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I. INTRODUCTION

The major economic problems faced by modern economies increasingly require an understanding of the short-run effects of possible exogenous developments and policy alternatives on the pattern of consumer expenditure. Drawing intra-year implications about consumer behavior from studies based on annual data can be dangerously misleading. Based on their epic study of consumer expenditure in the United States, Houthakker and Taylor concluded that consumption habits have a far greater effect than household stocks on the pattern of consumer demand.[1/] However, this investigation shows that short-run consumer behavior is influenced more by consumer inventories than habits. The effect of habits as opposed to inventories on consumption is not an absolute, but is relative to the time horizon.

The Houthakker-Taylor state adjustment model (H-T model) is the first dynamic demand model which encompasses both the effect of inventories and the influence of habits arising from past consumption on current demand. The dynamic mechanism in this model is a "state" variable. The coefficient (β) on the state variable indicates an inventory adjustment effect when negative

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1/ H. S. Houthakker and L. D. Taylor, Consumer Demand in the United States: Analyses and Projections, Second Edition, Harvard University Press, Cambridge, Mass. (1970).

and a habit formation effect when positive. Based on an analysis of consumer expenditure for 82 commodities using annual data, Houthakker and Taylor conclude that "habit formation quite clearly predominates in United States consumption."[2/]

This study reveals that the stock coefficient (β ·) is a conceptual function of the time dimension of the data and that the importance of habit formation relative to inventory adjustment in the economy decreases as the time period analyzed decreases. In this study, the Houthakker-Taylor demand equation is estimated by regression analysis for sixteen major consumer commodities for four different data intervals: annual, semi-annual, quarterly, and monthly. The data cover a 26-year post-war period, 1947-1972 and the commodities account for 53% of 1965 consumer expenditure, ranging from food to auto parts.

II. THE HOUTHAKKER-TAYLOR DEMAND MODEL

The basic postulate underlying the H-T model is that past behavior has an influence on current decisions. Past behavior is embodied in the current value of a "state variable", which encompasses not only stocks held by the consumer, but also habits formed by past consumption. The model is based on two equations: a demand function in which income, prices, and the state or stock variable are the explanatory variables and a stock identity.

[2/] Houthakker and Taylor, p. 164.

Let: $q_i^j(t)$ = demand for good i at time t by the j^{th} consumer

$x^j(t)$ = income at time t of the j^{th} consumer

$p_i(t)$ = price of good i at time t

$s_i^j(t)$ = the state variable for good i at time t: the j^{th} consumer's physical inventory and psychological stock, habits, associate with good i

Then: $$q_i^j(t) = \alpha + \beta s_i^j(t) + \gamma x^j(t) + \eta p_i(t) + u_t \qquad (1)$$

Where: $\beta < 0$ indicates an inventory adjustment effect, which applies to durables

$\beta > 0$ indicates a habit formation effect, which applies to non-durables

In the case of a consumer durable, say furniture, an individual's demand depends not only on his current income and the price, but also on his present stock of furniture. The expectation is that the greater the amount of furniture in his house, then the less will be the consumer's need to buy more. For durables, one expects the coefficient (β) on the stock variable to be negative. In the case of a non-durable, say cigarettes, demand is a function of income, the price, and a consumer's cigarette smoking habit. Cigarette demand is perhaps the most obvious example of a habit formation effect, since smoking is considered addictive or habit-forming in a biological sense. Current consumption of cigarettes is positively influenced by consumption in the recent past. The smoker develops a psychological stock, a smoking habit, which has a positive effect on his current demand. In the demand function for cigarettes, the coefficient (β) should be positive.

The second equation, which along with the above demand function establishes the structural form of the model, is a stock (physical or psychological) depreciation equation:

$$\dot{s}_i^j(t) = q_i^j - \delta s_i^j(t) \qquad (2)$$

where $\dot{s}_i^j(t)$ is the change in stock around time t, $q_i^j(t)$ is purchases, and $\delta s_i^j(t)$ is depreciation or the "using up" of the stock. The parameter δ is a constant depreciation rate. In the case of habit formation, the parameter δ measures the speed at which the habit dissipates or wears off. For most goods, δ measures simultaneously the rate of physical depreciation and the rate at which habits wear off.

