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Stability of U.S. Consumption Expenditure Patterns: 1996–1999

Lester D. Taylor
University of Arizona

Department of Agricultural and Resource Economics
College of Agriculture and Life Sciences
The University of Arizona

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Abstract

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A cornerstone of macroeconomic analysis since publication of Keynes's *General Theory* in 1936 has been a strong belief in a stable aggregate consumption function. At a micro level, there has been an equally strong belief in invariant individual tastes and preferences. The usual approach in testing for structural stability is to examine consumption, expenditure, or demand functions estimated over different time periods for evidence of changes in marginal propensities to consume, price and income elasticities, and other parameters. This paper takes a different approach. Rather than analyzing stability (or its absence) in terms of invariance in behavioral parameters (i.e., the coefficients in consumption, demand, or Engel functions), the focus is on direct relationships amongst exhaustive categories of U. S. consumption expenditure, using household expenditure information from the on-going quarterly BLS Consumer Expenditure Surveys. Sixteen quarters of data for 1996 through 1999 are analyzed. The results provide strong empirical evidence in support of structural stability in underlying consumption relationships that account for about 85 percent of the variation in U. S. consumer expenditure. Some (speculative) thoughts relating this structural stability to common underlying cultural and genetic factors are offered in conclusion.

Correspondence:

Lester D. Taylor
Department of Economics
University of Arizona
Tucson, AZ 85718

520 299 7334
ltaylor@bpa.arizona.edu

May 15 - October 1:

Box 689
Wilson, WY 83014

307 733 7656

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I. Introduction

A cornerstone of macroeconomic analysis since publication of Keynes's *General Theory* in 1936 has been a strong belief in a stable aggregate consumption function. At a micro level, there has been an equally strong belief in invariant individual tastes and preferences. The usual approach in testing for structural stability is to examine consumption, expenditure, or demand functions estimated over different time periods for evidence of changes in marginal propensities to consume, price and income elasticities, and other parameters. This paper takes a different approach. Rather than analyzing stability (or its absence) in terms of invariance in behavioral parameters (i.e., the coefficients in consumption, demand, or Engel functions), the focus is on direct relationships amongst exhaustive categories of expenditure, using household expenditure information from the on-going quarterly BLS Consumer Expenditure Surveys. Sixteen quarters of data for 1996 through 1999 are analyzed.[1] The results provide strong empirical evidence in support of structural stability in underlying consumption relationships that account for about 85 percent of the variation in U. S. consumer expenditure.

II. Principal Component Analyses of 14 CES Expenditure Categories

The data analyzed in this paper are taken from household expenditure information that is collected quarterly in diary and interview surveys by the U. S. Bureau of Labor Statistics. The analysis proceeds via a principal component analysis of 14 categories of consumption expenditure for each of the 16 quarters in the data set, and then examining the stability of the underlying eigen-vectors. The 14 categories of expenditure that are the focus of the analysis are listed in Table 1.

To fix the technical ideas underlying the analysis, let X denote an n by m matrix of n observations on m variables, and suppose that we want to find an m-by-m matrix K that transforms the variables represented by the columns of X into a set of new variables $Z = (z_1, z_2, ..., z_m)$ that are orthogonal to one another, *viz*.:

(1) $$Z = XK,$$

such that

(2) $$Z'Z = [\lambda],$$

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[1] All data analyzed in this paper are taken from the Public Use Microdata CD-ROMs of Consumer Expenditure, 1996-1999, obtained from the Bureau of Labor Statistics, U. S. Department of Labor.

Table 1

Consumption Categories
BLS CES Quarterly Surveys

Category	Mnemonic
Food	Food
Alcoholic Beverages	Alco.Bev.
Housing	Housing
Apparel	Apparel
Transportation	Trans.
Health	Health
Entertainment	Entertain.
Personal Care	Per.Care
Reading	Reading
Education	Educ.
Tobacco	Tobacco
Miscellaneous	Misc.
Cash Contributions	CashCtrb.
Personal Insurance	Pers.Ins.

where [λ] is a m by m diagonal matrix. From (1),we then have for $Z'Z$:

(3) $$Z'Z = K'X'XK ,$$

so that

(4) $$K'X'XK = [\lambda] .$$

Since $X'X$ is real, symmetric, and positive definite, it follows that the columns of K will be the (normalized) eigenvectors associated with the k latent roots of $X'X$, which in turn are given by the diagonal elements of [λ] .

To find the columns of Z (which are called the *principal components* of $X'X$), we proceed as follows. Since K is an orthonormal matrix, $K'K = I$, which means that the trace of $Z'Z$ will be equal to the trace of $X'X$. This being the case, we can find for the "first" principal component (PC) of $X'X$ the z that makes a maximum contribution to the trace of $Z'Z$, subject to the condition that $k_1'k_1 = 1$, that is, we want to maximize:

(5) $$\Phi(z_1, \kappa) = z_1'z_1 - \kappa(z_1'X'Xz_1 - 1)$$

with respect to z_1 and κ, where κ is a Lagrangian multiplier associated with the constraint $k_1'k_1 = 1$. From the first-order conditions:

$$(6) \qquad 2z_1 - 2\kappa X'Xz_1 = 0$$

$$(7) \qquad z_1'X'Xz_1 - 1 = 0,$$

we eventually find that

$$(8) \qquad z_1'z_1 = \kappa.$$

Since the z_1 that is desired is the one that makes a maximum contribution to the trace of $Z'Z$, which in turn is equal to sum of the latent roots of $X'X$, it accordingly follows that the k that yields the "first" PC will be the k that is associated with the largest latent root of $X'X$.

The "second" PC of $X'X$ will then be obtained as the z that makes the second largest contribution to the trace of $Z'Z$, but now subject not only to $k_2'k_2 = 1$, but also to $k_2'k_1 = 0$. Skipping details, the k_2 that yields this PC will be the eigenvector associated with second largest latent root of $X'X$. The remaining m - 2 principal components are obtained accordingly.

