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ESTIMATION OF CONSUMER DEMANDS: AN APPLICATION TO U.S. APPAREL EXPENDITURES

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ABSTRACT

A set of new statistical methods will be presented to model the U.S. men's wear markets along with the general consumption trends among U.S. male and female populations. The Almost Ideal Demand (AID) system of Deaton and Muellbauer (1980) was extended to include general, nonlinear and nonadditive habit effects. By employing a "Habit Stock" model into a first-order differential demand system, the pattern of shifts as well as the dynamic changes in the market shares were estimated. The results of analysis on four categories of men's bottom during 1990-96 suggest that the dynamic habit stock formation is a highly promising new concept for explaining the current and emerging fashion trends and market shares. The paper will also discuss the potential of using social science data obtained from consumers' general social behaviors during 1990-1998 for the projection of future apparel consumption trends.

1. INTRODUCTION

Under a highly dynamic economic and social environments created by economic globalization, it is vital for U.S. textile and apparel firms to develop and estimate a system of interrelated demands based on consumer responses. In econometrics, development of theories on consumer demand system has had a long history. Stone (1954) developed linear expenditure demand system as early as 1950's. Since then, numerous studies have been made for developing practical demand theories as well as in applying the system of equation. For example, studies by Barten (1977) and Deaton and Muellbauer (1980) used an ordinary demand system to model consumer expenditures and test the underlying theoretical hypotheses.

Compared to the long history in econometrics, research on consumer demand in clothing and apparel areas, has not been formalized until recent years. Apparel items, along with food and housing, are considered to be basic and important consumer goods. According to recent estimates, Americans spent over $165 billion on apparel in 1999. In spite of the large expenditures, analysis of market demand has been considered difficult and hence little formal research has been conducted in modeling and forecasting of apparel demands perhaps due to the complexed dynamic consumer behaviors coupled with extremely short fashion life cycles.

In recent years, there has been growing interest in the role of habit formation in the consumer's allocation decisions. Several researchers have attempted to formulate a consumer behavior model based on habit formation. The main idea is that goods may be purchased and consumed based on "formed habits" in such a way that an individual's current preferences on his past consumption patterns. Therefore, a change in price or income would cause a change in consumption which would induce a change in tastes, and subsequently promote a further

change in consumption. We have applied the habit formation model to a variant of the differential demand system for examining the stock effects of advertising on consumption. To the best of our knowledge, however, we are the first to incorporate a dynamic habit stock characterization into a system of differential demand equations. The main purpose of this paper is to develop a demand system that links "habit stock variables" with observed social, economic, demographic, technological and other industry-specific fashion trend variables.

2. THEORETICAL BACKGROUND

2.1. Habit Formation Models

The approach used in the present study is to model the various categories of apparel demand by using habit formation models of the sort conceived by Manser(1976), Pollak and Wales(1969), Blanciforti and Green(1983), Pollak and Wales(1992), and Holt and Goodwin(1997), among others. Habit formation model is somewhat recent concept and based on hypotheses that are (1) past consumption influences current preferences and current demand and (2) a higher level of past consumption of a good implies, *ceteris paribus*, a higher level of present consumption of that good. Pollak (1970) developed dynamic demand function based on these hypotheses of habit formation. His dynamic demand system started from the basic assumption for the habit formation model, that is the consumption in the previous period influences current preference and demand, but that consumption in the more distant past does not. Then he generalized this assumption by allowing the necessary quantity of each good to depend on a geometrically weighted average of all past consumption of that good. After several steps of mathematical derivations, dynamic demand function was obtained and finally, it satisfied the second hypothesis, that is current preference depends on all past levels of consumption, not just on consumption in the previous period.

Similar to Pollak's dynamic demand system, we have applied a variant of Deaton and Muellbauer's (1980) Almost Ideal Demand (AID) system in conjunction with both linear and nonlinear habit augmentation terms to model habit formation in apparel demand.

