A Latent Class of Model for the Competitive Structure of the French Automobile Market

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Introduction

Marketing researchers have recently used latent class models to identify the competitive structure of brands within a product market (Grover and Srinivasan 1987, Jain, Bass and Chen 1990). These models provide the following information:

1) Number of consumer segments in the product market,
2) The sizes of the different segments and the extent of heterogeneity (in choice probabilities) in these segments.
3) The brands that dominate each segment and also characterize the underlying segment.

These results are obtained under the assumption that (a) consumers follow a zero-order choice process in each segment and (b) the vector of choice probabilities is Dirichlet distributed in each segment.

The above information has substantive implications for a product manager. It can be effectively used in developing marketing strategies in areas such as product policy, advertising and sales promotion, and pricing.

We discuss below the results obtained from an application of the latent class model to analyze the nature of competition among automobiles in the 1989 French market. The details of the model and estimation procedure are available in Grover and Srinivasan (1987) and Jain, Bass and Chen (1990), and Jain and Rao (1991).

Results and Discussion

The first part of the empirical analysis is determining the number of segments. As discussed in Jain, Bass and Chen (1990), this is obtained from a factor analytic procedure. For the French automobile data, this yielded 6 segments. Having determined the number of segments, the 6-segment solution obtained from estimating the parameters of the latent class model (using the MLLSA program of Clogg 1977) is presented in Table 1. The values of the two commonly used goodness of fit measures for a latent class model are $\overline{R}^2 = 0.96$ and $\Delta = 0.078$. The former measure is analogous to the adjusted R^2 in a regression model. The latter represents the index of dissimilarity between the observed switching matrix $\hat{P}$ (the French automobile data for 1989) and the matrix P estimated from the latent class model.

In order to get a clearer picture of the competitive structure of the French automobile market, we retained only those automobiles in a segment that had "large" choice probabilities in that segment. The results are summarized in Table 2.

We notice from Table 2 that some automobiles compete in more than one segment. Therefore, the automobile market can be interpreted as having an "overlapping" structure. The first segment consists of Citroen, Peugeot and Renault - all French automobiles, and it is largest in size (35% of the total market). It has a low heterogeneity factor, implying that the buyers in this segment are fairly homogenous in their preferences for these automobiles. Further, the choice probabilities for the manufactures are about equal in that segment. We label it as a "French automobiles" segment.

The second segment, accounting for 20% of the market, consists of GM, Peugeot and Renault. However, the two French automobiles Peugeot and Renault dominate this segment. The third segment consists of a single automobile - Renault and its size is 8%. This segment can be characterized as being "Renault loyal". The heterogeneity factor here is the lowest. The fourth segment is one that consists of Citroen and VW/Audi but it is largely dominated by Citroen whose share in this segment is about five times that of VW/Audi. That segment is fairly heterogeneous. The fifth segment of size 17% is dominated by Peugeot. The final segment accounting for 10% of the market consists of Fiat, Ford and VW/Audi and may therefore be characterized as the "Imported Automobiles" segment. The three automobiles have about the same share in that segment.

In summary, the structure of the French automobile market exhibits some very discernable patterns. First, the market is largely dominated by the French Automobile manufacturers. In five out of the six segments, consumers seem to be switching between French automobiles. Further, three of these five segments are dominated by a single French automobile manufacturer. The imported automobiles (Fiat, Ford, VW/Audi) while drawing some buyers from the French automobiles, seem to be competing more with each other.

We feel that the above discussion provides useful managerial insight into the competitive nature of the 1989 French automobile market.

Table 1: 6 - segment market: the French automobile data for 1989

SEGMENTS

	1	**2**	**3**	**4**	**5**	**6**
Segment Size	.35	.20	.12	.08	.17	.10
Heterogeneity Factor	.25	.30	.08	.63	.47	.50

WITHIN SEGMENT MARKET SHARES

Brands	**1**	**2**	**3**	**4**	**5**	**6**
Alfa Romeo	.005	--	--	--	.023	.048
BMW	--	--	--	.036	.053	.039
Citroen	**.232**	--	--	**.716**	--	--
Fiat	.103	--	--	--	--	**.224**
Ford	.049	.103	-	--	.050	**.206**
GM	--	**.141**	--	--	--	.114
Lada	--	.027	--	.030	--	--
Mercedes	--	--	--	.043	.041	--
Peugeot	**.263**	**.263**	--	--	**.501**	--
Renault	**.323**	**.367**	**.945**	--	**.211**	--
Rover	.020	--	.011	--	--	.074
Saab	--	--	.001	--	--	--
Seat	--	.037	--	--	--	.027
VW/Audi	--	.062	.043	**.147**	**.121**	**.230**
Volvo	.005	--	--	.028	--	.038

Table 2: Nature of the six segments

SEGMENT	SIZE	HETEROGENEITY	BRANDS	CHOICE PROBABILITIES
1	.35	.25	Citroen Peugeot Renault	.232 .263 .323
2	.20	.30	GM Peugeot Renault	.141 .263 .367
3	.12	.08	Renault	.945
4	.08	.63	Citroen VW/Audi	.716 .147
5	.17	.47	Peugeot Renault VW/Audi	.501 .211 .121
6	.10	.50	Fiat Ford VW/Audi	.224 .206 .230

Appendix: The Latent Class Model

Suppose the population of N automobile buyers can be grouped into L segments. Let P_{ij} denote the probability that the most recent purchase of an automobile is brand j and the previous make is i, $i, j = 1, 2...n$, where n denotes the number of automobiles in the market. Consider a randomly drawn consumer from the population. He may belong to any of the L segments. Let P_{ijk} denote the probability that the current make of his automobile is j and the previous make was i given that he belongs to the k^{th} segment, $k = 1, 2...L$. Then we can write

$$P_{ij} = \sum_{k=1}^{L} w_k P_{ijk} \tag{1}$$

where w_k is the probability that he belong to the k^{th} segment. The following two assumptions are made regarding the consumer's choice process: a) consumers follow a zero-order choice process in each segment, b) the vector of choice probabilities is Dirichlet distributed over the consumers in each segment. Using these assumptions and following Bass, Jeuland and Wright (1976) we can write

$$\begin{aligned} P_{ijk} &= (1-\theta_k)P_{ik}P_{jk} \qquad i \neq j \\ P_{ijk} &= \theta_k P_{ik} + (1-\theta_k)P_{ik}P_{ik} \qquad i = j \end{aligned} \tag{2}$$

where θ_k denotes the heterogeneity parameter for segment k and P_{ik} is the probability of choosing make i in segment k. Substituting expression (2) in expression (1), we get

$$P_{ij} = \begin{cases} \sum_{k=1}^{L}(1-\theta_k)w_k P_{ik}P_{jk} & i \neq j \\ \sum_{k=1}^{L}\theta_k w_k P_{ik} + \sum_{k=1}^{L}(1-\theta_k)w_k P_{ik}P_{ik} & i = j \end{cases} \tag{3}$$

The following conditions need to be satisfied by the parameters in (3): $\sum_{i=1}^{n} P_{ik} = \sum_{i=1}^{n} P_{jk} \quad \forall \quad k = 1,2,\ldots L\,; P_{ik}, P_{jk}, \theta_k, w_k > 0 \quad \forall\ i, j, k$. Equation (3) together with these conditions represents the latent class model (Goodman 1974). The parameters θ_k, w_k, P_{ik}, P_{jk}, $i,j = 1,2,...n$ and $k = 1,2,...L$ is estimated using the procedure described in Jain, Bass and Chen (1990).