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ADVERTISING'S EFFECT ON THE PRODUCT EVOLUTIONARY CYCLE

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ADVERTISING'S EFFECT ON THE PRODUCT EVOLUTIONARY CYCLE

ABSTRACT

Criticism of the product life cycle (PLC) concept concerns problems with theory, empirical validation, and practical use. It has been suggested that the product evolutionary cycle (PEC), an alternative concept based on the field of biology, provides a more complete picture of marketing mix effects and competition on product sales (Tellis and Crawford 1981). In this research, the U.S. cigarette industry is used as the arena in which to assess empirically the PEC framework. Advertising-sales causation is tested on three levels of segment competition: (1) individual brand (2) intracategory, and (3) intercategory competition. Our findings indicate that more distantly related "organisms" compete as well as those closely related in terms of background. Specifically, we demonstrate a gradual but marked decrease in the effect of advertising on sales as products with more distant lineage co-exist and compete. The PEC is demonstrated to be an information-laden framework to use in making marketing mix decisions.

ADVERTISING'S EFFECT ON THE PRODUCT EVOLUTIONARY CYCLE

INTRODUCTION

The Product Life Cycle (PLC) has been used by marketing researchers in the context of product management and strategic planning. As Kotler (1988, p. 394) writes in his marketing management textbook, "The product life cycle is an attempt to recognize distinct stages in the sales history of the product. Corresponding to these stages are definite opportunities and problems with respect to marketing strategy and profit potential." Although decision variables are not explicitly incorporated in the framework, different levels of marketing, finance, and production effort are required in each of the four stages of the life cycle (Kotler 1988). The reader is encouraged to see Tellis and Crawford (1981) and Day's (1981) introduction to a special *JM* issue on the product life cycle for comprehensive presentations of its application.

Despite its pervasive use and the empirical evidence that supports the PLC, there are those who doubt its validity. Tellis and Crawford (1981) cite problems involving theoretical, practical, specification, and empirical aspects of the life cycle idea.

Much criticism has been leveled at the managerial applicability of the concept (Dhalla and Yuspeh 1976; Hunt 1976). Among the most crucial is that controllable marketing variables, competitive information, and other important environmental factors are omitted from the PLC (Wind and Claycamp 1976). Other problems or limitations cited with respect to the life cycle concept include the lack of empirical validation and uncertainty regarding the aggregation level (product, class, form, or brand) at which it applies (Polli and Cook 1969; Rink and Swan 1979). Additional limitations are cited in a recent paper by Lambkin and Day (1989) on the ecological aspects of competitive structure.

Recognizing the need for a broader framework pertaining to product growth, Tellis and Crawford (1981) drew from concepts in the field of biology to suggest an alternative to the PLC concept, the Product Evolutionary Cycle (PEC). The authors describe the PLC as an "oversimplification" of the more diagnostic PEC, which models product evolution as a function of three underlying forces: (1) market dynamics (actions of consumers and competitors), (2) managerial activity (promotional themes and changes), and (3) government mediation.

It is our purpose in this study to perform the first empirical investigation of the evolutionary cycle. To accomplish this, we assess the impact of the three evolutionary forces on closely and more distantly-related "species" or products. Of specific interest to us in our empirical test are sales response factors including promotion, competitive reaction, and product segmentation in the context of advertising-sales causality. Our research focuses on a product category in which a clear evolutionary path of distinct subcategories or forms can be identified. This dynamism at the category, form, and brand levels allows for a unique investigation of causality and the relationship between advertising and sales within and among product subgroups. Our product setting is analogous to biological evolution in which competitive relationships between organisms of the same species and more distantly related members of a family or genus may be assessed.

Our research findings have important methodological and managerial implications. From a methodological perspective, the study recognizes the existence of causality in an evolving market. Managerially, our research provides guidance for strategic decisions associated with product management over time, based on our investigation of advertising-sales causality over product evolutionary cycles. Specifically, this temporal evolution effect, which is captured by the relationships between "species" or products with longer lineage and newer additions to the product line, is shown here. Above all, we demonstrate the value of the PEC and the use of genetic concepts in recognizing and assessing the source of competition among products over time.

Our presentation is organized in the following manner. We begin with a review of the relevant literature pertaining to the biological sciences, evolution theory, and analogous issues in marketing. Also included is a discussion of marketing effort results, particularly the relationship between advertising and sales. This is followed by a description of the industry of focus, in which we detail the PEC and its applicability. Research hypotheses are presented, followed by our methodology, a description of our analysis plan, and reporting of results. We conclude with a discussion of research implications, caveats, and future topics to be investigated.

THE PRODUCT EVOLUTIONARY CYCLE

The distinction between the PLC and the PEC may be likened to that which distinguishes the literal Biblical view of creation from Darwin's theory of organic evolution introduced in the late 18th century. The former contends that the world was created by God and has remained essentially unchanged since the time of creation and will remain so until it ceases to exist. According to Darwinian theory, species evolve through a process that "...consists chiefly of adaptive radiations into new environments, adjustments to environmental changes that take place in a particular habitat, and the origin of new ways for exploiting existing habitats" (Dobzhansky et al. 1977, p. 7).

In keeping with evolution theory, life forms evolve through a process involving change which is: (1) cumulative, (2) motivated by well-defined forces, (3) directional, and (4) patterned (Tellis and Crawford 1981). In an analogous manner, products may evolve in a cumulative, patterned way. As an example, one might draw an analogy between products and the dynamic transformation of Darwin's famous finches. According to Darwin, the first finches (pioneer product) that reached the Galapagos islands were able to increase rapidly in number because of the lack of competition for food (consumers). The increasingly larger finch population soon outstripped the supply of seeds (saturated market), thus causing more birds to seek alternate food sources such as insects, leaves, or fruit (market segmentation). Natural selection allowed proliferation of finches with an appropriately modified beak (product development or product line extension), and ultimately a distinctive variation (Racle 1979, pp. 26-29). Like Darwin's finches, products may co-exist and have an indeterminate life in the context of the PEC.

Three forces are the basis for product evolution (Tellis and Crawford 1981). Managerial creativity in the form of strategic decision variables is the most controllable underlying mechanism. Consumer behavior and competitive actions compose market dynamics, the force that essentially allows for survival of the fittest. The third factor, government mediation, serves as a regulatory force. These three underlying forces are applicable to our industry of focus. Before discussing our research hypotheses and methodology, we provide the following description of the industry and its evolution.

1. The U.S. Cigarette Industry

Because of its unique characteristics and availability of data, the U.S. cigarette industry has been used in studies spanning many social science disciplines. Marketing-related research can be categorized as: (1) studies that investigate aspects of the advertising-sales relationship (Aykac et al. 1985, Bass 1969, Horsky 1977, Leeflang and Reuijl 1985, Schmalensee 1972, Telser 1962) and (2) research that focuses on public policy topics related to advertising (Holak and Reddy 1986; Teel, Teel, and Bearden 1979).

