An empirical study of industrial customer buying behaviour: How airlines buy airplanes

Abstract

We show that commercial aircraft customers buy aircraft brands probabilistically and that their aggregate buying patterns conform to the well-known double jeopardy and duplication of purchase laws. This is a major conceptual contribution to the analysis of industrial buyer behavior with important implications for industrial marketing management. Analysis using stochastic models of brand choice with consumer panel data is the norm in fmcg categories, but the lack of such data in industrial markets should not be seen as insuperable; a variety of data gathering techniques make it possible to assemble sufficient data even in markets where purchases are spread out over many years. Thus our second contribution is to show that competitive market structure can be revealed by data readily available to marketing managers that can be analyzed simply, with basic analysis tool, but with profound managerial implications.

Key Words: Laws, Brand-buying, Probabilistic

Conference Track: 2B Marketing

How Airlines Buy Airplanes

1 Introduction

Over the last thirty years or so, our understanding of consumer markets, in particular fmcg markets, has been hugely advanced by the mathematical modeling of consumer choice behavior. This type of analysis, based on the NBD-Dirichlet model led to the formulation of well known empirical generalizations in marketing, such as the Double Jeopardy Law (DJ) and the Duplication of Purchase Law (DoP) (Goodhardt, Ehrenberg & Chatfield, 1984). In this paper we show that these laws also apply to an industrial market. The extension to such markets has been attempted only a few times before, e.g. ready-mix concrete (Pickford & Goodhardt, 2000) aviation fuel (Uncles and Ehrenberg 1990), prescription pharmaceuticals (Stern, 1994), and B2B services (Bowman & Lele-Pingle, 1997). The current study is the first to analyze the complex and drawn-out buying decisions for commercial passenger aircraft.

At first sight, the passenger aircraft market looks very different to fmcg markets:

1. The purchasing process is drawn out, from order to delivery often taking 5 years or more,
2. Final prices and service components are subject to protracted negotiation at every stage,
3. Planes are purchased in stages--from order, to firm order, to secured finance (often based on long-term leases, or lease-to-own contracts) to delivery,
4. Contracts vary from one-off purchases to lots of 50 or more aircraft,
5. Buying centres are structured according to the volume and types of planes being purchased and the company's philosophy about cost management.
6. Buying takes place within an intricate network of participants who make, maintain, service and sell planes and components, continuously updating them over a 30 year life.

These factors may lead to the presumption that models of buyer choice behavior, proven in consumer markets cannot be applied. In addition, a few large airlines (heavy buyers) have chosen to buy from only one supplier, which almost never happens in consumer markets (Uncles Ehrenberg & Hammond, 1995). However, in common with fmc, the aircraft market does have many customers who choose from a number of similar and closely competing brands, and these customers have ongoing needs for products to both maintain capacity and to add to it, and so they make repeated purchases over time. These qualities make it possible to conduct a probabilistic analysis of buying behavior—provided there is appropriate data.

Thus, this study seeks to show that brand buying patterns in fmcg markets can also seen in industrial markets. These include: a) customers allocating purchases across a number of suppliers simultaneously, b) standardized product classes across brands that make it rational to choose one brand or another amongst very similar offerings, and c) repeat purchases spread stochastically over the long term.

We do not address the extent of the differences between organizational buying behavior and consumer purchasing, but previous work by McCabe & Stern (2009) presents a theoretical framework to investigate the common ground between stochastic modeling and industrial network theory, demonstrating that the two approaches offer complementary insights. Here we follow a recommendation from that paper to show that industrial buyer behavior can be represented in a stochastic manner.

2 Method and Data

There is a saying in the transport business that if it floats or flies, you should rent it—there are ruder versions of this epigram—hinting that airplanes are not like household goods.

The perennial problem for airlines is lack of cash and therefore many purchases are 'finance leases' with complex funding and ownership arrangements. Altogether the 800 or so airlines buy about 1,900 new aircraft per year (Boeing estimate, 2015) with about 30% 'bought' on lease contracts, many by leasing companies such as AerCap, and GECAS, which are included here as customers because they initiate purchases and accept delivery of new aircraft.

The major barrier to modeling industrial buyer behavior is the lack of systematic data about customer purchasing. Fmcg markets rely on consumer panel data—which is clearly not available in most industrial markets. Instead, we use data from records of delivery of aircraft to final customers. Measuring buying in this way is necessary because many aircraft contracts are cancelled before delivery—for any number of reasons, e.g. the economic crisis of 2008 led to 20-25% of all orders being cancelled; the 2010 eruption of an Icelandic volcano cost airlines about $1.7billion (IATA, 2011), leading to a number of cancellations. In this study we therefore count deliveries as the consummation of the purchase process.