For the situation at hand, each row of X will represent the expenditures for a particular household in each of the 14 expenditure categories listed in Table 1, as taken from a particular quarterly BLS CES survey. The latent roots (normalized so that they sum to one) for the 16 quarterly surveys analyzed are tabulated in Table 2.[2]

From the table, we see that the largest principal component (i.e., the PC associated with the latent root) accounts for about 60 percent of the total variation in expenditure, while the second largest principal component accounts for about 25 percent.[3] In contrast, the five smallest PC's (i.e., those associated with latent roots 10 through 14) account for less than one percent of the total variation in expenditure. Given the minuteness of these roots, the variation they measure might be thought to be meaningless noise. However, this would be a false conclusion, for, as will be seen below, all of the "small" PC's can in fact be identified with specific categories of expenditure; #14, for example, which typically accounts for less than one one- hundredth of one percent of the total

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[2] All mathematical and statistical calculations have in SAS.

[3] It is important to keep in mind that the 60 percent and 25 percent refer to the *total variation* in consumption expenditure (where "total variation" is defined as the sum of squared expenditures over all of the households in a sample over all 14 categories of expenditure), and accordingly *does not refer to the proportion of total consumption* that, on the average, is accounted for by the principal components in question. With regard to the latter, the largest principal component typically accounts for about 40 percent of total expenditure, while the second largest typically accounts for about 10 percent.

Table 2

Latent Roots for 14 CES Expenditure Categories
1996 - 1999

Latent Root	1996Q1	1996Q2	1996Q3	1996Q4	1997Q1	1997Q2	1997Q3	1997Q4
1	0.60385	0.61274	0.57089	0.55001	0.61914	0.62163	0.60412	0.60375
2	0.25284	0.23209	0.20789	0.21223	0.24360	0.24700	0.23415	0.24056
3	0.04442	0.06506	0.12853	0.14030	0.03369	0.03809	0.07533	0.03773
4	0.02493	0.02908	0.02905	0.02769	0.02302	0.03222	0.03197	0.03247
5	0.02011	0.01971	0.02073	0.02085	0.01793	0.01982	0.01971	0.02554
6	0.01746	0.01307	0.01308	0.01742	0.01698	0.01050	0.01015	0.01893
7	0.01371	0.01076	0.00898	0.01142	0.01464	0.01018	0.00825	0.01404
8	0.01047	0.00666	0.00829	0.01059	0.01076	0.00891	0.00785	0.01173
9	0.00796	0.00516	0.00618	0.00495	0.00970	0.00587	0.00379	0.00801
10	0.00280	0.00439	0.00499	0.00332	0.00883	0.00415	0.00333	0.00572
11	0.00064	0.00058	0.00068	0.00059	0.00074	0.00082	0.00070	0.00074
12	0.00052	0.00045	0.00047	0.00039	0.00061	0.00053	0.00040	0.00053
13	0.00018	0.00018	0.00017	0.00015	0.00018	0.00019	0.00017	0.00017
14	0.00011	0.00008	0.00008	0.00008	0.00017	0.00010	0.00009	0.00010

Latent Root	1998Q1	1998Q2	1998Q3	1998Q4	1999Q1	1999Q2	1999Q3	1999Q4
1	0.60950	0.61481	0.58659	0.59920	0.60645	0.54761	0.52546	0.61113
2	0.24208	0.24573	0.23366	0.22984	0.26096	0.24881	0.22686	0.25281
3	0.03486	0.03584	0.06613	0.06721	0.03868	0.10108	0.15219	0.03938
4	0.03225	0.02919	0.05235	0.03528	0.03051	0.03848	0.03249	0.02498
5	0.02293	0.02085	0.02091	0.02068	0.01685	0.01799	0.02081	0.02046
6	0.01592	0.01608	0.01192	0.01701	0.01496	0.01159	0.01833	0.01569
7	0.01415	0.01575	0.00934	0.00989	0.00985	0.01008	0.00826	0.01073
8	0.01283	0.01080	0.00898	0.00761	0.00873	0.00839	0.00737	0.00991
9	0.00849	0.00616	0.00498	0.00629	0.00589	0.00781	0.00433	0.00863
10	0.00544	0.00353	0.00396	0.00568	0.00561	0.00694	0.00303	0.00492
11	0.00074	0.00057	0.00054	0.00058	0.00068	0.00053	0.00049	0.00063
12	0.00053	0.00043	0.00039	0.00045	0.00051	0.00043	0.00034	0.00050
13	0.00017	0.00015	0.00015	0.00017	0.00020	0.00016	0.00013	0.00015
14	0.00013	0.00012	0.00009	0.00008	0.00011	0.00008	0.00006	0.00009

variation in expenditure, is highly correlated with expenditures for reading materials. But this is getting ahead of the story.

Since the transformation from non-orthogonal X to orthogonal Z involves a full-rank linear transformation, the (linear) relationships amongst the columns of X will now be represented in the eigenvectors forming the columns of K[4]. From this, it follows that questions involving stability of expenditure patterns can equivalently be investigated in terms of the stability of the columns of K. My (exceedingly simple) approach to investigating this stability has proceeded via a sequence of regression analyses, in which the eigenvectors for a quarter are regressed on their counterparts for other quarters. High R^2's will obviously be in support of stability. A total of 35 regressions have been estimated, of which 15 entail contiguous quarters and 5 (arbitrary) non-contiguous quarters. The final regressions involve a pooled framework to be discussed below.

The R^2's for the contiguous and non-contiguous regressions are tabulated in Table 3. Eigenvectors are represented in columns in the table, while quarters are represented in rows. The very first element of the table (0.997) thus represents the R^2 in the regression of the eigenvector associated with largest latent root for 1996Q2 on the same for 1996Q1. Similarly, for the non-contiguous entries, the first element (0.984) represents the R^2 in the regression of the eigenvector associated with largest latent root for 1999Q1 on the same for 1997Q3. Since our concern is with eigenvector stability across time, what we obviously are looking for are columns with uniformly high R^2's. This is clearly evident in columns 1, 2, 13, and 14, and to lesser extent in columns 5, 11, and 12. The principal components associated with these eigenvectors typically account for about 90 percent of the total variation in consumer expenditure, hence a great deal of stability in consumption patterns (at least by this measure) appears to be present.