The unobservable state variable is eliminated by the following procedure. First drop the superscript j and the subscript i and solve equation (1) for s(t), then using this expression eliminate s(t) from (2) which yields:

$$\dot{s}(t) = q(t) - \delta/\beta \,[q(t) - \alpha - \gamma x(t) - \eta p(t)] \qquad (3)$$

Differentiate (1) with respect to time:

$$\dot{q}(t) = \beta \dot{s}(t) + \gamma \dot{x}(t) + \eta \dot{p}(t) \qquad (4)$$

Substitute (3) into (4) for $\dot{s}(t)$:

$$q(t) = \beta [q(t) - \delta/\beta \,[q(t) - \alpha - \gamma x(t) - \eta p(t)]] + \gamma \dot{x}(t) + \eta \dot{p}(t) \qquad (5)$$

which after simplification becomes:

$$\dot{q}(t) = \alpha\delta + (\beta - \delta) q(t) + \gamma \dot{x}(t) + \gamma \delta x(t) + \eta \dot{p}(t) + \eta\delta p(t) \qquad (6)$$

Rather than simply replacing derivatives by finite differences, Houthakker and Taylor develop a linear approximation for the continuous function and derive the following estimating equation.

$$q_t = \frac{\alpha\delta}{1 - \frac{1}{2}(\beta - \delta)} + \frac{1 + \frac{1}{2}(\beta - \delta)}{1 - \frac{1}{2}(\beta - \delta)} q_{t-1} + \frac{\gamma(1 + \delta/2)}{1 - \frac{1}{2}(\beta - \delta)} \Delta x_t$$

$$+ \frac{\gamma\delta}{1 - \frac{1}{2}(\beta - \delta)} x_{t-1} + \frac{\eta(1 + \delta/2)}{1 - \frac{1}{2}(\beta - \delta)} \Delta p_t$$

$$+ \frac{\eta\delta}{1 - \frac{1}{2}(\beta - \delta)} p_{t-1} + v_t \qquad (7)$$

or for simplification:

$$q_t = A_o + A_1 q_{t-1} + A_2 \Delta x_t + A_3 x_{t-1} + A_4 \Delta p_t + A_5 p_{t-1} + v_t \qquad (8)$$

where the above estimating coefficients, the A's, are composite terms from which the structural parameters may be derived.[3/] In particular:

$$\beta = \frac{2(A_1 - 1)}{A_1 + 1} + \frac{A_3}{A_2 - \frac{1}{2} A_3} \qquad (9)$$

[3/] For a detailed discussion of the derivation see Houthhakker and Taylor, pp. 13-24.

III. THEORETICAL ANALYSIS

On the basis of their empirical results, Houthakker and Taylor stress the importance of habit-formation and the relative unimportance of stock adjustment in United States consumption. For the 65 commodities to which the dynamic state adjustment model is applicable, the coefficient (β) is positive for 46 commodities, negative for 15, and zero for 4. The 46 categories affected by habit formation add up to 61.1% of total 1964 consumption expenditure; whereas the 15 categories affected by stock adjustment account for only 27.7%.[4/]

These results are dependent on the length of the interval of analysis though. Houthakker and Taylor overlooked the possible conceptual dependence of their model on the time dimension of the data. The stock coefficient (β) is a function of the time interval. Not only the magnitude, but even the sign of β is influenced.

The Dual Nature of β

The conceptual dependence of β on the time horizon originates in the dual nature of β. Most commodities are subject to both a habit formation and a stock adjustment effect. The observed β is the sum of the two effects. Specifically,

$$\beta = \beta_H + \beta_I \tag{10}$$

[4/] Houthakker and Taylor, p. 164.

with:

$$\beta_{Habit} > 0$$

$$\beta_{Inventory} < 0$$

Houthakker and Taylor understood that "the single stock coefficient reflects an amalgam of these opposing tendencies."[5/] The estimated β indicates only the net effect, the dominance of habit formation or inventory adjustment over the other, but says nothing about the specific size of β_H or β_I. The coefficient β_H arises from the psychological stock; β_I from the physical stock. For a durable $\beta_I > \beta_H$ and for a non-durable $\beta_H > \beta_I$.

The value of the stock adjustment component (β_I) for a given commodity is a function of the time period of the data, because the relative importance of household inventories as a factor in consumption is dependent on the interval of analysis. As the time period approaches zero ($t \to 0$), the observed β for most conceivable commodities tends toward negativity as inventory adjustment (β_I) increasingly dominates habit formation (β_H). In this analysis, β should change sign, from positive to negative, for those goods that are non-durables with annual data, but which assume the characteristics of a durable at a semi-annual, quarterly, or monthly period of observation.

