

THE USE OF LOG-LINEAR MODELS TO ASSESS COMPOSITIONAL EFFECTS:
THE CASE OF HOUSEHOLD HEADSHIP IN THE UNITED STATES, 1970-1985

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Lawrence L. Santi
Center for Demography and Ecology
University of Wisconsin
Madison, Wisconsin 53706

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Abstract

This paper demonstrates the use of log-linear models to assess the effects of changing population composition by age and by marital status on changes in the likelihood of heading one's own household in the United States from 1970 to 1985. Although standard logit models do not address traditional demographic concerns with compositional effects, various non-logit formulations can be used to deal with questions more traditionally addressed within the framework of direct standardization. Substantively, the analysis shows that the effects of the compositional factors varied over the 15-year interval, at times operating at cross-purposes. The propensity to head one's own household, net of compositional change and compositional effects, increased from 1970 to 1980 and decreased in the first half of the 1980's.

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One of the more fundamental insights of demographic analysis is the recognition of the potentially crucial role of population composition in affecting aggregate-level outcomes (Stinchcombe, 1968). The hallmark of this "compositional approach" is the explanation of social phenomena by reference to the numbers of persons within substantively relevant categories and to differential behavioral propensities of persons within these specific categories. This approach has been particularly fruitful in comparative research and in the study of social change.

Traditionally, demographers have approached such compositional questions by means of one or another variant of a general analytic strategy referred to as "standardization" (Fleiss, 1981). The logic of these various standardization procedures is the estimation of what the overall rate of some event would be in a particular group if that group had the same composition or the same schedule of composition-specific rates as some comparison group. The estimated value is then compared to the actual rate as a means of assessing the impact of compositional differences or differences in schedules of composition-specific rates on the overall differences between the two groups.

A novel approach to the analysis of compositional questions has been taken by Clogg and his associates (Clogg, 1978; Clogg, et. al., 1985), who have attempted to recast such traditional demographic techniques as "standardization" and "rate adjustment" within the framework of the log-linear analysis of categorical data. One of the greatest advantages of the log-linear approach is that it provides a unified statistical framework within which

to perform the more traditional techniques. Having such a framework facilitates, indeed requires, that our assumptions about both the processes which generate the observed data and the implications of our data manipulations be made more explicit. The present paper can be seen as an attempt to build on this new approach.

Substantively, the present paper is concerned with recent changes in the likelihood of adults in the United States heading their own households. One starting point for this research is Sweet's (1984) analysis of change between 1970 and 1980 in the number of households in the U.S. Using a traditional standardization procedure, Sweet attributed approximately two-thirds of the increase in households over this decade to changes in population size and population composition by age and marital status, and the residual increase to changes in age-by-marital status-specific headship rates.

Sweet's analysis is instructive in at least two respects. First, it illustrates the utility of the status of household headship as a means of linking population change to household change. Second, the analysis focuses our attention on the importance of changes in population composition for processes of household formation in the decade under investigation.

What remains unclear in Sweet's analysis, however, is the precise mechanism by which compositional changes were affecting these processes. This is an interesting question, because there is presumptive evidence which might lead one to suspect that changes in age composition and changes in marital status composition may have been operating at cross-purposes over this period. In 1970, the large baby boom cohorts were just

entering the ranks of potential householders, possibly depressing overall headship rates. By 1980, these cohorts had moved into "higher headship" age categories, which may have exerted an upward pressure on aggregate headship. As far as marital status is concerned, this was a decade of increasing age at first marriage and increasing marital disruption, both of which might be expected to exert a downward pressure on headship rates.

The purpose of the present analysis, then, is to specify more precisely the mechanisms by which changes in population composition (by age and by marital status) were affecting processes of household formation over the 15-year period from 1970 to 1985. Substantively, our interest is less in changes in absolute numbers of households than it is in changes in the underlying structure of household formation. Thus, in contrast to Sweet's work, our focus will be on changes in rates of household headship rather than on changes in total numbers of households.

