Structural Change via Threshold Effects: Estimating U.S. Meat Demand Using Smooth Transition Functions

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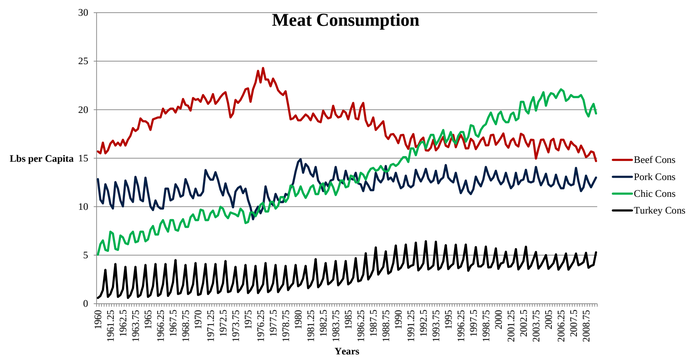
Introduction

Structural change has been a focus in the food demand literature. Studies have analyzed structural change using a variety of different approaches and methodologies. This paper uses time and the economic events of the past few years as motivation to examine structural change under a new context. Economic activity, as measured by GDP, has contracted and recently stabilized. This led to higher unemployment rates. Policymakers have instituted expansionary monetary and fiscal policies. However, these policies are potentially inflationary in the long run. Understanding how these will affect consumer behavior is important. This study examines the effects of time and inflation on U.S. consumer meat demand. The goals of this study are: 1) To measure structural change in meat demand and when it occurred over the last fifty years, and 2) To measure structural change in U.S. meat demand and when it occurred due to changes in inflation over the last fifty years.

U.S. Meat Demand



American meals have traditionally revolved around meat consumption. Looking at the figure above, it suggests that underlying preferences in meat demand have changed over this time period. This is most apparent in beef and chicken. Beef consumption increased into the seventies but then hit a peak in the mid-seventies and then fell and has leveled off. Chicken consumption experienced continuous growth over the last half-century. Pork and turkey consumption were flat during this time period.

Data

Quarterly data on consumption and retail prices for beef, pork, chicken, and turkey were collected from various USDA sources for the 1960 – 2009 period. In this analysis, chicken and turkey are aggregated to obtain a single "poultry" category. The retail price for poultry are derived by determining the share – weighted averages for chicken and turkey prices where shares are with respect to total expenditures on chicken and turkey. To account for seasonality, quarterly dummy variables are used.

Inflation indicators were collected from the Federal Reserve Bank of St. Louis. Specifically, the FRED system compiles macroeconomic indicators in a host of areas. Inflation was measured using the real Consumer Price Index (CPI). The index was collected in monthly format and averaged over every quarterly period. To account for seasonality, the index was fourth – differenced.

Methodology

When modeling meat demand, a framework that has been employed is what is know as an inverse demand system. In such a system, normalized prices adjust to exogenous changes in quantities. Short – run supplies are assumed to be perfectly inelastic because of production lags and a reasonably short shelf-life. The Inverse Almost Ideal Demand System (IAIDS) will be used here. It was introduced by Eales and Unnevhr and also developed independently by Moschini and Vissa. It is:

$$w_i = \alpha_i + \sum_j \delta_{ij} \ln(q_j) + \beta_i (\ln(Q))$$

where

$$\ln Q = \alpha_0 + \sum_i \alpha_i \ln(q_i) + \frac{1}{2}\sum_i \sum_j \delta_{ij} \ln(q_i) \ln(q_j)$$

Interpretation of ordinary demand relies largely on evaluation of elasticities. For inverse demands, interpretation is based on comparable measures called flexibilities. They measure the percentage change in normalized prices to changes in quantities. Flexibilities can be calculated from the above estimated coefficients. In order to model structural change, the following model is developed:

$$w_{it} = f(\boldsymbol{X_t}, \theta_1)(1 - G(t^*; \gamma, c)) + f(\boldsymbol{X_t}, \theta_2) G(t^*; \gamma, c) + e_{it}$$

where θ_i is the set of parameters explaining meat demand for two different regimes that are determined by a transition variable t*. Transition occur from regime one to regime two according to the transition function, G, which is a function of t*. γ and c are parameters that describe characteristics of the transition function. The model above is an offshoot of the time-varying regression models considered in a univariate context by Terasvirta. These are known as Smooth Transition Regression (STR) models. A common specification of the transition function is the first order logistic function:

$$G(t^*; \gamma, c) = 1/(1+e^{\frac{-\gamma(t^*-c)}{\sigma_{t^*}}}), \ \gamma > 0$$

where γ is the speed of adjustment parameter that determines the speed with which the model shifts from one regime to another. The centrality parameter, c, determines at what point in the sample the structural change is fifty percent complete.