The distinction between durables and non-durables is ambiguous and depends on the time dimension. "The distinguishing characteristic of a durable commodity is that its utility is derived from its services over time rather than from consumption of the commodity itself at a point in time."[6/]

[5/] Houthakker and Taylor, p. 164.

[6/] Marc Nerlove, "Distributed Lags and Demand Analysis," Agricultural Handbook No. 141 United States Department of Agriculture (1958).

If the time period is short enough, almost any commodity can be conceived of as a durable, providing a stream of services over time. For an annual period, an automobile is a durable and bread is not. However, for the family that grocery shops only weekly, then during the period of a week,. bread is a durable. From day to day, the family consumes a stream of services from the stock of bread purchased just once a week. If weekly observations were available, the household inventories of bread would be large enough to produce a significant stock adjustment effect (β_I). On an annual basis though, household inventories of bread are insignificant in relation to consumption. The inventory effect (β_I) dissipates as the time period is lengthened, because the inventory-consumption ratio decreases.

In the proper time frame, many services possess the attributes of a durable. In a routine visit to the dentist, what is really purchased is a stock of clean teeth and the assurance no dental problems exist. This stock then steadily depreciates over time and after six months or a year, the individual must return to the dentist to renew his stock. The observed β could be negative in the short-run for many services.

The habit formation component (β_H) is also a conceptual function of the time horizon. Due to temporary satiation of a consumer's desire for a commodity, β_H may become negative at a short enough period. A saturation point in consumption, at which the psychological stock effect shifts from positive to negative, may be reached as the time interval approaches zero ($t \to 0$). The most addicted cigarette smoker usually will not want another cigarette one second after putting out the last one. A person who indicates that he is "fed up" with going out to dinner or to the movies is expressing temporary satiation.

Even services produce a negative psychological stock effect, which lasts for some interval and deters immediate re-purchase.[7] However, the shortest interval of analysis in this study is a month, which is too long a period to observe a significant temporal satiation effect for most goods.

The argument, that the stock coefficient (β) is conceptually dependent on the interval of analysis is distinctly different from Houthakker and Taylor's observation that the structural parameters of their model, including β, are mathematically a function of the time period.[8] Houthakker and Taylor postulated that the parameters, α, β and δ are linear functions of the time period analyzed. In other words, the β derived with quarterly data should be one-fourth the β from annual data. Houthakker and Taylor's own estimated equations for aggregate consumption based on quarterly and annual data were inconsistent with this proposition. The quarterly estimate for β was .90; the annual value 1.33.[9] The former is certainly not one-quarter of the latter. Houthakker and Taylor found this discrepancy between the theory and the facts disturbing, but did not offer any explanation.

7/ Walter W. McMahon, "Dynamic Interdependence in Consumer Stocks, Tastes, and Choices," Unpublished manuscript, College of Commerce and Business Administration, University of Illinois, (1971).

8/ Houthakker and Taylor, p. 283.

9/ Houthakker and Taylor, p. 283.

Specification of the Model

The basic demand function, equation (1), is a misspecification of the true structure of the model, since the observed β for most commodities embodies both habit formation (β_H) and inventory adjustment (β_I). The theoretically correct specification would introduce two state variables, one for each effect.[10/] In addition, the coefficient on each state variable should be conceived of as a function of the time period of observation. Hence, if income and price are excluded for simplicity, then:

$$q(t, \tau) = \alpha(\tau) + \beta_H(\tau) s_H(t, \tau) + \beta_I(\tau) s_I(t, \tau) \qquad (11)$$

where:

τ = the length of the period of observation

$\beta_H(\tau) > 0$ (habit formation)

$\beta_I(\tau) < 0$ (inventory adjustment)

and for most commodities:

$$\frac{\partial \beta_I(\tau)}{\partial \tau} > 0$$

$$\frac{\partial \beta_H(\tau)}{\partial \tau} \lessgtr 0 \quad \text{(the sign is uncertain)}$$

10/ The author is indebted to Lester D. Taylor for the following specification.

The variable s_H is the psychological stock, while s_I is the physical stock of a particular good. The stock adjustment effect is a positive function of the time period of analysis; whereas the relation between the habit formation effect and time is indeterminant.