Additional evidence in support of stability is offered by a final set of 14 "pooled" contiguous-quarter eigenvector regressions, in which the coefficients on the "lagged" quarter are constrained to be equal across the 15 quarters from 1996Q2 through 1999Q4, which is to say that the equations estimated are of the form:

$$k_{ijt} = \alpha + \beta k_{ij(t-1)} + u_{ijt}, \tag{9}$$

for i,j = 1, ..., 14 and t = 1996Q2, ..., 1999Q4. The R^2's for these 14 equations are tabulated in Table 4. The R^2's are seen to be very high for eigenvectors 1, 2, 13, and 14 (0.9600 or higher), and moderately high for numbers 5 and 11 (0.4550 and 0.7556).[5]

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[4] Orthogonal and non-orthogonal in this context refers to the columns of Z and X.

[5] "Seasonal" effects are allowed for in the equations through inclusion of three quarterly dummy variables, both singly and interacted with the lagged eigenvector. The only equations displaying any seasonal effects at all are for eigenvectors 2, 4, 5, 7, 8, and 12. The strongest seasonal effects are in the equation for number 12. For eigenvector 2, the only seasonal variable with a t-ratio greater than 2 is the linear term for the second quarter.

Table 3

R^2's for Eigenvector Regressions
14 CES Expenditure Categories
1996 - 1999

Quarter	1	2	3	4	5	6	7	8	9	10	11	12	13	14
							Eigenvector							
							*Contiguous Quarters**							
1996Q2	0.997	0.899	0.954	0.051	0.234	0.028	0.070	0.891	0.931	0.836	0.856	0.992	0.994	0.999
1996Q3	0.971	0.975	0.993	0.974	0.946	0.765	0.886	0.684	0.107	0.144	0.958	0.968	0.998	0.997
1996Q4	0.998	0.984	0.983	0.970	0.769	0.008	0.076	0.012	0.005	0.001	0.998	0.999	0.999	0.999
1997Q1	0.978	0.991	0.066	0.000	0.174	0.292	0.178	0.153	0.061	0.015	0.895	0.919	0.752	0.783
1997Q2	0.985	0.993	0.328	0.120	0.019	0.128	0.338	0.003	0.078	0.031	0.637	0.705	0.746	0.778
1997Q3	0.996	0.998	0.993	0.974	0.946	0.765	0.886	0.684	0.107	0.144	0.958	0.968	0.998	0.997
1997Q4	0.997	0.997	0.029	0.002	0.932	0.010	0.065	0.462	0.955	0.980	0.456	0.453	0.998	0.999
1998Q1	0.997	0.998	0.640	0.016	0.860	0.000	0.062	0.023	0.972	0.989	0.990	0.992	0.973	0.975
1998Q2	0.973	0.989	0.617	0.002	0.694	0.022	0.454	0.003	0.142	0.211	0.740	0.793	0.972	0.974
1998Q4	0.987	0.982	0.534	0.591	0.813	0.080	0.003	0.015	0.888	0.915	0.582	0.667	0.998	0.999
1999Q1	0.987	0.984	0.186	0.256	0.855	0.898	0.936	0.865	0.059	0.094	0.592	0.671	0.999	0.999
1992Q2	0.978	0.907	0.030	0.153	0.637	0.006	0.802	0.800	0.000	0.549	0.942	0.956	0.996	0.997
1999Q3	0.963	0.871	0.000	0.732	0.702	0.009	0.023	0.485	0.026	0.878	0.827	0.863	0.998	0.999
1999Q4	0.971	0.963	0.024	0.002	0.527	0.985	0.038	0.082	0.001	0.014	0.868	0.898	0.999	0.999
							Non-Contiguous Quarters							
1999Q2/ 1997Q3	0.984	0.909	0.003	0.834	0.824	0.000	0.013	0.679	0.015	0.878	0.767	0.811	0.998	0.999
1998Q4/ 1996Q2	0.947	0.975	0.997	0.995	0.807	0.070	0.083	0.949	0.008	0.012	0.682	0.748	0.990	0.990
1999Q4/ 1998Q1	0.996	0.994	0.064	0.064	0.499	0.027	0.062	0.017	0.035	0.075	0.876	0.905	0.981	0.983
1998Q3/ 1997Q1	0.973	0.985	0.721	0.244	0.062	0.067	0.055	0.044	0.874	0.923	0.963	0.972	0.713	0.748
1997Q2/ 1996Q2	0.974	0.987	0.862	0.867	0.954	0.439	0.048	0.012	0.739	0.819	0.552	0.633	0.996	0.996

* The contiguous equations have the form, $k_{i\,j\,t} = \alpha + \beta k_{i\,j\,(t-1)} + u_i$, where $k_{i\,j\,t}$ represents the j^{th} element of the i^{th} eigenvector in quarter t, for i,j = 1, ..., 14 and t = 1996Q2, ..., 1999Q4.

Table 4

R^2's for Pooled Eigenvector Regressions
14 CES Expenditure Categories
1996 - 1999

Eigenvector	R^2
1	0.9774
2	0.9708
3	0 2415
4	0.2377
5	0.4550
6	0.1087
7	0.0750
8	0.0951
9	0.1693
10	0.2022
11	0.7556
12	0.0728
13	0.9600
14	0.9626

The conclusion from Tables 3 and 4 (especially Table 4) would seem to be that there is something pretty special about the principal components associated with both the two largest and two smallest latent roots. The components associated with latent roots 5 and 11 appear to be somewhat special as well. One way of examining what might be going on with the principal components is to obtain the "factor" loadings for the PC's by regressing each of them on the fourteen underlying categories of expenditure as predictors. For illustration, "loadings" for the first and last quarters of the study are tabulated in Table 5.[6] "Key" loadings are highlighted in bold print.

The following results emerge from this table:

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[6] Since principal components are (by construction) exact linear combinations of the 14 underlying categories of expenditure, the R^2's of the regressions will obviously all be equal to 1. Equally obviously, the resulting vectors of "factor loadings"simply reproduce the corresponding eigenvectors. However, formulating principal components in regression terms has always seemed to me to enlighten interpretation.

(1). The stability of eigenvectors 1, 2, 13, and 14 is immediately apparent.

(2). PC 2 is virtually identical with PC 1, except for a *negative* loading on transportation.

(3). PC's 6 - 10 and 13 and 14 are all associated with a single expenditure category (cf., PC 7 with education in 1996Q1, PC 10 with apparel in 1999Q4, etc.).