The cigarette industry lends itself to research on advertising and competitive topics because of its relatively pristine environment. Throughout its history, the "Big Six" firms [R.J. Reynolds, Philip Morris, Liggett and Myers, American Brands, Brown and Williamson (BAT Industries, Inc.), and Lorillard (Loews Corp.)] have dominated the industry. To illustrate this, Horsky (1977) indicated that the combined sales of these six competitors in 1966 comprised

99.7% of total industry sales. Although relative market shares may change somewhat, the overall domination of the "Big Six" has remained a fact of the competitive environment.

During the first half-century of the industry's existence, each company promoted only one or a few reliable brands (Overton 1981, Tennant 1950). Even up through the early 1950s there were only a handful of brands from which to choose. We will discuss later how this reliance on a small number of choices ended. The industry eventually evolved into one of many brands, each possessing a relatively small market share (Horsky 1977).

Because of the relative homogeneity of prices and distribution policies across brands at any given point in time, the industry is viewed as an attractive research environment for advertising-related topics (Overton 1981, Telser 1962, Tennant 1950). According to Tennant (1950, p. 5), "The major cigarette industry companies compete among themselves by means of heavy advertising expenditures. The leading brands are usually sold at identical wholesale and retail prices, and the former may stay unchanged for years at a time. It is unusual for price to be used as a competitive weapon." In addition, Telser (1962) notes that the industry represents a prime example of the use of advertising as the key competitive weapon in its role as a barrier to entry for new firms. Thus, we are able to concentrate on one managerially controllable variable in our study of the PEC's mechanisms.

Health-related information "shocks" that occurred in 1953 and 1964, as well as the ban on broadcast advertising effective January 2, 1971, also make the cigarette industry an attractive topic for public policy research (Holak and Reddy 1986, Ringold 1987). It was this negative publicity that served as a catalyst for much of the industry evolution and specialization that is a fundamental part of the present study.

Once pre-rolled cigarettes began to be produced by the "Big Six" in the mid- to late nineteenth century, companies typically offered one non-filter product. According to Tennant (1950), the success of early products like Camel was due to the appealing blend of tobacco leaves featuring "Turkish taste" and "Virginia lightness." There was no need for innovation in the industry.

With the first major pronouncements about health hazards in 1954, however, the situation changed. Filter cigarettes experienced a meteoric rise in popularity (Overton 1981). For example, the current leading filter product, Marlboro, soon outsold the prominent non-filter brands, Lucky Strike and Pall Mall. Although they existed earlier, menthol filters contributed to the major sales growth in the industry during the 1960s. Similarly, the innovation for the 1970s following the advertising ban was the low-tar/low-nicotine product. Although some brands of this type existed earlier, they failed to gain much attention until the 1970s (Overton 1981). Product development in the high nicotine categories effectively ceased. Other recent cigarette innovations include products such as Virginia Slims and Eve targeted at female smokers, ultra-low-tar cigarettes, the generics, and most recently, the "designer" category (e.g., YSL, Ritz). For the first time, price became somewhat of a competitive element in cigarette purchases with the advent of generics. Figure 1 depicts the evolutionary process just described. Our discussion turns to evolution theory and its application to product settings.

Insert Figure 1 about here.

<u>2. An Industry Application of the PEC</u>

A process familiar to evolutionists is the taxonomy or categorization of organisms according to their common background. Principal taxonomic hierarchies from most general to most specific include: (1) kingdom, (2) superphylum, (3)phylum, (4) class, (5) order, (6) family, (7) genus, and (8) species (Dobzhansky et al. 1977). According to the same authors, "If a classification is to reflect evolution, all the members of a taxon should be closely related and descended from a common ancestor" (p. 234). To further illustrate application of evolutionary theory to product settings, Table 1 contains taxonomic categories with a biological example and an analogous hierarchy for cigarettes.

Insert Table 1 about here.

One reason for considering taxonomic hierarchies is to identify competing organisms. For example, because of a common heritage, the Monarch butterfly is more likely to compete for food and resources with members of its own species or with other types of butterflies than with other more distantly related insects or animals (Dobzhansky et al. 1977, pp. 233-241). Analogously, the more closely related product "species" compete for resources (customers). For example, menthol filter cigarette brands such as Salem and Kool may be more likely to compete with each other for consumers than with a non-filter product such as Pall Mall. To some extent, of course, all creatures compete for some food resource just as non-comparable products (such as VCRs and vacations) compete for consumers' (entertaining) budgets.

Recall that Polli and Cook (1969) investigated the appropriate aggregation level of the PLC curve by studying cigarettes at the category, form, and brand levels. They concluded that the form level was the only aggregation option to hold true to the shape of the PLC. Actually, the life cycle applied to non-filter cigarettes, which as a sub-category essentially ceased development because of publicized health concerns. Filter products, on the other hand, have evolved through adaptive radiations into several other sub-categories. In comparing the two concepts, the PEC describes this phenomenon much better than the PLC. The evolutionary tree in Figure 2 illustrates the PEC in terms of filter forms. Unlike non-filters, which spawned only the soon-to-be-extinct high nicotine category, filters have radiated into several distinct forms.

Insert Figure 2 about here.

The three evolutionary mechanisms for survival and selection that apply to managerial settings appear in Table 2. Species evolve or become extinct through genetic, natural, or artificial selection (Minkoff 1983). Genetic selection reflects the species itself as stronger members survive and their traits are passed on. External environmental factors such as limited food resources and their roles in evolution are reflected in natural selection forces. Finally, the role of man in biological evolution in terms of his intervening actions is reflected in artificial selection.

Insert Table 2 about here.

From a business/marketing perspective as noted in Table 2, internal managerial effectiveness is analogous to genetic selection in biological evolution, since a manager's actions determine product offerings. In terms of the U.S. cigarette industry, the decision-making includes a brand's advertising activity, new product development, and other marketing mix variables. Similarly, external market variables in the form of competition and other externalities are likened to natural selection pressures. Among tobacco industry participants, natural selection is reflected in new competitive entries, competitive actions, and primary demand. Governmental mediation is analogous to the artificial selection forces in the natural sciences. Interventions in the form of the 1971 ban on broadcast advertising, consumerism, and medical announcements by various agencies linking smoking to ill health serve as artificial selection forces in the tobacco industry.

AN EMPIRICAL TEST OF THE PEC FRAMEWORK

Recall that our main purpose in this research is to investigate the impact of the three evolutionary forces of the PEC on products which are closely or more distantly-related in terms of genetic heritage. Analogous to ***genetic selection*** having an impact on a species is the effectiveness of brand-level advertising decision-making within the ranks of the major cigarette manufacturers. An additional aspect of genetic selection is new product activity consisting mainly of brand extensions in this industry [e.g., package size (regular, king, etc.) and package form (hard box, soft pack, etc.)] which may be considered at the same taxonomic level. ***Natural selection*** pressures are captured by advertising-sales causality among members of the same species or product category as well as among evolving organisms (brands) in a higher taxon in an environment with declining primary demand. Specifically, cigarette brands within the same segment may compete in a manner reflected in advertising-sales causality. In addition, and perhaps of greater interest, brands in different product evolution categories may co-exist and compete in a way that is evident in intercategory causal relationships. The 1971 broadcast advertising ban on cigarettes serves as the outside force of ***artificial selection*** in the PEC. We believe that legislative intervention has an impact on all brands, although effects of the ban may vary across brands (Holak and Reddy 1986). This differential effect is allowed by the dummy variable in our analysis.

