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# The Demand for Food Consumed at Home and Away from Home

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## Abstract

Over the last 20 years, consumers have spent a declining portion of their income on food for consumption at home, while the share of income spent on meals purchased at restaurants, cafeterias, and fast-food chains has held constant This article attempts to explain this phenomenon by estimating a 3-equation translog system of quarterly consumer demand for food consumed at home, purchased meals, and nonfood items An explicitly additive, nonlinear, nonhomothetic translog system is found to be the best representation Results indicate that rising consumer incomes rather than changing relative prices are the principal reason consumers are eating away from home more often



## Keywords

Consumer food demand, translog system, dynamic model


A significant economic trend in recent decades is the declining share of consumer expenditures on food purchased for consumption at home Per capita expenditures for at-home consumption fell steadily from 16 9 percent of all expenditures in 1960 to 13 2 percent in 1980 This drop occurred while the share of consumer expenditures on meals purchased at restaurants, cafeterias, and fast-food chains remained constant at about 4 0 percent In contrast, the nonfood share of all consumer expenditures rose from 79 1 percent in 1960 to 82 8 percent in 1980 Hence, nonfood consumption has become more important relative to food consumption, and the consumption of purchased meals has become more important relative to food consumed at home

Few researchers have attempted to explain why the budget share of food purchased for consumption at home has declined relative to away-from-home consumption In their 1970 study, Houthakker and Taylor (*7*) did analyze the demand for food consumed at home and away from home, but, the recent systems work by Brown and Heien (*1*), Christensen and Manser (*3, 4*), and Manser (*9*) focuses only on at-home food demand [1] Furthermore, these studies consider only annual consumption patterns Although annual data can be used to explain why expenditures for food consumed at home declined relative to food purchased away from home, policymakers and forecasters are also interested in consumer demand over shorter periods

In this article, I examine the nature of quarterly demand for purchased meals and for food consumed at home by using a three-equation model of consumer demand I consider three aggregate goods meals purchased away from home, food purchased for consumption at home, and nonfood items The methodology used requires estimation of a family of competing translog demand functions I find an explicitly additive, nonlinear, nonhomothetic form to be the best system representation I then derive impact, interim, and total multiplier elasticities and review the implications of the results My major conclusion is that rising consumer income is the primary variable that explains why the consumption of purchased meals has become more important relative to food consumed at home

## The Model

Christensen, Jorgenson, and Lau (*2*) proposed the translog utility function as a second-order approximation to allow tests of different assumptions normally imposed on consumer demand systems The indirect form of the translog utility function is written as

$$\ln U = \alpha_0 + \sum_i \alpha_i p_i^* + \frac{1}{2} \sum_i \sum_j \beta_{ij} p_i^* p_j^* \qquad (1)$$

Maximization of this equation subject to the budget constraint leads to "share" equations of the form

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[1] Italicized numbers in parentheses refer to items in the References at the end of this article

$$w_i = \frac{\alpha_i + \Sigma \beta_{ij} p_j^*}{\Sigma\alpha_j + \Sigma\Sigma \beta_{ij} p_j^*} \qquad i = 1, \quad , I \tag{2}$$

where $w_i = p_i x_i / m$ (the budget share), $p_i^* = \ln(p_i/m)$, $p_i$ is price, $x_i$ is consumption, m is total expenditure, and $\alpha_i$, $\beta_{ij}$ $\forall i, j$ are parameters Multiplying through each side by $m/p_i$ gives demand equations which are neither additive nor homothetic [2]

Phlips (*10*), Manser (*9*), and other consumption analysts have criticized static demand systems because they neglect the influence of habit formation This would seem to be a particularly important aspect of food consumption Manser proposed a dynamic version of the indirect utility function to incorporate habit formation by defining the $\alpha_i$ as a linear function of lagged consumption This specification allows interaction between prices, total expenditures, and lagged consumption, and is written as

$$\ln U_t = \alpha_0 + \sum_i \phi_i p_{it}^* + \sum_i \delta_i x_{it-1} p_{it}^* + \frac{1}{2} \sum_i \sum_j \beta_{ij} p_{it}^* p_{jt} \tag{3}$$

It preserves the general characteristics of the translog approximation and yields budget equations of the form

$$w_{it} = \frac{\phi_i + \delta_i x_{it-1} + \Sigma \beta_{ij} p_{it}^*}{-1 + \Sigma\Sigma \beta_{ij} p_{jt}^*} \qquad i = 1, \quad , I \quad t = 1, \quad , T \tag{4}$$

where the normalization $\Sigma\phi_j + \Sigma \delta_j x_{jt-1} = -1$ is imposed to assure that budget shares sum to unity Importantly, from these share equations (*6*), impact, interim, and total multipliers (or elasticities) can be derived straightforwardly This property is crucial for interpreting the full implications of any set of dynamic demand functions

