

The Dirichlet's Buyer Behaviour Assumptions Really Do Matter

Byron Sharp
Director

Carl Driesener
Research Associate

Marketing Science Centre
University of South Australia

Abstract

When reliable models do not fit observed data it tells us that some condition in the market violates the underlying assumptions of the model – and this can be very useful information indeed. The Dirichlet model of repeat-purchase has been validated over a very wide range of conditions, across countries and time. The model has been so successful that we know of no published incidences of the model's failure. Which raises the question of whether the model is too robust to be used to detect anything other than major deviations from its assumptions about buying behaviour? In this exploratory research we examine this issue by applying the model to a situation with some known violations of Dirichlet's underlying assumptions – specifically a market with some in-built variety seeking (a degree of purchase feedback), some functional differences between brands and a degree of brand level segmentation. The results show an uncharacteristically poor fit for the Dirichlet, and the brand level deviations appear to be directly explainable by the violations to the model's assumptions.

Introduction: When a Good Fit is Not Always a Good Thing

Marketing scientists aim to develop *reliable* models, ones that have been tested and shown to yield accurate estimations in a wide range of circumstances. Somewhat paradoxically, however, if a model always fits then its estimations tell us little that we did not already know from our observed data. Finding boundary conditions for reliable theories is an important part of the development of scientific knowledge (Wright and Kearns 1998). The failure of a reliable model can provide some very insightful information; it shows that the particular circumstances violate one or more of the model's underlying assumptions. This is true only for reliable models, ones that have been found to routinely fit the observed data; models that seldom fit are just poor models with very little practical value.

We have extremely few reliable models in marketing, few of our models have ever been exposed to tests across a wide range of markets and even fewer still have survived such tests. The Dirichlet model of repeat-purchase behaviour stands out as probably the most widely validated model (Uncles et al. 1995). The Dirichlet model of repeat-purchase has been validated over a very wide range of conditions, across countries and time (see Table 1 below) (Ehrenberg and Uncles 1999). Recently, it has been found that the model even performs well under non-stationary conditions, that is, new brand launches (Ehrenberg and Goodhardt 2000; Wright and Sharp 1999). The model has been so successful that we know of no published incidences of the model's failure. Every successful prediction, by Dirichlet, of a particular brand performance measure has been said to be a test of the model's underlying individual-level theoretical assumptions (Ehrenberg 1994) – but how severe a test? The question arises concerning whether the model is too robust to be used to detect anything other than major deviations from its assumptions about buying behaviour. If this were true we feel that it would be a major shortcoming - it would certainly limit the wider implications that have been drawn from Dirichlet's widespread good fit – eg that brand level segmentation does not exist, that advertising works mainly to reinforce existing propensities.

Table 1: Varied Conditions for Dirichlet-Type Patterns

Products	Services
50 Food, Drink, Cleaners, and Personal Care Products.	Retail Stores and Chains (incl. for Womenswear).
OTC Medicines, Prescription Drugs.	Brands within Stores.
Gasoline, Aviation Fuel, Cars, PCs, R-t-m Concrete.	TV Programs and Channels.
Brands and Variants	Time, Space, and People
Large and Small brands;	Different points in time, 1950-2000.
Pack-sizes; Flavors;	Different-length analysis-periods.
Private labels;	Britain, USA, Japan, Germany, Australasia, etc.
Price Bands.	Light and Heavy Buyers; Demographic subgroups.
	Household or individual purchases.
Market Conditions	
Near-steady state and non-partitioned markets.	
Dynamic markets for loyalty measures.	
Within partitioned sub-markets.	

In this exploratory research we examine this issue by applying the Dirichlet model to a situation with some known violations of Dirichlet's underlying assumptions.

Dirichlet's Underlying Assumptions

The Dirichlet model of repeat-purchase was first fully documented publicly in 1984 (in Goodhardt et al. 1984), it is a stochastic model that specifies probabilistically how many purchases each buyer makes in a particular time period as well as specifying the probability of each brand being bought on each purchase occasion.

Dirichlet is underpinned by the assumption that each buyer has steady propensities to buy any particular brand (different propensities for different brands). While these propensities are assumed static there is assumed to be great variation between buyers in terms of these propensities (which are reflected in the brands they buy, ie the repertoires they hold) and their purchase frequencies.

The Dirichlet's assumptions (for a full discussion see Ehrenberg 2000) mean that the model applies to markets which exhibit two characteristics: (1) they are under stationary or "no trend" conditions and (2) the different brands show no special groupings, ie no market partitioning. It is an interesting discovery, surprising to many people, that so many markets apparently exhibit these characteristics. The reason why Dirichlet type markets must be stationary and non-partitioned is that non-stationary conditions would result in changes in individuals' purchase propensities, and partitioning would violate the assumption of a Dirichlet distribution of purchase probabilities.