To explain the model setup, the preference functions known as *PIGLOG* class, are represented via the expenditure function that defines the minimum expenditure necessary to attain a specific utility level at given prices. This function *e(u,p)* for utility *u* and price vector *p* can be denoted by

$$\log e(u, p) = (1-u)\log\{a(p)\} + u\log\{b(p)\} \quad (1)$$

Next, we take specific functional forms for $\log a(p)$ and $\log b(p)$. We take

$$\log a(p) = a_0 + \sum_i a_i \log p_{it} + \frac{1}{2}\sum_i\sum_j \gamma^*_{it} \log p_{it} \log p_{jt} \quad (2)$$

$$\log b(p) = \log a(p) + \beta_0 \prod_i p_{it}^{\beta_i} \quad (3)$$

so that the AIDS cost function is written

$$\log e\left(u, \underline{p}_t\right) = \alpha_0 + \sum_i \alpha_i \log p_{it} + \frac{1}{2}\sum_i\sum_j \gamma^*_{it} \log p_{it} \log p_{jt} + u\beta_0 \prod_{i=1}^{n} p_{it}^{\beta_i} \quad (4)$$

where p_{it} represents the price of apparel item *i* at time *t*, *u* is the consumer's (unobservable) utility index, and α_0, α_i, β_i, $\gamma_{ij} = \left(\tilde{\gamma}_{ij} + \tilde{\gamma}_{ji}\right)/2$ are the parameters to be estimated.

Demand functions can be derived directly from equation (4). It is fundamental property of the cost function that its price derivatives are the quantities demanded: $\partial e(u, p)/\partial p_{it} = q_{it}$. Multiplying both sides by $p_{it}/e(u, p)$ we find

$$\frac{\partial \log e(u, p)}{\partial \log p_{it}} = \frac{p_{it} q_{it}}{e(u, p)} = w_{it} \quad (5)$$

where $w_{it} = p_{it} q_{it}/\mu_t$ is the i^{th} expenditure (budget) share, with q_{it} denoting the quantity of the i^{th} item purchased. For a utility-maximizing consumer, total expenditure μ is equal to *e(u,p)* and this equality can be inverted to give *u* as a

function of *p* and *x*, the indirect utility function. Total group expenditure is denoted by $\mu_t = \sum_{i=1}^{n} p_{it} q_{it}$. Hence, logarithmic differentiation of (4) gives the budget shares as a function of prices and utility:

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} p_{jt} + \beta_i (\ln \mu_t - \ln P_t), \ i = 1, \ldots, n, \quad (6)$$

where

$$\ln P_t = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2} \sum_i \sum_j \tilde{\gamma}_{ij} \ln p_{it} \ln p_{jt} \quad (7)$$

is the price index used in the AID system to deflate total group expenditure.

The dynamic generalizations of the AID system considered so far have assumed that habit forming behavior is characterized by short memory; parameters in the distance function depend only on last period's consumption. Following Pollak (1970), Phlips (1972), McCarthy (1974), Ray (1985), and Pollak and Wales (1992), it is possible to allow base distance levels to depend on geometrically weighted average of the entire history of all past consumption levels of each item. That is, the stock of habit effects conditioning the representative consumer's current decisions is specified to depend on both recent and distant consumption histories - a 'long-memory' habit formation model.

To achieve this generalization, we have developed the dynamic AID system distance function:

$$\ln e(u, \underline{p}_t) = \alpha_0 + \sum_i \delta_i r_{it-1} + \sum_i (\alpha_i + \kappa_i \mu_{t-1}) \ln p_{it} + \frac{1}{2} \sum_i \sum_j (\gamma_{ij} + \theta_{ij} \mu_{t-1}) \ln p_{it} \ln p_{jt} + u \prod_{i=1}^{n} p_{it}^{(\beta_i + \eta_i \mu_{it-1})}, \quad (8)$$

where $r_{it-1} = p_{it-1} q_{it-1} / \mu_{t-1}$ is lagged expenditure on the i^{th} item, and where δ_i, κ_i, η_i, and $\theta_{ij}, i, j = 1, \ldots, n$ are additional parameters to be estimated that capture the consumers' 'habit response' with respect to lagged apparel purchases.

Subsequently, we obtained an estimable AID demand system that incorporates the general nonlinear, non-additive habit effects in its specification. The resulting *n*-equation demand system is given by:

$$w_{it} = \alpha_i + \kappa_i \mu_{t-1} + \sum_j (\gamma_{ij} + \theta_{ij} \mu_{t-1}) p_{jt} + (\beta_i + \theta_{ij} \mu_{t-1})(\ln \mu_t - \ln P_t^*) + v_{it}, \ i = 1, \ldots, n, \quad (9)$$

where ε_{it} is a white noise error term and where the general deflator $\ln P_t^*$ is now given by

$$\ln P_t^* = \alpha_0 + \sum_i \delta_i r_{it-1} + \sum_i (\alpha_i + \kappa_i \mu_{t-1}) \ln p_{it} + \frac{1}{2} \sum_i \sum_j (\gamma_{ij} + \theta_{ij} \mu_{t-1}) \ln p_{it} \ln p_{jt} \quad (10)$$