(4). The expenditure categories with high single loadings vary between quarters for PC's 6 - 10 (cf., for example, the loadings on education and health for PC 7 for 1196Q1 with the same for 1999Q4). PC's 13 and 14, on the other hand, are obviously associated with expenditures for personal care and reading materials, respectively, a result, incidently, that holds for all 16 quarters of data.

(5). PC's 11 and 12, it will be noted, are clearly associated with alcoholic beverages and tobacco, for these are the only components that have non-trivial loadings on those two categories of expenditure. This unique association holds for both PC 11 and PC 12 over all 16 quarters of data, as do the positive loadings for PC 11. On the other hand, while the signs for the loadings on alcoholic beverages and tobacco for PC 12 are always opposite to one another (as in the table), their *order* (i.e., whether +, −, or −, +) is not constant across quarters.[7]

III. Interpretation of Results

The principal-component/eigenvector analyses of the preceding section are essentially simply exercises in linear algebra. We now turn to a discussion and (attempted!) interpretation of the results that have been obtained to this point, beginning with the strong structural stability (across all 16 quarters of data) in four principal components that account for between 85 and 90 percent of the total variation in U.S. household consumption expenditure. The four principal components in question are the two "largest" (PC's 1 and 2) and the two "smallest" (PC's 13 and 14). Since the latter account for just a minor fraction of the total variation in expenditure, the former are obviously of most interest.

As was noted in Section II, two things stand out in connection with the "expenditure loadings" for PC's 1 and 2 in Table 5. The first is simply the congruence of the loadings, except for a switch in signs on transportation! At an extreme (i.e., if, except for the signs on transportation, the loadings on the two components were in fact identical), this result would have the following implications: (1) the *sum* of the two principal components would be independent (mathematically) of expenditures for transportation, while (2) the *difference* of the two components would be exactly

[7] This "flipping of signs" accounts, in Table 4, for the R^2 of 0.0728 for eigenvector 12, compared with the R^2 of 0.7556 for eigenvector 11.

co-linear with transportation expenditures.[8] Although this congruency seems almost too bizarre to be fortuitous, thoughts as to what might be being reflected behaviorally will be postponed till later.

The second thing that stands out in connection with the expenditure loadings in Table 5 for the first two principal components is the number of non-trivial loadings in each of the first two columns, as opposed to the at most two large loadings in most of the other columns. One way that the non-trivial loadings for PC's 1 and 2 can be viewed is as identifying a "basic" market basket of goods and services, consisting of expenditures for food, housing, apparel, transportation, health, entertainment, education, and personal insurance. Food, shelter, clothing, and health are, of course, intrinsic to survival, as indeed in our modern age (though perhaps at a higher level of "want") are certain levels of expenditure for transportation, entertainment, education, and personal insurance. Accordingly, in view of their strong structural stability over the 16 quarters of data, what it seems to me might be being captured in the first two principal components is a substantial part of consumption expenditure that reflects stable genetic, cultural, and demographic influences.

Since this last statement is admittedly highly speculative, let me try to be clear as to what is being said. By genetic influences, I simply have in mind the fact every human being is motivated "to make a living", in the sense of having to have certain amounts of food, clothing, and shelter in order to survive. At the most basic level, these influences can be seen as *biologically* determined and common to all individuals. On the other hand, by cultural influences, I have in mind a slowly varying set of factors that drive various forms of *social* consumption. The consumption governed by these influences can be seen as determining a "social subsistence" component of consumption. Finally, a third "subsistence" component can be seen as arising from the influence of a variety of time-varying demographic factors, such as age, education, family size, place of residence, etc. The thrust, accordingly, of the statement at end of the last paragraph is that these three sets of factors (genetic, cultural, and demographic) are sufficiently invariant so as to impart a basic structural stability to the 85-plus percent of the variation in consumption expenditure that is accounted for by the two largest principal components.

An obvious next step is to see how much of sample variation in these two principal components can be explained, in a conventional regression format, by variation in income and socio-demographic factors. However, before proceeding to this, it will be useful to examine briefly the loadings for the remaining principal components in Table 5. PC's 11 and 12, as was noted in Section II, are of interest because their unique association with alcoholic beverages and tobacco. Since the loadings for PC 11 are both positive and generally of the same magnitude over all 16 quarters of data, this component can clearly be "identified" as an "alcohol-tobacco" component. PC 12, on the other hand, is another matter. For, while the loadings on alcoholic beverages and tobacco for this component are always the only non-trivial ones, and are always of opposite signs, the order

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[8] For the data actually at hand, the regression of PC1 − PC2 on transportation expenditures for 1996Q1 yields an R^2 of 0.9960, while the regression of PC1 + PC2 on transportation expenditures has an R^2 of 0.0094. For 1999Q4, the comparable R^2's are 0.9993 and 0.0257.