In addition, the stock depreciation equation must also be respecified, since the observed δ is an amalgam of both the rate of physical depreciation and the rate of which the habit wears off.

$$\delta = \delta_H + \delta_I$$

The stock depreciation equation becomes:

$$\dot{s}(t, \tau) = q(t, \tau) - [\, \delta_H(\tau) s_H(t, \tau) + \delta_I(\tau) s_I(t, \tau) \,] \tag{12}$$

where:

τ = the length of the period of observation

$\delta_I(\tau) > 0$ (for most commodities)

$\delta_H(\tau) > 0$ (for most commodities)

The rate of physical depreciation is positive for most conceivable commodities, but $\delta_I(\tau) < 0$ could hold for a good that appreciates in value. Likewise the rate at which the habit wears off is positive in most cases, yet $\delta_H(\tau) < 0$ could occur if the habit is self-reinforcing.

From a theoretical viewpoint a dual specification of the state variable is clearly desirable. However, with this formulation the parameters are underidentified. Both state variables cannot be eliminated from the estimating equation as one state variable can by judicious substitution.

Tore Thonstad has indicated an additional specification problem in the H-T model which leads to estimates of β that are biased upwards.[11/] Depreciation of the physical stock of a durable produces a replacement demand, which is implicitly accounted for in β. Due to replacement demand, current demand partially depends on the size of current inventories. Rapid depreciation and not habit formation may cause a $\beta > 0$.

This problem could be solved by the separate specification of replacement demand, but this formulation also leads to an underidentification problem. The problem of replacement demand may be partially overcome through an empirical approach. The shorter the time period is, the greater the divergence between actual consumption and purchases of a commodity. In a month period, the depreciation of a consumer's clothing inventory will not necessarily lead to replacement demand in the same period. The shorter the interval is, the weaker the replacement demand component of β may be; hence the less upward bias in β, which also partially explains the dependence of β on the interval of analysis.

IV. ESTIMATION

Variables

In the regression analysis the variables were specified as follows:

q_t = per capita personal consumption expenditure on the good in question for a particular period (1967 dollars).

11/ Tore Thonstad, "Habit Formation and Stock Adjustment: Comments on the Houthakker-Taylor Model," (unpublished paper), (September 1968).

x_t = per capita personal income - seasonally unadjusted (1967 dollars).

p_t = relative price index for the good in question (1967 base).

Data

Consumer expenditure data for fourteen of the commodities studies are only available annually, but retail sales estimates for various types of stores are compiled monthly. On the basis of the annual data for retail sales by store type and for consumer expenditure by commodity, a ratio between the expenduture and the sales figure for corresponding categories was established for each year. The ratio is obtained by dividing consumer expenditure by commodity, by the equivalent store type retail sales.

Monthly consumer expenditure series are derived by multiplying the monthly retail sales figure by this conversion ratio. The ratio therefore converts store type sales into expenditures by commodity categories. The conversion ratios, which are annual, are applied on a monthly basis. This procedure makes the assumption, that the monthly conversion ratios for a given year which are unknown, can be satisfactorily approximated from the annual ratio.[12/] An eleven month moving average was applied to the ratios in converting sales to expenditure. This was done to eliminate a spurious jump in the expenditure estimates between December of one year and January of the next, since the ratios change somewhat from year to year.

[12/] For a thorough discussion of this derivation, see Benjamin H. Sexauer, The Role of Habit Formation and Inventory Adjustment in a Dynamic Demand Model, unpublished Ph.D. dissertation, Stanford University, September 1974.

Electricity (1) and new cars (2) are quantity measures and the data are available monthly. Electricity is measured in kilowatt hours used for residential purposes and new cars in new passenger car registrations.

Personal income is utilized rather than personal consumption expenditure (PCE) as in the H-T study. Income data are given monthly, whereas total expenditure data are not available on a monthly basis.

Monthly consumer price indices are available for many major consumer goods since 1946. The most recent base year is 1967 and the indices are U.S. city averages. However, the price data are not complete for several commodities nor do the price categories always correspond with the expenditure categories. In some of the series, the price data were only compiled quarterly for many years. These series were extended to 1947 on a monthly basis by simple linear extrapolation using the available prices as benchmarks. Also, some price series were not started until the mid-1950's.

