STAFF PAPER

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Multivariate Gradual Switching Systems and the Stability of U.S. Meat Demands: A Bayesian Analysis

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Abstract

A multivariate gradual switching system with stochastic cross-equation constraints is utilized within the framework of Bayesian inferential procedures to consider the stability of an AIDS demand system for meats. Results confirm the existence of a significant structural change which initiated in 1961 and was not complete until after 1983. Elasticity estimates reveal an increased sensitivity of beef demand to changes in its own price and in prices of pork and poultry and a decreased sensitivity of poultry demand to changes in its own price in the post-shift regime. The income elasticities for poultry and fish display dramatic changes while income elasticities for other meats remain fairly stable. The changing expenditure elasticities suggest that poultry and fish have gone from being inferior commodities prior to the shift to superior (luxury) commodities after the shift. The timing and nature of the shift is consistent with structural changes which may have arisen from increased consumption of processed convenience-type poultry products and from nutritional concerns which may have shifted demand away from red meats toward poultry and fish.

Key words: meat demands, structural change, Bayesian econometrics.

Multivariate Gradual Switching Systems and the Stability of U.S. Meat Demands: A Bayesian Analysis

U.S. meat consumption patterns have undergone significant changes over the post-war period. In particular, annual per-capita consumption of beef has declined substantially in recent years while annual per-capita consumption of poultry and fish has increased dramatically. Such prominent shifts in consumption patterns are often attributable to changes in relative prices and real income. Alternatively, changing consumption patterns may signal the occurrence of fundamental structural shifts in consumer preference relationships.

The observed shifts and trends have stimulated considerable interest in explaining the nature of meat consumption patterns. A number of recent empirical demand studies have addressed the issue of stability in U.S. demands for meats. These studies have failed to produce a consensus explanation of the observed consumption patterns. On the one side, Wohlgenant, Moschini and Meilke, Haidacher et al., and Chalfant and Alston found that the observed changes in meat consumption are explained by changes in relative prices and real income and thus that the fundamental demand relationships for meats have been stable. In contrast, studies by Chavas, Nyankori and Miller, Thurman, Dahlgran, and Eales and Unnevehr have concluded that significant structural changes have occurred in the fundamental demand relationships for meats. These studies have attributed such shifts to increased nutritional concerns which are thought to have shifted consumption away from red meats and to the introduction of new convenience-type poultry products.

The apparent conflict of empirical results is attributable to alternative approaches to modeling consumer behavior, as well as to differences in data and empirical and inferential procedures. Ideally, an investigation of demand stability should be as flexible as possible, allowing for gradual as well as instantaneous shifts. Formal tests of stability also should provide insights into the nature of the implied structural changes, as well as the timing and speed of such changes. Finally, the empirical procedures utilized to consider demand stability should be constrained in application to conform to the theoretical restrictions which are required by demand theory.

The objective of this paper is to develop and apply an alternative empirical procedure for investigating structural change within the meat demand complex. The analysis utilizes Bayesian inferential procedures within the context of a multivariate gradual switching system to detect the presence of fundamental structural changes in the demand for meats. The almost ideal demand system (AIDS) of Deaton and Muellbauer is chosen to model consumer preferences for meats. This empirical approach offers advantages over alternative approaches which have been applied to the demand stability question in that it provides a flexible test for the presence of structural change while identifying the exact nature of any shifts. In particular, the procedures identify the timing of the change while allowing the speed of adjustment between alternative regimes to be gradual. The empirical procedures also are consistent with economic theory in that a complete systems approach is utilized to maintain adherence to the theoretical restrictions of demand theory across alternative regimes.

The paper proceeds according to the following plan. The next section develops a model of consumer preferences for meats. The second section introduces a Bayesian empirical procedure for analyzing the stability of meat demand relationships. The third section applies the models and procedures to an empirical consideration of demand relationships for beef, pork, poultry, and fish using post-war consumption and price data. The empirical applications include a formal consideration of the timing and duration of structural changes which may have occurred in meat demands. The final section contains a brief review of the results and offers some concluding remarks.