Table 5

Loadings of Principal Components
On 14 CES Expenditure Categories

1996Q1 and 1999Q4

Expenditure	*Principal Component* 1	2	3	4	5	6	7	8	9	10	11	12	13	14
							1996Q1							
Food	**0.235**	**0.137**	0.532	0.452	-0.443	-0.456	-0.023	-0.095	-0.149	0.003	-0.041	-0.015	-0.022	-0.004
Alco. Bev.	0.015	0.009	0.027	0.005	-0.020	0.002	0.004	0.006	0.003	-0.005	**0.870**	**-0.492**	-0.012	0.001
Housing	**0.686**	**0.614**	-0.382	-0.053	0.049	0.003	-0.030	-0.003	-0.028	-0.007	-0.004	0.001	-0.005	-0.004
Apparel	**0.095**	**0.058**	0.170	0.044	-0.102	0.076	0.069	0.077	0.963	-0.025	-0.010	0.009	-0.035	-0.010
Transp.	**0.643**	**-0.763**	-0.068	-0.012	0.009	0.002	0.001	0.002	-0.004	0.001	-0.001	-0.001	-0.001	0.001
Health	**0.076**	**0.044**	0.229	0.571	0.771	0.140	-0.002	-0.020	-0.005	-0.006	0.002	-0.004	-0.008	-0.003
Entertain.	**0.104**	**0.062**	0.252	0.116	-0.336	0.873	-0.077	-0.044	-0.160	-0.007	-0.015	0.007	-0.005	-0.006
Pers.Care	0.014	0.008	0.022	0.012	-0.007	-0.002	0.001	0.002	0.027	0.002	0.004	-0.016	**0.988**	-0.145
Reading	0.009	0.007	0.015	0.000	-0.001	0.004	0.001	0.008	0.010	0.007	0.002	0.003	0.144	**0.989**
Educ.	**0.040**	**0.032**	0.056	-0.028	-0.008	0.049	0.991	0.028	-0.093	-0.005	-0.004	0.007	-0.000	-0.002
Tobacco	0.010	0.005	0.018	0.016	-0.012	-0.014	-0.005	-0.001	-0.008	-0.003	**0.491**	**0.870**	0.011	-0.005
Misc.	0.025	0.017	0.067	0.040	-0.026	-0.011	-0.041	0.990	-0.097	-0.033	-0.009	0.002	0.004	-0.008
CashCtrb.	0.012	0.010	0.020	-0.009	0.006	0.009	0.003	0.034	0.018	0.999	0.004	0.001	-0.004	-0.007
Pers.Ins.	**0.181**	**0.109**	0.642	-0.670	0.287	-0.036	-0.068	-0.026	-0.067	-0.022	-0.010	0.004	-0.007	-0.009
							1999Q4							
Food	**0.227**	**0.157**	0.306	0.483	-0.627	0.187	-0.365	-0.139	-0.013	-0.112	-0.041	-0.003	-0.020	-0.004
Alco. Bev.	0.015	0.010	0.018	0.010	-0.019	0.002	-0.012	0.014	0.000	-0.018	**0.712**	**-0.701**	0.001	-0.020
Housing	**0.653**	**0.642**	-0.326	-0.143	0.100	-0.151	-0.006	-0.032	0.004	-0.035	-0.006	0.004	-0.007	-0.002
Apparel	**0.069**	**0.051**	0.069	0.068	-0.072	0.004	-0.014	0.140	0.022	0.978	-0.014	0.021	-0.031	-0.017
Transp.	**0.682**	**-0.729**	-0.052	-0.022	0.030	0.004	-0.006	-0.010	0.003	0.002	-0.002	0.000	-0.001	-0.000
Health	**0.074**	**0.046**	0.083	0.128	-0.258	0.169	0.897	-0.302	-0.042	0.015	-0.003	-0.011	-0.015	-0.010
Entertain.	**0.095**	**0.056**	0.150	0.114	-0.109	-0.021	0.239	0.921	-0.082	-0.163	-0.018	0.003	-0.002	-0.009
Pers.Care	0.013	0.009	0.011	0.015	-0.015	-0.001	0.005	-0.003	0.002	0.026	0.002	0.004	**0.994**	-0.104
Reading	0.008	0.005	0.010	0.005	-0.007	0.083	0.010	0.007	0.002	0.018	0.009	-0.017	0.103	**0.994**
Educ.	**0.046**	**0.045**	0.056	0.767	0.629	0.049	0.045	-0.040	-0.009	-0.007	0.007	0.007	-0.003	-0.000
Tobacco	0.010	0.005	0.013	0.012	-0.026	0.003	-0.000	0.002	-0.000	-0.010	**0.705**	**0.713**	-0.001	0.006
Misc.	0.036	0.058	-0.167	-0.172	0.081	0.961	0.004	0.069	-0.058	0.012	0.003	0.000	0.007	0.018
CashCtrb.	0.016	0.016	0.021	-0.006	-0.004	0.063	0.054	0.059	0.993	-0.036	-0.002	- 0.000	-0.002	-0.003
Pers.Ins.	**0.184**	**0.135**	0.856	-0.304	0.328	0.056	-0.015	-0.096	-0.036	-0.021	-0.006	0.004	-0.004	-0.005

of the signs is not stable. If PC 11 is seen as representing the expenditures of households on alcoholic beverages and tobacco that both drink and smoke, then PC might be interpreted as representing expenditures for those households that do one or the other (but not both). However, the problem with this interpretation is the switching of signs. What does it mean for alcohol to have a negative loading in one survey, but positive in another, and *vice-versa* for tobacco?

Some insight into this last question may be obtained from consideration of the instability apparent in the loadings for principal components 3 through 10. Of these eight PC's, #'s 3, 4, and 5 typically have two or more non-trivial loadings over the 16 quarters of data, while #'s 6 through 10 invariably have just a single high loading, single high loadings, incidentally, that are always confined to one of apparel, entertainment, health, education, miscellaneous, or cash contributions. The thing that comes to mind in connection with expenditures in these categories is that they tend to be "lumpy" with respect to both time and households. One household might show a large apparel expenditure in a particular quarter, because of a change in employment, for example, while a second household might show a large health expenditure because of an accident, a third household might show a large education expenditure because of two children being in college, while a fourth household could show a large cash contribution because of warm feelings toward the nursing home that a parent had lived in, and so on and so forth. Lumpiness, combined with a certain amount of inherent randomness, of such expenditures accordingly means that the relative variation in expenditures across the six categories in question can shift from quarter to quarter, which in turn means (since the "sizes" of principal components are determined according to relative contributions to total variation) that expenditure categories need not always identify with the same principal components. Entertainment, for example, might identify with PC 6 in one sample, but with PC 7 in another (as the case with 1996Q1 and 1999Q4 in Table 5). Such considerations would seem to apply as well to PC's 3, 4, and 5, and maybe even can account for the sign switches on alcoholic beverages and tobacco with PC 12.

IV. Regression Models for PC's 1 and 2

The primary result to this point is the isolation of two stable consumption substructures that account for between 85 and 90 percent of the variation in U.S. household consumption expenditure. In this section, the principal components of consumption that define these two substructures are taken as dependent variables to be "explained", in a traditional regression framework, as functions of income and a variety of socio-demographic variables. The results for 1996Q1 and 1999Q4 are presented in Tables 6 - 9. Both linear and logarithmic equations are estimated. The estimated regression coefficients (together with their associated t-ratios and p-values) tabulated in Tables 6 and 7 for the linear equations, and in Tables 8 and 9 for the logarithmic models.[9] Of the 23 independent

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[9] The principal components for 1996Q1 and 1999Q4 have been calculated from samples consisting of 3670 and 7704 households, respectively. However, households with incomes less than $5000 are eliminated from the regression analyses, as are also the negative observations in the logarithmic equations for PC 2 (all observations are positive with PC 1). The resulting sample sizes are consequently 2750 and 5637 for 1996Q1 and 1999Q4 for the linear equations,

variables in the models, all are dummy variables, except for income, the number of earners in the household (no_earnr), the age of the reference person for the household (age_ref), and household size (fam_size). Definitions of all the variables can be found in the appendix. In view of the superior fit for the logarithmic models, the discussion that follows will focus primarily on Tables 8 and 9.

