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Household Demand for Pet Food and the Ownership of Cats and Dogs: An Analysis of a Neglected Component of U.S. Food Use

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I. INTRODUCTION

Since 1972/3 there has been a growing realization that U.S. food production is not unlimited and that man and animals are competing for a scarce resource at the "global dining table". Much has been made of the inefficient conversion of feedgrains by animals into animal protein for human food and the "wastage" of agricultural resources in non food uses -- e.g. the use of fertilizers on golf courses and the feeding of pets.[1/] Pet food also received attention as a result of the inflation and growing unemployment of the past several years and from reports that old age pensioners (and students) were using pet food for human consumption [1, 2]. In all of these discussions, little or no hard evidence was available to document the value and extent of the U.S. consumption of food by pets (or of pet food by humans). The purpose of this paper is to correct this deficiency and present an analysis of a set of data which does provide a means of objectively examining some of these issues.

Although there is little doubt that the U.S. pet population has been "exploding" in the last decade there is little reliable information on number of pets in the U.S. Pets include not only dogs, cats, birds, fishes, small rodents and a variety of exotic animals but also recreational horses and donkeys. This paper examines only cats and dogs owned households. It excludes animals owned by commercial establishments

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1/ Former Secretary of Agriculture, Earl Butz, was severely criticized for suggesting that the U.S. do away with 50 per cent of its cats and dogs in order to reduce pressure on U.S. grain supplies.

(e.g. kennels), for research purposes or feral animals that are owner-less or "wild". It is interesting that the U.S.D.A. has not collected statistics on farm horses since 1960. Estimates -- and they are no more than that -- suggest that in 1976 there were more than 10 million horses (compared to a peak of 26 million in 1915 when farm draught animals began to decline as a result of replacement by tractors) [3, 4]. These horses are for the most part recreational or saddle horses many of which are located in suburban fringes and not on farms. In terms of feedgrain consumption they are undoubtedly more important that cats and dogs.[1/] On the other hand the exclusion of pet birds, fishes and rodents (hampsters, jerbels, white mice, etc.) is probably not so an omission -- although again no hard data are available on numbers of such pets or their consumption of food and feed.

In this paper after a preliminary description of the data an analysis is made of household demand for pet foods and of the demand for cats and dogs themselves. Subsequently some of the issues raised in this introduction are examined in the light of these analyses.

The MRCA Data

The data for this study was obtained from Market Research Corporation of America (MRCA) which, together with other non-government market

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1/ The U.S.D.A. estimates for livestock production units based on all feed would suggest that 10 million horses consume the equivalent (in feed units) as about 3.5 million milk cows. There were 11.8 million milk cows on January 1, 1972 (excluding followers and beef cattle, etc.) [See 4].

research agencies, collects data on household expenditures. These non-government sources of data are the only sources of data available at the present time which permit reasonably accurate estimates of national aggregates or analysis of household behavior in regards to pets and pet food expenditures. The United States 1960-61 Consumers Expenditure survey did not collect data on pet ownership. There is such information in the subsequent 1972-73 Consumer Expenditure Survey but it is not yet available. MRCA made its data available to us at no charge, apart from the cost of transcribing data tapes and we gratefully acknowledge their assistance.[1/]

MRCA obtains its records from the commercially maintained National Consumer Panel (NCP) of 7500 households who report their purchases of many grocery and household type items in a weekly diary. In constructing this panel, MRCA uses the Census Bureau's definition of a household as being a collection of persons occupying a house, apartment, room, or group of rooms, used as a separate living unit and equipped with cooking facilities. The composition and maintenance of the NCP is designed to provide a representative sample of all U.S. households, and to accurately reflect the latest Bureau of Census statistics on socio-economic characteristics of all households in the mainland U.S.

Underlying this overall sample design is the delineation of the NCP into more than 400 cells according to geographical location, city size, and household size. This stratification allows MRCA to report

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1/ Dr. Abrahams, Chief Statistician, MRCA, was particularly helpful in this matter.

data for a wide variety of client regions and major metropolitan areas. However, since the size and composition of the sample within each cell is maintained according to the latest Census Bureau Statistics, the entire 7500 household panel still provides a representative sample of the 64,550,000 total U.S. households, (1971 census estimate for the 48 mainland states). Another set of NCP features are the "diary and base count projection factors" built into the sample cells. The diary projection factor is a weight used for correcting under-reporting of missing records in a particular time period. The base count projection factor is a weight for each household used to obtain national aggregates. The purpose of the projection system is to compensate for any disproportionality which might occur from month to month in the number of diaries returned by households in the cell, or in the number of active households within each cell. Thus, while the actual panel size at any moment may be less than the original 7500, these projection factors maintain the representativeness of the overall sample while new households are recruited into the under represented cells.

The records of the cat and dog food expenditures by NCP households cover a 6 month period, January-June 1971. Due to panel turnover, the sample size is less than 7500, but as mentioned, the sample remains representative because of the compensating projection factors. To make the 6 months of cat and dog food expenditure records compatible with the 12 months household income figures, the pet food expenditure value for each household was simply doubled.

Pet Food Expenditures

Using this 1971 MRCA data, the estimated annual mean expenditure on dog food by dog owning households is $27.64 with a standard deviation of 31.80. The estimated annual mean expenditure for cat food by cat owning households is $22.20 with a standard error of 32.74. The total U.S. expenditure on pet food in 1971 was some $1.4 billion.

These dog and cat food expenditure figures can also be expressed in the context of a percentage of total household consumption. Calculating from the Census Bureaus 1971 estimates of the total number of U.S. households and total U.S. consumption, the average total consumption per household was $10,334.6 [5,6]. Of this average total, 17.5% or $1808.55 was for food purchases (excluding alcoholic beverages).

The dog food expenditures by dog owners represents an estimated 0.26% of total consumption of 1.53% of the food budget for these households. The cat food expenditures by households owning cats comprises an estimated 0.21% of total consumption or 1.22% of the food budget for these households. For households owning both cats and dogs, the average percentage of budget figures are 0.47% of total consumption, and 2.75% of food consumption.