The data come from a variety of sources; the main ones being organizations dedicated to the practice of plane-spotting (planespotters.net) to whom we are deeply indebted. Plane-spotters are diligent data trackers and their data has been verified against manufacturers' data where possible. The data here covers deliveries of new planes to the world's 51 largest customers from June 2005 to June 2015. It includes 9,214 purchase records, which represent about 80% of all commercial airliners sold during that time. The data was then used to generate descriptive statistics for observed and theoretical values for standard brand performance metrics (BPMs).

3. Summary of brand performance measures

Overall, observed purchases and predicted values agree closely. We see in Table 1 that aircraft brands differ greatly in both market share and penetration. While the brands have very different numbers of buyers (penetration) these are in line with their market shares (from 46% down to 3%). Overall, the observed and theoretical penetration values are very close (r = .99).

Table 1. Model theoretical estimates compared to observed metrics

Commercial Aircraft brand	Market Share %	Penetration (observed) %	Penetration (theoretical) %	Purchases per buyer (observed)	Purchases per buyer (theoretical)
Boeing	46	86	85	101	97
Airbus	43	82	81	95	94
Canadair	4	18	18	47	41
Embraer	4	16	16	37	34
Other	3	16	16	31	30
Average Brand	20	44	43	62	59

As with penetration, the number of purchases per buyer varied with the size of the brands. However, the degree of variation was smaller—the largest brands got 3 times the number of purchases of smaller brands, but 5.4 times the penetration level of the smallest. These systematic variations are consistent with general findings about Double Jeopardy (DJ) that say that compared to a large brand; fewer customers buy a smaller brand less often.

Table 2 shows BPMs that are routinely calculated for consumer goods markets. In the first column we see that on average 7% of plane buyers were loyal to a single brand of aircraft for the past 10 years—in fmcg categories 10-20% of buyers buy only one brand over the space of a year (Uncles, Ehrenberg & Hammond, 1995). The second column shows the portion of sales accounted for by the top 20% of customers—and the 56% average level is in

line with other categories (Romaniuk & Wight, 2015). So too is share of requirements, which is the portion of each aircraft buyer's requirements fulfilled by the bought brands. Finally, the portion of buyers who bought only one plane from a manufacturer during the ten years shows a distinct double jeopardy effect, as does the final column showing that buyers make more purchases over the time period from the bigger brands—again, a double jeopardy effect.

Table 2. Brand performance measures vary systematically with the size of the brands.

Commercial Aircraft brand	100% Brand loyal %	Pareto Share (observed) %	Share of requirements (observed) %	Once only buyers (observed) %	Purchases per buyer (observed)
Boeing	14	53	53	0	95
Airbus	7	43	53	3	95
Canadair	0	85	24	11	46
Embraer	13	35	28	12	46
Other	0	63	17	12	21
Average Brand	7	56	35	7	61

3.1 Customers shared between brands

The competitive structure of the market is shown in a duplication of purchase analysis (Table 3). Reading across reveals that 84% of Boeing's customers also bought Airbus, 11% bought Canadair and Embraer, and 18% bought Other (a composite of several small brands). The same holds for all brands—duplications decline with the size of the brands, arranged by size from left to right and top to bottom. Reading down the columns the numbers are broadly similar—so Boeing attracts a similar portion of customers from each other brand, as does every brand. This fits with the Duplication of Purchase Law (DoP) which says that buyers of a brand also buy other brands in line with the size of the other brands, i.e. all brands share customers, but they share more with the bigger brands than with the smaller ones.

Table 3. Duplication of Purchase for customers of aircraft brands

Buyers of	Who also bought				
%	Boeing	Airbus	Canadair	Embraer	Other
Boeing	-	84	11	11	18
Airbus	90	-	10	14	19
Canadair	56	44	-	33	33
Embraer	50	63	38	-	25
Other	100	100	38	25	-
Average Duplication	74	73	24	21	24

Some deviations in the table stand out—100% of the customers of Other also bought Boeing and Airbus, but this can be explained by the presence of declining brands amongst 'Other' such as McDonnell Douglas, which was phased out as a brand by 2009, so the buyers of MD aircraft shifted their purchases of large aircraft to Boeing and Airbus.

We can examine the sharing of customers across brands further by using the Duplication of Purchase Law equation:

1. Duplication of purchase, $b_{y|x} = Db_y$

Where $b_{Y|X}$ is the percent of buyers of X who have also bought Y; b_Y is the percent of the

population who have bought Y and D is a constant known as the duplication coefficient. We calculate the value of D = .99. In other words, the buyers of one brand are just about equally likely to buy any other brand. We then use D times the penetration of each brand to work out the predicted duplication level and compare that to the observed level. Table 4 shows the deviations of actual from expected levels of duplication making it immediately apparent that buyers of Canadair and Embraer buy from Boeing and Airbus less than expected, and Boeing and Airbus buyers buy less than expected from Canadair, Embraer and Other.