3. MODELING AND ANALYSIS

3.1 Structure of NPD data and GSS data

For this study, two sets of data were analyzed. The NPD data was obtained from the NPD group, one of the largest market research firms in the United States. The consumer panel reports detailed monthly purchases in diary form allowing for very detailed records of apparel-related transactions at the consumer level. This contains very detailed information on the products (style, color, size, fiber contents, and etc.), the consumers (age, sex, income, education, and etc.), and purchase specifics (store type, price, and etc.). For the first part of analysis, four categories of men's bottom from 1990 to 1996 was chosen. For the second part of analysis, various categories of men's and women's data from 1990 to 1998 were chosen.

The General Social Survey (GSS) data is a cumulative data set that merges 20 years of the GSS conducted by the NORC (National Opinion Research Center) annually since 1972 except for the years 1979, 1981, and 1992 (a supplement was added in 1992). Each year, the Roper Center for Public Opinion Research prepares a cumulative data set that merges previous years of the GSS into a single file, with each year or survey constituting a sub-file. The content of each year's survey changes slightly as some items are added to or deleted from the interview schedule. Main areas covered in the GSS include socioeconomic status, social mobility, social control, the family, race relations, sex relations, civil liberties, and morality. NORC conducts surveys using national probability

sampling based on all non-institutionalized English-speaking persons of 18 years of age or older living in the United States. The survey asks over 1100 questions and the responses are counted by category.

3.2 Application of Habit Formation Model

At this stage, the nonlinear, non-additive habits version of the AID system identified in equations (9) and (10) has been used to estimate a four-equation model of expenditure allocations for men's bottoms. Specifically, the categories included are (1) jeans (2) casual slacks (3) dress slacks and (4) shorts. As explained in the previous section, in the nonlinear habit formation model, aside from prices and deflated group expenditure, one-period lagged total group expenditure is used as an explanatory variable as well. The notion is that if there is 'persistence' in consumer purchase patterns with respect to men's bottoms, then the total expenditure in the previous period should help determine the demand for the various categories being considered in the present period.

The data used to conduct the analysis are monthly, and cover the period January 1990 through December 1996. Preliminary analysis was done to deseasonalize the data, that is, systematic seasonal factors were removed from the data prior to using statistical techniques to estimate the parameters in the linear habits AIDS model.

As well, additional dynamic features were incorporated into the model by correcting for the first-order serial correlation in the residual terms. Because the resulting system is highly nonlinear in its parameters, the provisional model was estimated by using nonlinear full information maximum likelihood (FIML) statistical estimation techniques. Specifically, the Davidon-Fletcher-Powell algorithm, as implemented in version 6.06 of the FORTRAN-based package GQOPT, is used to obtain FIML estimates of the four-equation AID system of equations for men's bottoms.

All parameters, asymptotic standard errors and T-ratios were obtained and tested for their statistical superiority to a static model of the sort identified in equations (6)-(7) in the previous section. The nonlinear, non-additive model presented here is also found to be statistically superior to a more traditional linear, additive habits type model. The results show that a one-percent change in the price of casual slacks has a larger spillover effect on the demand for jeans than do any of the other categories considered. This result makes intuitive sense, and indicates that men's jeans and casual slacks are closer substitutes than, say, men's jeans and dress slacks. Similar patterns were observed among the other own- and cross-price elasticity estimates. In Figures 1 through 4, the actual demands are compared against the theoretically estimated demands based on the "habit stock" models. The combined trends are shown in Figure 5 based on the total (100%) standardized demand.