To focus and simplify our investigation of evolution in a marketing context, we have chosen to concentrate on the "fittest" brands of the tobacco industry rather than on others that have become extinct. Given the longitudinal requirement of the time-series approach, we have confined our focus to the earlier phases of product category evolution (non-filter --> filter --> menthol filter categories) as delineated in Figure 1. More recent product forms like low-tar and generics were excluded because of few observations.

1. Research Hypotheses

Much of the prior research investigating the advertising-sales relationship has focused predominantly on the advertising causes sales causality direction. Other relationships, however, have received some recognition. In their macroeconomic overview of advertising's effects, Jacobson and Nicosia (1981) indicated that four core relationships, two representing a sales response market mechanism and two feedback relationships, might be investigated. Comparatively few studies in the advertising literature have dealt with feedback effects. Bass (1969) included effects of past sales on future advertising in his simultaneous equation model estimated using cigarette industry data. In his analysis using the Lydia Pinkham vegetable compound data, Hanssens (1980a) found a sales causes advertising causal relationship. In the present study, we focus on the basic causal and feedback relationships incorporated in the sales response mechanism.

Advertising and sales are causally related through a sales response mechanism at the following three levels:

1) individual brand level (species)

2) intracategory level (inter-species or genus)

3) intercategory level (inter-genus or class).

Each level deserves further clarification prior to development of hypotheses.

Beginning at the micro-level, some causal relationships would occur between advertising and sales of an individual brand by definition. This will be explained further later in the paper. At the intracategory level, we hypothesize causal relationships to exist for sales and advertising among brands in any one category; in the present case this includes non-filter, regular filter, and menthol filter cigarette categories. At a macro-level, we consider intercategory causal relationships between brands across the three product types. The advertising-sales causal relationship and the three environmental levels are used as the basis for generation of research hypotheses. The probabilities of causation of these three levels are denoted as P_1, P_2, and P_3, respectively.

H1: Individual Brand Level Causality Exists With Some Probability $P_1 > 0$

The tradition of sales-response research supports the existence of a causal relationship between an individual brand's advertising and its own sales.

H2: Intracategory Level Causality Exists With Some Probability $P_2 > 0$

Similar to the justification for H1, an intracategory advertising and sales causal relationship is hypothesized to exist. From an evolutionary perspective, members of the same genus or family are expected to compete for resources because of their common heritage. Actions taken by one organism in the quest for food or other limited resources would have some impact on like organisms, particularly in situations of scarce supply.

H3: Intercategory Level Causality Exists With Some Probability $P_3 > 0$

An intercategory advertising and sales causal relationship is expected due to brands obtaining sales from one another in a similar zero-sum game framework. Given a fixed or declining primary demand, intercategory causality may exist as more distantly related products or "species" compete for limited resources (consumers).

H4: $P_1 > P_2 > P_3$

As one might expect based on evolution theory, individual organism or brand-level advertising and sales causality should have the highest probability of occurrence followed by intracategory (genus) and intercategory (class) levels, respectively. Most of the theoretical studies such as Moorthy (1984) have assumed the independence of segments, making the probability of intercategory competition nonexistent. Therefore, our hypothesis testing is set up to reject the null hypothesis that $P_1 = P_2 = P_3 = 0$, and to suggest such alternative values **H4: $P_1 > P_2 > P_3$** from the empirical results.

2. Data

Historical data pertaining to the U.S. cigarette industry have been collected from as early as 1923 by Schoenberg (1933). Tennant (1950) provided a comprehensive analysis of the industry's early years. Because of the dramatic changes that occurred in the industry after World War II, most research in the marketing literature involving cigarettes concerns the post-war period. The present study follows this precedent and utilizes data that span the 28-year period from 1952-1979.

Twelve cigarette brands were used as subject matter in the research. They represent a comprehensive set of the available cigarette products in the taxonomic hierarchy described in Table 1. Two brands can be categorized as non-filter products, seven are plain filters, and three are menthol filter cigarettes. The categorization described is similar to that used in prior literature involving cigarette data (Aykac et al. 1985, Holak and Reddy 1986, Horsky 1977). Table 3 contains a detailed listing of the twelve brands, their introduction dates, and periodic market shares. It should be noted that two early market leaders, Lucky Strike and Chesterfield, are no longer part of the tracked top 25 brands in the industry and, therefore, could not be used in the analysis.

Insert Table 3 about here.

It is important to recognize that the post-war drive for product innovation in the industry makes the categorization of product segments a bit blurred. Recall that many brands now exist in multiple forms as described in Figure 2. There is substantial precedent, however, to support categorization of brands according to the segment from which a brand receives the majority of its sales (Overton 1981).

3. Variable Measures

Annual sales data (in billion units) for brands in the three categories were obtained from Maxwell (1982) and supplemented by Advertising Age (1960, 1966, 1971, 1976, 1980). The annual brand advertising expenditures were obtained from Advertising Age and Leading National Advertisers (LNA) annual reports. To deflate these expenditures, annual cost indices of advertising for different media were procured from McCann-Erickson Advertising Agency for later years in the series and from Media/Scope (1968) for earlier years. With the proportions of annual industry media expenditures as weights, an overall cost index was computed that was then used to deflate the raw advertising expenditure data.

As indicated by Jacobson and Nicosia (1981), there may be limitations to using annual data in a study of this type. They maintained that annual data may not be appropriate if there are substantial fluctuations in the time series. The cigarette industry data possess many of the same attractive characteristics associated with the Lydia Pinkham data. Specifically, advertising is essentially the only marketing instrument used, price changes are small and rare, distribution is homogeneous and constant, and a long data series is available (Hanssens 1980a).

The single possible element of fluctuation in our data may be due to the 1970 ban on broadcast advertising. In a similar situation, Hanssens (1980b) used airline industry data in which an industry strike occurred as a potential impact mechanism. Given this precedent and the unavailability of cigarette industry data with a shorter interval, we felt it appropriate to use annual values.

4. Analysis

The marketing literature is replete with studies that focus on the relationship between advertising and sales. The approach taken by most researchers is an econometric one (see, for example, Farley and Lehmann 1986, Naert and Leeflang 1978, and Parsons and Schultz 1976).

Often, information about competitive market structure can be derived from the coefficients of estimated sales response models. For instance, the effectiveness of the advertising of various brands can be examined by advertising-sales cross-elasticities; significant cross-elasticity values with negative sign may indicate direct advertising competition among brands (Clark 1973, Tesler 1962; see Russell and Bolton 1988 for a discussion of price competition).

Although there are methods to deal with estimation problems, econometric studies of the advertising-sales relationship often are plagued by multicollinearity, heteroskedasticity, and autocorrelation. As a result, some researchers have turned to multiple time-series analysis (MTSA) as an alternative or complementary estimation procedure to explore this relationship

(Hanssens, Parsons, and Schultz 1989).. One advantage of MTSA used alone or in conjunction with econometric modeling compared to the a priori model specification required by a solely econometric approach is causality detection.