As indicated by the standard error, there is considerable variation in the level of pet food expenditures by households. Pet food expenditures are strongly related to location and income (Table 1). This table also indicates that there are a substantial number of pet owners not buying any dog or cat food, or are doing so in small amounts that do not nearly meet the nutrient requirements of the average pet. The farm and small town location of many of the zero and low level pet

Table 1. Proportion of Pet Owning Households by Location and Expenditure Group, 1971

(Per Cent)

Annual Expenditures ($) on Pet Food	FARM		SUBURBS		CITIES		SMALL TOWNS		TOTAL	
	Dogs	Cats	Dogs	Cats	Dogs	Cats	Dogs	Cats	Dogs	Cats
0	43.4	66.1	7.6	15.9	8.0	4.9	16.6	16.3	13.2	19.8
.05 - 10	18.7	15.6	18.3	20.1	19.2	22.3	24.6	29.3	20.1	22.6
10 - 20	11.5	5.6	19.2	18.3	17.8	23.5	20.4	21.3	18.4	18.7
20 - 30	7.2	6.1	16.4	14.8	17.0	15.9	13.5	10.2	15.0	12.8
30 - 40	4.3	2.2	12.4	12.7	12.8	8.6	8.2	7.6	10.7	9.1
40 - 50	3.0	1.1	7.4	6.3	7.4	6.7	4.1	6.3	6.2	5.8
50 - 60	3.8	.6	5.8	4.7	5.4	7.0	3.1	2.4	4.9	4.1
> 60	8.1	2.9	12.8	7.3	12.3	15.6	9.5	7.6	11.4	7.1
Totals	100	100	100	100	100	100	100	100	100	100

Source: Compiled from MRCA data.

food expenditures suggests that many animals in these locations are able (not surprisingly) to derive much of their nutrition requirement from hunting and farm scraps. There is undoubtedly feeding of table scraps or even purchase of "human" food for pets occuring at all locations which is not reflected in the data on expenditures on pet food. Tables 2 and 3 give an expenditure breakdown of the different types of dog and cat foods purchased during the 6 month period of the survey. These tables show that the largest percentage of total dollar expenditure is for canned dog and cat food. However, due to the relative price differences, dry varieties of dog food are the most important by weight. The cost of cat food for all types is noticeably higher than for dog food -- at least in part this is due to higher protein requirements of cats.

Research done by the National Academy of Science on daily nutrition requirements for dogs can be used to establish food needs for various weight levels of dogs and cats, (Tables 4 and 5). Projecting this estimated daily requirement to a full year shows that the average 35 pound dog[1/] would require over 900 lbs. of canned dog food. If the average dog was fed only dried dog food to meet its minimum requirements, a year's consumption would total over 270 lbs., worth more than $32.00 at the average price for dry dog food. Adjusting this figure for the average of 1.4 dogs per household and contrasting with the average dog food expenditure level of $27.64 shows that an estimated 55.6% of the

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1/ MRCA data recorded dog weights (of heaviest dog in household) but no cat weights.

Table 2. Dog Food by Type: Price and Percentage of Expenditure and Quality, 1971.

Dog Food Type	Price per Pound ($)	Proportion of Total Expenditure (per cent)	Proportion of Total Quantity (per cent)
Semi Moist	.382	15.85	6.8
Dry	.119	35.83	49.4
Bisquits	.272	3.59	2.1
Canned	.173	43.71	41.4
Novelty Treats	.848	1.02	.2
Total	.164	100	100

Source: Computed from MRCA data.

Table 3. Cat Food by Type: Price and Percentage of Expenditure and Quantity, 1971.

Cat Food Type	Price per Pound ($)	Proportion of Total Expenditure (per cent)	Proportion of Total Quantity (per cent)
Semi Moist	.750	75.52	73.15
Dry	.268	2.42	.90
Canned	.276	24.95	25.90
Novelty Treats	.562	.10	.05
Total	.278	100	100

Source: Computed from MRCA data.

Table 4. Dogs: Estimated Daily Food Required for Maintenance by Weight of Dog and Food Type

Weight of dog (Lb.)	Dry Dog Food [a/] Lb/dog	Canned Dog Food [b/] Lb/dog
5	.198	.682
10	.33	1.122
15	.418	1.43
20	.55	1.804
30	.748	2.57
50	1.254	4.2
70	1.74	5.87
110	2.64	9.086

Source: From Committee on Animal Nutrition, National Academy of Sciences Nutrient Requirements of Dog, 1972.

a/ Calculations of the amounts of dry food are based on energy supplied by food containing 90% of dry matter. Available energy is calculated at 2784 Kcal per kg.

b/ Calculated on the basis of 25% of dry matter. According to assumed nutrient contents, available energy is calculated at 821 Kcal. per kg.

Table 5. Cats: Estimated Daily Food Required for Maintenance by Weight of Cat and Food Type

Weight of cat Lb.	Dry Cat Food [a] Lb/cat [c]	Canned Cat Food [b]
3	.11	.33
5	.165	.55
7	.231	.77
10	.33	1.01
15	.495	1.65

Source: Developed from Committee on Animal Nutrition, National Academy of Sciences, 1972, Nutrient Requirements of Laboratory Animals, and J. P. Greaves, Protein and Calorie Requirements of the Feline, 1964.

a/ Calculated on the basis of 90% dry matter. Available energy calculated as 2784 K cal. per kg.

b/ Calculated on the basis of 25% dry matter. Available energy calculated at 821 K cal. per kg.

c/ Estimated assuming a maintanence requirement of 90 K cal. per kg. body weight ; as indicated by J. P. Creaves, op. cit.

average adult dog's nutrition requirements are being purchased commercially when measured in dried dog food equivalents. Of course, this percentage is actually lower because of the amounts of canned and semi-moist foods, which are lower in energy, being purchased.