The latter condition of there being no partitioning often seems unreasonable to marketers, which is perhaps a reflection that marketing textbooks strongly imply that particular brands appeal to particular and distinct customer groups. The reality is that brands within competitive product categories appear to be close substitutes (branded versions of much the same product). Market partitioning tends to be the result of major functional differences/similarities between brands or distribution differences (Ehrenberg 2000).

The Empirical Test - a market with some known violations

We knew of a repeat-purchase market which was somewhat unusual, it was our colleagues' decisions on where to lunch each day. We collected data on this market via an Internet delivered Java-based survey that all 15 members of our central office could access without difficulty. All respondents were sent a reminder email with the URL for the survey at 2.00pm each working day. The data was collected over a period of 39 days beginning in late November, 1999.

This market clearly was a repertoire market with most people buying from a range of cafes, pubs, or restaurants, or bringing lunch from home, and purchases restricted to a limited range of brands (essentially those establishments within walking distance). It also had no reason to believe that the market was not stationary, the brands were not changing much or offering new incentives, and we were eating lunch in the same frequency as always (once a day). But this market did have the following unusual characteristics. We were able to observe these differences at close-hand during the data collection - particularly because we ourselves were part of the buying panel.

Very frequent buying - This is an interesting feature of the market though is not a violation of Dirichlet, and Dirichlet patterns have been observed in other very frequent purchase markets (see Stern and Hammond 1997). The high number of observations helps to remove sampling error.

Some group buying - Lunch is often a social event. Meaning that the brand choice decision will often be a group one, though of groups of varying size. We think that this might have two effects: (1) certain restaurants will be favoured for those occasions that a really large group lunches together, eg those restaurants that can seat everyone and/or that offer a wider variety of dishes (or at least dishes that are attractive to a broader audience), and (2) group buying will increase the average size of repertoires in that it will take some buyers to restaurants that they otherwise might not go to.

Variety seeking - We observed a degree of variety seeking. Some buyers were reluctant to go to a restaurant that they had been to yesterday ("but I had pizza yesterday, let's go to the pub instead"), ie a temporary form of purchase feedback. Another form of variety seeking was to not allow restaurants to drop of the repertoire - "let's go to X - we haven't been there in ages". The overall effect of these forms of variety seeking would be, we think, to increase the average size of people's repertoires.

Some segmentation - We noted that a few brands were distinct in that they were highly favoured by some buyers but largely shunned by the majority. Two buyers were largely solely loyal to buying sandwiches from the local deli, one small group would go almost every Wednesday to the local Hari Krishna café.

Some large functional differences between brands - Unlike typical brands the choice options for lunch did feature some obvious functional differences in restaurant size, ambience, distance from work offices, and, of course, food style (from Italian to Organic vegetarian). Perhaps surprising, prices did not vary a great deal. Normally we would expect that these functional differences would cause deviations from Dirichlet resulting in partitioning and segmentation. However, this may be countered by the somewhat natural variety seeking that occurs in food consumption.

Some distribution effects - These have been documented previously in causing individual brand deviations from Dirichlet predictions (as with other 'unavailability effects' such as fires in warehouses (Ehrenberg 2000)). During our survey one brand, *Lush for Life* (an organic vegetarian café) closed down. We expected this to curtail the level of repeat-purchase the brand could register.

Results

The following table shows brand performance statistics for all brands in the market, it compares the observed market statistics against those predicted by the Dirichlet model.

The Dirichlet model shows an unusually poor fit. The mean absolute deviation for penetration predictions is 12 percentage points, where the Dirichlet typically fits to within a percentage or so. This poor fit appears to be due to the violations in Dirichlet assumptions we identified *a priori*.

Table 1: all brands, 39 days, 388 purchases

Brand	Market share (%)	Penetration (%)		Average Purchase Frequency		Share of Requirements (%)		Sole Buyers (%)	
		Obs.	Pred.	Obs.	Pred.	Obs.	Pred.	Obs.	Pred.
Any (used for fitting)		100	100	25.9	25.9	100	100	0	0
World's End	13	87	80	3.7	4.0	14	13	0	0
Home	12	67	78	4.5	3.8	18	13	0	0
Deli	9	40	73	6.0	3.3	24	11	0	0
Viva Vegi	8	67	69	3.1	3.0	12	9	0	0
Caos	7	73	66	2.6	2.9	10	9	0	0
Lush for Life	7	80	65	2.3	2.8	9	9	0	0
Hari's	6	47	61	3.4	2.6	13	8	0	0
Marcelina's	3	67	42	1.3	2.1	5	6	0	0
Uni Café	3	40	43	2.2	2.1	9	6	0	0
Other	31	99	94	8.1	8.5	31	31	0	1
Average		67	67	3.7	3.5	14	11	0	0
Mean Absolute Deviation			12		0.7		3		0
With Hari's and Deli removed from the calculations:									
Average		72	67	3.5	3.7	13	12	0	0
Mean Absolute Deviation			9		0.4		2		0
S= 41.2									

Segmentation Effect: Two brands stand out as major deviations: the nearby *Deli* and the *Hari Krishna* café. These both showed signs of segmentation with a small, dedicated group of buyers. As would be expected then, these brands show the classic signs of niche brands - lower than expected penetration and higher than expected purchase frequency (Kahn et al. 1988).