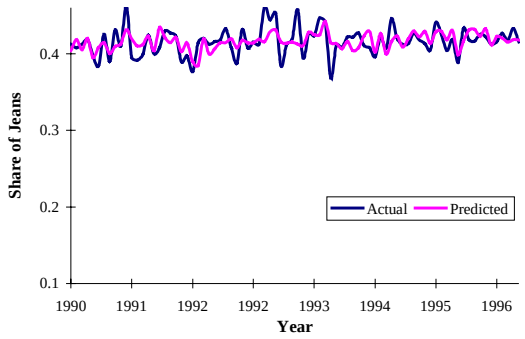


Figure 1. Actual vs. Estimated Demand for Jeans from Habit Stock Models

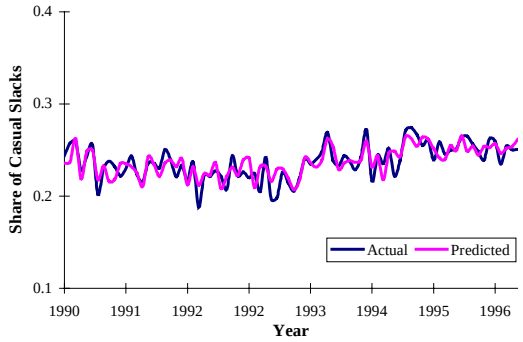


Figure 2. Actual vs. Estimated Demand for Casual Slacks from Habit Stock Models

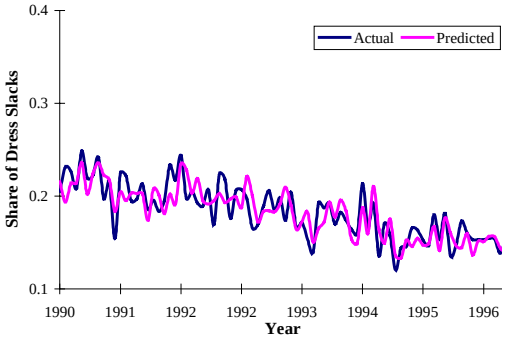


Figure 3. Actual vs. Estimated Demand for Dress Slacks from Habit Stock Models

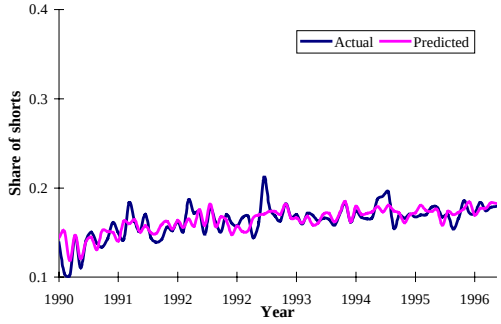


Figure 4. Actual vs. Estimated Demand for Shorts from Habit Stock Models

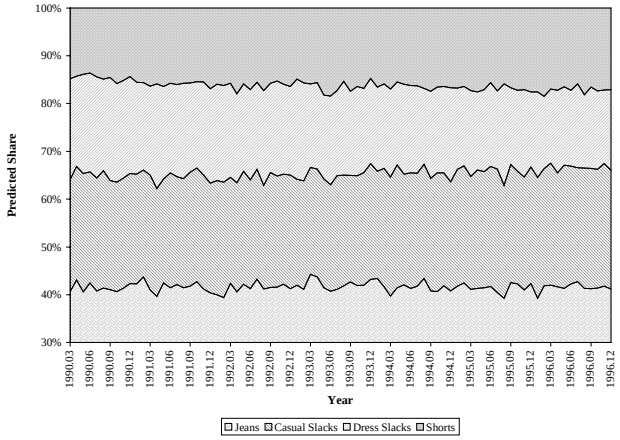


Figure 5. Predicted Men's Bottom Shares(%) Based on Linear Habit Stock Model

In addition, all expenditure elasticities were obtained to indicate the change in demand for a particular category if there is a one-percent increase in expenditure on all items in the group. Results show that all expenditure elasticities are positive, and that they are nearly equal to unity in each case. For brevity, all the estimated parameters and the elasticities are not included in this report. Last of all, we found that the inclusion of habit terms has a substantial effect on the magnitudes of the elasticity estimates. Again, these results underscore the importance of including habit formation terms in the demand equations for apparel items.

3.3 Fashion Trend Analysis with General Social Survey Data

We have attempted using the results of the estimated demand systems to link habit stock variables with observed social, economic, demographic, technological and other industry-specific fashion trend variables. In this way, we will be able to identify which factors aside from prices and income are important in explaining consumers' buying patterns.

For our analyses, men's and women's data from NPD were chosen. Men's jeans and casual slacks were selected for men's *casual* category and men's dress slacks and suites separates were done for men's formal wear category. For women, jeans, slacks, casual dress slacks, and shorts were picked for casual category and dress slacks, suites separates and skirts were chosen for *formal* category. NPD data consist of monthly data from 1990 to 1998. To make appropriate comparisons, the total annual sales units of each item for each year were calculated.

The General Social Surveys have been conducted annually from 1972 to 1993 except 1979, 1981, and 1992 and then, biannually since 1994. There are a total of 38,116 completed interviews. The GSS cumulative data set merges all 22 surveys into a single file with each year or survey acting as a subfile. 1993, 1994, 1996 and 1998 data were filed with an individual year but the rest of the surveys were merged with a subfile, such as, 1972-1982, 1983-1987, and 1988-1991. For this analysis, the corresponding years to NPD data were selected; they were 91, 93, 94, 96, and 98.