Purchases of most goods reflect a marked seasonal pattern. Seasonal variations in consumption arise from two effects. First, consumer expenditure varies in response to seasonal changes in relative prices and in personal income. For example, most categories of consumer expenditure reach a seasonal low in the first quarter, when personal income reaches its seasonal low. The use of seasonally adjusted series would eliminate intra-year variation in the data, which can be explained by the model. Second, there is a purely seasonal element, which can be viewed as a short-term, systematic change in tastes.[13/] The demand function for the residential use of

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[13/] Richard Stone and D. A. Rowe, "Dynamic Demand Functions: Some Econometric Results," The Economic Journal, Vol. 68, No. 270 (June 1958) pp. 256-270.

electricity shifts to the right in the winter. In other words, the seasonal weather pattern causes exogeneous shifts in demand. The largest purely seasonal shift in consumer expenditure is associated with holiday shopping. Unadjusted sales for all retail stores during December are approximately 120% of the seasonally adjusted figure.

Because of the two aspects of seasonality, seasonally unadjusted series were used to capture the first effect and dummy variables were included, if necessary, to handle the second effect. Retail sales data and prices were available in a seasonally unadjusted form. A seasonally unadjusted income series was derived by developing a seasonal factor and then reversing the normal adjustment process. The sources for all the data were U.S. government publications.[14/]

Estimation Procedure

All the estimation was first conducted with ordinary least squares (OLS). However, for the full estimating equation with both income and price terms, this procedure is inadequate because the parameter δ is over-identified. To obtain a unique estimate of δ, the restriction that

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[14/] U.S. Department of Commerce, Business Statistics, Washington (published biennually--1951 through 1971 editions utilized). Also, U.S. Department of Commerce, The National Income and Product Accounts of the United States, 1929-1965, Washington. For 1971 and 1972 data, U.S. Department of Commerce, "Survey of Current Business," Washington (January 1972 and January 1973 editions utilized). For price data, U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Price Index Series for Urban Wage Earners and Clerical Workers: U.S. City Average," (not a publication, but available as mimeographed sheets).

$A_2 A_5 = A_3 A_4$ must be satisfied in equation (8). One approach to this problem is to substitute the constraint directly into the estimating equation, which produces an equation non-linear in the parameters.[15/]

First, the constraint $A_2A_5 = A_3A_4$ can be transformed to:

$$A_2 = \frac{A_3A_4}{A_5} \tag{13}$$

One could of course solve for A_3, A_4, or A_5: (13) was simply chosen arbitrarily.

Then by simple substitution the estimating equation becomes:

$$q_t = A_0 + A_1 q_{t-1} + \left(\frac{A_3A_4}{A_5}\right) \Delta x_t + A_3 x_{t-1} + A_4 \Delta p_t + A_5 p_{t-1} \tag{14}$$

Equation (14) satisfies the constraint, so that the two estimates of δ are similar. This equation can be estimated by a computer program that can handle equations non-linear in the parameters.[16/]

Problems of Estimation

The main econometric difficulties encountered in estimating the H-T model are multicollinearity and a serious problem of autocorrelation.

[15/] Houthakker and Taylor conceive of the problem as one of constrained least squares. See Houthakker and Taylor, p. 48.

[16/] For a full description of this non-linear estimation procedure, see Sexauer, pp. 73-76.

A high level of correlation frequently exists between several of the explanatory variables in the Houthakker and Taylor estimating equation. In most of the estimates though, the degree of collinearity is tolerable.

Autocorrelation in the Houthakker and Taylor model presents a problem that is complex, troublesome and to a large degree insoluable. The complexity arises because even if the residual in the structural equation is serially independent, the error term in the estimating equation will be autocorrelated. Because the estimating equation contains a lagged dependent variable (q_{t-1}) as an explanatory term, the implications and detection of autocorrelation are particularly troublesome. Lastly, the alternative estimation procedures suggested for use with autocorrelation either offer little or no improvement over OLS results or make heavy demands on computation time and create adverse side effects.

V. THE EMPIRICAL RESULTS

Overview of the Results

The level of statistical significance and explained variance was very high in most of the regressions. The statistical quality of the estimates was generally at least as good as in Houthakker and Taylor's results. For the sake of brevity, the regression results are not presented here.[17/]

The empirical results concerning the stock coefficient (β) as a function of the interval of analysis are summarized in Table 1. The standard errors

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[17/] For a presentation and analysis of the regression results, see Sexauer, pp. 97-197.

