories
 + change in demand for other brands in other categories
 + primary demand

To accommodate cannibalization and brand switching effects resulting from multiple brands, a time-varying vector error correction (VEC) model, framed as a dynamic linear model (DLM), is developed. It explicitly allows for multivariate dependencies across the different brands and categories through direct cross effects and correlated error structures.

To allow for *time variation*, the changes in incumbents’ base sales caused by the pioneering innovation are captured through time-varying long-run intercepts. There are both *gradual adjustments* to the new base sales levels and *stochastic variations* around these levels. By adding the base sales of the pioneering brand to the system, it is possible to derive the primary demand effect as the difference between the total impact on that series and the sum of the impacts across all competitor brands.

Bayesian techniques are used to handle *missing data*. Instead of a necessary list-based deletion with traditional estimation procedures, a single model is applied, that at any moment includes all available brands. All cross-effect parameters are selectively updated for the available product pairs. The estimation method ensures that all available information is used on all variables, even if observations are partially missing.

in which of the categories the cannibalization and brand-switching rates will be strongest. These products add a new dimension to the consumers’ decision process, making it less obvious which categories will be affected. Some possibly affected categories might even be overlooked.

For example, Apple’s iPhone crossed the boundaries of two categories (portable media players and mobile phones), with a clear cannibalization potential for Apple along with an anticipated primary demand expansion. Similarly, Febreze, manufactured by Procter & Gamble (P & G), may draw from the air freshener category because it eliminates odors, but it also may draw from the laundry detergent category because it works directly on fabric. Given P & G’s presence in both categories, there are again two potential sources of cannibalization. Both cannibalization sources are unattractive to the company, as neither implies that the net unit sales increase (although profit may increase, depending on the respective margins). Therefore, it is crucial to measure cannibalization effects *within* categories as well as *between* categories. In contrast, within and between category *brand switching* comes at the expense of other brands and is therefore much more attractive from the introducing company’s perspective. Finally, part of a new product’s demand can be really new, i.e., representing a *primary demand* effect without any direct negative effects in related categories.

» A radical innovation is difficult to assign to a particular category a priori, and it is unclear in which of the categories the cannibalization and brand-switching rates will be strongest. «

» It is crucial to measure cannibalization effects within categories as well as between categories. «

{ Box 2 }

THE DATA

Data on both categories (Luxury SUVs and Luxury Sedans) was provided by a leading data supplier in the automotive industry for California. The dataset contained weekly pre- and post-entry data on the aggregate sales of all brands in California and on the price series of the major brands. Advertising expenditures were obtained from TNS Media Intelligence. The Lexus RX 300 is classified in the Luxury SUV category by the data supplier.

Challenges of Estimating Cannibalization Effects Across Categories

An assessment of the extent of cannibalization is crucial for understanding whether or not the introduction can be considered a success for the company as a whole. Such an assessment has to integrate the different sources of demand for the pioneering innovation: cannibalization within the category, cannibalization between categories, brand switching within the category, brand switching between categories and primary demand. Further, it needs to control for effects caused by marketing activities like advertising or price. At first sight this task does not appear to be difficult, but such an assessment is a tricky problem because a measurement model has to meet important challenges to be useful:

- > It needs to accommodate cannibalization and brand switching effects resulting from multiple brands within and among categories, as it is unlikely that just one brand is affected. Cross effects and/or correlated error structures across all relevant brands need to be handled simultaneously.
- > When the pioneering innovation has been introduced, not all potential customers will react immediately and changes in demand are unlikely to fully materialize

instantaneously. Rather, they are likely to evolve over time. Further, there are many factors such as seasonal fluctuations or special promotions that can cause temporary disturbances in the base sales level. The method should allow for time variation in the effects and isolate sustained changes in base sales, after accounting for these temporary disturbances.

- > Finally, markets experience frequent product introductions and withdrawals. Therefore the method should cope with missing data because complete data are typically not available for products introduced or withdrawn from the market during the period of observation. Missing data is particularly relevant when assessing the effects of marketing instruments such as advertising and price on the focal and other brands over time.

Previous models did not meet all the requirements outlined above. Especially the issue of missing data was not solved sufficiently. The new approach has been successfully applied in the automotive industry. The following case study demonstrates how it helped to evaluate the introduction of the Lexus RX 300.