Parallel computations for cat food yield similar results. Assuming a 7 pound cat being fed only canned cat food, more than 270 lbs. of cat food worth over $74.00 at 1971 average prices would be required to satisfy a cat's minimum nutrition requirements during one year. By feeding only dry cat food, over 83 lbs., worth approximately $22 at 1971 prices is required per cat. By using dried cat food equivalents and adjusting for an average of 1.8 cats per household, an estimated 51.2% of the required nutrition for cats is being purchased commercially at the assumed calorie requirements levels.

Although these statistics indicate that it would be expensive to feed cats or dogs solely on canned food, Table 6 shows that 17.8% of dog owing households are reported as purchasing only canned dog food. Examining single type dog food purchases according to income level does not suggest a strong pattern of substituting lower priced dry dog food for higher priced canned dog food in the low income households.

These statistics, suggesting varying degrees of non-commercial pet food supplements to dog and cat diets, point out some of the causes of the wide range of reported dog and cat food expenditures by the NCP households. The analysis in section II of this paper is devoted to an exploration of this variation in dog and cat food expenditures by U.S. households.

Table 6. Proportion of Dog Owners Purchasing Only One Variety of Dog Food by Household Income Level.

Dog Food Type	Household Income: Under $5,000	$5,000-7,500	$7,500-10,000	$10,000-15,000	$15,000-20,000	Over $20,000	Total
Single Food Type Purchases							
Soft Moist	.3	.5	.45	.93	.75	.2	3.17
Dry	2.96	2.75	3.37	5.54	1.96	1.3	17.91
Biscuit	.41	.27	.14	.27	.10	.17	1.37
Canned	3.68	2.72	3.44	4.82	2.03	1.10	17.81
Novelty treats	.17	.03	.14	.14	.14	.10	1.72
Total	7.52	6.27	7.54	11.70	4.98	2.87	40.10
Households Purchasing 2 or More Food Types	92.48	93.73	92.46	88.30	95.02	97.13	59.90
Total	100	100	100	100	100	100	100

Source: Calculated from MRCA data.

Dog and Cat Ownership Characteristics

Ownership of cats and dogs in the U.S. is widespread; 38.1% of the households own at least one dog and 20.5% of the households own at least one cat. Eliminating the double counting for the presence of both dogs and cats means that 48% of households own at least one cat or dog. In 1971 there was estimated pet population of 33 million dogs and 22 million cats. Although the levels of cat and dog ownership shows some variation over most of the usual socio-demographic variables, there is high inter correlation among several of these variables. For example, the percentage of Jewish and Black households reporting ownership of pets were considerably lower than the national average. However, other factors such as location, income, occupation and education levels of these two groups are also influencing factors in the patterns of pet ownership.

Both dog and cat ownership appears to follow a similar pattern within each demographic variable. It is interesting to note that the socio-economic variables relating to location, household size and income appear to be most strongly related to pet ownership. The percentage of household owning dogs or cats is highest on farms,(67.2% and 49.2% respectively) and lowest in the central cities. The largest number of dogs and cats are owned by suburban households. (Table 7).

Another important variable is household size (Table 8) which shows a very definite pattern of higher pet ownership percentages in larger households. For dogs, the proportion increases from 15.2% for single person households to over 50% for households of more than 5 people. Although less pronounced, the percentage of households owning cats increases steadily from a low of 11.4% for single person households

Table 7. Pets by Location: Distribution of Dog and Cat Owning Households Classified by Location, 1971.
(Per Cent)

Location	Household Distribution	Proportion of Households Owning a Pet		Proportional Pet Population	
		Dog	Cat	Dog	Cat
Farms	5.2	67.2	49.2	9.2	12.5
Small Towns	24.3	38.0	22.3	24.2	26.4
Central Cities	35.3	30.9	13.2	28.6	22.7
Suburbs	35.3	41.1	22.7	38.1	38.4
Total	100	38.1	20.5	100	100

Source: Calculated from MRCA data.

Table 8. Pets by Household Size: Distribution of Dog and Cat Owning Households Classified by Household Size, 1971.
(Percent)

Household Size (Number)	Household Population Distribution	Proportion of Households Owning a Pet		Proportion of Pet Owners	
		Dog	Cat	Dog	Cat
1	12.1	15.1	11.4	4.8	6.7
2	32.8	28.3	17.1	24.4	27.5
3	18.6	41.9	21.8	20.5	19.9
4	17.6	50.2	22.4	23.3	19.4
5	9.9	53.9	26.7	14.1	13.0
6	5.0	54.7	29.5	7.3	7.3
7	2.5	53.1	37.1	3.5	4.6
8	1.0	56.6	23.7	1.6	1.3
9 or more	.4	51.6	16.1	.6	.4
Total	100	38.	20.4	100	100

Source: Computed from MRCA data

to 37.1% for seven person households. This relation of increasing pet ownership with larger households has implications for several other demographic variables since an increase in household size could result either from more adult members, or through the addition of children.

A more specific examination of the household composition is possible by grouping households according to the age of the housewife and presence of children (Table 9). In this survey, a housewife is defined as the wife, the male or female in a single person household, or the head of a single parent household. This means that every household has a housewife. The first category with the housewife less than 35 years old and no children includes all newly married couples as well as all young singles organized into a separate household. The fifth category with housewives greater than 35 years old includes older couples with children no longer at home as well as households of older individuals or groups of individuals without children. Within these 5 age categories, the percentage of households owning dogs or cats is substantially higher in those households where children are present, and highest in households with teenage children. Families within this age category are most likely to be completed, and if of average size, will have approximately 5 members.

The pattern of pet ownership also appears to be strongly influenced by the income level of the household. Breaking household income into $2,000 intervals in Table 10 shows a steady increase in the percentage of households owning pets for higher levels of income.

Table 9. Pets by Family Age: Distribution of Dog and Cat Owning Households by Age of Household, 1971.
(Percent)

Family Age Category	Population Distribution	Proportion of H.H.'s Owning Pet		Proportion of Pet Owners	
		Dog	Cat	Dog	Cat
0 child. and housewife < 35	19.1	16.5	14.2	8.6	13.8
Only pre-teen children	25.0	44.9	21.2	29.5	25.9
Only teenage children	9.5	56.4	27.6	14.0	12.8
Pre-teen and teenage children	12.3	56.1	30.5	18.1	18.3
0 child. and housewife > 35	33.3	34.0	18.0	29.7	29.2
Total	100	38.1	20.5	100	100

Source: Computed from MRCA data.