Table 1. The Stock Coefficient (β) for Different Intervals of Analysis

		Annual	Semi-Annual	Quarterly	Monthly
1.	Electricity	1.9354	1.9029	1.3335	1.7485
2.	New Cars	-1.6812	-.4676	-.4651	-.3741
3.	New & Used Cars	-1.2395	-.3004	-.5251	-.0049
4.	Clothing & Shoes	.0493	-.4157	-.5568	-1.5302
5.	Men's & Boy's Clothing	-.0354	-.4451	-.9099	-1.3294
6.	Women's & Girl's Clothing	.0096	-.4340	-1.8307	-1.4983
7.	Shoes	-.1405	-.2513	-.8902	-1.4252
8.	Homefurnishings	-.2689	(-.6271)	-.3818	-.9374
9.	Furniture	-.5624	-.6822	-.7104	-1.0556
10.	Appliances	.0576	-.0542	(-.6268)	-.4952
11.	Drugs & Sundries	.5886	.3566	.0202	.2004
12.	Food	.1369	-.5103	-.4979	-1.1545
13.	Auto Parts	.3189	.5612	-.1294	-.2106
14.	Purchased meals	1.7393	1.8613	-.0637	-.0168
15.	Alcoholic beverages	1.8122	1.8232	-.1058	-.1380
16.	Gasoline	1.9108	1.9556	-.0094	.0045

for β are not presented, because they are only indirect approximations and laborious to compute.[18/] The β for most cat egories was derived from estimating equation coefficients that are significant at the 5% level.

For each commodity, the equations from which the β's are drawn are consistent with regard to the presence of absence of a constant term and the inclusion or exclusion of price terms. The estimated value of β for a given commodity and time period frequently proved quite sensitive to the specification of the equation, expecially the pattern of seasonal dummy variables included. Presenting only a single estimate of β for each good in each period oversimplifies the complexity of the empirical results.

The overall pattern of β in Table 1 argues persuasively for the acceptance of the hypothesis that β is a function of the time dimension of the data. Even a cursory glance at Table 1 indicates that β is not a simple linear function of the time period as Houthakker and Taylor argued. The results presented in Table 1 support two propositions : (a) for a group of commodities, the proportion of positive β's to negative β's falls as the period of analysis is reduced; (b) for specific commodities, β decreases as the time period decreases.

With regard to the first argument, the sixteen commodities taken as a group reflect an increase in the importance of inventory adjustment relative to habit formation as the period of analysis decreases. With annual data, β

[18/] See Houthakker and Taylor, pp. 51-52.

is positive for ten categories and negative for six. With semi-annual data, β is positive for six categories and negative for ten categories. With quarterly data, β is greater than zero for only two commodities, electricity (1) and drugs and sundries (11), and less than zero for fourteen items. And with monthly data, $\beta<0$ for thirteen items and $\beta>0$ for only three, electricity (1), drugs and sundries (11) and gasoline (16).

One of the shortcomings of this study is that of the commodities analyzed; several are major household durables, which are subject to a strong stock adjustment influence even with annual data. Also no services are included which are the items with the strongest habit formation effect. Therefore, the shift to inventory adjustment is undoubtedly more marked than would be the case for an all inclusive group of commodities, that accounted for 100% of personal consumption expenditure as in the Houthakker and Taylor study.

With regard to the second argument, based on a comparison of the annual and monthly results, the estimated value of β decreases for fourteen of the sixteen categories. By a decrease in value, a decrease in real, not absolute value is meant. The exceptions are new cars (2) and new and used cars (3), which are different measures of basically the same commodity. The β's for these two goods decrease in absolute value, but not in real value. Of the ten categories subject to habit formation ($\beta>0$) with annual data, the stock coefficient shifts to inventory adjustment ($\beta<0$) for seven with monthly data. The exceptions are electricity (1), drugs and sundries (11), and gasoline (16). Possible explanations for these exceptions are examined in the following analysis of the pattern of β for each commodity.

The Pattern of β for Specific Commodities

Shifts in the value of β are caused by changes in the relation of the inventory adjustment (β_I) to the habit formation (β_H) component of the observed coefficient. The specific results for individual commodities seem to conform to three basic patterns.