A Model of U.S. Meat Demand

The AIDS demand system for m goods consists of share equations of the following form:

$$(1) \qquad w_i = \alpha_i + \Sigma_j \gamma_{ij} \ln p_j + \beta_i \ln (x / p^*) \qquad i = 1,\ldots,m,$$

where w_i is the i^{th} good expenditure share, p_i is the price of the i^{th} good, x is a measure of total expenditures or income, and p^* is defined by:

$$(2) \qquad \ln p^* = \alpha_0 + \Sigma_i \alpha_i \ln p_i + \tfrac{1}{2} \Sigma_i \Sigma_j \gamma_{ij} \ln p_i \ln p_j \quad .$$

In order for the system to be consistent with classical demand theory, the following restrictions must be imposed:

$$(3) \qquad \Sigma_i \alpha_i = 1, \quad \Sigma_i \gamma_{ij} = 0, \quad \Sigma_i \beta_i = 0 \qquad \text{(Adding-Up)},$$

(4) $$\Sigma_j \gamma_{ij} = 0$$ (Homogeneity),

(5) $$\gamma_{ij} = \gamma_{ji}$$ (Symmetry).

Deaton and Muellbauer have shown that the AIDS model has the preferable property of allowing exact and consistent aggregation to a market level.

For the applications of the AIDS model pursued in this analysis, it is assumed that food consumption decisions are weakly separable from consumption decisions involving other goods. To this end, x is defined to include total consumption expenditures on food. Thus, it is assumed that specific food consumption decisions are made in the second stage of a two-stage budgeting process where the first stage determines expenditure allocations among broad consumption categories, including overall expenditures on food. This assumption allows the demand parameters for meats to be considered independently of those for nonfood commodities.

An additional simplification is made to the general AIDS model by redefining p_t^* as:

(6) $$\ln p_t^* = \Sigma_i w_{it-1} \ln p_{ti} .$$

Such a specification is a particular form of Stone's index which uses lagged rather than current budget shares in order to overcome the potential for simultaneity biases. This index is suggested by Blanciforti et al., who note that it depends upon a high degree of correlation between current and lagged budget shares.

Econometric Procedures

Empirical considerations of the stability of consumer demand relationships are commonly undertaken within the framework of parametric statistical inference procedures. The parametric approach to testing for structural change is maintained within this analysis. In particular, the Bayesian inferential procedures of Tsurumi et al. are utilized to detect the presence of structural change in a multivariate regression model with stochastic cross-equation constraints. The analysis utilizes transition functions to identify the join point and speed of adjustment between alternative regimes. It should be acknowledged that parametric tests of demand stability may be sensitive to the choice of specification utilized to model consumer preference relationships.

An alternative approach to considerations of demand stability involves the use of nonparametric analysis techniques within the framework of revealed preference theory. The nonparametric approach to demand analysis was introduced by Afriat and Varian (1982, 1983). This approach was utilized by Thurman and Chalfant and Alston to search for the presence of structural change in meat demands. Their results find no evidence of such changes. However, as Thurman notes, steady growth in real expenditures may limit the power of nonparametric techniques when they are used to consider the stability of preferences. The nonparametric procedures were applied to the consumption data utilized in this analysis. The results indicated no violations of the axiom of revealed preference and thus did not reveal the presence of consumer meat preference shifts.[1]

We can write each of the m linear share equations identified by (1) and (6) in matrix form as:

(7) $$y_i = X \beta_i + \epsilon_i \qquad i = 1,\ldots,m,$$

where y_i represents an $n \times 1$ vector of annual observations for the i^{th} good, X is an $n \times k$ matrix of annual price and expenditure observations ($k = m + 2$), β_i is a $k \times 1$ vector of unknown demand parameters, and ϵ_i is an $n \times 1$ vector of random disturbances for the i^{th} share equation. A structural change can be interpreted as a shift in the demand parameters β_i from one regime to another. We allow this change to initiate at an unknown join point t^* and to occur at an unknown gradual rate of η. The join point t^* and rate of adjustment η thus will be treated as unknown parameters in a transition function, defined as $trn(s_t/\eta)$, where:

(8) $$s_t = \begin{cases} 0 & \text{for } t \leq t^* \\ t - t^* & \text{otherwise .} \end{cases}$$

The use of transition functions to identify movements between alternative structural regimes was introduced by Bacon and Watts and has been recently applied by Tsurumi and Tsurumi et al. An appropriate transition function will satisfy the following conditions:

