WP 2011-12
April 2011
Revised September 2011

Working Paper

Charles H. Dyson School of Applied Economics and Management
Cornell University, Ithaca, New York 14853-7801 USA

How have agricultural policies influenced caloric consumption in the United States?

Bradley J. Rickard, Abigail M. Okrent, and Julian M. Alston

How have agricultural policies influenced caloric consumption in the United States?

Bradley J. Rickard, Assistant Professor
Charles H. Dyson School of Applied Economics and Management
Cornell University, Ithaca, NY 14853
Tel: +1.607.255.7417; E-mail: bjr83@cornell.edu

Abigail M. Okrent, Economist
United States Department of Agriculture, Economic Research Service
Washington, D.C. 20009

Julian M. Alston, Professor
Department of Agricultural and Resource Economics
University of California, Davis, CA 95616

September 2011

Abstract:

Many commentators have speculated that agricultural policies have contributed to increased obesity rates in the United States, yet such claims are often made without any analysis of the complex links between real-world farm commodity support programs, prices and consumption of foods, and caloric intake. This article carefully studies the effects of U.S. agricultural policies on prices and quantities of ten agricultural commodities and nine food categories in the United States over time. Using a detailed multimarket model, we simulate the counterfactual removal of measures of support applied to U.S. agricultural commodities in 1992, 1997, and 2002, and quantify the effects on U.S. food consumption and caloric intake. To parameterize the simulations, we calculate three alternative measures of consumer support (the implicit consumer subsidy from policies that support producers) for the ten agricultural commodities using information about government expenditures on agricultural commodities from various sources. Our results indicate that removing subsidies on grains and oilseeds in the three time periods would have caused caloric consumption to decrease minimally while removal of all agricultural policies (including barriers against imports of sugar and dairy products) would have caused total caloric intake to increase. Our results also indicate that the influence of agricultural policies on caloric intake has diminished over time.

Keywords: agricultural policy; caloric intake; consumer support; food consumption; obesity; simulation model.

JEL Classification: I18, Q18

1. INTRODUCTION

Obesity is an escalating problem around the world that has received much attention recently, particularly in the United States. In less than 45 years, the prevalence of obesity among Americans more than doubled; in 1960-62, 13.4 % of U.S. adults were obese and by 2007-08, 33.8% were obese (Flegal *et al*., 1998; Flegal *et al*., 2010). The recent upward trend in the adult obesity rate is attributable to an energy imbalance, where calories consumed are greater than calories expended, given a genetic predisposition. Arguably, the genetic composition of the United States has not changed significantly in the past 45 years; thus, increases in the rate of obesity suggest that many individuals have increased their consumption of calories or decreased their physical activity or both.

Economic researchers have examined various explanations for increased calorie intake. Cutler, Glaeser, and Shapiro (2003) argued that most of the increase in obesity in the United States between 1975 and 2000 is attributable to increased caloric consumption between meals. Chou, Grossman, and Saffer (2004) examined the influence of various socio-economic and cultural factors on obesity, and their econometric results indicated that increasing obesity was driven primarily by the rise in the number of food-away-from-home (FAFH) establishments. Lakdawalla and Philipson (2002) estimated that 40% of growth in the Body Mass Index between 1970 and 2000 was attributable to increases in supply of farm commodities resulting from growth in agricultural productivity. A number of studies have focused on the likely effects of fiscal instruments (e.g., taxes on fat content of food or subsidies on fresh fruit and vegetables) on consumer response to food consumption. Such studies suggested that various policies may be somewhat effective in reducing caloric consumption and obesity, but with limited impact in most cases (e.g., Kuchler, Tegene, and Harris 2004; Cash, Sunding, and Zilberman 2005; Schroeter, Lusk, and Tyner 2008; Allais, Bertail, and Nichèle 2010; Bonnet and Requillart 2011).

The United States has a long history of agricultural policy and many commentators—including prominent economists, nutritionists, journalists, and politicians—have claimed that American farm subsidies have contributed significantly to the “obesity epidemic.” They argue that farm subsidies have made fattening foods relatively cheap and abundant, and that reducing these subsidies will go a long way towards solving the problem. These commentators often treat the point as self-evident, and do not present details on the mechanism by which farm subsidies are supposed to affect obesity, nor evidence about the size of the likely impact. In particular, Pollan (2003, 2007) has claimed that subsidies on commodities such as corn and wheat have led to lower prices of high-calorie, processed foods. As proof of this effect, he has pointed to the correlation between increased subsidies to corn farmers and rising obesity rates in the United States between 1970 and 2005. Likewise, Nestle (2002), Tillotson (2004), Muller, Schoonover and Wallinga (2007), Ludwig and Pollak (2009) and Popkin (2010) have attributed the growth in U.S. obesity rates to agricultural policies, and advocated a reorientation of government spending away from corn and wheat to fruits, vegetables and whole grains. Such sentiments have also been voiced in popular documentary movies like *Food, Inc.* and *King Corn*, and alluded to in public policy recommendations, such as First Lady Obama’s “Let’s Move” campaign (White House Task Force on Childhood Obesity 2010).[1]