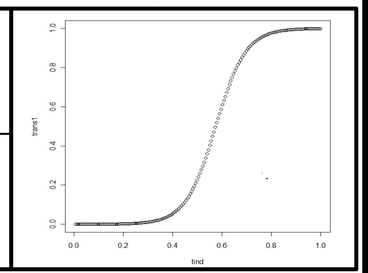
Results – No Structural Change

Flexibilities			
	Beef	Poultry	Pork
Beef	**-0.70795**	-0.13526	-0.09823
Poultry	-0.41368	**-0.50119**	-0.23255
Pork	-0.21964	-0.19908	**-0.60011**
Scale	**-0.94144**	**-1.14743**	**-0.98748**
LLK:	**1339.26**		

In the basic Inverse AIDS model, all own-price flexibilities are negative. All scale flexibilities are negative and in the vicinity of negative one.

Results – Structural Change (Time)

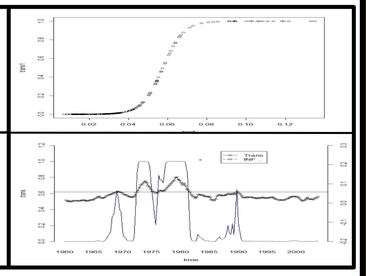
Flexibilities			
Regime One			
	Beef	Poultry	Pork
Beef	**-0.63711**	-0.06422	-0.03949
Poultry	-0.12041	**-0.69962**	-0.29791
Pork	-0.22037	-0.13539	**-0.65993**
Scale	**-0.74082**	**-1.57146**	**-1.01569**
Regime Two			
	Beef	Poultry	Pork
Beef	**-0.88350**	-0.24169	-0.21723
Poultry	-0.03967	**-0.28238**	0.167209
Pork	-0.19754	-0.30123	**-0.53993**
Scale	**-1.34241**	**-0.35264**	**-0.88488**
Gamma	**4.74**	**LLK: 1364.33**	
c	**0.5751**		



Using time as a transition variable, there was a smooth transition from regime one to regime two. The γ parameter is equal to 4.74 and c is .5751. This indicates that the smooth transition from regime one to regime two occurred around 1985. In both regimes, all own-price flexibilities are negative. In both regimes, all scale flexibilities are negative.

Results – Structural Change (Inflation)

Flexibilities			
Regime One			
	Beef	Poultry	Pork
Beef	**-0.75019**	-0.16053	-0.13046
Poultry	-0.04422	**-0.46074**	-0.17193
Pork	-0.2186	-0.15283	**-0.58901**
Scale	**-1.04117**	**-0.95148**	**-0.96044**
Regime Two			
	Beef	Poultry	Pork
Beef	**-0.63181**	0.02722	0.018748
Poultry	-0.65888	**-0.96134**	-0.25442
Pork	-0.15642	-0.12426	**-0.71745**
Scale	**-0.58584**	**-1.98499**	**-0.96207**
Gamma	**5.30**	**LLK: 1360.33**	
c	**0.0575**		



Using inflation as a transition variable, there were several smooth transitions from regime one to regime two. The γ parameter is 5.30 and c is .0575. The individual transitions over time are indicated in the bottom right picture above while the transition function itself is in the top right picture above. Several transitions occurred in the mid to late seventies and early eighties which were periods of high inflation in the U.S. In both regimes, all own-price flexibilities are negative. In both regimes, all scale flexibilities are negative.

Conclusion

Structural change in U.S. meat demand was examined using an Inverse AIDS model in combination with smooth transition regressions. Results indicate that structural change did occur over the last fifty years. In terms of time, there was a smooth transition from one regime to another around 1985. In terms of inflation, there were several regime changes. These occurred during the mid to late seventies and the early eighties consistent with periods of high inflation in the U.S. This methodology not only pinpoints when there was structural change but also suggest what consumers might be reacting to. This provides researchers with another tool to add to their toolkit in modeling structural change. Given recent events, using certain major macroeconomic indicators can provide ready cues into changes in U.S. meat demand. These results can be informative to industry, policy makers, and researchers who examine and analyze this particular market.

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