THE LEXUS RX 300 CASE

Introducing the Lexus RX 300 in the USA

In March 1998, the Lexus RX 300 was introduced to the U.S. market. It was widely seen as a pioneering innovation, as it was the first crossover between an SUV and a Sedan. Even though in terms of emissions and fuel economy regulations, the Lexus RX 300 was considered a Sedan, it was explicitly designed to compete in the Luxury SUV category. As such, it was conceivable that the Lexus RX 300 could draw secondary demand from both categories: Luxury SUVs and Luxury Sedans. As Lexus was already active in both categories (with prior shares of 12.3 % and 25.3 %), there was a clear cannibalization potential. While Lexus' management perceived a slight cannibalization threat for the Sedan category, key industry observers expected cannibalization to be strongest in the Luxury SUV category. The RX 300 was expected to create additional primary demand because new car sales, in general, were still growing. Other expected sources for primary demand effects included new (first-time) buyers, sales to existing used-vehicle owners, as well as additional (e.g., second or third) automobiles for some households.

In the Luxury SUV category, four other brands were available in the market at the time of the RX 300's introduction: Other Lexus Luxury SUVs (the 450 and

470), Lincoln (Navigator), Mercedes-Benz (M series), and Infiniti (QX4). The market share, prices and advertising expenditures of the five brands in this category are described in Table 1.

In the Luxury Sedan category, the top five brands were Acura, Infiniti, Lincoln, Lexus and Mercedes-Benz (see Table 1). In combination, these brands account for 62 % of the Luxury Sedan market. The remaining 38 % was treated as one group whose sales evolution was tracked, and for which the cross effects emanating from the five leading brands were captured directly. Across the two categories, a system of 11 equations (5 Luxury SUVs and 6 Luxury Sedans) had to be estimated. As Table 1 shows, not all brands are available for the entire duration of the data, which underscores the importance of the Bayesian estimation to avoid the excessive list-based deletion with traditional estimation procedures.

Figure 1 displays the observed sales data for the Lexus RX 300. Automotive sales are known to exhibit seasonal fluctuations (e.g., Labor Day and Memorial Day weekend). Short-term effects might further be caused by promotion activities (e.g. end-of-quarter promotions). To account for such effects and isolate base sales levels, control dummies were added.

TABLE 1:
Luxury Sedans and Luxury SUVs: Market Share, Prices and Weekly Advertising of Brands

Category	Start of sample period	Brand	Within-category market share	Price	Advertising (x 1.000)
Luxury Sedan	10/13/1996	Acura	17.4 %	US \$ 27,300	US \$ 30
	10/13/1996	Infiniti	4.4 %	US \$ 30,060	US \$ 14
	10/13/1996	Lexus	10.2 %	US \$ 39,630	US \$ 46
	10/13/1996	Lincoln	7.3 %	US \$ 37,920	US \$ 12
	10/13/1996	Mercedes-Benz	22.6 %	US \$ 48,370	US \$ 14
		Rest	38.1 %		
		Total	100 %		
Luxury SUV	11/24/1996	Infiniti	16.4 %	US \$ 33,470	US \$ 34
	10/13/1996	Lexus Other	25.1 %	US \$ 60,710	US \$ 9
	03/22/1998	Lexus RX 300	10.6 %	US \$ 34,420	US \$ 147
	07/06/1997	Lincoln	25.1 %	US \$ 41,600	US \$ 55
	09/21/1997	Mercedes-Benz	22.8 %	US \$ 39,240	US \$ 30
		Total	100 %		

Sales Effects of the RX 300 introduction on the Sedan and SUV Markets

The sources of demand for the pioneering innovation were derived from changes in sales of the new product itself, and of same-brand and cross-brand varieties in the same and other categories. The introduction of the Lexus RX 300 significantly affected the base sales of five other cars (Table 2). There was within-category brand switching (from Mercedes-Benz and Lincoln Luxury SUVs), between-category brand switching (from Acura and Lincoln Luxury Sedans), and between-category cannibalization (of Lexus Luxury Sedan). Interestingly, there was no cannibalization of other Lexus models in the Luxury SUV category. This is consistent with the fact that the Lexus Other SUV was in a much higher price tier than the Lexus RX 300 (Table 1).

For the five brands that were significantly affected by the introduction of the Lexus RX 300, it took between 18 and 73 weeks for the base sales to settle. For one brand, Infiniti Luxury SUV, base sales did not settle (i.e., its base sales were non-stationary).

The graph in Figure 2 shows the composition of demand for the Lexus RX 300 in terms of secondary demand effects and primary demand effects, and how this changed over time.