Several research philosophies exist with respect to the study of causality. The concept of "causality" as discussed in this paper is associated with Granger (1969) and may be expressed as follows: x is said to cause y if knowledge of past x values reduces the variance of the errors in forecasting future y values more than the knowledge of past y values alone.

To investigate the PEC framework, our analysis proceeds through three distinct phases, the first two corresponding to the Pierce-Haugh test. First, the univariate ARIMA series (Box and Jenkins 1976) is pre-whitened to eliminate systematic elements. Following this, the two residual series are cross-correlated and a related chi-square independence test performed (Haugh 1976, Pierce and Haugh 1977). Since we have 12 brands in the study, a total of 144 Pierce-Haugh tests were conducted. In phase three, aggregate chi-square values ($S_{i,j}$) were calculated based on the chi-square distribution property (Mood, Graybill, and Boes 1974). The aggregate p-value for each competition level can then be obtained. These three phases are described in the Appendix in detail.

STATISTICAL CAUSALITY RESULTS

The first stage of the PEC framework investigation involves construction of the univariate ARIMA models and estimation of the intervention effects. To check diagnostically that each residual series constitutes a white noise process, the auto-correlation, inverse auto-correlation, and partial auto-correlation functions (ACF, IACF, and PACF), available in SAS results (SAS/ETS 1984, chapter 8), were visually inspected.

Diagnostic checking has two important roles in the pre-whiting procedure; first, it assures that all systematic elements are removed and only white noise series are obtained for the next stage of the analysis; second, the chi-square values [Ljung and Box's (1978) Q-statistic] from the white noise series generally are less than the critical values which indicate the residuals are independently, identically, and normally distributed. As a result, the identified models are permissible.[1]

The results from our causality detection at the second stage of the analysis are summarized in Table 4. Advertising of the brand is listed on the horizontal axis and sales of the brand appear vertically in the table. The table depicts a 12 x 12 brand matrix that is divided into nine smaller blocks according to cigarette types. Three square matrices are contained along the 12 x 12 diagonal [non-filter (2 X 2), filter (7 x 7), menthol (3 x 3)].

Insert Table 4 about here.

Throughout our discussion, the reader's attention is called to diagonal elements of the 12 x 12 matrix for a discussion of H1, the hypothesis relating to ***individual*** brand causality. Similarly, hypothesis H2, which pertains to ***intracategory*** competition, is discussed in accordance with the three square blocks along the main diagonal in the figure. Finally, ***intercategory*** causality, the focus of H3, is depicted in off-diagonal blocks. The temporal level causality involving old-to-new categories pertains to off-diagonal results in the lower two-thirds of the table, while new-to-old causality is indicated in the upper off-diagonal portions.

Three pieces of "preliminary" causality information are contained in each cell of Table 4 and later summarized in aggregate in Table 5. The first value represents the simple correlation between sales and advertising, which is calculated directly from sales series $Z_{i,t}$ and advertising series $Z_{j,t}$ without time lag. The result shows that at individual brand levels, the correlation between a brand's sales and its own advertising is positive for all twelve brands. Advertising can be considered a significant factor in explaining the sales for most of the brands. Aggregate results for individual level causality reiterate this finding in Table 5, thereby supporting conventional thinking regarding advertising-sales causality. Some of the correlations in off-diagonal cells are negative, however, an indication of the competitive effects of advertising among brands. All off-diagonal aggregate cell entries in Table 5 are negative, again substantiating the existence of intra- and inter-category competition.

Insert Table 5 about here.

Since correlation does not imply causation, we are more interested in the second value appearing in each cell of Table 4, the $S_{i,j}$ statistic. The $S_{i,j}$ value represents an analogous chi-square test which investigates the existence of a causal relationship or empirical interdependence between sales and advertising series. As indicated previously, the $S_{i,j}$ statistic is an "exploratory" tool in defining competitive market structure which is not specified a priori. The acceptance/rejection of the statistic is generally reported on a .50 significance level in order not to "throw the baby out with the bath water" (see for example, Majeski and Jones 1981, p. 273). For a more restrictive standard, however, the observed confidence interval (1 - *p-value*) greater than .80 is reported for each test in the study. Adjacent values in parentheses indicate the associated observed confidence level for the relationship between advertising and sales.

The third value, if present, in each matrix cell in Table 4 represents the significant spike(s) (at the .05 level) of the cross-correlation function related to Granger's prima facie causality. CCF (+k) indicates that advertising (prima facie) causes sales, but not instantaneously; CCF (-k) indicates the reverse, i.e., that sales cause advertising, also not simultaneously; and CCF (0) indicates instantaneous causality only.

According to H1, we expect elements on the main diagonal to indicate a causal relationship between advertising and sales. This hypothesis is strongly supported by Marlboro and Viceroy, each with an observed confidence level greater than .90; and is moderately supported by Winston, L & M, Kent, and Salem, each with an observed confidence level greater than .80. Three long-time segment leaders, Marlboro, Winston, and Salem show instances of one-way causality (advertising causes sales), as evidenced by a significant CCF at some positive lag k. In two instances, for Viceroy and L & M, instantaneous causality is present; and in one case, Camel, a reverse one-way causal relationship (sales causes advertising) exists. The aggregate observed confidence levels summarized in Table 5 for the non-filter, filter and menthol segments at the individual levels are .533, .977, and .344, respectively. Our findings support the conventional philosophy that advertising and sales are causally related in econometric modeling, particularly in the plain filter sub-category in which there is strong evidence for the existence of advertising-sales causality.

In H2, intracategory causal relationships between advertising and sales are expected within the diagonal blocks. This hypothesis is supported by four dyads at a level greater than .90 and five at a level greater than .80 in the filter segment, but by none in either the non-filter or the menthol filter segments. The aggregate observed confidence levels for the non-filter, filter, and menthol filter categories are .012, .866, and .230, respectively, which corroborate the finding. The lack of support for interdependent causality among non-filter products may be due to the fact that smokers of such brands as Camel and Pall Mall are loyal and addicted buyers who selectively screen out information about health hazards as well as competing advertising information.

For the filter segment, the largest category of cigarette products, competitive interactions also are the greatest. The significant sample CCFs presented in Table 4 indicate that Winston's advertising expenditures cause Marlboro's sales, Viceroy's advertising levels cause Kent's sales, and Winston's sales cause Kent's advertising. Instantaneous causalities are also observed for the Viceroy-L & M and Kent-Tareyton dyads.

These findings suggest some important implications for intracategory competition particularly with respect to the relative market share of brands. It is well-known that the Marlboro brand currently dominates the cigarette market. It is apparent that the past segment leader, Winston, contributed its advertising expenditures significantly to Marlboro's sales at the .94 level, while Marlboro's advertising caused Winston's sales at only a moderate .85 level. It appears that Marlboro's advertising expenditures are more effectively managed than Winston's.