Data and Analyses

The data on which this analysis is based are cross-tabulations of the dichotomous variable householder status (head/non-head) by age, marital status and sex from the March Current Population Surveys for the years, 1970, 1975, 1980 and 1985. Age was recoded into thirteen five-year intervals ranging from 15 to 19 years of age up to 75 years of age and older. Four categories of marital status were recognized: never-married, currently married (spouse present), widowed and divorced/separated/spouse absent. To allow consistency across the four time points, each spouse within a married,

spouse-present household was designated a "co-head". The data were appropriately weighted so as to reproduce both estimated population proportions and sample totals.

The data were analyzed using techniques proposed by Goodman (1978) and elaborated in Clogg and Shockey (1985). To avoid having to deal with interactions by period and by sex, four-way tables of headship by year, age and marital status were analyzed separately for men and for women over three separate five-year intervals. The results of these analyses are presented in Table 1.

Table 1 About Here

Fourteen models were found to be of particular interest in the present analysis. The first four models in Table 1 are standard logit models in which headship is considered the dependent variable and change in the independent compositional variables is taken for granted. The objective of these models (and of logit models more generally) is to arrive at a model which can be said to "adequately" describe the effects of the various independent variables (including year) on the dependent variable. Such models are appropriate when one is not particularly concerned about the effects of compositional change, per se, but rather is concerned primarily with the structure of relationships given whatever compositional changes may have taken place. Consequently, standard logit models are not suited to the kinds of questions which constitute the stock-in-trade of a great deal of demographic analysis. Nonetheless, selection of a "preferred model" (and thus positing a certain structure of effects on the dependent variable) represents the starting point of this analysis.

In the present context, Model 4 was selected for each sex at each five-year interval. Model 4 allows for changes in the distribution of the population by age/marital status, posits joint effects of age and marital status on headship which are constant over time, and allows for uniform change in headship rates across all age/marital status categories. Although Model 4 cannot be said to provide a good fit to the observed data by means of conventional statistical criteria, it does account for approximately 99% of the residual variation left by Model 1, the model of independence. Additional analysis of the residual variation left by Model 4 revealed no particularly striking pattern over the remaining 51 degrees of freedom. Furthermore, the use of Raftery's (1986) BIC criterion would have led to the selection of Model 4 in four of the six analyses. Thus, it will be in the context of Model 4 that we will attempt to unravel the effects of compositional changes on headship.

Models 5 through 14 are particularly relevant in this connection. These models take the proposed structure of effects of the compositional variables upon headship for granted, and investigate various hypotheses of change given this structure. In this sense, models of this form seem to be more closely related to traditional demographic concerns than are logit models.

There are two basic ways in which Models 5 through 14 may be used to shed light on change in the system of relationships among age, marital status and headship. Both have as their starting point Model 5, which posits no change of any sort within the four-way tables.

The first approach, presented in Clogg and Shockey (1985), involves decomposing the residual variation left by Model 5 into components attributable to compositional change, change in the dependent variable and interactions among year, the dependent variable and the compositional variables. In practice, this involves examining reductions in residual variation as one moves from Model 5 through hierarchically related models down to Model 14. As practitioners of more conventional decomposition techniques are well aware, intercorrelations among non-experimental data prohibit a "unique" decomposition, and Clogg and Shockey point out that their approach offers no "royal road" around this difficulty. However, the emphasis on decomposition with respect to explicit models may make the substantive implications of alternative paths more obvious. (Moreover, the set of models presented in Table 1 makes calculation of the alternatives quite simple.)

In the present context, compositional changes may be thought of as "causally prior" to the decision of whether or not to head one's own household. (This assumption may be less defensible in the case of marital status than in the case of age, but it seems to me that changes in marital status are at least sufficient to warrant a reconsideration of one's living arrangements, if not necessary; neither necessity nor sufficiency would seem to hold for the effects of living arrangements on marital status.) By a similar logic, one's age is less a product of one's volition than is one's marital status, which suggests assigning a certain priority to age among the compositional factors. This line of reasoning resulted in the particular path of decomposition presented in Table 2.