FIGURE 1:
Observed Sales of Focal New Product: Lexus RX 300

Category	Brand	Significantly affected by Lexus RX 300 introduction?	Median 90 % duration interval (weeks)
Luxury Sedan	Acura	Yes	23
	Infiniti	No	137
	Lexus	Yes	22
	Lincoln	Yes	22
	Mercedes-Benz	No	21
	Rest	No	62
Luxury SUV	Infiniti	No	–
	Lexus (other)	No	21
	Lexus RX 300	Yes	73
	Lincoln	Yes	18
	Mercedes-Benz	Yes	21

TABLE 2:
Effect of RX 300 Market Introduction on Other Car Models and Duration for the Base Sales Level to Settle

FIGURE 2:
Time-Varying Decomposition of the Demand (units/week) for Lexus RX 300

Four weeks after the market introduction, sales in the respective markets showed the following pattern:

$\Delta ES_{\text{Lexus RX 300, } t = t_0 + 4} = 114 \text{ units} =$ (100 %)								
0 units	+	20 units	+	25 units	+	16 units	+	53 units
(0 %)		(18 %)		(22 %)		(14 %)		(46 %)
a) within-category cannibalization		(b) within-category brand switching		(c) between-category cannibalization		(d) between-category brand switching		(e) primary demand effect

While there was no within-category cannibalization, there was a significant cross-category cannibalization effect. That is, base sales of Lexus in the Luxury Sedan category were reduced by 25 weekly units, corresponding to 22 % of the 114 units of demand of the Lexus RX 300. Within-category brand switching effects contributed 18 %, whereas between-category brand switching effects (14 %) were substantive as well. Primary demand effects represented 46 % of the demand for the Lexus RX 300 in these early weeks of its existence.

The effects had settled in new base sales levels around 73 weeks after the introduction and the absolute and relative contribution for each of the effects had changed relative to the snapshot at week $t_0 + 4$.

$\Delta ES_{\text{Lexus RX 300, } t = t_0 + 73} = 235 \text{ units} =$ (100 %)								
0 units (0 %)	+	49 units (21 %)	+	62 units (26 %)	+	39 units (16 %)	+	85 units (36 %)
a) within-category cannibalization		b) within-category brand switching		c) between-category cannibalization		d) between-category brand switching		e) primary demand effect

Whereas total demand for the Lexus RX 300 equaled 235 units, net extra demand for Lexus as a whole equaled 173 units, since 62 units (26 %) were lost due to a (between-category) cannibalization effect. The 173 units of weekly sales represented the net success of the Lexus RX 300

introduction. The primary demand effect (36 %) represented the part of the own demand that could not be attributed to sales reductions of other products. To make sure that there were no lost sales in other categories, Non-Luxury SUVs were included in the analyses but did not show any significant effects.

Marketing Mix Effects

In addition to the observed changes in the base sales levels within the related product categories, the model made it possible to estimate the effect of price and advertising by calculating their effect on demand via elasticities. The most significant effect was observed for price changes. A 1 % price increase of the RX 300 reduced demand by 3.54 % (median price elasticity of – 3.54). The price effect on other models was significant: a 1 % price increase of the RX 300 increased demand of another model (within-category and within brand across category) by 1.37 %, on average. The median own advertising elasticity is rather low at 0.07 and the median cross-advertising elasticity of 0 indicates a balance between negative (substitution) effects and positive (primary demand or spill-over) effects.

In general there were more significant effects of advertising and price on the RX 300 itself than on other brands or models. Nevertheless, it is important to control for cross effects. For example, in the focal category (Luxury SUV), there is a significant positive cross effect of Lincoln's price on the sales of the Lexus RX 300 in the long run (cross elasticity = 1.58). The data also showed a slight spill-over effect of advertising for Lincoln's Luxury Sedans on the sales of its SUVs (long-run elasticity = 0.06). The model can be used to calculate price and advertising effects for all the brands and car models and to test the outcome of possible competitive reactions by means of "what-if" scenarios.

Using the Model to Plan Competitive Action

Key players in the market may use the results to reduce their sales losses due to the introduction of the new product. Table 3 shows key figures of two car models that were heavily affected by the introduction of the RX 300, the Acura and the other (high-price) Lexus model in the Luxury Sedan category.

	<i>Acura Luxury Sedan</i>	<i>Lexus Luxury Sedan</i>
Base sales before introduction of Lexus RX 300	114	197
Base sales after introduction of Lexus RX 300	103	135
Difference	– 11	– 62
Mean price	US \$ 27,300	US \$ 39,630
Long-term own price effect	– 0.028	n.s.
Required price change to recoup sales loss	– US \$ 399	n.a.
Required new price to recoup sales loss	US \$ 26,901	n.a.
Mean advertising level (× US \$ 1000)	30	46
Long-term own advertising effect	n.s.	0.471
Required advertising change to recoup sales loss (× US \$ 1000)	n.a.	+ 131
Required new advertising level to recoup sales loss (× US \$ 1000)	n.a.	177

n.s. = not significant (90 % posterior interval includes 0)
n.a. = not applicable