Hypothesis H3 predicted that intercategory causality would exist in a temporal direction between old and new segments in the upper and lower off-diagonal blocks. In the lower off-diagonal blocks, only three of forty-one cases (i.e., Pall Mall-Raleigh, Pall-Mall-Newport, and Kent-Salem) have significant $S_{i,j}$ values. In addition, none of the aggregate causal probabilities is significant (.035 for non-filter advertising --> filter sales, .636 for non-filter advertising --> menthol sales, and .011 for filter advertising --> menthol sales). These results suggest that old segment advertising did not cause new segment sales. Intuitively, lack of intercategory competition between old and new segments can be interpreted as an indication that old segment advertising information was not appealing and usually was ignored by new segment smokers.

However, another temporal causation direction from new to old in the upper off-diagonal blocks of Table 4 suggests that increasing advertising of new segments has had an impact on the declining sales of older categories. This is supported in six of forty-one dyads at significant observed confidence levels (.90) and nine at moderate observed confidence levels (.80), with most of the lagged k values in significant CCFs exhibiting a negative sign (suggesting a feedback relationship such that the decline in old category sales stimulated an increase in new cigarette advertising). The aggregate observed confidence level between menthol advertising and filter sales is extremely high (.996), and that between menthol advertising and non-filter sales is marginally high (.875), which suggest that menthol brands (new segment) basically are responsive to competitive segment sales.

In summary, the three levels of competition based on genetic heritage (individual, intracategory, and intercategory) disclose a great deal about a species' or brand's existence over time. For example in the case of Kool, note that the probability of this brand's advertising causing its own sales is only 8%. There is, however, an observed 77 percent chance that Kool's (menthol) advertising expenditures cause an increase in Marlboro's (filter) sales, a 38 percent chance that they cause Salem's (menthol) sales to decline, and a 62 percent chance that Kool's advertising expenditures decrease Newport's (menthol) sales. As a result, the one-time menthol segment leader may have gained from Salem and Newport in its own category (intra), but lost market share over the period studied to Marlboro in the other segment.

Hypothesis H4 predicted that the causation between advertising and sales follows a gradually decreasing pattern as more distantly related species or products with more distant lineage are considered. For a more restrictive calculation, the aggregate observed confidence level for different competition levels can be summarized from Table 5 as follows:

	Observed Confidence Level **(1 - *p-value*)**	**(Chi-square, d.f.)**
H_1: Brand (Species) Level	0.916	(154.93, 132)
H_2: Intra-Category (Genus) Level	0.658	(562.90, 550)
H_3: Inter-Category (Class) Level	0.592	(911.27, 902)

This result suggests that the observed confidence level pertaining to whether an individual cigarette brand's advertising is causally related to its own sales is 0.916. Within the same category, however, the probability that a brand might benefit (or suffer) in sales from the advertising of a closely-related product drops to 65.8 percent. [If we consider intracategory competition including individual brand levels, the probability of causation rises to 83.4 percent (chi-square = 717.83, d.f. = 682).] Finally, as we expected, intercategory competition has the lowest causation rate with 59.2%.

Although we did not explicitly test consumer brand-switching behavior, results indicate that there is a small proportion of intra- and intercategory exchange from which individual brands might benefit (or suffer) from the advertising of other brands. It is generally known, however, that cigarette smokers usually consume within a category and tend to be brand-loyal (Alsop 1989).

DISCUSSION

Recall that our research intent was to investigate empirically the three underlying forces of the PEC, especially managerial effectiveness and competition. In doing so, we have provided a basis on which to compare and contrast the PLC and PEC concepts. According to the PEC, related "species" that evolve from a common ancestor or from one another may co-exist. It was determined that a time-series investigation of advertising-sales causality would establish relationships among members of the same genus or product forms and between more distantly related evolutionary organisms or products. Three bases of inquiry were used.

According to our first inquiry phase, which dealt with industry classification, variations in the sales histories at the category, form, and brand levels reflected across the life cycles were captured by the PEC. In the second phase, turning points in the life cycles of various cigarette brands were generated by the natural, genetic, and artificial selection effects of the PEC. Finally, our empirical test focused on advertising as it related to both concepts, given the dominance of this marketing mix variable as a competitive weapon in the U.S. cigarette industry. Because the tobacco industry is a mature one, only limited information related to advertising was provided by the PLC. In the context of the PEC, ad-sales relationships were investigated at the species, genus, and class levels.

Results from our time-series and econometric analyses indicate that causal relationships exist at all three levels, and their relative probability of occurrence is commensurate with their "genetic" commonality. At the individual brand level, advertising and sales causal relationships are supported most strongly. This follows from traditional sales response literature. In terms of the PEC and our original research objective, since the twelve brands tested are species that have survived rather than become extinct, the high causal probability reflects managerial creativity and genetic selection as successful marketing mix strategies were developed.

In the case of intracategory competition, the probability of causation is not as high. It is, however, more pronounced than competition at the intercategory level. This relative finding supports our evolution taxonomic hierarchy and the traditional view of segmentation.

The most pronounced intracategory relationships occurred within the regular filter category. Intercategory causality was indicated predominantly in the new causes old categories temporal direction lending support to the existence of relationships among co-existing "species" in different "genera" evolved through the PEC.

To our knowledge, this is the first empirical study involving the PEC concept. We feel that our research makes potentially important contributions in terms of: (1) market dynamics, (2) the relationship between biological evolution and product competition, and (3) product line management.

1. Market Dynamics

A basic tenet of biological evolution is that events occur over time. Following from this, the manner in which species coexist also evolves as time passes. In our example, the ways in which tobacco products coexisted in 1960, 1970, and 1980 might differ substantially. We have chosen for our analysis to take a "snapshot in time." The time-series methodology used in the analysis required nearly three decades of data. As time passes and more data become available, however, it becomes possible to take "a moving window" approach to the estimation in order to provide further insight into how a competitive structure evolves.

2. Biological Evolution and Product Competition

To carry our biological analogy a step further, one might consider that our organisms possess one dominant gene in terms of genetic selection ---advertising. An important question is raised as to which genes or genetic traits influence competition among species and survival over time.

3. Product Line Management

Our research has shown primarily that competitive sales response and reactivity are more intense on an intercategory level than one might anticipate. This empirical result has important implications for theoretical research, which traditionally has assumed independence.

Future research efforts might be directed to replication of this type of dynamic analysis, should shorter-interval data become available. Quarterly or monthly data would allow a study including more of the recent innovation categories than we were able to consider using annual measures. As noted, replication of this analysis in a setting with multiple genetic traits would provide valuable information with respect to the dynamics of genetic selection and competition among species.

FOOTNOTES

[1] Summaries of the sales and advertising results are available from the authors upon request.

APPENDIX

Step 1: ARIMA Intervention Model

In accordance with the two-stage Pierce-Haugh cross-correlation method described, the advertising and sales data series for 12 cigarette brands were pre-whitened in this step. This pre-whitening procedure is conducted to remove systematic patterns in the data series that might yield spurious causality in the next step. The model in equation (1) considers the genetic effect (advertising), natural selection effect (segment competition), and artificial selection shock (advertising ban) on the survival of the fittest (brand sales). The parameters ϕ_i and θ_i represent the cumulative pattern (strategy) that the life forms (brands) adopt in adapting to the environments.