(9) $$\lim_{s\to\infty} trn(s_t/\eta) = 1,$$

(10) $$\lim_{\eta\to 0} trn(s_t/\eta) = 1, \text{ and}$$

(11) $$trn(0) = 0.$$

Given an appropriate transition function, we can write our gradually switching regression equation as:

(12) $$y_{it} = X_t \beta_i + trn(s_t/\eta) X_t \theta_i + \epsilon_{it} \qquad i = 1,\ldots,m,$$

where θ_i is a $k \times 1$ vector of unknown parameters.[2] Because only m-1 of the share equations are independent, we delete one equation in estimating the system. The AIDS demand system can thus be represented in matrix form as:

(13) $$y = Z\theta + \nu ,$$

where y is a $np \times 1$ vector of shares ($p = m - 1$), $Z = [I_p \otimes (X, trn(s_t/\eta)X)]$ is an $np \times 2pk$ matrix of price and expenditure data, θ is a $2pk \times 1$ vector of unknown parameters, and υ is an $np \times 1$ vector of random disturbances.

The linear AIDS model represented by (13) must be estimated subject to the linear constraints given by (3) through (5). For the purposes of examining the system for evidence of structural change, we treat these linear constraints as being stochastic[3] and adopt the hierarchical representation of Lindley and Smith:

(14) $$\theta = Q\Gamma + u ,$$

where Q is a $2pk \times q$ matrix, Γ is a $q \times 1$ matrix of unrestricted parameters, and u is a 2pk $\times$ 1 stochastic vector.[4]

Using the hierarchical representation, we assume that u is $u \sim N(0, \sigma^2 I_{2pk})$ and that ν is $\nu \sim N(0, \Sigma)$ with $\Sigma = \Omega \otimes I_n$ where Ω is an $p \times p$ covariance matrix. Following Tsurumi et al., a convenient diffuse prior joint probability density function (pdf) for the parameters is given by:

$$(15) \qquad p(\theta, \Gamma, t^*, \eta, \sigma, \Omega) \propto \sigma^{-1} \ |\Sigma|^{-1/2} \ ,$$

which yields the following posterior pdf:

$$(16) \ p(\theta, \Gamma, t^*, \eta, \sigma, \Omega | \text{data}) \propto \sigma^{-(2pk+1)} \ |\Sigma|^{-(n+1)/2} \times \exp[\ (1/2\sigma^2)\ (\theta - Q\Gamma)' (\theta - Q\Gamma) - \tfrac{1}{2}(y - Z\theta)' \ \Sigma^{-1} \ (y - Z\theta)] \ .$$

Upon integration over θ and Γ, one derives the joint marginal pdf for t^* and η conditioned upon σ and Ω:

$$(17) \ p(t^*, \eta | \sigma, \Omega, \text{data}) \propto |\sigma^{-2}(I_n - Q(Q'Q)^{-1}Q') + Z'\Sigma^{-1}Z|^{-1/2} \times \exp[-\tfrac{1}{2}(y'\Sigma^{-1}y - (Z'\Sigma^{-1}Z)'(\sigma^{-2}(I_n - Q(Q'Q)^{-1}Q') + Z'\Sigma^{-1}Z)^{-1} \ Z'\Sigma^{-1}y)] \ .$$

Equation (17) can be used to examine the stationarity of the AIDS demand system. In particular, numerical integration techniques can be applied to (17) to gain distributional insights regarding the existence of structural changes in consumer preferences for meats.

Empirical Application

The multivariate gradual switching AIDS system was applied to annual price and consumption data covering a period from 1946 through 1986 using the econometric procedures outlined above. Prices and per-capita consumption figures were collected for beef and veal, poultry, pork, and fish from the U.S. Department of Agriculture's Food Consumption, Prices, and Expenditures series. The per-capita consumption figures were quoted on an edible-weight basis. The price series were consumer price indices for each item. In that we have assumed that food consumption decisions are separable from consumption decisions regarding nonfood items, per-capita personal consumption expenditures on food items are used as the relevant measure of expenditures. Total personal consumption expenditures on food were collected from selected issues of the Economic Report of the President and were converted to a per-capita basis using Census Bureau population figures taken from the same source. Budget shares were calculated by transforming the individual item price indices into current dollar form using conversion ratios calculated from per-capita expenditures on each item. The per-capita expenditures were collected from selected issues of the U.S.D.A.'s Livestock and Poultry Situation and Outlook series for beef, poultry, and pork and from Christensen and Manser for fish. A composite price for all other foods was calculated using the relationship specified by equation (6), where the consumer price index for all food items was used for p^*.