## Empirical Implementation

Because all the parameters of a *k* equation translog demand system can be derived from estimating any *k* − 1 equations and because the system variance-covariance matrix is singular, only the budget share equations for food consumed at home and for purchased meals need to be estimated The stochastic system of interest is then

$$w_{1t} = \frac{a_1 + d_1 x_{1t-1} + b_{11} p_{1t}^* + b_{12} p_{2t}^* + b_{13} p_{3t}^*}{-1 + \Sigma b_{1j} p_{1t}^* + \Sigma b_{2j} p_{2t}^* + \Sigma b_{3j} p_{3t}^*} + e_{1t} \tag{5}$$

$$w_{2t} = \frac{a_2 + d_2 x_{2t-1} + b_{12} p_{1t}^* + b_{22} p_{2t}^* + b_{23} p_{3t}^*}{-1 + \Sigma b_{1j} p_{1t}^* + \Sigma b_{2j} p_2^* + \Sigma b_{3j} p_3^*} + e_{2t} \tag{6}$$

where symmetry ($b_{ij} = b_{ji}$ $\forall i, j$) and the normalizations, $a_1 + a_2 + a_3 = -1$ and $\Sigma d_i x_{it-1} = 0$, are imposed on the general translog form [3] Equation (5) is the budget share equation for food consumed at home, and equation (6) is the budget share equation for purchased meals The subscripts 1, 2, and 3 denote food consumed at home, purchased meals, and nonfood items, respectively Each equation represents a general, nonhomothetic, nonadditive utility function which allows for habit formation

By the imposition of restrictions on equations in demand systems, special cases of the utility function are implied For the indirect translog function, those cases of greatest interest include explicit additivity (imposed using $b_{ij} = 0, i \neq j$), homogeneity (imposed with $\Sigma b_{ij} = 0$ $\forall i$), and the absence of habit formation (introduced by setting $d_i = 0$ $\forall i$) As long as equations (5) and (6) can be estimated, these restrictions can be tested explicitly as nested maintained hypotheses This is the approach Manser used when choosing among alternative models which are special cases of the general translog system

In practice, it is difficult to estimate equations (5) and (6), the large number of parameters, nonlinearity, and the probability of collinearity between $e_1$ and $e_2$ complicate matters Christensen, Jorgenson, and Lau estimated a three-equation translog system using Malinvaud's (*8*) maximum likelihood estimator Christensen and Manser (*3*) and Manser (*9*) used the nonlinear, iterative Zellner (*12*) estimation procedure (which converges to maximum likelihood estimators) to estimate a four-equation translog system Both these studies utilized annual data which generally contain fewer measurement errors than do the quarterly data I consider here and, consequently, they were easier to estimate

## Estimation Results

I attempted to estimate equations (5) and (6) using the nonlinear, iterative estimation technique proposed by Gallant (*5*) The estimation algorithm is contained as part of the Statistical Analysis System (*11*) and uses the modified Gauss-Newton iterative approach to solve for estimators It allows restrictions to be imposed through parameter definition Even with a large range of possible starting values, conver-

[2] The literature on translog demand systems is well developed (*2, 3*) The indirect utility function is used in lieu of the direct function because elasticities are easily obtained from budget share equations

[3] The symmetry restriction is testable, but it requires significantly increasing the number of parameters contained in the model The normalizations facilitate estimation

gence could not be attained for the general equations However, attempts to estimate most of the restricted forms of the system were successful [4]

Table 1 presents estimation results On the basis of the asymptotic standard errors, most parameters are highly significant statistically and of appropriate magnitude [5] The calculated error sums of squares for each equation differ significantly The explicit additivity restriction with habit formation gives the best fit for both equations, the error sums of squares are 0 32 $10^{-5}$ and 0 41 $10^{-5}$, respectively Imposing homogeneity with habit formation gives the second best fit with error sums of squares of 2 58 $10^{-5}$ and 0 69 $10^{-6}$

Given explicit additivity and habit formation, one can test whether homogeneity and no habit formation are suitable restrictions using likelihood ratios Table 2 presents the appropriate chi-square test statistics and the critical chi-square values at the 99-percent confidence level In both instances, further restriction of the explicit additive form with habit formation is rejected with more than 99-percent confidence It is also possible to test whether additional restrictions on the homogeneous system with habit formation are acceptable Again, the imposition of no habit formation, explicit additivity, and explicit additivity without habit formation are rejected with more than 99-percent confidence