Table 10. Pets by Income Level: Distribution of Dog and Cat Owning Households by Income, 1971

(Per Cent)

Annual Income ($)	Proportion of Households Owning Pets (Per Cent)	
	Dog	Cat
< 5000	25.1	16.8
5-6000	30.1	16.2
6-8000	37.2	20.0
8-10,000	40.1	22.7
10-12,000	40.7	19.9
12-14,000	44.0	21.6
14-16,000	46.2	21.1
16-18,000	45.7	21.8
18-20,000	43.6	26.3
>20,000	49.3	25.5

Source: Computed from MRCA data.

II. THE DEMAND FOR DOG AND CAT FOOD

The preceding description shows that a substantial number of households own pets and make significant expenditures on commercial pet foods. The analysis of household expenditure patterns for pet food is cast in the standard framework of demand analysis. The cross sectional MRCA data provides information on economic, social and demographic characteristics that are related to expenditure behavior of households.

It is postulated that demand determinants for both dog and cat food expenditures are similar in nature. The following variables are hypothesized to be relevant: 1) household income, 2) household size, 3) number of pets units in household and 4) the location of the household. The underlying logic and direction in which these factors work is outlined below.

Household Income. Pet food is expected to be a "normal" good with a positive correlation with income and elasticity of demand less than one. It has to be recognized that strong correlations exist between household incomes and many demographic variables such as occupations, education level, and age of housewife. These variables are not included in our demand specification and household income may represent many of these separate effects in the model.

Household Size. Increases in household size can have several possible effects on pet food expenditure. As noted above their is a positive relationship between pet ownership and size of households so that one would also expect higher cat and dog food expenditures in the larger households. However, larger households create a possible "economy of size" effect by which extra table scraps are available for

the pet, thereby reducing the amount of purchased pet food. A third consequence of household size results from the reduction in per capita income for a given household income as family size increases. This last effect can be "removed" by using per capita income (i.e. Household income/Household size) as the relevant income variable. Nevertheless, even with this transformation the expected sign of this household, size variable remains indeterminate, depending on whether the "ownership" or "size" effects is the larger.

Number of Pet Units. The level of the expenditure on pet food is affected by both the number and size of the pets in the household. A composite of these influences was obtained for dogs by multiplying the weight of the heaviest dog by the number of dogs present. Since only the heaviest dogs weight was available from the MRCA data, the assumption is made that households with more than one dog are likely to own similar size dogs. The number of dogs times weight of the heaviest dog is a reasonable approximation of household dog units, although biased upward for households with multiple dogs. The number of cat units is composed of only the number of household cats. Although cats do vary in size the range is not nearly as great as for dogs so this measure seems appropriate. Because of the increased physical requirements of larger pet number and sizes, a positive relation between pet units and expenditure is expected.

Location

The location of households (farm, suburban, city, etc.) influences to varying degrees the opportunity for pets to scavenge. For example,

compared to suburban and city pets, a rural dog or cat is much more likely to find all or part of its food by scavenging (e.g. rodents, farm feed, etc.). To handle this effect it was hypothesized that location results in an intercept shift in the expenditure function but not in its slope. The suburbs (where the majority of cats and dogs are located) acted as the omitted "control" variable with a lower expenditure level expected for the farm and small town households. The expenditure level for the central city household were not expected to be significantly different from the central city households.

The Statistical Model

The hypothesized relationships detailed earlier were formulated into general models and formally tested using straightforward OLS regression techniques. To examine pet food expenditures, six models were postulated:

(1) $Y = f(I, NS, HS, L)$

(2) $Y = f(I/HS, NS, L)$

(3) $Y/NS = f(I, HS, L)$

(4) $Y/NS = f(I/HS, L)$

(5) $Y/HS = f(I, NS, L)$

(6) $Y/HS = f(I/HS, NS, L)$

where

Y = Household expenditure on dog/cat food

Y/HS = Per capita household expenditure on dog/cat food

Y/NS = Household expenditure per unit of dog size or number of cats

I = Household income

HS = Household size

L = Location (expressed as 4 dummy variable)

Variations of these six general models were created by a natural log transformation of the dependent and independent variables, and a log transformation of only the dependent variable.

Due to the presence of zero dog food expenditure levels for a number of households owning dogs, it was necessary to impute a value of $.01 to these households to allow the logarithmic transformation.

The OLS coefficient estimates and the standard errors from several of the more significant models are listed in Table 11 and 12. Despite the high significance level of all equations, the percentage of expenditure variation explained is rather low. However R^2 values of this magnitude are not unusual in cross-sectional data of this scope.

Within the five models presented, all variables were significant at the 1% level and all anticipated variables had the expected signs. The only unanticipated variable, household size, turns out to be negatively related to pet food expenditures. This negative coefficient in both the linear and log models suggests that additional family members effect a reduction in pet food purchases by producing extra table scraps or alternatively that this "economy of size" effect in combination with the negative effect on per capita income of increasing family size, outweight the possible pet ownership effects.