For PC1 in Table 8, after income, which not surprisingly is the strongest predictor, we find the expenditures represented by this component to be positively related to the number of earners in a household, family size, and education, and negatively related to single-person households, living in a rural area, living in the northeast, mid-west, or south (as opposed to living in the west), and the receipt of food stamps. Moreover, the R^2 for this equation is a very respectable (for a cross-section sample) of about 0.50. For PC2 in Table 9, we again find a very strong effect of income, and strong negative effects associated with single households, rural households, and living in the mid-west or south (again relative to living in the west). The R^2 for this component, however, is much lower than for PC1. Since the loadings for PC1 and PC2 for the most part differ only in the sign of the loading on transportation expenditures, this difference obviously has to be manifested somewhere, and is seen to reside principally in the change in sign on the number of earners in the household (with little loss in statistical significance), emergence of strong positive effects of children in the household (countered by a decrease in the importance of the raw size of the household), and a greatly reduced negative effect of food stamps. However, the result that perhaps most leaps out of the columns in Tables 8 and 9, is the virtually identical income elasticities for the two principal components, at a value of about 0.45.[10]

V. Summary and Conclusions

This paper has undertaken a detailed examination of the stability of U.S. household consumption patterns by employing a combined principal-component/regression analysis of 16 quarters of consumer expenditure data from the BLS Consumer Expenditure Surveys. The primary findings of the study are as follows:

(1). Five stable consumption structures are isolated that regularly account for between 85 and 90 percent of the total variation in 14 (exhaustive) categories of consumption expenditure.

(2). Four of the structures in question are associated with both the two "largest" and two "smallest" principal components of consumption expenditure. The largest principal component typically accounts for about 60 percent of the total variation in expenditure, while the second largest component accounts for another 25 percent.

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and 2433 and 5022 for the logarithmic equations.

[10] The income elasticities for the two PC's over the 16 quarters of data vary from 0.39 to 0.46, and never differ in any quarter by more than 0.03.

Table 6

Regression Models for PC 1
1996Q1 and 1999Q4

linear models

1996Q1

Variable	Parameter	t-ratio	p-value
intercept	376.17	0.30	0.7672
income	0.1264	17.45	< 0.0001
no_earnr	254.97	3.30	0.0010
age_ref	-2.787	-0.75	0.4530
fam_size	236.69	3.95	< 0.0001
dsinglehh	-272.02	-1.61	0.1077
drural	-241.10	-1.38	0.1678
dnochild	-208.12	-1.17	0.2431
dchild1	-6.929	-0.03	0.9748
dchild4	-173.17	-0.72	0.4746
ded10	402.19	1.60	0.1102
dedless12	520.44	0.45	0.6556
ded12	523.84	0.45	0.6523
dsomecoll	961.31	0.83	0.4094
ded15	1733.83	1.48	0.1382
dgradschool	1355.00	1.15	0.2489
dnortheast	-294.53	-1.70	0.0887
dmidwest	-371.10	-2.33	0.0198
dsouth	-315.05	-2.05	0.0406
dwhite	533.27	1.86	0.0636
dblack	549.61	1.67	0.0944
dmale	219.14	1.82	0.0684
dfdstmps	-767.69	-3.45	0.0006
d1	-19.06	0.06	0.9530

$R^2 = 0.2751$ d.f. = 2726
mean of PC1: $3395

1999Q4

Variable	Parameter	t-ratio	p-value
intercept	692.94	0.67	0.5009
income	0.1392	27.93	< 0.0001
no_earnr	184.83	2.84	0.0045
age_ref	1.653	0.52	0.6016
fam_size	118.32	2.16	0.0308
dsinglehh	-614.57	-4.31	< 0.0001
drural	-208.46	-1.28	0.2013
dnochild	-109.08	-0.74	0.4579
dchild1	100.64	0.51	0.6112
dchild4	-12.73	-0.06	0.9537
ded10	-381.10	-1.59	0.1123
dedless12	989.88	1.02	0.3094
ded12	1069.92	1.11	0.2690
dsomecoll	1651.84	1.71	0.0881
ded15	2028.42	2.09	0.0370
dgradschool	2722.23	2.78	0.0055
dnortheast	-334.89	-2.34	0.0194
dmidwest	-544.34	-4.08	< 0.0001
dsouth	-591.42	-4.75	< 0.0001
dwhite	364.93	1.70	0.0886
dblack	143.25	0.56	0.5757
dmale	-21.91	-0.23	0.8205
dfdstmps	-723.16	-2.90	0.0037
d1	304.35	-1.81	0.0708

$R^2 = 0.2641$ d.f. = 5613
mean of PC1: $3933

Table 7

Regression Models for PC 2
1996Q1 and 1999Q4

linear models

1996Q1				1999Q4			
Variable	Parameter	t-ratio	p-value	Variable	Parameter	t-ratio	p-value
intercept	1027.65	0.81	0.4203	intercept	847.70	0.85	0.3957
income	0.00728	7.02	< 0.0001	income	0.0624	12.87	< 0.0001
no_earnr	-200.92	-2.59	0.0097	no_earnr	-213.69	-3.39	0.0007
age_ref	5.304	1.42	0.1549	age_ref	2.162	0.70	0.4811
fam_size	-40.13	-0.67	0.5042	fam_size	20.60	0.39	0.6982
dsinglehh	-208.30	-1.23	0.2197	dsinglehh	110.81	0.80	0.4231
drural	-168.74	-0.96	0.3362	drural	-331.83	-2.10	0.0359
dnochild	-305.09	-1.70	0.0883	dnochild	-205.48	-1.44	0.1492
dchild1	157.98	0.72	0.4729	dchild1	216.71	1.13	0.2588
dchild4	74.76	0.31	0.7584	dchild4	421.44	1.98	0.0475
ded10	-479.07	-1.90	0.0580	ded10	239.27	1.03	0.3038
dedless12	-361.81	-0.31	0.7574	dedless12	-489.89	-0.52	0.6038
ded12	-146.77	-0.13	0.8999	ded12	-183.46	-0.20	0.8450
dsomecoll	-111.31	-0.10	0.9242	dsomecoll	-379.46	-0.40	0.6861
ded15	73.14	0.06	0.9503	ded15	257.19	0.27	0.7850
dgradschool	477.90	0.41	0.6854	dgradschool	291.65	0.31	0.7588
dnortheast	189.55	1.09	0.2750	dnortheast	129.17	0.93	0.3521
dmidwest	-317.26	-1.99	0.0472	dmidwest	-155.69	-1.20	0.2285
dsouth	-425.33	-2.76	0.0059	dsouth	-314.92	-2.61	0.0091
dwhite	-92.38	-0.32	0.7488	dwhite	-54.45	-0.26	0.7932
dblack	-286.95	-0.87	0.3842	dblack	107.72	0.43	0.6642
dmale	-80.40	-0.67	0.5053	dmale	-24.33	-0.26	0.7950
dfdstmps	119.65	0.54	0.5918	dfdstmps	-79.86	-0.33	0.7410
d4	217.66	0.67	0.5027	d4	214.13	1.31	0.1898