This process reduces the model selection problem to a choice between the explicit additive system with habit formation and the purely homogeneous system with habit formation Based on the error sum of squares, the former is preferred on the basis of fit More information can be generated if dynamic simulations of the system are performed and if the resulting percentage root mean square errors (RMSE) and mean absolute errors (MAE) are computed [6] Table 3 presents

[4] Data on expenditure shares, prices (measured by the appropriate expenditure class deflator), and total expenditures are from the U S Department of Commerce One can obtain consumption series by dividing total expenditures in each class by the expenditure class deflator The sample consists of 83 observations covering the period from 1960 I to 1980 III The food-consumed-at home variables are defined as the Commerce food-consumed-off-premises series, whereas the purchased meals variable is defined as the Commerce food consumed on-premises series

[5] Autocorrelation may be an important, but neglected, consideration

[6] The Gauss-Seidel method for solving nonlinear systems is utilized The nonlinear simulation algorithm is part of the Statistical Analysis System Actual lagged endogenous variables are used as starting values for each simulation

Table 1—Nonlinear, iterative Zellner estimates for various forms of the indirect translog utility function[1]

| Parameter | Explicit additivity, habit formation | Explicit additivity, habit formation, homogeneity | Explicit additivity, homogeneity | Homogeneity, habit formation | Homogeneity |
|---|---|---|---|---|---|
| $a_1$ | -0 663 | -0 319 | -0 146 | -0 302 | -0 150 |
| | ( 071) | ( 011) | ( 001) | ( 010) | ( 001) |
| $a_2$ | - 195 | - 036 | - 040 | - 018 | - 042 |
| | ( 023) | ( 001) | ( 000) | ( 002) | ( 000) |
| $d_1$ | - 118 $10^{-3}$ | 379 $10^{-3}$ | | 336 $10^{-3}$ | |
| | ( 016 $10^{-3}$) | ( 024 $10^{-3}$) | | ( 022 $10^{-3}$) | |
| $d_2$ | - 164 $10^{-3}$ | - 032 $10^{-3}$ | | - 154 $10^{-3}$ | |
| | ( 029 $10^{-3}$) | ( 010 $10^{-3}$) | | ( 019 $10^{-3}$) | |
| $b_{11}$ | - 078 | | | 061 | 086 |
| | ( 008) | | | ( 009) | ( 011) |
| $b_{12}$ | | | | - 016 | 014 |
| | | | | ( 009) | ( 003) |
| $b_{22}$ | - 024 | | | 027 | - 017 |
| | ( 003) | | | ( 003) | ( 002) |
| $b_{33}$ | 054 | | | | |
| | ( 022) | | | | |
| $\Sigma e_{1t}^2$ | 32 $10^{-5}$ | 3 53 $10^{-5}$ | 12 20 $10^{-5}$ | 2 58 $10^{-5}$ | 6 89 $10^{-5}$ |
| $\Sigma e_{2t}^2$ | 41 $10^{-6}$ | 1 47 $10^{-6}$ | 1 73 $10^{-6}$ | 69 $10^{-6}$ | 2 89 $10^{-6}$ |

Blanks indicate not applicable

[1] Asymptotic standard errors are presented in parentheses Symmetry is imposed for all models For additivity, $b_{12} = 0$, for homogeneity, $b_{11} + b_{12} + b_{13} = 0$ and $b_{12} + b_{22} + b_{23} = 0$ ($b_{11} + b_{12}$ replaces $b_{13}$ and $b_{12} + b_{22}$ replaces $b_{23}$ in estimation), and the absence of habit formation requires $d_1 = d_2 = 0$

Table 2—Test statistics for alternative restrictions on the general translog form

| Restriction | Degrees of freedom | $\chi^2$ | $\chi^2 0\ 005$ |
|---|---|---|---|
| | *Given explicit additivity and habit formation* | | |
| Homogeneity | 3 | 295 8 | 12 84 |
| Homogeneity, no habit formation | 5 | 421 9 | 16 75 |
| | *Given homogeneity and habit formation* | | |
| No habit formation | 2 | 148 0 | 10 60 |
| Explicit additivity | 3 | 81 5 | 12 84 |
| Explicit additivity, no habit formation | 5 | 207 7 | 16 75 |