Table 11. Regression of Dog Food Expenditure Formulations on Selected Independent Variables

	Dependent Var.	Constant	Income (in Thou. $)	Income / HHS (in Thou.$)	Dog Units	Household Size	Log Inc (in $)	Income in $ / Log H.H. Size	Log DogUnits
Model I	Expenditure	27.048 (1.325)	.42* (.076)		.1824* (.0108)	-2.4506* (.1626)			
Model II	LOG Exp / Dog Size	-.908 (.122)		.072* (.0099)					
Model III	LOG Exp / H.H. Size	-6.549 (1.07)						.84* (.0587)	.3442* (.04)
Model IV	LOG Exp / Dog Size	-4.126 (.682)						.4335* (.04179)	
Model V	LOG Exp / Dog Size	-2.490 (.810)					.3005* (.0452)		
Model VI	LOG Exp	-3.279 (.6653)					.53334* (.0731)		.4355* (.0487)

Table Continued on Following Page

Table 11. (continued)

	Log (H.H. S.)	(Farm) D_1	(Sm. Towns) D_2	(C. Cities) D_3	(Suburbs) D_4	F. Stat.	R^2
Model I		-20.718* (2.168)	-8.788* (1.543)	-1.9662 (1.4646)		71.944	.14719
Model II		-1.7175* (.1074)	-.5097* (.07684)	.02485 (.0732)		93.72	.13026
Model III		-2.1083* (.1515)	-.5373* (.1073)	.0756 (.1019)		106.928	.17606
Model IV		-1.6195* (.1069)	-.4572* (.7636)	.03946 (.07247)		109.163	.1485
Model V	-.75213* (.6025)	-1.682* (.1062)	-.5041* (.0758)	-.00605 (.072)		99.718	.16616
Model VI	-1.0744* (.0981)	-2.7835* (.1733)	-.7644* (.1225)	-.0583 (.1163)		83.1	.1662

Source: Computed from MRCA data. Values in parentheses are standard errors.

Table 12. Regression of Cat Food Expenditure Formulations on Selected Independent Variables

	Dependent Var.	Constant	Income (in Thou. $)	Income H.H.S. (in Thou. $)	Cat #	H.H. Size	Log (Inc.)	Inc Log HHS	Log (Cat No.)
Model I	LOG Exp Cats	18.257 (1.939)	.2981* (1.033)		2.882* (.5548)	-.9366* (.1677)			
Model II	LOG Exp Cats	.045 (.269)		.156* (.022)					
Model III	LOG Exp. H.H.S.	-7.2415 (1.289)						1.007*	-.1071 (.1003)
Model IV	LOG Exp Cats	-5.556 (1.446)						.884* (.0889)	
Model V	LOG Exp Cats	-4.067 (1.675)					.7621* (.0952)		
Model VI	LOG Exp	-4.086 (1.732)					.8013* (.0997)		-.1338 (.1146)

Table Continued on Following Page

Table 12. Continued

	Log (HHS)	(Farm) D_1	(Sm. Town) D_2	(C. Cities) D_3	(Suburbs) D_4	F. Stat.	R^2
Model I		-22.089* (2.7844)	-4.9688* (2.126)	4.4308** (2.2084)		21.7	.0832
Model II		-3.554* (.2062)	-.1762 (.1614)	.8872* (.1676)		117.51	.2466
Model III		-2.72* (.2011)		.7696* (.165)	.0006 (.1456)	104.85	.2675
Model IV		-3.387* (.2036)	.0954 (.159)	.8732* (.1648)		113.68	.2713
Model V	-1.1773* (.1222)	-3.428* (.2032)	-.1578 (.1594)	.8099* (.1652)		110.21	.2774
Model VI	-1.204* (.128)	-3.40* (.1735)	-.133 (.1668)	.7205* (.1735		85.09	.2625

Source: Compiled from MRCA data. Values in parentheses are standard errors.

Interpretation of Results

The behavior of households in regard to pet food expenditure is similar in nature to that of other consumption goods. Expenditures are strongly related to income, location and household size. Estimates of income elasticities of expenditure on cat and dog food are shown in Table 15. Pet food has a high income elasticity of demand -- higher than for most human foods [see 7]. This characteristic is consistent with the idea that consumers are purchasing pet food as a convenience item which has an important service "component" -- no mess, no fuss, assurance of providing balanced nutrition and so on.

In regards to location there is no significant difference between central cities and suburbs in the case of dog food (signs are variable according to model specifications and t tests not significant). However in the case of cat food there is a significant difference between central cities and suburbs. The difference between small towns and suburbs is not significant, although it is for dogfood, but all models have the same negative sign for cat and dog food. The reason for this difference is not clear although it does suggest that suburban household cats are less dependent on their owners to provide their nutritional needs i.e. that life in the suburbs offers opportunities for scavenging for cats but not for dogs. This may indicate that leash laws, which usually apply only to dogs, are effective to some degree in confining dogs in the suburbs.

The relationship between expenditures in pet food and dog size and numbers is, as expected, highly significant in all models. However, in

the case of cats, the relationships are not significant. The average number of cats per cat owning household is slightly higher than for dogs and we would expect a significant relationship between cat numbers and cat food expenditures. It will be remembered that the MRCA data did not permit allowance for weight of cats and we assumed that the variability of cat weight was insignificant. It is possible that cat numbers, in the light of the shorter breeding cycle, reflect more the presence of kittens than puppies in the case of dogs. Kittens may not stay in the household for very long and consume little food directly during this time. However the absence of an identifiable relationship with cat numbers remains unclear.

III. THE DEMAND FOR CATS AND DOGS

The decision by a household to purchase pet foods can be viewed as separate from the decision to own a cat or dog. Although "operating costs" (food, vet fees, taxes) are related to "investment" decisions -- in this case to acquire a pet (or even accept it as a gift, including in the extreme case the proverbial white elephant) -- the demand for ownership is of interest in examining in the more fundamental economic behavior of households in acquiring pets. The purpose of this section is to identify the significant factors affecting pet owernship and to illustrate a method of explaining and predicting pet ownership levels for the general population and for sub-classifications of the population.

In an economic analysis of cat and dog ownership, the household pet takes on many of the characteristics of a durable consumption item. The pet has an extended life expectancy in which there is a return of satisfaction from the ownership investment, and there is a continued maintenence cost associated with the pet's upkeep. Because of this maintenence cost, owning a pet can be considered as an economic decision, regardless of whether the pet was initially purchased or obtained freely.

One method of viewing this economic decision process is in terms of a threshold concept, where the decision maker reacts positively only after he has been exposed to a level of stimuli beyond his threshold level. If this threshold level, or "breaking-point" has not been reached, there is no reaction. In a threshold model involving an economic consumption decision, the stimuli is comprised of socio-economic factors acting in combination to produce either a positive acquisition

response or a non-response. Each of these factors exert a certain level of stimulus on the decision maker, and if of sufficient strength, the combined effects of this stimuli will result in the positive response, i.e. the decision to own a dog or cat. Once this threshold level has been exceeded, additional stimuli will not further affect the outcome. If the cumulative effects of the stimuli are below the threshold level, no purchase or acquisition takes place.

