United States Department of Agriculture

Structural Change via Threshold Effects: Estimating U.S. Meat Demand Using Smooth Transition Functions and the Effects of Demographic Composition of the Labor Force Across Time

Nestor M. Rodriguez*, James Eales**

December 1, 2015

Disclaimer: The views expressed are those of the authors and should not be attributed to ERS or USDA.

* Research Agricultural Economist, ERS-USDA
** Professor, Purdue University

General Overview

- 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 demographic changes in U.S. labor markets as motivation to examine structural change under a new context.
- Over the past five decades, there have been large changes in the composition of the U.S. labor force. Specifically, more females have entered the labor force.

General Overview

- Previous literature has noted how females entering the labor force has affected the demand for different food products.
- This study re-examines the effects of time and female labor participation on U.S. consumer meat demand.
- Additionally, it will analyze and compare the effects of the general unemployment rate with more specific measures of unemployment that account for female unemployment relative to the total unemployed population.

General Overview

- The goals of this study are:
  - To measure structural change in meat demand over time and when it occurred over the last fifty years
  - To measure structural change in U.S. meat demand and compare the effects when taking into account time, general unemployment, female labor participation, and female unemployment relative to the total unemployed population over the last fifty years.

U.S. Meat Consumption: 1960-2013

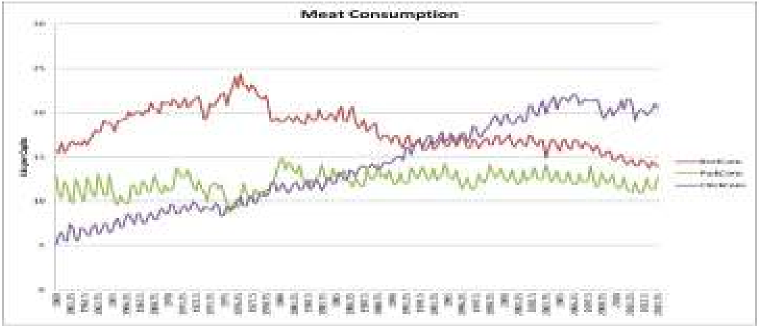

Figure: American meals have traditionally revolved around meat consumption. Looking at the figure above, it suggests that underlying preferences in meat demand have changed over this time period.

Data

- Quarterly data on consumption and retail prices for beef, pork, chicken were collected from various USDA sources for the 1960 to 2013 period. To account for seasonality, quarterly dummy variables are used.
- Data on the unemployment rate, unemployed female population and total unemployed population were collected from the Federal Reserve Bank of St. Louis. Specifically, the FRED system compiles indicators in a host of areas.
- The data was collected in quarterly format.

Methodology

- When modeling meat demand, a framework that has been employed is what is known 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 Unnevehr and also developed independently by Moschini and Vissa.

Methodology

- The Inverse AIDS model is:

$$w_i = \alpha_i + \Sigma_j \gamma_{ij} ln(q_j) + \beta_i (ln(Q)) \qquad (1)$$

where w_i is the budget share for good i for $i = 1$ and q_j is the quantity for good j. The quantity index, lnQ, is defined by:

$$lnQ = \alpha_0 + \Sigma_i \alpha_i ln(q_i) + \frac{1}{2} \Sigma_i \Sigma_j \gamma_{ij} ln(q_i) ln(q_j) \qquad (2)$$

- An approximation to the quantity index, the Stone Quantity Index is used:

$$lnQ = \Sigma_i w_i ln(q_i) \qquad (3)$$

Methodology

- 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 due to changes in quantities.
- Flexibilities can be calculated from the above estimated coefficients.

Methodology

- In order to model structural change, the following model is developed:

$$w_{it} = f(\mathbf{X_t}, \theta_1)(1 - G(t; \gamma, c)) \tag{4}$$

$$+f(\mathbf{X_t}, \theta_2)G(t; \gamma, c) + e_{it}$$

Methodology

- Where θ_i is the set of parameters explaining meat demand for two different regimes that are determined by a transition variable, t^*.
- Transitions 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.

Methodology

- A common specification of the transition function is the first order logistic function:

$$G(t;\gamma,c) = \left[1 + e^{\frac{-\gamma(t-c)}{\sigma_t}}\right]^{-1}, \gamma > 0 \qquad (5)$$

- 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.