Table 3—Comparisons of fit Explicit additivity with habit formation versus homogeneity with habit formation

| Budget share | Explicit additivity | | Homogeneity | |
|---|---|---|---|---|
| | RMSE | MAE | RMSE | MAE |
| | *Percent* | | | |
| Food consumed at home | 1 21 | 0 91 | 3 29 | 2 44 |
| Purchased meals | 1 44 | 89 | 1 97 | 1 49 |
| Nonfood items | 22 | 16 | 62 | 45 |

the resulting summary statistics For all three budget shares, the explicit additive form with habit formation performs best in terms of predictive ability Hence, given a choice between competing restrictions, the imposition of explicit additivity is more reasonable

## Implications

Assuming explicit additivity with habit formation as the best available translog approximation to consumer preferences, exploring the implications of the estimates is worthwhile It can be shown that the direct price and expenditure elasticities take the form [7]

$$\frac{p_i}{x_i}\frac{\partial x_i}{\partial p_i} = -1 + \frac{b_{ii}/w_i - b_{ii}}{-1 + \Sigma b_{jj}p_j^*} \qquad i = 1, \ldots, I \tag{7}$$

[7] A mathematical appendix illustrating the derivation of these expressions as well as equations (*9*) and (*10*) is available from the author

$$\frac{m}{x_i}\frac{\partial x_i}{\partial m} = 1 + \frac{-b_{ii}/w_i + \Sigma b_{ii}}{-1 + \Sigma b_{jj}p_j^*} \qquad i = 1, \ldots, I \tag{8}$$

Table 4 presents estimates of these elasticities for each commodity, evaluated at mean exogenous values for selected years Current-quarter demand for food consumed at home and for purchased meals is highly inelastic, both with respect to price and to total food expenditure In contrast, the demand for nonfood items is both price and expenditure-elastic

The results are generally consistent with prior expectations, the demand for food is traditionally assumed to be price- and income-inelastic But, it is usually presumed that the demand for purchased meals is more price- and income-elastic than the demand for food consumed at home, purchased meals are less necessary and more of a luxury than are meals at home For this reason, the initial findings are somewhat puzzling When the dynamic implications of the model are fully considered, however, one finds the demand for purchased meals is more elastic with respect to price and to total expenditure than is the demand for food consumed at home

To show the dynamic implications of the model, we must solve equations (5) and (6) for $x_i$ using $w_i = p_i x_i$ and we must substitute the resulting values sequentially for $x_{it-j}$ Computing the price and income elasticities at each stage of this process with respect to changes $t-j$ periods ago leads to the general expressions

$$\frac{p_{it-n}}{x_{it}}\frac{\partial x_{it}}{\partial p_{it-n}} = \eta_{iit-n}\prod_{k=0}^{n}\frac{d_i x_{it-k-1}}{w_{it-k}(-1 + \Sigma b_{jj}p_{jt-n}^*)} \tag{9}$$

$$\frac{m_{t-n}}{x_{it}}\frac{\partial x_{it}}{\partial m_{t-n}} = \eta_{imt-n}\prod_{k=0}^{n}\frac{d_i x_{it-k-1}}{w_{it-k}(-1 + \Sigma b_{jj}p_{jt-n}^*)} \tag{10}$$

where $\eta_{iit-n} = \frac{p_{it-n}}{x_{it-n}}\frac{\partial x_i}{\partial p_{it-n}}$

and $\eta_{imt-n} = \frac{m_{nt-n}}{x_{it-n}}\frac{\partial x_{it-n}}{\partial m_{it-n}}$

Table 4—Direct price and expenditure elasticities, selected years

| Year | Price elasticity | | | Expenditure elasticity | | |
|---|---|---|---|---|---|---|
| | Food consumed at home | Purchased meals | Nonfood items | Food consumed at home | Purchased meals | Nonfood items |
| | | | *Percent* | | | |
| 1960 | -0 38 | -0 10 | -1 02 | 0 34 | 0 11 | 1 03 |
| 1965 | - 30 | - 11 | -1 02 | 25 | 13 | 1 03 |
| 1970 | - 26 | - 08 | -1 02 | 21 | 10 | 1 03 |
| 1975 | - 25 | - 13 | -1 02 | 20 | 14 | 1 03 |
| 1980 | - 16 | - 11 | -1 02 | 11 | 12 | 1 03 |

These are the interim elasticities for price and total expenditures, respectively [8] Expression (9) gives the percentage impact on consumption this quarter resulting from a 1-percent increase in price *n* quarters ago Similarly, expression (10) gives the impact on consumption this quarter resulting from a 1-percent increase in total expenditures *n* quarters ago.