Special models to analyze this stimulus-response type behavior involving a threshold level have been developed and used extensively in the biological sciences [8, 9, 10]. Stemming from this work, a particular statistical technique, the probit analysis model pioneered by W. J. Finney has recently begun to find applications in economic decision making processes.[1/] In this paper's specific application of threshold theory, the Multivariate Probit Analysis model will be used to estimate this threshold level, and to identify and estimate the relevant economic stimuli affecting the pet ownership decision.

The Model

The Multivariate Probit model is associated with the cumulative normal probability function where the probability of observing a response (Py) is defined in terms of the level of an index or stimulus (Zi). This index (Zi) is assumed to be a normally distributed random variable, N(0, 1), we are also assuming that each individual observation or

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1/ See for example Thoaen et al, and Hill and Kau(10, 11).

household has an associated critical value, (Zi*) of the index (Zi). This critical value allows an explicit descriptive criterion for predicting pet ownership behavior:

If $Zi > Zi^*$, $Y = 1$ (the household owns a pet)

If $Zi \leq Zi^*$, $Y = 0$ (the household does not own a pet)

The relationship of the indexes to the probability is expressed in the following equation:

$$Py = F(Zi) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Zi} e^{\frac{-s^2}{2}} ds$$

where:

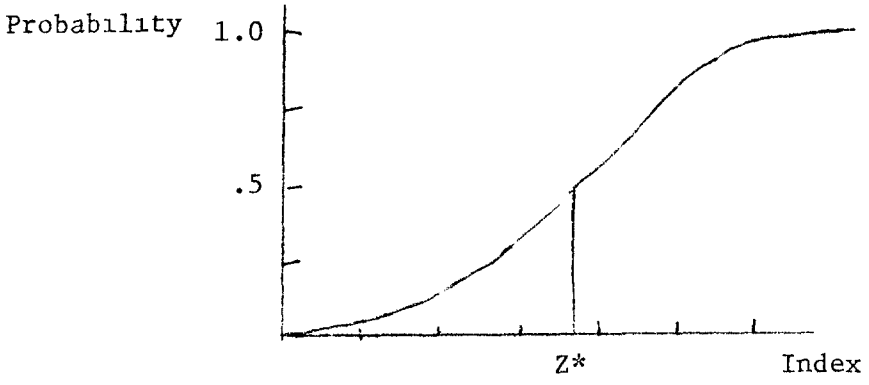
Py is the probability of observing a positive response.

Zi is the level of the index.

F() is the cumulative probability function.

By construction, the probability of ownership, (Pi) will lie in the (0, 1) interval. Figure 1 illustrates the relationship of the probability of response to the stimulus index under the Standard Cumulative Normal Distribution.

Figure 1. Probability Distribution Under Cumulative Normal Function.



This function, relating the stimulus index to the probability, is shown to follow a sigmoidal curve. Although the index (Zi) may take on any value between $-\infty$ and $+\infty$, according to the cumulative probability function, the estimated probability values (Py) will have the desired property of being between 0 and 1 (which is not the case with linear probability models).

Applying the probit model to economic survey data produces estimates of the probability of a positive consumption response, or purchase, based on the index level, which in turn is based on socio-economic stimuli such as incomes, household location and composition, and other relevant factors.

The consumption response expressed as a function of the index level (Zi) and the index level expressed as a linear combination of variables can be represented in the general form:

$$\hat{y}i = Zi + B_0 + B_1 X_1 i + B_2 X_2 i, \ldots, B_n X_n i$$

where:

i = 1, 2, 3, ... i are the observations which are assumed to be statistically independent.

Z_i = the unobserved index level for the tth observation.

B_n = the unknown parameter, n = 0, 1, 2, ... n.

$\hat{y}_i$ = estimated probability of a positive response.

Although this expression resembles a linear regression a stochastic error term has not been specified. The critical value of the index (Z_i*) plays the role of the disturbance term. Because this is not the

linear regression model, ordinary least squares cannot be used to estimate values for the parameters. The procedure generally adopted is maximum likelihood estimation of the B's. [9]

The Empirical Analysis

By using the multivariate probit model just described, estimates of the degree of causal relatedness between the pet ownership decision and the socio-economic variables can be made. This probit model can also be used to explain and predict cat and dog ownership for the entire population or for certain identifiable sub-sectors. The data used for this analysis is the same MRCA panel data as in the preceeding section although the entire set of data for 7040 panel members are used (not just those recording pet food expenditures).

The decision to acquire a pet is postulated to be a function of (1) household income (2) household size, (3) location, (4) family composition, (5) race, and (6) religion. Only household income and household size are in continuous form. The remaining 4 variables were classified as dummy variables. Table 13 contains a complete listing and definition of the included and excluded variables. The equation to estimate separate threshold indexes for dog and cat ownership is expressed in the general form:

$$Z_i = B_0 + B_1X_1 + B_2X_2, \ldots, B_nX_n$$

and specifically where:

Z_i = estimated index for the ith household

B_0 = 1 for all households

X_1 = household income

X_2 = household size

$X_3 - X_5$ = location

$X_6 - X_8$ = family composition

$X_9 - X_{10}$ = race

$X_{11} - X_{12}$ = religion

The maximum likelihood estimates of the parameters and standard errors for the dog and cat ownership equations are listed in Table 14. Fitting values for the variables gives estimates of the threshold index (Z_i) which can range between $-\infty$ and $+\infty$ and has an expected mean value of 0 and $\hat{\sigma} = 1$. These estimated (Z_i) values then correspond to a probability value from the cumulative normal distribution. This probability is then interpreted as the expected number of cat and dog owners out of the N number of households in a region or sub-region.