The general ARIMA procedure models with the intervention from the advertising ban in 1970 in this step can be written as (see also McCleary and Hay 1980, chapter 3):

$$Z_{i,t} = \mu_i + \psi_i I_t + \theta_i(B)/\phi_i(B)\, a_{i,t} \tag{1}$$

where

$Z_{i,t}$	is the original sales series for brand i ($Z_{j,t}$ represent advertising series, which follow the same process as in (1));
μ_i	is the constant term Mu;
ψ_i	is the transfer function weight for the dummy variable I_t;
I_t	is the dummy variable for the advertising ban intervention, I_t = 0 for observations before 1970 = 1 for observations after 1971;
$\phi_i(B)$	is the AR (Auto-Regressive) operator, $\phi_i(B) = 1 - \phi_{i,1}(B) - \ldots - \phi_{i,p}B^p$;
$\theta_i(B)$	is the MA (Moving Average) operator $\theta_i(B) = 1 - \theta_{i,1}B - \ldots - \theta_{i,q}B^q$
B	is the backshift operator, i.e., $B Z_t = Z_{t-1}$;
$a_{i,t}$	is the white noise of sales series, also called random error, which follows the i.i.d. (independent, identically distributed) assumption.

The ARIMA model-building for sales and advertising series is based on a three-step iterative cycle of : (i) model identification, (ii) model estimation, and (iii) diagnostic checking. The adequacy of the model at diagnostic checking stage is to examine whether the sample ACFs and PACFs of residuals are jointly zero. This is conducted by Ljung and Box's (1978) Q-statistic which is desirable for moderate-sized samples. The formulation for the Q-statistic is the same as in equation (2) below, except that CCF(k) is replaced by ACF(k) for any k = 1 to m (the description of the Q-statistic is also given in SAS/ETS 1984, p. 141).

Step 2: Causality Detection

Residual series were cross-correlated in a pairwise manner to test the independence of the causality hypothesis in this step. This is performed by cross-correlating one pre-whitened sales series with each of 12 pre-whitened advertising series. Since our interest in this study is to investigate all the possible causal events between advertising and sales, the significance of cross-correlation functions (CCF) was examined from the m positive lagged CCF to the m negative lagged CCF to detect causal relationships.

This step can be summarized in the following formulation:

The statistic $S_{i,j}$, under the null hypothesis that advertising ($a_{i,t}$) and sales ($a_{j,t}$) are not causally related, in particular,

$$S_{i,j} = N(N+2) \sum_{k=-m}^{m} CCF(k)^2/(N-2m-1) \qquad (2)$$

$$\text{where } CCF(k) = \frac{\sum_{t=1}^{N-k} (a_{i,t} - \bar{a}_i)\ (a_{j,t+k} - \bar{a}_j)}{s_{ai} \cdot s_{aj}}$$

and

N = the total number of residuals from equation (1)
k = time lag, k = 1, 2, ...k, k < N;
m = the maximum value chosen by the researcher (m = 5);

$\bar{a}_i$, $\bar{a}_j$ are the sample means of advertising and sales residual series, $a_{i,t}$ and $a_{j,t}$, respectively;
s_{ai}, s_{aj} are the sample standard deviations of $a_{i,t}$ and $a_{j,t}$;

$S_{i,j}$ is asymptotically distributed as chi-square with 2m+1 degrees of freedom (Pierce and Haugh 1977). Therefore, the hypothesis that $a_{i,t}$ and $a_{j,t}$, are not causally related would not be rejected at level α if and only if

$$S_{i,j} < X^2_{\alpha,2m+1}$$

This overall chi-square test implies that the higher the $S_{i,j}$ value, the lower the probability of such an $S_{i,j}$ value if there were an unrelated sales and advertising relationship. However, one must be cautious in interpreting the overall chi-square test, $S_{i,j}$. If two series are not causally unrelated, several possible causality events can be referred to such as instantaneous causality, feedback, advertising causing sales but not instantaneously, ...etc. (see Pierce and Haugh 1977, Table 3 for details). Such causal events are called "prima facie causality" (Granger 1980) and are treated as simply happening by chance.

Step 3: Overall Causality Test

Our individual causality results are summarized in the context of the PEC and three levels of the taxonomic hierarchy, such that relationships among close and more distantly related products in terms of evolution are noted.

The causality test at each level of competition can be obtained by summing $S_{i,j}$ for each block from the chi-square distribution property (Mood, Graybill, and Boes 1974) such that

$$\mathbf{S_K} = \sum_i \sum_j S_{i,j} \tag{3}$$

This new aggregate statistic $\mathbf{S_K}$ is also asymptotically distributed as chi-square with degrees of freedom obtained from the summing-up cells. For instance, the first diagonal block for the non-filter segment at the intracategory level is obtained by adding $S_{1,2}$ and $S_{2,1}$ as:

$$\mathbf{S_1} = 1.63 + 8.23 = 9.86$$

with d.f. = 22 and the associated observed confidence level (1 - *p-value*) = .012.

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Table 1

Biological Taxonomic Hierachies for Cigarettes

Categories	Taxa	Cigarette
Kingdom (Phylum)	Animalia (Arthropoda)	Agricultural Stimuli (tobacco, coffee, tea)
↓	↓	↓
Class	Insecta	Tobacco Product Class (cigarette, cigar, snuff)
↓	↓	↓
Family (Genus)	Danaidae (Dananus)	Cigarette Product Segment (nonfilter, filter, menthol)
↓	↓	↓
Species	Dananus Plexippus (Monarch Butterfly)	Cigarette Brands (Salem, Kool, Newport)
↓	↓	↓
Organism	Individual (Monarch Butterfly)	Brand studied at time t

Table 2

Evolutionary Product Management:

Mechanism of the PEC

Biology		Business/Marketing		Cigarette Industry
			--->	Advertising
Genetic Selection	-->	Managerial Effectiveness	--->	New Products
			--->	R & D, etc
			--->	Primary Demand
Natural Selection	-->	Competitive Environment	--->	New Entries
			--->	Competitors' 4Ps
			--->	FCC's Advertising Ban
Artificial Selection	-->	Governmental Mediation		Consumerism/American
			--->	Lung Cancer Society

Table 3

The 12 Leading Cigarette Brands from 1952 to 1979

Brand	Category/ Manufacturer	Year of Introduction	Market Share[a] 1952	1966	1979
Camel	Non-filter/RJR	Before 1925	27.2%	9.4%	4.7%
Pall Mall	Non-filter/AB	1937	10.8	14.2	6.2
Winston	Filter/RJR	1954	--	14.7	14.7
Marlboro	Filter/PM	1937	0.1	6.1	18.6
Kent	Filter/Loews	1952	0.2	5.9	3.4
Viceroy	Filter/BAT	1947	0.7	4.0	2.1
L&M	Filter/L&M	1954	--	3.9	1.4
Raleigh	Filter/BAT	1929	2.2	3.5	2.0
Tareyton	Filter/AB	1954	3.2	4.0	2.2
Kool	Menthol/BAT	1933	3.0	5.1	10.1
Salem	Menthol/RJR	1956	--	8.7	9.7
Newport	Menthol/Loews	1957	--	1.7	1.8
		Total Market Share :	47.4[b]	81.2	76.9

Data Source: Advertising Age

a. This is calculated from the top 25 brands listed in Advertising Age.

b. Lucky Strike and Chesterfield, which accounted for a combined 36.8% of market share in 1952, are not included.