It is conceptually possible that farm policies have contributed to lower relative prices and increased consumption of fattening foods by making certain farm commodities more abundant and therefore cheaper. However, several economic studies suggest that these effects are small or nonexistent given the small cost share of agricultural commodities in food products, and in light of international comparisons (Senauer and Gemma 2006; Miller and Coble 2007). In addition, the link between agricultural policy and obesity becomes less clear once border measures for food and agricultural products are also considered, as border measures generally increase domestic prices and decrease consumption (Alston, Sumner, and Vosti, 2006; Alston, Sumner, and Vosti 2008; Beghin and Jensen 2008).

In this article we examine the consequences of U.S. farm subsidies—including indirect subsidies provided by trade barriers as well as direct subsidies—for the prices paid by consumers for food products, and the implications for caloric consumption patterns in the United States. We extend previous work by economists in this arena in three ways. First, using a detailed simulation model that links markets for agricultural commodities to food product markets, we can directly trace the effects of agricultural policies on prices of food products, and consequently, on food consumption and calorie intake. The results from our analysis allow us to comment more directly on the consequences of agricultural policies for caloric intake and obesity rates in the United States. Second, we use three measures of the effect of agricultural policies on consumers, through their impacts on farm commodity prices between 1990 and 2004, to explore the relationship between agricultural policies and obesity over time. We model the effects of the removal of agricultural policies in three different time periods to better understand the relationship between agricultural policy and obesity patterns. Third, we pay explicit attention to FAFH. Although the effects of agricultural policies on FAFH are expected to be relatively small given the small cost share of agricultural commodities in such food items, we have seen a sharp increase in food expenditures for FAFH between 1990 and 2004 (for additional information see Lin, Guthrie, and Frazão 1999), and it is important to consider the effects on both FAH and FAFH in such analysis. Our research presents a novel approach for measuring the caloric effects of agricultural policies on consumption of seven food-at-home (FAH) products, FAFH and alcoholic beverages.

2. MEASURES OF CONSUMER SUPPORT FOR AGRICULTURAL COMMODITIES

The link between agricultural policy and producer prices and economic welfare has been studied for various commodities across a range of countries, and research shows that U.S. agricultural policy influences production, producer prices, and producer welfare (McDonald *et al*. 2006; Alston and Sumner 2007). Much less is known about the relationship between agricultural policies and consumer prices of food products. Some evidence suggests that changes in government support for agricultural commodities would lead to changes, albeit relatively small, in food prices (e.g., Bils and Klenow, 2004).

2.1 Available measures of consumer support

Different measures of consumer support of agricultural commodities in different countries have been developed, and the measures have been used by economists as parameters in partial and general equilibrium models. One widely used measure developed by the Organisation for Economic Cooperation and Development (OECD) is the Consumer Support Estimate (CSE); it has been calculated for fourteen agricultural commodities annually since 1986. A CSE measures the value of government expenditures on subsidies and other market interventions accruing as benefits to consumers relative to the total value of consumption for selected agricultural commodities. Anderson *et al*. (2008) calculated a Consumer Tax Equivalent (CTE) that provides another measure of consumer support applied to fifteen agricultural commodities. CTEs measure distortions to incentives for consumers of agricultural commodities in various countries between 1960 and 2007. The two measures are similar but different, as we discuss and explain next.