(i) For most commodities, a major shift in the relative importance of the two conceptual components (β_I and β_H) of the observed β occurs as the time dimension decreased. A $\beta > 0$ with annual data, but $\beta < 0$ with quarterly and monthly data denotes an increase in the strength of inventory adjustment relative to habit formation, such that $\beta_H > \beta_I$ with annual observations, but $\beta_H < \beta_I$ with quarterly or monthly observations. The commodity is treated as a non-durable in the longer period, but as a durable in the shorter time period. A good example of this shift is food (12). The pattern of β shows that a household's stock of food becomes a progressively more important influence on demand as the interval of analysis decreases.

(ii) For major consumer durables, inventory adjustment (β_I) predominates even with annual data. If the observed β is composed completely of the β_I component, $\beta = \beta_I$ and $\beta_H = 0$, the relation between β and the interval of analysis is probably roughly equivalent to the mathematical function suggested by Houthakker and Taylor. New cars (2) and new and used cars (3) are good examples. However, most likely no commodity has a $\beta_H = 0$ even with monthly observations. The stock coefficient (β) for even a major durable like automobiles probably contains an appreciable habit formation component (β_H) especially in the longer time periods. For this reason, the β's for (2) and (3) only approximate the mathematical relation between β and the interval of analysis suggested by Houthakker and Taylor.

(iii) For certain commodities for which consumer inventories are insignificant even in relation to monthly consumption, habit formation (β_H) predominates throughout and the estimated β will remain positive. Since holding a stock of electricity is a technical impossibility, a $\beta>0$ for every time period is not surprising. However, the state variable (β) for electricity largely reflects the technologically determined element of electricity consumption as a function of electrical appliances in the household. The relevant stock is really electrical appliances not electricity.

The β for electricity (1) is roughly equivalent for the four periods. These results for electricity are biased though, because Δx_t and x_{t-1} were replaced with x_t due to a lack of statistical significance, which constrains $A_2 = A_3$. If A_2 and A_3 are assumed equal, the second half of equation (9) is constrained to equal two which distorts β. The upward bias may be expecially strong in the shorter time periods.

The β results for the other commodities all fall into some variant of these three basic patterns. Clothing and shoes (4) is another example of pattern (i). The β for (4) is positive with annual data, becomes negative with semi-annual data and decreases further with quarterly and then with monthly data. This smooth decline in β is produced by an increase in the influence of inventory adjustment (β_I) relative to habit formation (β_H) in each successively shorter time period great enough to offset any absolute decline in β_I.

Women's and girl's clothing (6) also follows pattern (i). The quarterly estimate of β for (6) overstates the inventory adjustment effect, because of insufficient correction for the seasonal pattern. Clothing expenditure reaches a seasonal peak in the fourth quarter followed by a seasonal low in the first quarter. This high-low pattern biases β downward, unless both a first and fourth quarter dummy variable are introduced. In this case, a first quarter dummy variable could not be included, because it interfered with the statistical significance of the other coefficients.

Commodities (5), (7), (8) and (9) are further examples of pattern (i). Both men's and boy's clothing (5) and shoes (7) show only very weak inventory adjustment dominance with annual observations, but an increasingly stronger stock adjustment effect as the period decreases. A consumer's stock of clothing plays a major role in his monthly demand; whereas in annual clothing expenditure, the role of inventories is only minor and off-set to a large degree by habits established through past clothing consumption patterns.

Homefurnishings (8) and furniture (9) strongly indicate the significant role of habit formation in the longer time periods for many major consumer durables. For these two items, the β's are negative for every period, but increase in absolute magnitude as the interval of analysis decreases. The relative strength of the inventory adjustment (β_I) to the habit formation component (β_H) of the observed β becomes larger as the interval of analysis decreases. The semi-annual estimate for home furnishings (8) is not drawn from an equation which is consistent with the others in the series; therefore it is marked off by parentheses.

Appliances (10), although usually considered consumer durables, conform to pattern (i) with a $\beta_H > \beta_I$, hence a $\beta > 0$ with annual data, and then shift to $\beta_I > \beta_H$, hence a $\beta < 0$ with semi-annual data. A host of new products and improvements on old ones have appeared in the appliance field in the last two decades. This rapid technological change has given rise to a strong desire for newness in consumer demand for appliances, which appears as habit formation in the Houthakker and Taylor model. For item (10), a quarterly estimate could not be derived from an equation consistent with the others.