Estimation of the gradual switching AIDS system requires the selection of a specific functional form for the transition function which satisfies conditions (9) through (11). Many functional forms will satisfy these conditions, including proper probability distribution functions. We choose to represent the transition between alternative regimes with the hyperbolic tangent function:[5]

$$(18) \quad trn(s_t/\eta) = (\exp(s_t/\eta) - \exp(-s_t/\eta)) \,/\, (\exp(s_t/\eta) + \exp(-s_t/\eta)) \quad .$$

Posterior means and standard deviations for the parameters of the AIDS model were obtained by evaluating (16) for the parameter set θ, t^*, and η conditional on the sample data. In order for the parameter posterior mean estimates and resulting elasticities to fully satisfy the conditions required by classical demand theory, u in equation (14) is set equal to zero when obtaining the posterior means. In this case, the optimal Bayesian posterior mean estimates are given by the θ, t^*, and η which minimize the loss function:

$$(19) \qquad S(\theta, t^*, \eta, \Sigma) = \Sigma_{t=1}^{n} [y_t - Z_t\theta] \, \Sigma^{-1} \, [y_t - Z_t\theta]' \quad .$$

These mean estimates are thus equivalent to maximum likelihood estimates when iterative techniques are utilized to estimate Σ from sample data. In this case, we utilize constrained iterative seemingly unrelated regressions to estimate Σ.

The posterior means, standard deviations, and implied t-ratios for the parameters are presented in table 1. The estimates, in general, have small standard deviations and large implied t-ratios. The mean estimate of the join point t^* is 16.19, corresponding to a structural shift initiating in 1961. The estimate has a very small standard deviation, confirming the existence of a significant structural change to the demand system. The speed of adjustment parameter η has a posterior mean estimate of 8.30. This corresponds to a very slow rate of adjustment. In particular, this suggests that it took over 22 years, or until 1983, for 99% of the change to be complete.

The mean parameter values were utilized to calculate the compensated price and expenditure elasticities at the mean data values of each regime. These elasticity estimates are presented in table 2. In general, the elasticity estimates are of the expected magnitude and sign. However, exceptions do occur in a few cases. In particular, negative cross-price elasticities between beef and poultry in regime 1 and between pork and poultry in regime 2 would seem questionable. Likewise, several cross-price elasticities for fish are negative in both regimes. Such elasticities suggest a complementary demand relationship. However, in the majority of cases, the cross-price elasticities are quite close to zero. In this light, such results may represent a lack of substitutability in consumption between these products. Fish and miscellaneous foods also have positive own-price elasticities in the first regime, thus violating the negativity condition for demand. However, the results for fish may be somewhat questionable due to the small proportion of food expenditures attributable to fish (the average budget share for fish over the period of study was less than .018), which may complicate accurate inferences regarding the nature of demand relationships for fish.

The elasticity estimates provide valuable insights into the nature of the structural change. A consideration of table 2 reveals three particular areas of significant change between the alternative regimes. The first of these involves the behavior of own-price elasticities between the alternative regimes. Prior to the shift, the elasticities of demand for beef and pork were quite small in magnitude, having values of -.4499 and -.4176, respectively. In contrast, the demand for poultry in the pre-shift regime was price elastic, having a value of -1.0451. However, in the post-shift regime, the elasticities for beef and pork rise to -.9416 and -1.3573, respectively, and the elasticity for poultry falls dramatically to -.2635. This suggests that demand relationships for beef and pork have become much more sensitive to changes in their own prices while the demand for poultry has become less sensitive to changes in its price.

A second area of significant change between regimes involves the behavior of the cross-price elasticities between several of the meat commodities. In particular, the demand relationships for pork and poultry have become much more sensitive to changes in the price of beef. Likewise, the demand for beef has become more sensitive to changes in the prices of pork and poultry. This finding may suggest an increased degree of substitutability between beef, pork, and poultry. However, the demand relationships for pork and poultry remain quite insensitive to changes in each other's price. This result may suggest that substitution between pork and poultry remains quite limited.