Table 4. Deviations show that brands share customers more and less than expected

Deviation from predicted duplication					
	Boeing	Airbus	Canadair	Embraer	Other
Boeing		3	-7	-5	2
Airbus	5		-8	-2	3
Canadair	-29	-37		17	17
Embraer	-35	-18	20		9
Other	15	19	20	9	

These deviations are an indication of partitioning in the market. In this case, it is based on aircraft size. Boeing and Airbus make larger planes with capacities of 120 to 450 seats, sold mostly to airlines with intercontinental routes. Canadair and Embraer make planes with capacities of 80 to 150 seats, bought mostly by airlines with regional route networks. Thus the structure or partitioning in the marketplace has a functional basis—as is the norm in fmcg markets (Ehrenberg, 1995).

The deviations can be summarized by calculating the duplication coefficients for each pair of brands, and then aggregating based on aircraft size. Table 5 shows that buyers of large planes are more likely to buy other large planes (D = 1.1) than small planes (D = 0.7). In the same manner, buyers of small planes are more likely to buy other small planes (D = 1.8).

Table 5. Duplication Coefficients show partitioning

D-values		
	Large Planes	Small Planes
Large Planes	**1.1**	0.7
Small Planes	0.7	**1.8**

4 Implications for marketing management

Marketing managers face a complex, self-organizing business network (Ritter, Wilkinson & Johnston. 2004, McLoughlin & Horan, 2002) but from a probabilistic modelling perspective, brands differ much less in terms of loyalty measures (purchase frequency, share of category requirements) than in market share and penetration. This suggests that the path towards growth (and maintenance) lies in marketing interventions that improve penetration and market share, and not trying to affect either loyalty or the buyer's on-going purchase incidence or supplier choice probabilities (Ehrenberg et al. 2004). Pickford and Goodhardt (2000) also suggest that industrial marketing interventions should focus on keeping the brand in the repertoires of polygamous customers.

The predictive power of stochastic models of buyer behavior provides a rich context to study how buyers and sellers interact, e.g. a marketing manager can compare actual behavior in the industrial network relationship against the probability of a repeat purchase being made (Ehrenberg et al. 2004). An analysis of buyer behavior using stochastic modelling techniques allows an account team to estimate the expected probability of making a successful sale

against an incumbent competitor. This can then be used to inform strategic decision-making, for example the selection of new target customers.

While some companies take singular strategies—the sole brand buying by some low-cost airlines whose relentless focus on cost reduction drives them to streamline the acquisition process to one supplier—is one example. This is an economic decision most buyers do not take, most would rather have rivals compete for their business (the average number of suppliers was 2.3). If the frequency of purchase does not vary much between suppliers, then strategies to increase "share of wallet" by encouraging existing customers to buy more of the same product are unlikely to be successful. Companies wanting to grow in such markets would be well advised to focus on increasing market share by acquiring new customers and increasing penetration (Uncles & Ehrenberg 1990).

7. Conclusions

We show in this paper that the competitive structure of the commercial aircraft market is quite simple and familiar: a) the numerical patterns in Table 1 and 2 are regular and are much the same for the different brands except for a market share effect (DJ), b) Most customers have two or more suppliers and if suppliers operate to similar cost functions and negotiate similar contracts, the likely outcome is an as-if-random buying pattern of purchases, with contracts spread across different suppliers, c) These patterns closely resemble those found in a wide range of fast-moving consumer goods and also durable goods (Bennett & Graham, 2010) and conform to the double jeopardy law and the duplication of purchase law.

This may be surprising, given how vastly different the commercial aircraft market is to most consumer markets. And while other industrial markets may be even more different, e.g. one-off capital purchases, in as far as the buyer is dealing with nearly interchangeable items, where it is common to have a range of suppliers and the products or services are purchased frequently, then buyers will develop routines to simplify the repetitive choice-situation such that similar patterns to the ones observed here should be expected.

The competitive structure in the market also suggests that competitors will seek to enter via the more competitive, smaller aircraft subsector, and not just because development costs for smaller planes are less, but because customers are more inclined to buy from multiple suppliers. Indeed Comac of China is introducing a 160-seat plane in 2016 to compete directly with Boeing and Airbus as well as Canadair and Embraer. It has 517 orders so far. Bombardier will introduce the 150 seat C100 series in 2016 and has 243 orders. There are also Russian airlines ordering the 150-220 seat Irkut MC21 series. In response, the existing suppliers have a variety of strategic responses they could make, but given the nature of the marketplace, they would be best served by seeking to gain as many different customers as possible, rather than focusing on any one customer regardless how big they are.

This research makes an important contribution to modeling purchasing behavior for industrial goods, showing that an empirically-grounded approach using laws validated repeatedly in fmcg markets can help to clarify competitive market structure, and thereby help managers in their strategic decision-making. In addition, such analysis can be performed on readily available marketplace data, and manipulated with simple tools and off-the-shelf software.

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