1996Q1: $R^2 = 0.0525$ d.f. = 2726
mean of PC2: $775

1999Q4: $R^2 = 0.0560$ d.f. = 5613
mean of PC2: $1054

Table 8

Regression Models for PC 1
1996Q1 and 1999Q4

logarithmic models

	1996Q1				1999Q4		
Variable	Parameter	t-ratio	p-value	Variable	Parameter	t-ratio	p-value
intercept	3.0146	10.44	< 0.0001	intercept	2.7709	13.39	< 0.0001
lnincome	0.4371	24.68	< 0.0001	lnincome	0.4491	36.89	< 0.0001
no_earnr	0.0563	3.73	0.0002	no_earnr	0.0518	4.68	< 0.0001
age_ref	-0.0018	-2.59	0.0096	age_ref	-0.0000	-0.02	0.9824
fam_size	0.0470	4.12	< 0.0001	fam_size	0.0343	3.76	0.0002
dsinglehh	-0.1695	-5.19	< 0.0001	dsinglehh	-0.1718	-7.12	< 0.0001
drural	-0.0774	-2.33	0.0200	drural	-0.1034	-3.80	0.0001
dnochild	-0.0532	-1.57	0.1166	dnochild	-0.0412	-1.68	0.0927
dchild1	0.0250	0.60	0.5487	dchild1	0.0182	0.55	0.5810
dchild4	-0.0098	-0.21	0.8306	dchild4	0.0128	0.35	0.7258
ded10	0.0479	0.20	0.8444	ded10	-0.1324	-3.31	0.0009
dedless12	0.2015	0.91	0.3635	dedless12	0.3625	2.23	0.0255
ded12	0.2481	1.12	0.2619	ded12	0.4193	2.60	0.0094
dsomecoll	0.3521	1.59	0.1123	dsomecoll	0.5286	3.27	0.0011
ded15	0.4989	2.24	0.0251	ded15	0.6570	4.05	< 0.0001
dgradschool	0.4461	1.99	0.0464	dgradschool	0.7546	4.62	< 0.0001
dnortheast	-0.0589	-1.79	0.0738	dnortheast	-0.0781	-3.27	0.0011
dmidwest	-0.1164	-3.85	0.0001	dmidwest	-0.1241	-5.58	< 0.0001
dsouth	-0.0686	-2.35	0.0191	dsouth	-0.1581	-7.62	< 0.0001
dwhite	0.0410	0.88	0.3795	dwhite	0.0659	1.85	0.0650
dblack	0.0475	0.76	0.4465	dblack	0.0043	0.10	0.9204
dmale	0.0529	2.30	0.0215	dmale	0.0075	0.46	0.6446
dfdstmps	-0.1722	-4.01	< 0.0001	dfdstmps	-0.2071	-4.93	< 0.0001
d1	-0.0293	0.48	0.6340	d4	-0.0406	-1.45	0.1478

$R^2 = 0.5066$ d.f. = 2409 $R^2 = 0.4823$ d.f. = 4998

Table 9

Regression Models for PC 2
1996Q1 and 1999Q4

logarithmic models

1996Q1

Variable	Parameter	t-ratio	p-value
intercept	2.6381	5.64	< 0.0001
lnincome	0.4484	15.13	< 0.0001
no_earnr	-0.0674	-2.63	0.0086
age_ref	0.0005	0.41	0.6784
fam_size	0.0293	1.48	0.1384
dsinglehh	-0.0663	-1.22	0.2238
drural	-0.2581	-4.54	< 0.0001
dnochild	-0.1286	-2.25	0.0245
dchild1	0.1249	1.81	0.0709
dchild4	0.1369	1.79	0.0739
ded10	-0.0909	-1.14	0.2560
dedless12	-0.0016	-0.00	0.9962
ded12	-0.0281	-0.08	0.9354
dsomecoll	0.0357	0.10	0.9182
ded15	0.3491	0.65	0.5145
dgradschool	0.2292	0.65	0.5141
dnortheast	0.0174	0.32	0.7456
dmidwest	-0.2002	-3.99	< 0.0001
dsouth	-0.1907	-3.91	< 0.0001
dwhite	-0.0385	-0.43	0.6707
dblack	-0.0696	-0.67	0.5024
dmale	-0.0576	-1.50	0.1335
dfdstmps	-0.0751	-1.07	0.2849
d1	-0.2073	-2.03	0.0427

$R^2 = 0.2358$ d.f. = 2409

1999Q4

Variable	Parameter	t-ratio	p-value
intercept	2.4847	8.15	< 0.0001
lnincome	0.4379	24.06	< 0.0001
no_earnr	-0.0527	-3.15	0.0016
age_ref	-0.0003	-0.38	0.7068
fam_size	0.0419	3.03	0.0024
dsinglehh	0.0331	0.92	0.3569
drural	-0.2670	-6.47	< 0.0001
dnochild	-0.0990	-2.69	0.0071
dchild1	0.1871	3.80	0.0001
dchild4	0.1894	3.48	0.0005
ded10	-0.0532	-0.90	0.3682
dedless12	0.0296	0.12	0.9010
ded12	0.0270	0.11	0.9090
dsomecoll	0.1252	0.53	0.5963
ded15	0.3489	1.47	0.1416
dgradschool	0.5086	2.13	0.0335
dnortheast	0.0351	0.99	0.3209
dmidwest	-0.0932	-2.81	0.0050
dsouth	-0.1633	-5.28	< 0.0001
dwhite	0.0546	1.01	0.3133
dblack	0.0963	1.50	0.1336
dmale	-0.0336	-1.39	0.1640
dfdstmps	-0.0667	-1.08	0.2814
d4	-0.0228	-0.54	0.5864

$R^2 = 0.2737$ d.f. = 4998

At the other extreme, the two smallest components typically account for less than one-half of one percent of the total variation.