Table 4

Advertising - Sales Causation (Individual Brand Level)

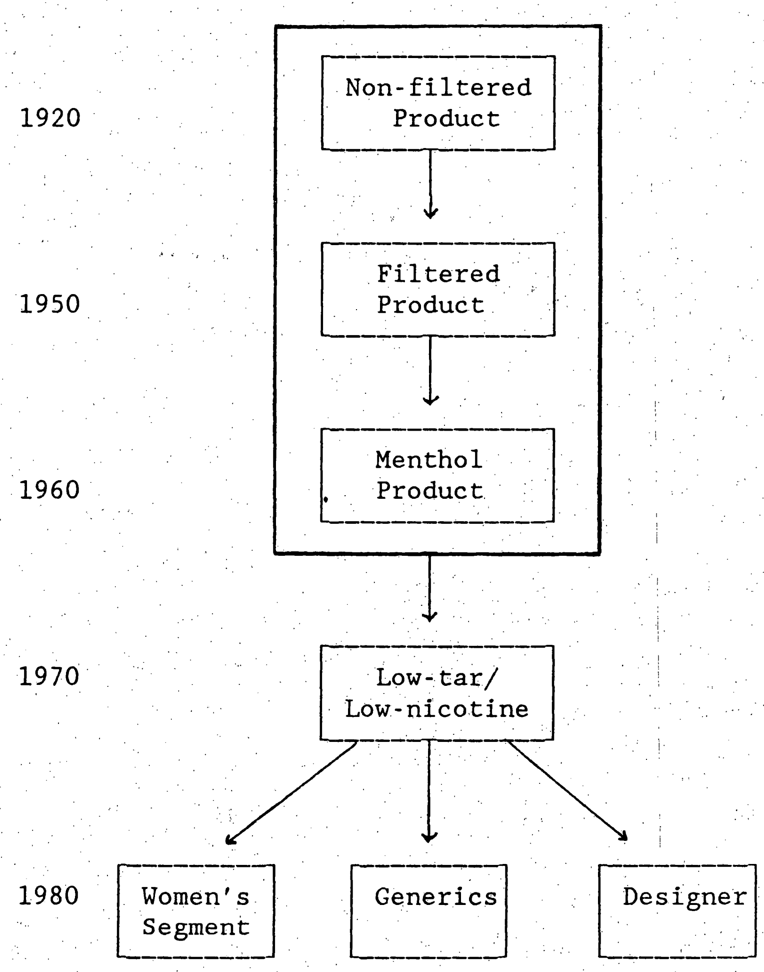
Advertising

Sales	Non-Filter: Camel	Non-Filter: Pall Mall	Filter: Viceroy	Filter: Winston	Filter: L&M	Filter: Marlboro	Filter: Raleigh	Filter: Tareton	Filter: Kent	Menthol Filter: Kool	Menthol Filter: Salem	Menthol Filter: Newport
Camel	0.283[a] 13.32[b] (0.73)[c] CCF (-1)[d]	-0.074 1.63 (0.00)	-0.400 18.95 (0.94) CCF (-4)	0.128 4.37 (0.04)	-0.375 11.00 (0.56)	0.284 14.21 (0.78) CCF (-2)	0.212 8.21 (0.31)	0.074 6.71 (0.18)	0.130 16.23 (0.87)	-0.155 6.88 (0.19)	-0.015 17.00 (0.89) CCF (-5)	-0.027 10.86 (0.55)
Pall Mall	0.002 8.23 (0.31)	0.061 8.56 (0.34)	-0.130 9.11 (0.39)	-0.424 18.56 (0.93)	0.147 10.20 (0.49) CCF (5)	-0.365 10.82 (0.54)	-0.202 7.66 (0.26)	0.209 12.34 (0.66) CCF (2)	0.103 14.15 (0.78)	-0.552 14.04 (0.77) CCF (0)	0.316 15.98 (0.86)	-0.180 14.57 (0.80) CCF (1)
Viceroy	-0.121 10.31 (0.50) CCF (-1)	0.145 9.82 (0.45)	0.494 17.48 (0.91) CCF (0)	-0.349 10.34 (0.50)	0.501 13.38 (0.76) CCF (0)	-0.303 10.65 (0.53)	-0.285 11.63 (0.61)	-0.049 12.24 (0.65)	-203 9.34 (0.41)	-0.096 7.15 (0.21)	0.113 17.05 (0.89) CCF (-5)	-0.200 21.17 (0.97) CCF (-4)
Winston	-0.317 9.24 (0.40)	0.263 6.78 (0.18)	0.326 8.13 (0.30)	0.226 16.85 (0.89) CCF (1 & 2)	0.477 12.29 (0.66) CCF (0)	0.074 15.84 (0.85) CCF (2)	-0.128 10.07 (0.48)	-0.151 5.37 (0.09)	-0.011 17.15 (0.90) CCF (-1)	-0.122 16.42 (0.87) CCF (2)	-0.188 12.17 (0.65)	-0.186 12.14 (0.65)
L&M	-0.172 12.70 (0.69)	0.062 5.67 (0.11)	0.701 18.56 (0.93) CCF (0)	-0.098 13.57 (0.74)	0.647 16.20 (0.87) CCF (0)	0.117 10.06 (0.48) CCF (2)	-0.206 13.93 (0.76)	-0.216 9.51 (0.42)	-0.235 14.59 (0.80) CCF (1)	-0.016 10.59 (0.52)	0.226 20.51 (0.96) CCF (-2)	-0.297 9.02 (0.38) CCF (-1,-4)
Marlboro	-0.236 9.94 (0.46)	0.086 5.55 (0.10)	0.338 9.10 (0.39)	0.152 18.99 (0.94) CCF (5)	0.080 6.21 (0.14)	0.308 19.12 (0.94) CCF (2)	0.165 10.22 (0.49)	-0.196 7.71 (0.26)	-0.452 11.62 (0.61) CCF (0)	0.141 12.08 (0.77)	-0.075 13.99 (0.64)	-0.483 17.21 (0.90) CCF (0)
Raleigh	-0.018 6.34 (0.15)	-0.334 17.90 (0.92)	-0.143 4.43 (0.04)	-0.394 13.61 (0.74)	0.173 5.77 (0.11)	-0.188 8.86 (0.36)	0.220 7.10 (0.21)	-0.102 10.20 (0.49)	-0.089 10.83 (0.54)	-0.106 15.59 (0.84) CCF (1)	-0.007 9.65 (0.44) CCF (2)	0.196 6.48 (0.16)
Tareyton	0.359 8.50 (0.33)	0.144 5.93 (0.12)	-0.178 13.02 (0.71) CCF (1)	-0.230 14.44 (0.79)	-0.197 13.96 (0.76)	-0.312 11.03 (0.56)	-0.046 10.90 (0.55)	0.073 12.18 (0.65)	0.489 19.66 (0.95) CCF (0)	-0.157 16.15 (0.86) CCF (-5)	0.385 20.12 (0.96) CCF (-1)	-0.249 16.76 (0.88) CCF (1)
Kent	-0.299 11.84 (0.62) CCF (3)	-0.084 3.22 (0.01)	-0.347 16.87 (0.89) CCF (2)	-0.012 10.57 (0.52)	-0.226 14.58 (0.80) CCF (4)	-0.167 10.86 (0.54)	0.113 13.56 (0.74)	0.048 11.70 (0.61) CCF (1)	0.282 14.91 (0.81)	-0.128 12.01 (0.64) CCF (-2)	0.055 13.61 (0.74) CCF (-1)	0.567 11.60 (0.61) CCF (0)
Kool	0.079 6.39 (0.15)	0.141 13.97 (0.77)	-0.104 6.60 (0.17)	0.315 7.64 (0.25)	-0.135 5.04 (0.07)	0.198 6.04 (0.13)	0.459 8.67 (0.35) CCF (0)	0.145 10.83 (0.54)	0.028 4.01 (0.03)	0.304 5.21 (0.08)	-0.071 9.86 (0.46) CCF (3)	0.149 11.56 (0.60) CCF (4)
Salem	-0.184 9.13 (0.39)	-0.096 13.13 (0.71) CCF (-2)	0.076 13.27 (0.72)	0.017 5.84 (0.12)	-0.225 11.38 (0.59)	0.086 7.12 (0.21)	0.149 8.63 (0.34)	-0.186 10.55 (0.52)	0.074 17.86 (0.92)	-0.084 9.00 (0.38)	0.026 15.49 (0.84) CCF (5)	0.149 8.50 (0.33) CCF (6)
Newport	-0.083 9.08 (0.39)	-0.068 17.70 (0.91) CCF (+3, -1)	-0.033 5.59 (0.10)	-0.173 10.73 (0.53)	-0.163 8.72 (0.35)	-0.298 9.93 (0.46)	-0.004 5.18 (0.08)	-0.159 7.28 (0.22)	0.073 13.87 (0.76)	-0.383 11.75 (0.62)	0.085 6.57 (0.17)	0.329 8.51 (0.33)