Table 5 presents calculated, mean sample, interim elasticities for food consumed at home, purchased meals, and nonfood items over 8 quarters as well as the total multiplier elasticities obtained by summing all interim multipliers over 20 quarters (after which additional quantity impacts converge to approximately zero) The total multiplier elasticities represent the ultimate effect on consumption of a 1-percent increase in prices or in total expenditures many quarters ago Clearly, the longrun demand for food consumed at home is less price- and expenditure-elastic than is the demand for purchased meals, total price and expenditure elasticities are -0 630 and 0 507 for food consumed at home and -0 701 and 0 995 for purchased meals This finding is consistent with traditional theory In addition, the longrun demand for nonfood items is more elastic with respect to both price and expenditure

The evidence presented in table 5 further suggests that the effects of changes in own price or expenditures quickly affect food consumption at home, whereas the effects of changes in own price or expenditures for purchased meals are felt only after many quarters Thus, over two or three quarters, increases in disposable income will have a greater effect on food consumed at home than on purchased meals Similarly, price changes in grocery stores have a larger shortrun impact on food consumption at home, substantially more than the effect of changes in purchased meal prices on food consumption away from home This may simply reflect the fact that lunches during work days or food consumed while traveling must generally be purchased In the long run, however, adjustment occurs, and the amount of food purchased in grocery stores for home consumption is less sensitive than is the consumption of purchased meals to price and expenditure changes

[8] The terms impact, interim, and total multiplier elasticities, as used here, are analogous to Goldberger's original usage, but each is expressed as a unit-free elasticity

Table 5—Interim price and expenditure elasticities for food consumed at home, purchased meals, and nonfood items[1]

| Lag | Food consumed at home | | Purchased meals | | Nonfood items | |
|---|---|---|---|---|---|---|
| | Price | Total expenditure | Price | Total expenditure | Price | Total expenditure |
| | | | *Percent* | | | |
| 0 | -0 255 | 0 206 | -0 075 | 0 114 | -1 020 | 1 186 |
| 1 | - 149 | 120 | - 067 | 102 | 192 | - 179 |
| 2 | - 089 | 071 | - 060 | 092 | - 023 | 028 |
| 3 | - 054 | 043 | - 055 | 083 | 003 | - 005 |
| 4 | - 033 | 027 | - 050 | 076 | - 001 | 001 |
| 5 | - 021 | 017 | - 046 | 070 | 000 | - 000 |
| 6 | - 013 | 010 | - 043 | 064 | - 000 | . 000 |
| 7 | - 008 | 007 | - 039 | 059 | 000 | - 000 |
| 8 | - 005 | 004 | - 036 | 055 | - 000 | 000 |
| Total | - 630 | 507 | - 701 | 995 | - 888 | 1 031 |

[1] Evaluated at mean sample levels Total multipliers are 20-quarter sums of interim multipliers

## Conclusion

I have fitted indirect translog budget share equations for a three-good aggregate system using quarterly data An explicitly additive, dynamic form provides the best approximation to consumer behavior Shortrun demand for food consumed at home and for purchased meals is highly inelastic, whereas shortrun demand for nonfood items is elastic The longrun demand both for foods consumed at home and for purchased meals is determined to be inelastic, but less so than the shortrun demand The demand for food consumed at home is also somewhat more inelastic than that for purchased meals, which confirms prior expectations

Prices for food consumed at home and for purchased meals have increased at similar rates over the last two decades, implying little relative price change However, per capita consumer expenditures on all items increased about 13 percent per year over the same period Thus, rising consumer incomes are the primary reason that consumption of purchased meals has increased relative to consumption of food at home Consequently, the purchased meals share of the consumer's budget has substantially increased relative to the share of consumers' at-home food expenditures

These findings have important implications for the food-retailing industry as well as for the restaurant and fast-food trade Rising consumer incomes and increased expenditures signal a continuation of the trend toward consumption of purchased meals relative to at home food consumption Recent efforts by retail food chains to offer on-premises food services in grocery stores (for example, delicatessens, instore fast-food service, and small restaurants) suggest industry recognition of this fact

Other developments suggest an acceleration towards increased consumption of purchased meals In particular, recent policy proposals to reduce minimum wages for individuals under 18 would benefit restaurants, cafeterias, and the fast-food trade more than it would benefit food retailers Grocery chains rely more on higher wage, unionized labor, whereas most workers in restaurants, cafeterias, and fast-food establishments receive the minimum wage Hence, new legislation would likely lower relative prices for purchased meals as reduced labor costs are passed through to consumers This would have a longrun positive effect on the consumption of purchased meals

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