- Methodology:Time Varying - Smooth Transition Regression (TV-STR) Model

$$w_{it} = [f(\mathbf{X_t}, \theta_1)(1 - G(t; \gamma_1, c_1)) \tag{6}$$

$$+f(\mathbf{X_t}, \theta_2)G(t; \gamma_1, c_1)](1 - G(t; \gamma_2, c2))$$

$$+[f(\mathbf{X_t}, \theta_3)(1 - G(t; \gamma_1, c_1))$$

$$+f(\mathbf{X_t}, \theta_4)G(t; \gamma_1, c_1)](G(t; \gamma_2, c2)) + e_{it}$$

Results

Table: Basic IAIDS Model

Uncompensated Flexibilities			
	Beef	Chicken	Pork
Beef	**-0.704**	-0.091	-0.085
Chicken	-0.395	**-0.502**	-0.293
Pork	-0.273	-0.206	**-0.609**
Scale	**-0.879**	**-1.190**	**-1.088**

Table: **LLK** : **1609.57**. In the basic Inverse AIDS model, all own-price flexibilities are negative. All scale flexibilities are negative and in the vicinity of negative one.

STR IAIDS LSTAR (TIME) (One)

	Beef	Chicken	Pork
Beef	**-0.761**	0.0587	0.0053
Chicken	-0.348	**-0.860**	-0.4395
Pork	-0.196	-0.2229	**-0.672**
Scale	**-0.697**	**-1.645**	**-1.092**

LLK : **1643.71** $\gamma = \mathbf{6.24}$

STR IAIDS LSTAR (TIME) (Two)

	Beef	Chicken	Pork
Beef	**-0.777**	-0.155	-0.185
Chicken	-0.136	**-0.360**	-0.132
Pork	-0.329	-0.190	**-0.533**
Scale	**-1.118**	**-0.630**	**-1.053**

$\mathbf{c} = \mathbf{0.425}(\mathbf{1983})$

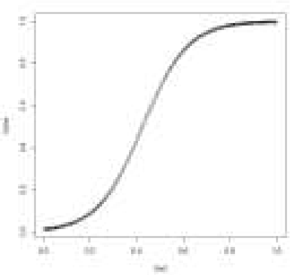

Figure: LSTAR Transition Function Over Time

STR IAIDS LSTAR (UNE) (One)

	Beef	Chicken	Pork
Beef	**-0.555**	0.028	-0.030
Chicken	-0.799	**-0.952**	-0.465
Pork	-0.254	-0.092	**-0.581**
Scale	**-0.556**	**-2.217**	**-0.928**

LLK : **1641.813** $\gamma =$ **1033.201**

STR IAIDS LSTAR (UNE) (Two)

	Beef	Chicken	Pork
Beef	**-0.768**	-0.143	-0.117
Chicken	-0.197	**-0.325**	-0.189
Pork	-0.300	-0.239	**-0.622**
Scale	**-1.030**	**-0.712**	**-1.162**

c $= -$**0.101**

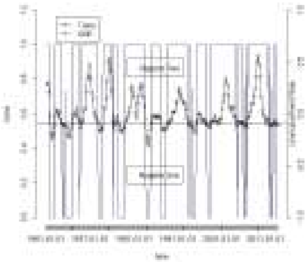

Figure: Trans Function-UNE

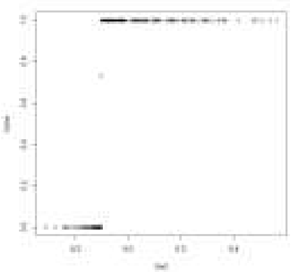

Figure: Trans Function

Nestor M. Rodriguez*, James Eales**

STR IAIDS LSTAR (FLR) (One)

	Beef	Chicken	Pork
Beef	**-0.760**	-0.201	-0.199
Chicken	-0.164	**-0.226**	-0.111
Pork	-0.342	-0.203	**-0.522**
Scale	**-1.161**	**-0.503**	**-1.067**

LLK : **1649.82** γ = **1.61**

STR IAIDS LSTAR (FLR) (Two)

	Beef	Chicken	Pork
Beef	**-0.861**	0.290	0.165
Chicken	-0.589	**-1.616**	-0.724
Pork	0.185	-0.091	**-0.762**
Scale	**-0.405**	**-2.931**	**-0.668**

c = **0.019**

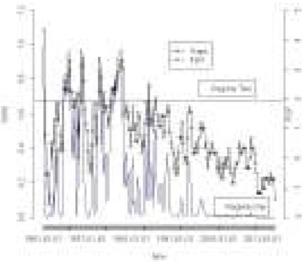

Figure: Trans Function-FLR

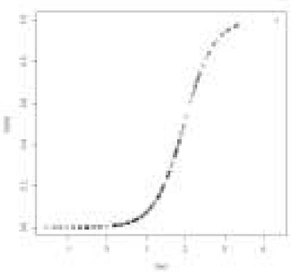

Figure: Trans Function

STR IAIDS LSTAR (FEMTOT) (One)