Table 2 About Here

We see in Table 2 that for both sexes over all three intervals, compositional change was significant and substantial, accounting for two-thirds to four-fifths of the total change in the system of variables. Once these compositional changes were taken into account, significant changes in headship (of both the uniform and interactive varieties) were also noted. (In contrasting the chi-square contributions of "main" and interactive changes in headship, one might want to keep in mind the differences in degrees of freedom associated with each type of change.)

A cautionary note about the preceding paragraph may be in order. Despite apparent similarities, the above decomposition is only partly related to more traditional approaches to decomposition. Whereas the latter are typically concerned with attributing change in a dependent variable to various components, the present approach is partitioning total change in a system of variables. As Clogg and Shockey point out (1985:403), "This information cannot be used, however, to infer the magnitude or even the direction of the effect of composition change on crude rates. Existence of composition-period interaction has been documented, but this is only a necessary condition for composition effects on rates." As a result of this difference in focus, it is unlikely that this particular approach to decomposition will be greeted favorably by practitioners of the more traditional demographic techniques. It is to this more traditional concern that the second approach is directed.

This second approach also relies on Models 5 to 14, but uses the information con-

tained in these models in a different way. Pairwise comparisons of models in the second panel of Table 1 with appropriate models in the third panel constitute tests of (uniform) changes in headship rates, in the context of various types of change in the compositional variables (as well as the constant effects of the compositional variables upon headship). The logic of this approach is that changes in the year effect as different kinds of compositional change are introduced can give us insights into the effects of the compositional changes themselves upon changes in headship. The relevant quantities for this assessment are presented in Table 3.

Table 3 About Here

The upper panel of Table 3 contains relatively straightforward tests of the year effect on headship, conditional on various forms of compositional change (and constant effects of the compositional variables upon headship). For illustrative purposes, we will focus on the results for males over the 1970 to 1975 period. Test 1 represents a test of the year effect given no compositional change; it is equivalent to the comparison of Models 1 and 2 in Table 1 and tests the gross change in headship rates between 1970 and 1975. Substantively, the test and the odds ratio indicate a slight decrease in headship among males between 1970 and 1975. Allowing for a change in the age distribution (Test 2) changes the year effect to a statistically non-significant increase, suggesting that the slight decrease observed in Test 1 was related to changes in the age distribution. Similar results obtain when one introduces change in the marital status distribution (Test 3), changes in both the age distribution and the marital status distribution (Test

4) and changes in the distribution of marital status by age (Test 5). In each of these last three tests, introduction of compositional change results in significant increases in headship, suggesting that when not taken into account, these compositional changes were acting to suppress headship. The odds ratio describing the year effect in Test 5 (which, incidentally, is a test of the significance of the year effect in our preferred model) indicates that net of compositional changes, the propensity to head one's own household increased substantially from 1970 to 1975.

These conclusions about the impact of compositional change on headship propensities are strictly inferential. However, these inferences may be facilitated by the quantities displayed in the bottom panel of Table 3. These numbers are the ratios (ignoring the compositional change:taking it into account) of the odds ratios describing the year effect on headship. Values greater than 1.0 suggest that the compositional factor was tending to push headship rates up, values less than 1.0 suggest a downward effect of the compositional factor, while values equal to 1.0 suggest no effect. I make no claims for the statistical properties of these numbers, and present them merely as descriptive devices which more closely address the question, "What were the effects of changing population composition on headship rates?"

Again, referring to the first column, we see that change in the age distribution (by itself) tended to depress headship rates slightly, while change in the marital status distribution (net of changes in the age distribution) was exerting a more pronounced downward effect. Change in the joint distribution of age by marital status (net of

changes in the univariate distributions) also seemed to exert a slight downward effect on the likelihood of heading one's own household.

Thus, during this first five-year interval, compositional changes were tending to depress headship rates. Change in the marital status distribution seemed to be the main factor driving headship down. However, propensities to head one's own household (net of compositional changes and effects) were increasing over this same interval, counterbalancing the compositional pressures and resulting in only a slight decline in headship at the gross, aggregate level.