A final area of significant change between the alternative regimes involves the behavior of the expenditure elasticities. Dramatic changes occur in expenditure relationships for the meats, most notably for poultry and fish. In particular, poultry and fish, with expenditure elasticities of -.7302 and -.9115, respectively, exhibit expenditure patterns characteristic of inferior goods in the pre-shift period. During the same period, expenditure elasticities for beef and pork indicate relatively inelastic but positive expenditure relationships. However, in the post-shift regime, the expenditure elasticities for poultry and fish rise to 4.4828 and 3.4645, respectively, becoming very large relative to those for other food commodities. This suggests that poultry and fish have become superior (luxury) food items. In contrast, the expenditure elasticities for beef and pork exhibit much smaller increases and maintain the inelastic expenditure relationship characteristic of necessary food items. The interpretation is as follows: for each additional percentage point of total income allocated to food expenditures in the first stage of our two-stage budgeting process, expenditures on poultry and fish will increase by 4.5 percent and 3.5 percent, respectively, while expenditures on beef and pork will increase by only .3 percent and .9 percent, respectively. The expenditure elasticities can be converted to income elasticities by multiplying by some representative measure of the overall income elasticity for total food expenditures (Manser). Using Capps et al.'s conversion ratio of .3231, we obtain respective income elasticities of .10, .30, 1.45, 1.12, and .30 for beef, pork, poultry, fish, and miscellaneous foods in the later period.

The distributional properties of the structural change can be further investigated through a consideration of the marginal posterior distributions of key change parameters. Because we are motivated with detecting the existence of such a change, we will isolate our distributional considerations on the join point parameter t^*. In order to obtain the marginal posterior distribution of the join point parameter t^*, we applied Gauss-Legendre quadrature numerical integration to equation (17). The conditional joint pdf was evaluated for t^* by choosing a value for σ and integrating over values of η. An appropriate value of σ should be on the same order of magnitude as the diagonal elements of the Ω matrix. This ensures that the constraints are not perversely violated by the stochastic nature of the hierarchial constraints. The marginal posterior pdf for t^*, conditional on $\sigma = 10^{-6}$, is presented in figure 1. The distribution has a posterior mode of 16.3. Alternative values of σ revealed nearly identical posterior distributions for t^*. The distribution is strongly centered about the mode and further confirms the existence of a significant structural change initiating sometime in 1961.

Concluding Remarks

In this paper, we have developed a model of consumer preferences and applied Bayesian inferential procedures to a consideration of structural changes in demand relationships for meats. The econometric applications make use of a multivariate gradual switching AIDS system for meats. The empirical procedures used to consider structural change are flexible in that they allow identification of changes which initiate at a priori unknown points and occur gradually over time.

The applications of the switching demand system revealed a significant structural shift of considerable duration. In particular, the shift was revealed to have initiated in 1961 and to have taken over 22 years, or until 1983, to have been 99 percent complete. These results are rather unique in that they suggest a shift initiating much earlier than is commonly perceived (see for example Thurman, Chavas, and Dahlgran). The elasticities reveal an increased sensitivity of beef and pork demands to changes in their own prices. In contrast, poultry was found to have become less responsive to its own price in the post-shift regime. The elasticities also suggest that beef demand has become more sensitive to changes in the prices of poultry and pork. This finding is consistent with conclusions reached by Wohlgenant and Moschini and Meilke and may point to an increased level of substitutability of poultry for beef. Perhaps the most interesting element of change involves the behavior of the expenditure (and implied income) elasticities across the alternative regimes. The expenditure elasticities for poultry and fish display dramatic increases between 1961 and 1983. These increases indicate that poultry and fish have gone from being inferior commodities (with negative expenditure and income elasticities) before 1961 to superior (luxury) goods after 1983. At the same time, income elasticities for other meats have remained fairly stable.

In general, these results are consistent with structural changes which may have arisen from increased consumption of processed convenience-type poultry products and from nutritional concerns which shifted demand away from red meats toward poultry and fish. The timing of the shift corresponds with a period of significant demographic changes in the composition of the aggregate labor force and thus may reflect changes in the economic costs of preparing and consuming certain meat products. In particular, these results may reflect the introduction of new convenience-type poultry products. In this light, care should be noted when interpreting these results as definite evidence of changes in consumer taste relationships for meats.