	Beef	Chicken	Pork
Beef	**-0.809**	-0.112	-0.107
Chicken	-0.126	**-0.456**	-0.144
Pork	-0.278	-0.200	**-0.679**
Scale	**-1.028**	**-0.725**	**-1.158**

LLK : **1624.014** $\gamma =$ **2.199**

STR IAIDS LSTAR (FEMTOT) (Two)

	Beef	Chicken	Pork
Beef	**-0.574**	-0.105	-0.107
Chicken	-0.681	**-0.531**	-0.362
Pork	-0.309	-0.156	**-0.511**
Scale	**-0.786**	**-1.575**	**-0.975**

c $=$ **0.016**

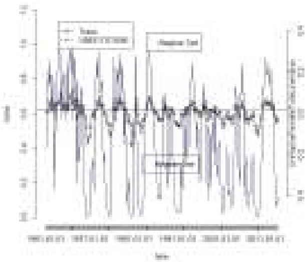

Figure: Trans Function-FEMTOT

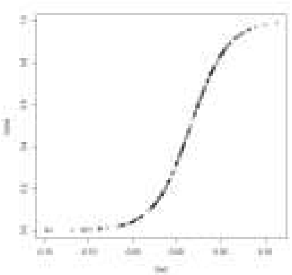

Figure: Trans Function

Nestor M. Rodriguez*, James Eales**

STR IAIDS TVSTR (FEMTOT) (I)

	Beef	Chicken	Pork
Beef	**-0.774**	0.098	-0.014
Chicken	-0.083	**-1.069**	-0.173
Pork	-0.377	-0.139	**-0.837**
Scale	**-0.691**	**-1.326**	**-1.353**

LLK : **1675.306** $\gamma_1 = \mathbf{34.079}$

STR IAIDS LSTAR (FEMTOT) (II)

	Beef	Chicken	Pork
Beef	**-0.735**	0.031	-0.014
Chicken	-0.428	**-0.828**	-0.427
Pork	-0.188	-0.193	**-0.642**
Scale	**-0.717**	**-1.685**	**-1.024**

$\mathbf{c_1 = -0.0017}$

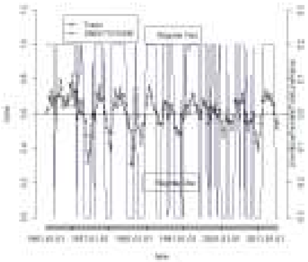

Figure: Trans Function-FEMTOT

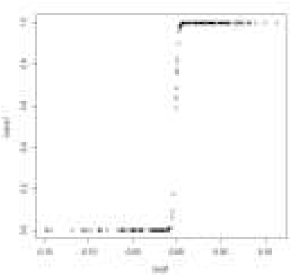

Figure: Trans Function

STR IAIDS TVSTR (FEMTOT) (III)

	Beef	Chicken	Pork
Beef	**-1.109**	-0.049	-0.093
Chicken	0.223	**-0.499**	-0.312
Pork	0.042	-0.289	**-0.574**
Scale	**-1.252**	**-0.589**	**-0.821**

LLK : 1675.306 $\gamma_2 = \mathbf{14.308}$

STR IAIDS LSTAR (FEMTOT) (IV)

	Beef	Chicken	Pork
Beef	**-0.678**	-0.174	-0.294
Chicken	-0.159	**-0.351**	-0.097
Pork	-0.506	-0.158	**-0.347**
Scale	**-1.147**	**-0.608**	**-1.012**

$c_2 = \mathbf{0.447}$**(1984ish)**

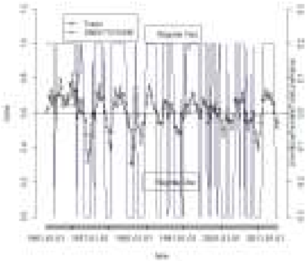

Figure: Trans Function-FEMTOT

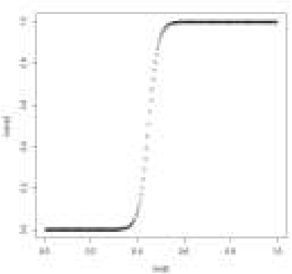

Figure: Trans Function-Time

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 1983.
  - In terms of unemployment, there was an abrupt change that occurred many times over the time period.

Conclusion

- In terms of female labor participation, there were several regime changes. These occurred from the mid-60s until the mid-80s.
- In terms of measuring the female unemployed population as a proportion of the general unemployed population, there were many regime changes that occurred over the time period and results seem to coincide with overall changes in meat consumption.
- In terms of measuring the effects of the female unemployed population as a proportion of unemployed population over time, there were two distinct regimes due to time, with many regime changes in each regime.

Conclusion

- 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.
- These results can be informative to industry, policy makers, and researchers who examine and analyze this particular market.

Thank you!