TABLE 3:
Possible Responses by
Competitors to Recoup the
Sales Loss as a Result of the
RX 300 Introduction

Acura Luxury Sedan base sales dropped from 114 to 103 cars a week. The model allows Acura management to contemplate ways to recoup this loss of 11 cars per week (or 572 cars per year). Since Acura's long-term own price effect is – 0.028 (a significant estimate), it would take a price reduction of US \$ 399 on its average price of US \$ 27,300 to bring its base sales level to the original level (recoup the 11 cars lost per week). However, this move is not necessarily profitable, as there will be a margin loss on all cars sold. Spending more on advertising is not a solution for this brand, as its long-term own advertising effect is insignificant. Increasing its advertising would therefore have resulted in spoiled arms, because it would not have increased sales.

In the Luxury Sedan category, the sister model Lexus is the most affected brand: base sales become 135 units a week after the introduction of the Lexus RX 300 SUV, down from 197 weekly units. For this brand, reducing price is not an option for recouping the lost 62 cars a week (or 3,224 cars per year), because its long-term price effect is insignificant. Instead, management may consider increasing advertising spending to overcome the sales loss, since its long-term advertising parameter

(0.471) is significant. To increase weekly car sales by 62 units, Lexus needs to almost quadruple its weekly advertising for its Luxury Sedan: from US \$ 46,320 to US \$ 178,000. This translates to US \$ 903 of advertising per car (= US \$ 178,000/197), which are sold at an average price of US \$ 39,630. Again, it depends on various other considerations (costs, margins, positioning) whether such a move will be advisable. The key is that the model allows for an informed strategic response.

» The new approach decomposes the demand for a pioneering innovation into cannibalization, brand switching and primary demand expansion. «

» It is better to cannibalize yourself than allow competitors take the share of the market. «

Conclusion

To sum up, the new method constitutes a useful management tool for assessing the success of pioneering innovations, and this already shortly after introduction (i.e. when only few post-introduction data points are available). The time-varying decomposition allows for the generation of several key insights.

> *Identification of sources of demand across categories*

In this and other cases in which a radical innovation is difficult to assign to one category a priori, the method can provide real-time information in which category cannibalization and brand switching rates are the strongest. Knowing the source of demand for new products is crucial for the evaluation of new products' ultimate success. The new approach decomposes the demand for a pioneering innovation into cannibalization, brand switching and primary demand expansion. Demand effects can be assessed across multiple categories and within- and across-category cannibalization as well as brand switching can be distinguished.

> *Estimating and evaluating additional net sales for a brand*

Managers of the pioneering brand can use the proposed approach to evaluate the net sales of the new product, after accounting for within- and across-category cannibalization. The Lexus case results show that 26 % of its sales (or 62 weekly units in the Californian sample) were drawn from Lexus' Luxury Sedan sales. While this number may look quite large, this "sibling rivalry" was actually a small price for Lexus to pay. Indeed, management felt that without the RX 300 introduction, 15 % of their Lexus Sedan owners would have defected anyway to the SUV category. This loss corresponds to approximately 30 units ($= 0.15 \cdot 197$). As such, the "net" cannibalization becomes much smaller (i.e., $62 - 30 = 32$ units), especially in light of the 88 units of brand switching, and the 85 units of primary demand expansion. So, offering a model of their own actually prevented Lexus customers defecting to another brand. This is in line with Steve Jobs' iPhone considerations cited at the beginning: it is better to cannibalize yourself than allow competitors take the share of the market.

> *Observing sustained effects*

In contrast to short-term effect models used in promotion research, the new model considers the time-varying long-term decomposition of the demand for the new product by finding a solution for the frequently encountered problem of missing when a longer time span is observed. It looks beyond instantaneous effects and rather considers how the effects of marketing investments persist over time.

> *Exploring competitive options*

The results are generated while controlling for the own- and cross-marketing mix effects. Managers of competing brands may therefore use the method to assess the extent to which their products (across different categories) are affected, and how they may recoup potential losses. Moreover, management may also learn about the ability of new products to generate new (primary) demand.

> *Predicting the cannibalization effect*

The model updates the size of the cannibalization effect on a week-by-week basis. Every week, it gives a one-week forecast of the effect based on the most up-to-date information. However, the model in its current form is not suited for predicting the cannibalization effect prior to the introduction of the new product. The issue is that the extent of cannibalization will depend to a large extent on the similarity to the extant products within the company's own line and competitor products, on which we lack data. If similarity data were available (based on expert judgments, for instance), it would be feasible to augment the model in order to predict the anticipated cannibalization effect. •

FURTHER READING

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