Footnotes

1. The nonparametric analysis was undertaken using Varian's program for nonparametric demand analysis.

2. Note that we have assumed that the join point t^* and rate of adjustment η are the same for each share equation of the AIDS system. We follow this assumption on the grounds that the parameters β_i and θ_i are intimately related across equations through cross-equational restrictions. Thus, one would anticipate shifts in consumer preference relationships for meats to impact the entire system. As an alternative, one might allow each of the $i = 1,\ldots,m$ equations to have a unique join point and rate of adjustment.

3. The stochastic nature of the constraints may be attributed to errors induced by aggregation and utility maximization under uncertainty.

4. Note that q represents the number of unrestricted parameters (i.e., the rank of the Q matrix).

5. Results contained in Tsurumi et al. indicate that empirical results obtained from the application of transition functions are not, in general, sensitive to the choice of functional form for the transition function.

Table 1: AIDS Model System Parameters: Posterior Means, Standard Deviations, and Implied t-Ratios

Parameter	Mean Estimate	Standard Deviation	t-ratio
Regime I (1946-1960)			
α_1	.22875	.04252	5.38
α_2	.14436	.02206	6.54
α_3	.12464	.01788	6.97
α_4	.06486	.00611	10.61
γ_{11}	.04737	.01000	4.73
γ_{12}	.00662	.00500	1.33
γ_{13}	-.02115	.00354	5.98
γ_{14}	-.00648	.00164	3.94
γ_{22}	.04650	.00688	6.76
γ_{23}	.01433	.00198	7.23
γ_{24}	.00385	.00153	2.53
γ_{33}	.00069	.00181	.38
γ_{34}	-.00188	.00065	2.91
γ_{44}	.01984	.00353	5.61
β_1	-.07035	.02630	2.67
β_2	-.04454	.01350	3.30
β_3	-.05691	.01105	5.15
β_4	-.02892	.00375	7.72
Regime II (1961-1986)			
α_1	.16177	.07974	2.04
α_2	.00710	.03917	.18
α_3	-.17735	.03623	4.89
α_4	-.07023	.01204	5.83
γ_{11}	.00262	.01752	.15
γ_{12}	.02483	.00753	3.30

Table 1: (continued)

Parameter	Mean Estimate	Standard Deviation	t-ratio
γ_{13}	.02845	.00741	3.84
γ_{14}	.00250	.00258	.97
γ_{22}	-.03078	.00941	3.27
γ_{23}	-.01511	.00481	3.14
γ_{24}	-.00658	.00263	2.51
γ_{33}	.01792	.00583	3.07
γ_{34}	.00691	.00231	2.98
γ_{44}	.00878	.00423	2.07
β_1	-.08045	.04526	1.78
β_2	-.00415	.02247	.18
β_3	.10344	.02064	5.01
β_4	.04737	.01000	4.73
t^*	16.18884	.75086	21.56
η	8.30353	1.80957	4.59

Table 2: Compensated Price and Expenditure Elasticities:[a] AIDS Meat Demand Model[b]

Quantities	Prices: Beef	Pork	Poultry	Fish	Other Food	Expenditures
Regime I (1946-1960)						
Beef	-.4499	.0924	-.2303	-.0695	-.1318	.2109
Pork	.1200	-.4176	.1826	.0521	-.4553	.4818
Poultry	-.7081	.3729	-1.0451	-.0683	-.2816	-.7302
Fish	-.5095	.1764	-.1545	.2975	-1.7215	-.9115
Other Food	.0783	.0164	.0535	-.0007	.1109	1.2584
Regime II (1961-1986)						
Beef	-.9416	.2358	.2537	.0266	-.0266	.3084
Pork	.4529	-1.3573	-.1809	-.0753	1.1032	.9426
Poultry	1.4794	-.1845	-.2635	.3072	2.1441	4.4828
Fish	.5528	-.1445	.5173	-.4160	1.9549	3.4645
Other Food	.0309	.1028	-.0225	.0002	-.1897	.9217