The GSS cumulative data set is composed of more than 1100 questions and responses. One example of the GSS data is shown in Figure 6. All questions were carefully examined and screened so that only applicable responses were

included in this analysis. Finally, of the over 1100 questions, 12 questions that are likely to be correlated with consumer apparel purchasing behavior have been selected. In addition, one or more of the dominant responses have been chosen to test 12 separate hypotheses. The questions and matching hypotheses are tabulated in Table 1. Each hypothesis was examined to see if the response rates are correlated significantly with the apparel purchase volumes. For example, if the hypothesis is for *People wear more casual wear than formal wear*, then each of the men's and women's casual items was analyzed.

1. Last week were you working full time, part time, going to school, keeping house, or what?

HAND CARD A

CIRCLE ONE CODE ONLY. IF MORE THAN ONE RESPONSE, GIVE PREFERENCE TO SMALLEST CODE NUMBER THAT APPLIES.

[VAR: WRKSTAT]

RESPONSE	PUNCH	YEAR									COL. 9
		1972-82	1982a	1983-87	1987b	1988-91	1993	1994	1996	1998	ALL
Working full time (ASK A) . .	1	6150	144	3662	169	2,894	809	1594	1641	1568	18,631
Working part time (ASK A) . .	2	1174	33	811	39	648	167	315	302	304	3,793
With a job, but not at work because of temporary illness, vacation, strike (ASK B) . .	3	321	2	155	2	126	33	60	60	46	805
Unemployed, laid off, looking for work (GO TO Q. 2)	4	441	25	242	11	130	52	88	75	58	1,122
Retired (ASK C)	5	1437	38	916	49	842	243	425	350	394	4,694
In school (ASK C)	6	405	11	190	11	215	47	79	84	79	1,121
Keeping house (ASK C) . . .	7	3507	86	1463	67	973	216	382	338	328	7,360
Other (SPECIFY AND ASK C)	8	191	15	103	5	79	39	47	54	54	587
No answer	9	0	0	0	0	0	0	2	0	1	3

[SEE REMARKS]

Figure 6. The Structure of GSS Cumulative Data Set

Table 1. Selected questions and matching hypotheses that are likely to be correlated with consumer purchasing behavior.

H_{01}: People wear more formal wear than casual wear if their answer is
Q: Are we spending too much, too little, or about the right amount on halting the rising crime rate? A: Too little
H_{02}: People wear more formal wear than casual wear if their answer is
Q: Are we spending too much, too little, or about the right amount on the military, armaments and defense? A: Too little
H_{03}: People wear more formal wear than casual wear if their answer is
Q: Go to a bar or tavern? A: About once a year
H_{04}: People wear more formal wear than casual wear if their answer is
Q: Do you think it should be possible for a pregnant woman to obtain a legal abortion if the woman wants it for any reason? A: No
H_{05}: People wear more casual wear than formal wear if their answer is
Q: Go to a bar or tavern? A: Almost everyday
H_{06}: People wear more casual wear than formal wear if their answer is
Q: Go to a bar or tavern? A: Several times a month
H_{07}: People wear more casual wear than formal wear if their answer is
Q: In the next 12 months, how likely do you think it is that you will lose your job or be laid off? A: Not at all likely
H_{08}: People wear more casual wear than formal wear if their answer is
Q: On the whole, how satisfied are you with the work you do? A: Very satisfied
H_{09}: People wear more casual wear than formal wear if their answer is
Q: Do you belong to a labor union? A: Respondent belongs
H_{010}: People wear more casual wear than formal wear if their answer is
Q: Do you approve or disapprove of a married woman earning money in business or industry if she has a husband capable of supporting her? A: Approve
H_{011}: People wear more casual wear than formal wear if their answer is
Q: If your party nominated a woman for President, would you vote for her if she were qualified for the job? A: Yes
H_{012}: People wear more casual wear than formal wear if their answer is
Q: Do you think it should be possible for a pregnant woman to obtain a legal abortion if the woman wants it for any reason? A: Yes

Each apparel item was analyzed with R-square value and R-square values of 0.5 and above have been collected to give the following summary:

Hypothesis: *These people are more likely to wear formal than casual.*

Men's and women's formal wear items were analyzed and significant items were women's dress slacks(1) and women's suites(2).