Auto parts (13) is another item which, ostensibly a durable, indicates the dominance of habit formation with annual and semi-annual data. The relevant stock is really the inventory of automobiles, in which case a $\beta > 0$ makes sense. The greater the number of automobiles, the greater the expenditure on auto parts.[19/]

Drugs and sundries (11) follow pattern (iii) and are treated as nondurable even during a monthly period, which sounds reasonable. The β for (11) declines as the interval of analysis decreases though. This decline indicates either an increase in the relative importance of β_I to β_H or a decrease in habit formation.

Finally, purchased meals (14), alcoholic beverages (15), and gasoline (16) each correspond to pattern (i). The β indicates habit formation dominance at the longer intervals of analysis, but inventory adjustment plays a dominant role in the shorter periods. For (14), dining out at restaurants in the recent past has a negative effect on dining out this

[19/] Houthakker & Taylor, p. 110.

month, which sounds plausible for the average consumer. For (15), most households keep a small stock of liquor, beer, and wine on hand, which plays a role in monthly and quarterly demand. However, in the annual and semi-annual demand function, past consumption has built up habits which have a greater influence than stocks.

Gasoline (16) has been subject to a strong upward trend in demand in the post-war period, plus its β is also largely technologically determined. The relevant stock is the inventory of automobiles. The shift back to a $\beta > 0$ with monthly data may just be the result of a poor estimate. For items (14), (15) and (16), the form of the equation is not consistant across the four periods. With annual and semi-annual data, it was necessary to constrain $A_2 = A_3$ to obtain a significant income coefficient. This constraint probably biases the estimate of β.

The Role of Stocks

The state coefficient (β) in the H-T model reflects the increasing influence of consumer inventories in relation to consumption habits as the time horizon decreases. Consumers treat an increasingly larger number of commodities as durables as the time horizon is shortened. As the time interval analyzed decreases, the household inventory: consumption ratio increases for most items because of the lumpiness of consumer purchases. The lumpiness in consumer purchases exists due to both technical and economic causes.

Most commodities are sold in a specified unit size for technical and economic reasons. Goods are sold in a particular unit for strictly technical reasons, half an automobile or television is of little use. From the merchandisers viewpoint, packaging size also reflects certain economies of scale. The packaging cost for a loaf of bread is much less than the cost of packaging each individual slice.

From the consumer's viewpoint, buying a loaf of bread entails significant costs other than simply the price of the bread itself. These costs entail transport to and from the store and above all the consumer's time; time to acquire the necessary information and time to actually make the transaction. For the consumer, there are economies of scale in purchasing, primarily because his time is not a free good.[20/] To conserve a scarce resource, their own time, a family tries to buy enough groceries in one visit to the market to last a week.

Household stocks exist for technical reasons, an automobile being an example. However, as the time horizon decreases, the holding of consumer inventories increasingly becomes a function of the transaction costs involved in purchasing commodities, the primary cost being the opportunity cost of the consumer's time. When the housewife with a family of four buys three loaves of bread, enough to last a week, she is economizing on the use of her time, since she is buying more than the normal package size, a loaf, which is the technical restraint.

[20/] Gary S. Becker, "A Theory of the Allocation of Time," The Economic Journal, Vol. 75, No. 299 (September 1965), pp. 493-517.

VI. CONCLUSION

The weighted average value of β for the sixteen commodities studied for each time period of analysis is:

annual	semi-annual	quarterly	monthly
.2973	.0757	-.3419	-.7136

The weights used in determining this average value of β were derived by dividing the 1965 consumer expenditure on each commodity by the total amount of 1965 consumer expenditure accounted for by the items in this study. This total was $227.3 billion or 53% of the total 1965 consumer expenditure of $431.5 billion. To avoid double counting, the following categories were excluded from the calculation: new cars (2), which are covered by new and used cars (3); the three apparel sub-groups, which are covered by apparel and shoes (4); categories (9) and (10), which are subgroups of homefurnishings (8).

The weighted average value of β decreases for each successively shorter time period. The effect of habit formation predominates with annual data, but its influence on the economy is significantly less with semi-annual data. With quarterly data, inventory adjustment dominates and its overall influence is even stronger with monthly data. For 53% of 1965 consumer expenditure, Houthakker and Taylor's conclusion that habit formation predominates in the U.S. economy holds for annual and barely for semi-annual data, but their conclusion is not true with quarterly or monthly data.

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