[a]In the AIDS model, expenditure elasticities are given by:

$$e_i = 1 + \beta_i / w_i \;, \quad \text{and}$$

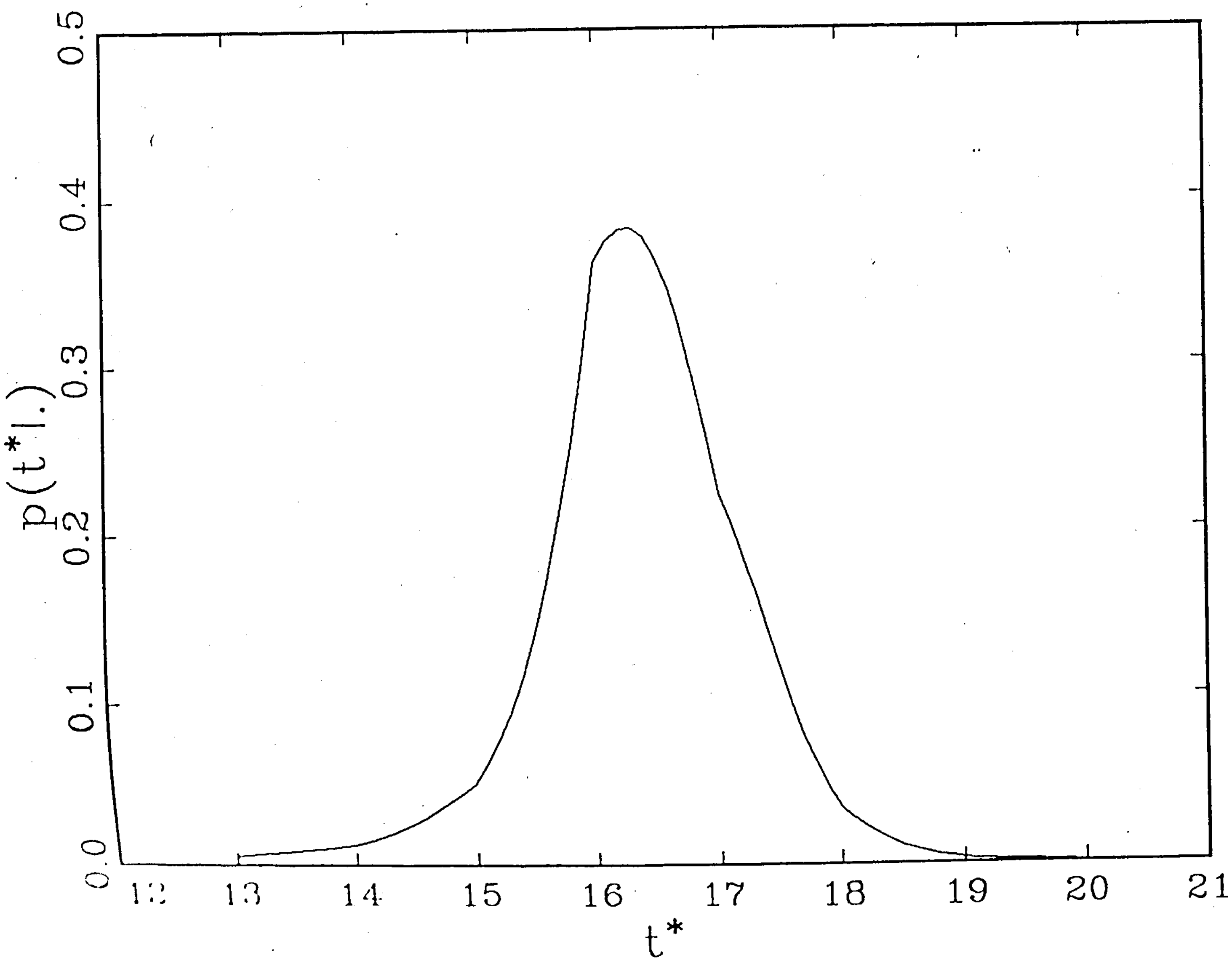
the compensated price elasticities are given by:

$$e_{ij}^u = (\gamma_{ij} / w_i) - \delta_{ij} + w_j[\beta_i / w_i + 1] \quad ,$$

where δ_{ij} is the Kronecker delta.

[b]Elasticities are evaluated at the mean data values of each regime.

Figure 1: Marginal Posterior pdf for Join Point t^*, Conditional on $\sigma = 10^{-6}$



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