Their survey answers were:

"spending too little for military, armament, defense" (R-square = 0.52 and 0.75 for 1 and 2, respectively)

"go to a bar about once a year" (R-square = 0.65 and 0.76 for 1 and 2)

"against legal abortion even if the woman wants" (R-square = 0.67 and 0.76 for 1and 2).

Hypothesis: *These people are more likely to wear casual than formal.*

Men's and women's casual wear items were analyzed and significant items were men's jeans (1), women's jeans (2) and women's shorts (3).

Their survey answers were:

"go to a bar or tavern almost every day" (R-square = 0.69 for 1),

"legal abortion if the woman wants" (R-square = 0.70 for 3)

"belong to a labor union" (R-square = 0.73 for 3)

"approve married women making money when her husband is capable of supporting her" (R-square = 0.51, 0.66, and 0.71 for 1, 2, and 3)

"vote for women president" (R-square = 0.51, 0.66, and 0.71 for 1, 2, and 3)

"not likely to lose my job in the next 12 months" (R-square = 0.54, 0.69, and 0.67 for 1, 2, and 3, respectively)

"on the whole, I am very satisfied with my job" (R-square = 0.53, 0.68, and 0.69 for 1, 2, and 3 respectively).

Some of the above are shown in Figure 7(a) - (d) with the corresponding regression analyses. Although the sample size was rather small, it seems that the selected items have shown significant positive correlation between the response rates and the sales volumes.

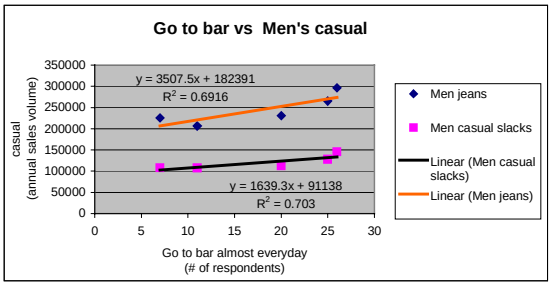
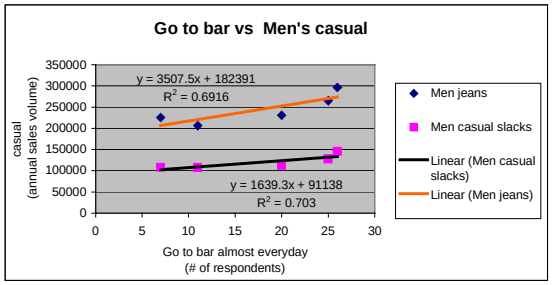
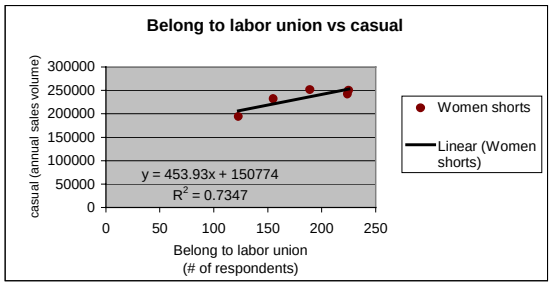


Figure 7(a). Selected Social Behavior vs. Apparel Consumption





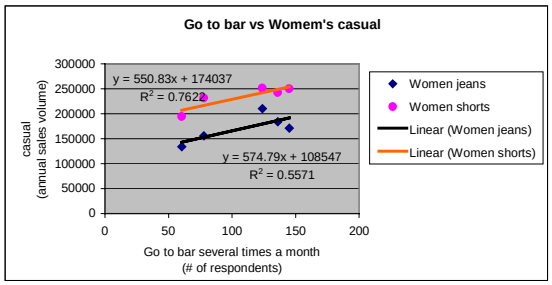


Figure 7(b) - (d). Selected Social Behavior vs. Apparel Consumption

4. CONCLUSIONS

In this study, a set of new statistical methods has been presented to model the U.S. men's wear consumption trends. The models depict the pattern of shifts as well as the dynamic changes in the market shares. The analyses are based on the NPD American Shoppers Panel Data for the last 7 years, 1990 through 1996. By employing the "Habit Stock" model into a first-order differential demand system, the consumption

trends and price-consumption interrelationships for men's wear have been estimated. It was confirmed that in men's wear, habit formation plays a major role in purchasing decision. It was also discussed that using social science data obtained from consumers' general social behaviors was good indicators for the consumer's purchasing behavior. Further analyses will be made with GSS data for the projection of future apparel consumption trends.

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