This procedure can be illustrated for a hypothetical, white, Protestant family of four, with 2 pre-teenage children having a $12,000 annual income, and living in a central city. The sum of the values from these variables yield an estimated index level of -.133 for dogs and -.874 for cats. Under the cumulative normal probability distribution, these levels correspond to a 44.6% dog owning probability and a 19.21% cat owning probability. These probit probabilities contrast to an observed 38.1% dog ownership and 20.5 cat ownership level in the 7040 MRCA household. By a similar procedure, the specification of household characteristics into the equation enables estimates of dog and cat ownership probabilities for any of the possible sub-categories of the population.

In addition to this estimation capability, the probit model provides an objective measure of influential variables affecting dog and cat ownership. Examining Table 13 shows fewer significant predictive variables in the cat ownership equation than in the dog ownership equation. The lower significance of income for predicting cat ownership suggests a higher expense for owning and feeding a dog. The relationships between pet ownership and the socio-economic variables suggested by the coefficient signs are consistent with expectations and with the patterns observed in other analysis. In observing the significance levels of these dummy variables, it should be remembered that there is always one excluded category within each group of dummy variables. The calculated T value is a measure of how different each of the included variables is from the excluded variable.

Although the form of the Probit model resembles a regression model, it is not possible to interpret the effects of changes in the independent variables on pet ownership probability directly from the coefficients. This is because the expected value of the index (Z_i) is a function of not only the change in the index level, but also of the initial value of the index [3]. Under the cumulative normal distribution, the initial position o of the index (Z_i) along the sigmoidal curve will affect the rate of probability change for a constant change in the index value. To estimate the effect of a change in one of the variables, the index should be recalculated.

Table 13. Variables Defined

X_1 = Household Income

X_2 = Household Size

X_3 = Farm Location

X_4 = Small Town Location

X_5 = Central City Location
Surburban Location (Omitted category)

X_6 = Family Composition; pre-teen children present

X_7 = Family Composition; teenage children present

X_8 = Family Composition; Housewife 35 years old and no children present

Family Composition; Housewife 35 years old and no children present (omitted category)

X_9 = Race; Black

X_{10} = Race; Others
Race; White (omitted category)

X_{11} = Religion; Catholic

X_{12} = Religion

X_{13} = Religion; other
Religion; Protestant (omitted category)

Table 14 Probit Model of Cat and Dog Ownership: Coefficient and Standard Error Estimates for Selected Variables.

	Dogs $\hat{B}$	s.e.	Cats $\hat{B}$	s.e.
Constant	-1.109	.055	-1.081	.058
Income ($1000)	.013*	.0024	.0051**	.0026
H.H. Size	.114*	.012	.075*	.013
Loc (Farm)	.691*	.075	.708*	.073
Loc (Small Town)	-.025	.423	.006	.045
Loc (Cities)	-.137*	.038	-.242*	.044
Family (pre-teen children)	.501*	.051	.087	.055
Family (teen children)	.711*	.056	.268*	.061
Family HW>35 and 0 child)	.390*	.046	.060	.051
Race (black)	-.485*	.067	-.618*	.086
Race (other)	.098	.194	.248	.203
Rel. (Catholic)	-.205*	.040	-.343*	.464
Rel. (Jewish)	-.611*	.096	-.591*	.120
Rel. (other)	-.031	.067	-.029	.074
- 2 log likelihood ratio	892.38		488.75	

Source: Computed from MRCA data

* significant at 1% kevel

** significant at 5% level

Interpretation of Results

The probit analysis provides a good "explanation" of the dog and cat ownership patterns and, as mentioned above, provides an accurate estimate of dog and cat ownership levels for the general population and for specific sectors of the population. This analysis does not really answer the question as to why people own cats or dogs but it does permit some cautious speculation about cat and dog ownership. In general both cat and dog ownership are related to the same set of variables in similar ways i.e. to location, family "stage" race etc. although the relationship appear to be generally stronger for dogs than cats.

Our analysis does not address the question as to what is the "utility" or "satisfaction" derived from pet ownership. Although, particularly on farms, dogs and cats may perform services (e.g. mouse catching, guard dog and security) it is not apparent that this is a central motive for owning pets. The relationship between household size and the stage of family lifecycle in explaining pet ownership is of particular interest. It would appear that as a family unit moves from young, single to young married with no children and on through the stages of having pre-teens and teenage children in the house there is increasing probability of pet ownership. This observable pattern is consistent with casual observation and raises some intriguing questions as to whether dogs and cats act as complements to or substitutes for affection and emotional satisfaction derived from children.

The strong relationship between pet ownership and race is also interesting. This relationship exists even after seperating out income and location effects. Is this evidence of different "cultural" attitudes to pets? If so, what are the reasons for such differences?

IV. SUMMARY AND CONCLUSIONS

This paper has shown that significant household expenditures are being made on cat and dog food. Projected to national levels the MRCA data suggest that total retail sales of cat and dog food was about $1.3 billion in 1971. Ownership of cats and dogs is widespread and strongly related to socio-economic variables. The economic behavior of households in purchasing pet food is no different from that of any other consumer good.

It has been claimed that pet foods use up significant amounts of grain which could be used for human food or animal feed. A brief examination of our data and of other information suggests that less than 1 per cent of U.S. grain production is directly being used in pet food in 1975 (6, 12). This amounts to about 1.5 million tons of grain or sufficient, at LDC standards of grain consumption, to feed about 8 million persons. To give some perspective to this figure it should be remembered that annually world population is growing at about 80 million persons.

Pet food demand is certainly increasing the cost of human food to human consumers and contributing to maintenance of farm prices for grains. Nevertheless on the other side of the coin pet foods also use up meat byproducts (and others) which, by increasing the value of the total carcass, reduces the cost to consumers of edible meat (13, 14). It will be the subject of a subsequent paper to look at in more detail the effects on farm and retail prices of the demand for pet food.

An interesting aspect developing from this pet food investigation is the identification of 427 households, 6.0% of the panel, reporting expenditures on cat or dog foods without reporting ownership of either a cat or a dog. Of these 427 households, 51 reported purchases of both cat and dog food. These households were examined more closely to see if they prove evidence of human consumption of pet food.