From 1975 to 1980, different forces appear to have been at work. Changes in the marital status distribution continued to exert a substantial downward pressure on headship, although by this time, the age distribution was pressing in the opposite direction. Increasing propensities to head one's own household (net of composition) combined with these compositional forces to produce a substantial increase in aggregate-level headship.

During the final period, changes in the age distribution continued to exert an upward pressure on headship, while the depressing effect of changes in the marital status distribution was weakening. However, propensities to head one's own household were themselves decreasing, counterbalancing the net positive contribution of changing composition and resulting in another slight decrease in aggregate headship.

The same patterns of change seemed to be operating for both men and women over the fifteen-year period under investigation.

Discussion

These findings are substantively interesting in at least a couple of ways. First, with respect to the expressed purpose of this research, we have separated the effects of changing age composition from changes in the distribution of the population by marital status, and have shown that the effects of these compositional changes varied over time and did, indeed, operate at cross-purposes over some intervals. Second, we have also shown that propensities to head one's own household (net of compositional changes and compositional effects) have themselves changed over this decade and a half; these propensities increased from 1970 to 1980, but declined from 1980 to 1985. If these results and those of previous literature (Kobrin, 1973, 1976) are at all comparable, then the post-1980 results may signal a turnaround in a decades-long trend toward increasingly independent living arrangements among adults. (For a previous consideration of this possibility, see Heer, et. al., 1985.)

From a methodological point of view, I would hope that these analyses have demonstrated certain advantages over more traditional standardization procedures. In the first place, the present analyses were performed with reference to explicit models of the four-way cross-classifications of headship by age, sex and year. Each of these models embodies an explicit hypothesis about the pattern of interrelationships among the four variables, whose goodness of fit to the observed data may be explicitly assessed. Secondly, these various models can be readily generated using any of a number of widely available programs for log-linear analysis. This permits the "unpacking" of the separate

(and possibly contradictory) effects of more than one compositional variable. While such an investigation is possible with the more traditional techniques, the calculations would be more cumbersome, particularly with respect to higher-order interactions.

TABLE 1: SOME LOG-LINEAR MODELS FOR THE FOUR-WAY CROSS-CLASSIFICATION OF HOUSEHOLDER STATUS BY YEAR, AGE AND MARITAL STATUS: BY SEX, OVER THREE 5-YEAR INTERVALS

MODEL	MARGINS FITTED*	df	MALES			FEMALES		
			70-75	75-80	80-85	70-75	75-80	80-85
1	234	103	84,631.02	90,721.87	93,209.02	76,764.24	82,009.13	83,603.14
2	"	102	84,624.33	90,679.10	93,196.45	76,761.14	81,939.94	83,602.82
3	"	52	288.01	241.31	195.76	169.48	162.03	171.91
4	"	51	178.87	189.78	155.83	61.17	113.88	156.41
5	134	103	865.18	1,142.28	951.55	575.84	1,063.00	953.30
6	"	91	664.98	729.74	628.29	420.17	626.09	616.89
7	"	100	635.24	1,022.45	842.49	461.36	922.57	862.02
8	"	88	452.20	435.36	310.07	301.60	325.14	349.35
9	"	52	288.01	241.31	195.76	169.48	162.03	171.91
10	134	102	858.49	1,099.52	938.96	572.74	993.81	952.97
11	"	90	664.82	702.65	378.66	405.18	617.94	478.27
12	"	99	550.31	836.05	842.13	370.48	748.79	854.65
13	"	87	374.48	395.99	260.84	214.54	287.38	327.65
14	"	51	178.87	189.78	155.83	61.17	113.88	156.41

* WHERE 1 = HOUSEHOLDER STATUS (YES/NO)

2 = YEAR

3 = AGE (13 5-YEAR INTERVALS; 15-19, 20-24, ..., 70-74, 75 +)

4 = MARITAL STATUS (NEVER MARRIED, CURRENTLY MARRIED, WIDOWED, DIVORCED/SEPARATED)