[a] Simple correlation between sales series, $Z_{i,t}$, and advertising series, $Z_{j,t}$.
[b] Ljung-Box's Q-statistic based on calculation of CCFs from equation (2) in the Appendix.
[c] The observed confidence interval (1 - p-value) of Q-statistic.
[d] Indication of Granger's prima facie casuality.

Figure 1

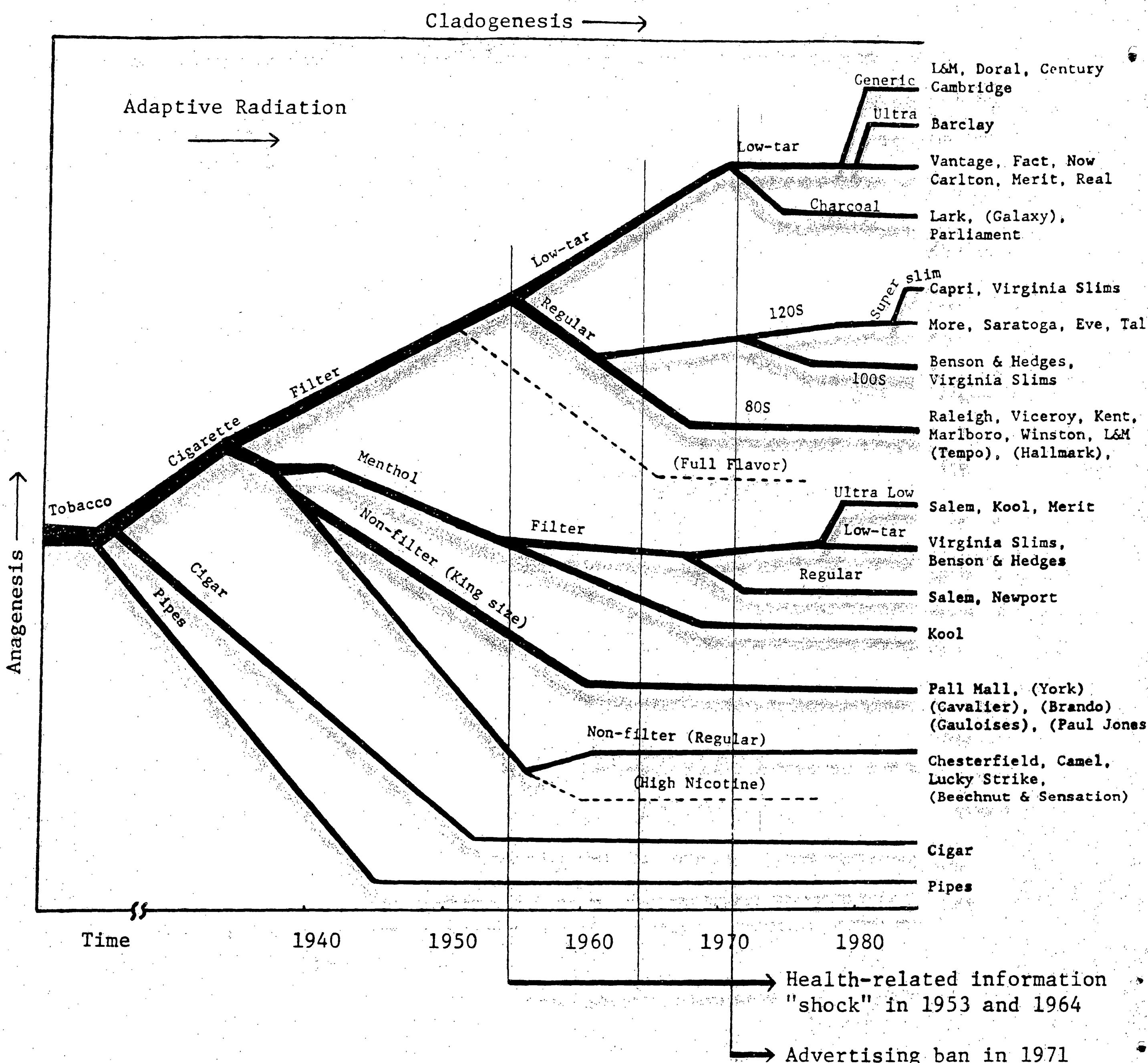
Major Innovation Segments in U.S. Cigarette Industry



Note: The three blocked segments are the focus of this analysis.

Figure 2

Product Evolutionary Cycle of the U.S. Tobacco Industry



Interpretation
Nodal Points: Cladogenesis
Vertical Branching: Anagenesis
Horizontal Radial Branching: Adaptive Radiation
Unbranched Horizontal Lines: Stasigenesis
Parenthetical Branches: Extinction

Adapted from Tellis and Crawford (1981), J. of Marketing, p. 128