Table 15 shows that the average pet food expenditure for the households without pets is well below the expenditure levels for household owning cats and dogs. Tables 16, 17, and 18 look at the distribution of these non-pet owning households classified by income levels, age of the housewife, and location of the households and contrasted with the levels for the entire population. The type of pet food purchased by the households listing no pets owned, also shows little deviation from the purchasing pattern of the households with pets (Table 19 and 20). If these purchases were indeed for human purposes it might be expected that canned food expenditures would relatively be more important.

Thus, although rather significant numbers of household (6 percent) report buying cat and dog food but not the presence of cats or dogs the data does <u>not</u> suggest that these are the old, the young and the poor who are buying pet food as <u>human</u> food. Why these household report pet food expenditures (in significantly lower $ amounts) is not clear. It may be due to reporting or coding errors or, perhaps more likely, to acquisition (or disposal) of a pet after (or prior to) the time at which the households reported on the presence of cats and dogs (a one shot, not a weekly reporting).

It can be argued that panel data might be quite reliable for picking up expenditures on "sensitive" subjects such as human consumption of pet food. Nevertheless, the MRCA data does not indicate that such purchasers are in the economic and age categories which are popularly believed to be the most common users of pet food for this purpose. United Press International reported on June 19, 1974 "In the world's wealthest country as much as one third of the dog and cat food sold in city slums is being eaten by humans, a panel of nutrition experts reported today". Robert J. Samuleson (2)

Table 15. Pet-Owning and Non-Pet Owning Households Purchases of Pet Food

	H.Hs. buying cat food w/o pets	Cat owning H.Hs.	H.Hs. buying dog food w/o pets	Dog owning H.Hs.
% of total sample population	2.2	20.5	4.6	38.1
Av. Annual Expenditure	$7.84	$22.20	$8.70	$27.64

Table 16. Pet Food Purchasing Households Without Pets Classified by Income and Contrasted with National Population Distributions. (per cent)

Income	H.Hs. With Cat Food Exp. and No Pets	H.Hs. With Dog Food Exp. and No Pets	U.S. Population Distributions
<$5,000	34.1	23.7	21.2
5, - 7,500	17.0	16.2	14.5
7,5 - 10,000	20.5	20.2	16.8
10, - 15,000	34.0	23.7	27.2
> 15,000	14.8	16.2	20.2
	100	100	100

Table 17. Pet Food Purchasing Households without Pets Classified by Housewife Age and Contrasted with National Population Distributions. (per cent)

Age of Housewife	H.Hs. With Cat Food Exp. and No Pets	H.Hs. with Dog Food Exp. and No Pets	U.S. Population Distribution
< 25	12.3	8.4	7.0
25-30	8.5	12.1	9.7
30-40	15.1	15.3	17.2
40-50	17.0	16.5	19.4
50-60	24.5	21.2	21.3
> 60	22.6	26.5	25.4
	100	100	100

Table 18. Non Pet Owners Purchases of Pet Food by Location

Location	H.Hs. with Cat Food Exp. and No Pets	H.Hs. with Dog Food Exp. and No Pets	U.S. Population Distribution
Farm	1.9	4.3	5.2
Small Town	27.4	22.2	24.3
City	44.3	38.9	35.3
Suburb	26.4	34.6	35.3
	100	100	100

Table 19. Dog Food Expenditures for Households without Pets by Type

	National Distribution by Varity in % (%)	Distribution for 4.6% of H.H. with out pets
Semi-Moist	15.85	15.94
Dry	35.83	34.4
Bisquits	3.59	5.16
Canned	43.71	43.2
Nov. treats	1.02	1.23

Table 20. Cat Food Expenditure for Households without Pets by Type.

	National Distribution by Variety in % (%)	Distribution for 2.2% of H.H. with out pets
Canned	72.52	65.4
Soft-moist	2.42	2.4
Dry	24.95	32.1
Treats	.10	.1

roundly criticized UPI for its "press release journalism" and carefully traced the origin (or lack of it) for such sensational statements. The MRCA data also does not support the nation that significant quantities of pet food are being consumed by humans.

There has been rapid growth of pet food sales during the 1970's (Table 21). Our analysis of the demand for pets and pet food does not fully explain these increases in demand. The changes in demographic characteristics of the population (age, household size, location, race, etc.) have been slight in this short time period. Income changes in real terms have also been very small -- although some redistribution of income may have occurred. In other words such changes as have occurred are not sufficient to lead to the observed changes through the mechanisms of our cross sectional analysis. It is probable that structural changes are also taking place in the economy which lead to more rapidly growing demand for cat and dog ownership and expenditures on pet food. It is interesting to note that our data do support an economic response by cat and dog owners to changed economic conditions. There have been numerous reports of increased abandonment of animals during the recent recession and consumers adjusting their expenditures by letting animals run wild (see 15).

The analysis of ownership characteristics provided highly significant results and suggests that ownership of cats and dogs is strongly related to income, location, family size, age and race. The proportion of households owning cats and/or dogs (48 per cent) is truly astonishing.

Table 21. U.S. Pet Food Sales 1970-75

Year	Quantity	$Value
	(thousand metric tons)	(million dollars)
1970	2,622	1,192
1971	2,808	1,365
1972	2,958	1,481
1973	3,201	1,784
1974	3,281	2,168
1975	3,279	2,471

Source: Information supplied by Pet Food Institute, Chicago.

This paper has examined the economic behavior of households in regard to pet food and ownership of cats and dogs. Pets, or companion animals as they are also called, give rise to significant other expenditures which we have not analyzed -- veterinary fees, clothing, toys, burial and disposal costs (including headstones), beautician costs (trimming, shampooing), birth control and legal fees (including registration and defense in suits) are only some of these. The provision of this range of pet services is clearly an important element of national economic activity and a multiple of several times the direct cost on pet food. There are other "social" costs which could be counted -- advertising (particularly on T.V.), disease, pollution of sidewalks, traffic accidents caused by stray pets etc. It is strange that so little is known about the economic impacts of cats and dogs and the services (or "satisfactions") they provide. This paper has attempted to provide some new information on part of this major industry.

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