Functional Difference Effects: Another pattern we observe is that each of the brands that are well suited to group lunches (ie *World's End*, *Caos*, *Marcelina's*) show more penetration than predicted and less purchase frequency. This is especially true for *Marcelina's*. This is the classic 'change of pace', 'mass market' (opposite to niche) or 'deficit loyalty' pattern, and what we would expect given that a few large group lunches will drag along some buyers who would not normally favour the brand. The result is that these brands show an excess of light users. In total contrast, the 'brands' that are suited more to lunching occasions when individuals eat alone (ie bringing much from *home* and the *uni café*) showed the opposite 'niche' pattern, they had a deficit in observed penetration and excess of purchase frequency, they had a slightly heavier customer base.

Distribution Effect: We noted previously that one brand, *Lush for Life*, closed during the period. We see this effect on its repeat-purchase statistics. It shows the expected deficit loyalty pattern. Given its level of penetration it attracted an unusually low level of purchase frequency, for the obvious reason that people were unable to repeat purchase - it had closed its doors.

Variety Seeking Effect: Finally, it is worth noting the absence of the classic Dirichlet pattern, where differences in market share are mainly due to differences in penetration, not purchase frequency. Here the brands show even more variation in purchase frequency than they do in penetration. We did not expect this effect, though it is logical in light of the variety seeking (and group buying) leading to larger repertoires. In a typical grocery product repertoire market with this many purchases from the category, the average repertoire size would be only 2 or 3 brands, yet here even tiny brands were bought by nearly half of the buyers. Normally repertoire markets show low levels of solely loyal buying, in this market it is non-existent.

Conclusion

The Dirichlet is not so robust as to never be able to reveal when repertoire markets deviate from its underlying assumptions. We took a market with known deviations and they resulted in expected brand deviations from Dirichlet predictions. This test of the underpinning assumptions lends strength to the implications derived from

the Dirichlet model, and, indeed, the model itself. This research has been exploratory in nature, seeking to test the effects on the Dirichlet model of violated assumptions. As such, it represents only the beginning, and we would recommend that other research into markets with assumption deviations be conducted to further test the Dirichlet model of repeat-purchase.

References

Ehrenberg, A.S.C. (1994), "Author's Reply by A.S.C. Ehrenberg," in *Research Traditions in Marketing*, Gilles Laurent and Gary L. Lilien and Bernard Pras, Eds. Boston: Kluwer Academic Publishers.

Ehrenberg, Andrew and Gerald Goodhardt (2000), "New Brands: Near-Instant Loyalty," London: South Bank University.

Ehrenberg, Andrew S.C. (2000), "Repeat Buying Facts, Theory and Applications," *Journal of Empirical Generalisations in Marketing Science*, 5.

Ehrenberg, Andrew S.C. and Mark D. Uncles (1999), "Understanding Dirichlet-Type Markets," London: South Bank University and University of New South Wales.

Goodhardt, Gerald J., Andrew S.C. Ehrenberg, and Christopher Chatfield (1984), "The Dirichlet: A Comprehensive Model of Buying Behaviour," *Journal of the Royal Statistical Society*, 147 (part 5), 621-55.

Kahn, Barbara E., Manohar U. Kalwani, and Donald G. Morrison (1988), "Nicheing Versus Change-of-Pace Brands: Using Purchase Frequencies and Penetration Rates to Infer Brand Positionings," *Journal of Marketing Research*, 25 (November), 384-90.

Stern, Philip and Kathy Hammond (1997), "Long Run Loyalty - An Exploratory Study," in 26th European Marketing Academy Conference, David Arnott, Dr. and Susan Bridgewater, Dr. and et.al. (Eds.) Vol. 4. Warwick Business School, U.K.: The University of Warwick.

Uncles, Mark, Andrew Ehrenberg, and Kathy Hammond (1995), "Patterns of Buyer Behaviour: Regularities, Models, and Extensions," *Marketing Science*, 14 (No. 3, Part 2 of 2), G61-G70.

Wright, Malcolm and Zane Kearns (1998), "Progress in Marketing Knowledge," *Journal of Empirical Generalisations in Marketing Science*, 3, 1-21.

Wright, Malcolm and Anne Sharp (1999), "New Brand Effects in a Dirichlet Market," in 28th European Marketing Academy Conference Vol. CD proceedings. Berlin, Germany: Institute of Marketing II, Humboldt-University.