(3). The two largest principal components are stable across several categories of expenditure, while the two smallest components each identify with just a single category of expenditure. The fifth stable principal component identifies with expenditures for alcoholic beverages and tobacco.

(4). Except for opposing signs on transportation expenditures, the two largest components have virtually identical loadings on the 14 categories of expenditure.

(5). Virtually identical, as well, are the income elasticities of demand for the two largest principal components, with values that vary between 0.39 and 0.46 over the 16 quarters of CES data.

Let me now speculate a bit about what all this might mean. As was noted in Section III, one interpretation of the stability of the two largest principal components of consumption is that the expenditure structures represented in these components derive from three (basically invariant) motivating bases (or *substrates*) of behavior:

(i). Biological (i.e., genetic) factors that define certain levels of expenditure for food, housing, clothing, transportation, health, education, and entertainment.

(ii). Cultural factors that give rise to a variety of social patterns of consumption.

(iii). Demographic factors such as the age- and ethnic-distributions of the population, labor-force participation, place of residence, etc.

Of the expenditures associated with these factors, those of biological origin should obviously be more invariant (since they drive from a shared genetic basis) than those associated with cultural and demographic factors. Nevertheless, over moderate periods of time (such as the four years represented in the 16 quarters of data analyzed in this study), invariance ought to apply to cultural and demographic factors as well.

On the average, about 50 percent of total consumption expenditure is associated with the two largest principal components. As has just been suggested, these expenditures can be identified with tastes and preferences that are (1) common to individuals (i.e., genetically based) or (2) reflect stable cultural and demographic agglomerations. The remaining half of total expenditure (under this interpretation) can therefore be attributed to those aspects of tastes and preferences that vary across individuals and households as represented in the structures of the principal components (specifically, #'s 3 through 10) that vary from quarter-to-quarter depending upon the idiosyncracies of particular surveys. A household's consumption behavior, under this view, can accordingly be viewed as emanating from four distinct substrates: (1) a *genetic* substrate that is common to households: (2)

a *cultural* substrate that is stable (over moderate periods of time) across households; (3) a *demographic* substrate that varies across households, but which is distributionally stable (again, over moderate periods of time); (4) an *idiosyncratic* substrate that reflects genetic and experiential variation across households. For the 16 quarters of data that have been analyzed in this study, substrates (1), (2), and (3) are represented in principal components 1, 2, 11, 13, and 14, while substrate (4) is represented in principal components 3 - 10 and 12.

This interpretation of the results of this paper, if valid, should have the following implications:

(1). The genetic factors ingrained in the two largest principal components of consumption should be constant both over time and across cultures. However, this should not be the case for the cultural or demographic factors. Hence, because of slowly occurring changes in the latter factors, the relationships between the eigenvectors associated with the largest two principal components of consumption for any two points in time should be weaker the greater the temporal separation. Similarly, one should be expect to find weaker relationships between eigenvectors (at the same point in time) across countries than within countries.

(2). The proportion of total variation in consumption expenditures accounted for by the two largest principal components ought, in general, to be a decreasing function of the level of income. There are two aspects to this implication. The first is simply the idea that, as income increases, genetically motivated consumption will probably be subject to satiation, implying a low income elasticity, which in turn would imply reduced relative variation in this expenditure across households. The second aspect is that, as the "core" expenditures associated with the two largest principal components of consumption decrease with income as a proportion of total expenditure, the individual idiosyncrasies of households should become increasingly important. Thus, not only will the "core" constituents of expenditure claim a decreasing proportion of total expenditure as a function of income for a given *relative* variation in consumption expenditures, but the variation in "non-core" expenditures will itself become a relatively more important part of the total.[11]

In closing, let me turn to the implications of the results of present exercise for the question of stability in the aggregate consumption function. In approaching this, we must be careful to distinguish between two different concepts of stability, a concept of stability that refers to the structure of tastes and preferences, and a concept of stability that refers to the relationship between aggregate consumption and aggregate income. The most important finding of the paper would seem to be that, with reference to tastes and preferences, there exist two stable structures of consumption

[11] However, the implication in this paragraph is not as clear-cut as it might seem because of a possibility that culturally based "habit-formation" effects becoming increasingly more important with increases in income.

that, at a micro level, account for about 50 percent of total expenditure. In turn, these two structures are shown to have income elasticities, both of which are of the order of 0.45, that show little variation over the 16 quarters of data that have been analyzed. The suggestion, accordingly, is that roughly 50 percent of total consumption expenditure can be said to have a simple stable relationship with income. Whether the micro-based results of this paper extend to macro-consumption is, of course, another matter. The thought that they might, however, is rich with possibilities.

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Appendix

Definitions of Independent Variables Appearing in Tables 6 - 9

income:	after tax income of household
no_earnr:	number of income earners in household
age_ref:	age of reference person
fam_size:	family size of household
dsinglehh:	single-person household
drural:	household resides in rural area
dnochild:	no children in household
dchild1:	oldest child under 6
dchild4:	oldest child over 17
ded10:	8^{th} grade graduate, reference person
dedless12:	some high-school, reference person
ded12:	high-school graduate, reference person
dsomecoll:	some college, reference person
ded15:	college graduate, reference person
dgradschool:	graduate school, reference person
dnortheast:	household resides in northeast
dmidwest:	household resides in midwest
dsouth:	household resides in south
dwhite:	reference person is white
dblack:	reference person is black
dmale:	reference person is male
dfdstmps:	household is recipient of food stamps
d1,d2,d3,d4:	quarterly dummy variables

Note: All variables beginning with “d”are dummy variables.