TABLE 2: CHI-SQUARE DECOMPOSITION OF CHANGE IN AGE, MARITAL STATUS AND HOUSEHOLDER STATUS

COMPONENT	CONTRAST ^a	df	M A L E S						F E M A L E S					
			70-75		75-80		80-85		70-75		75-80		80-85	
			L ²	%	L ²	%	L ²	%	L ²	%	L ²	%	L ²	%
COMPOSITION	5-9	51	577.17	66.7	900.97	78.9	755.79	79.4	406.36	70.6	900.97	84.8	781.39	82.0
AGE	5-6	12	200.20	23.1	412.54	36.1	323.26	34.0	155.67	27.0	436.91	41.1	336.41	35.3
MARITAL/AGE	6-8	3	212.78	24.6	294.38	25.8	318.22	33.4	118.57	20.6	300.95	28.3	267.54	28.1
AGE x MARTIAL	8-9	36	164.19	19.0	194.05	17.0	114.31	12.0	132.12	22.9	163.11	15.3	177.44	18.6
HEADSHIP	9-14	1	109.14	12.6	51.53	4.5	39.93	4.2	108.31	18.8	48.15	4.5	15.50	1.6
INTERACTION ^b	L ² of 14	51	178.87	20.7	189.78	16.6	155.83	16.4	61.17	10.6	113.88	10.7	156.41	16.4
TOTAL	L ² of 5	103	865.18	100.0	1142.28	100.0	951.55	100.0	575.84	100.0	1063.00	100.0	953.50	100.0

^a REFERS TO COMPARISON OF MODELS IN TABLE 1

^b CONSISTS OF HIGHER-ORDER (I.E., 3- AND 4-WAY) INTERACTIONS AMONG HEADSHIP, YEAR AND THE COMPOSITIONAL VARIABLES

TABLE 3: TESTS OF CHANGE IN HOUSEHOLDER STATUS, CONDITIONAL UPON VARIOUS SORTS OF COMPOSITIONAL CHANGE

TEST	COMPOSITIONAL CHANGE	CONTRAST	M A L E S						F E M A L E S					
			75:70		80:75		85:80		75:70		80:75		85:80	
			L ²	ODDS RATIO	L ²	ODDS RATIO	L ²	ODDS RATIO	L ²	ODDS RATIO	L ²	ODDS RATIO	L ²	ODDS RATIO
1	NONE	5 - 10	6.69	0.964	42.76	1.092	12.59	0.956	3.10	1.026	69.19	1.121	0.33	0.993
2	AGE	6 - 11	0.17	1.008	27.09	0.904	249.63	0.759	14.99	1.081	8.15	0.948	138.62	0.814
3	MARITAL	7 - 12	84.93	1.281	186.40	1.368	0.36	1.011	90.88	1.250	173.78	1.320	7.37	1.052
4	AGE, MARITAL	8 - 13	77.72	1.293	39.37	1.171	49.23	0.860	87.06	1.265	37.76	1.152	21.70	0.909
5	AGE x MARITAL	9 - 14	109.87	1.366	51.53	1.200	39.93	0.872	108.31	1.309	48.15	1.178	15.50	0.921

"COMPOSITIONAL EFFECT"*	CONTRAST	M A L E S						F E M A L E S								
		1970 - 1975		1975 - 1980		1980 - 1985		1970 - 1975		1975 - 1980		1980 - 1985				
		T ₁ : T ₂	T ₂ : T ₄	T ₄ : T ₅	T ₁ : T ₂	T ₂ : T ₄	T ₄ : T ₅	T ₁ : T ₂	T ₂ : T ₄	T ₄ : T ₅	T ₁ : T ₂	T ₂ : T ₄	T ₄ : T ₅			
ΔAGE		0.956	0.780	0.947	1.207	0.772	0.976	1.260	0.882	0.987	0.949	0.854	0.966	1.182	0.822	0.978
ΔMARITAL/ΔAGE																
ΔAGE x MARITAL/ΔAGE, ΔMARITAL																

* EXPRESSED IN TERMS OF RATIOS OF ODDS RATIOS, BASED UPON TESTS IN THE UPPER PANEL

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Mailing Address:

Center for Demography and Ecology
University of Wisconsin
1180 Observatory Drive
Madison, Wisconsin 53706-1393
U.S.A.