Figure 1 shows the aggregate rates of CSEs and CTEs in the United States between 1986 and 2007; positive CSE values imply a consumer subsidy while positive CTE values imply a consumer tax. To make the two alternative measures more clearly comparable, we multiplied the CTEs by –1, to convert to a subsidy equivalent rate, before plotting in Figure 1. In 1986, both measures indicated that agricultural policies entailed net taxes on consumers, increasing the consumer cost of food. Between 1986 and 2007, the rates of tax implied by the aggregate CSE and the aggregate CTE generally decreased, indicating a drift away from agricultural policies that taxed consumers, reflecting the combined effects of policy changes and changes in world markets (many farm subsidies are countercyclical and when world prices are higher, subsidies to farmers and implicit taxes paid by consumers tend to be lower both in per unit and percentage terms). During this same period, the share of overweight or obese people increased from approximately 45% in 1986 to 65% in 2007 (CDC, 2009). The long-term patterns in Figure 1 suggest that increases in CSEs (or decreases in CTEs) may have contributed to increases in obesity rates during this time. Loureiro and Nayga (2005) used aggregate CSE data across OECD countries between 1990 and 2002 and found evidence of a negative and statistically significant relationship between aggregate transfers from consumers to the agricultural sector (using CSE data) and obesity; likewise, Alston, Sumner, and Vosti (2008). However, aggregate measures of consumer support, like those shown in Figure 1 do not capture the effects for individual agricultural commodities, nor the complex interactions between markets for agricultural commodities and markets for the food products that use these commodities as ingredients.

We report five-year average values of the CSEs and CTEs for fifteen commodities in three time periods in Table I. Both the CSEs and CTEs show that consumers of milk and sugar were taxed significantly across the three time periods, and the tax rate on these commodities remained relatively stable over these periods. The CSE rates differ from the CTE rates for many grains and meat commodities, primarily because the measures are based on different calculations. The CSEs measure government transfers to consumers as a share of the total value of consumption for an agricultural commodity. CSEs are not designed to measure the price or quantity effects of agricultural policies for consumers, and do not represent equivalent ad valorem tax or subsidy rates. Because government transfers to consumers of grains, oilseeds, and meats are relatively small, and because the total value of consumption of these commodities is very large, the CSE rates are small. In contrast, the CTE calculations provide a measure of distortions to the incentives facing food consumers, and therefore CTEs do provide a reasonably good measure of the price effect of agricultural policies for food consumers. CTEs for grains and meat products are negative and substantial in many cases indicating that consumers have benefited from explicit or implicit subsidies applied to commodities.

Another important difference between the CSEs and CTEs is that, along with transfers through farm commodity programs, in the CSE data files the OECD reports expenditure information for cross-commodity policies, in particular food and nutrition programs like food stamps, school lunch, and the WIC program (Special Supplemental Nutrition Program for Women, Infants, and Children). In the United States, the OECD (2010) reported that cross-commodity transfers from the government to consumers were $26.2 billion in 2007, of which approximately 50% funded the School Lunch Program, 27% supported the Food Stamp Program, and 20% financed the WIC program. Although it is debatable whether these cross-commodity policies affect market prices for farm and food products, they do influence consumption patterns and we incorporate them into parts of our analysis.

2.2 Three consumer support measures used in the analysis

To analyze the implications of agricultural policies for caloric intake we calculated three consumer support measures (CSMs) for ten agricultural commodity groups in three time periods. Table II shows the values for the three CSMs for ten agricultural commodities in 1992 (using data for the years 1990 through 1994), 1997 (using data for the years 1995 through 1999) and 2002 (using data for the years 2000 through 2004).

The first CSM in Table II, denoted by CSM_A, is based primarily on the commodity-specific CSEs reported in Table I. We adjusted the reported commodity-specific CSEs two ways. First, we aggregated some of the fifteen commodities listed in Table I to facilitate a more parsimonious simulation model. We combined four grain commodities into one, three meat commodities into one, and poultry and eggs into one, using weights based on relative consumption shares (OECD, 2010). Second, we included consumer support that applies to horticultural commodities and to fish and aquaculture. This second step warrants some explanation, and more details are provided next.

CSEs or CTEs were not reported for horticultural commodities in Table I, yet these commodities are included in our simulation model and it is not clear that the CSMs for fruits and vegetables should be equal to zero. Over the past 30 years several policies applied to horticultural markets in the United States are speculated to have influenced production and consumption of fruits and vegetables. The World Trade Organization (WTO) reported that the average tariff applied to U.S. fruits and vegetables was 5% (WTO, 2007). Gibson *et al*. (2001) and Donovan and Krissoff (2001) showed that post-Uruguay Round tariffs applied to selected horticultural products entering the United States typically ranged between 2% and 9%; average tariffs on vegetables have been slightly higher than those for fruits.[2] Karov *et al*. (2009) showed that consumer prices for selected fruits and vegetables have also been influenced by sanitary and phytosanitary regulations. In addition, the 1990 Farm Bill introduced fruit and vegetable planting restrictions on base acres for program crops. Evidence suggests that planting restrictions have influenced horticultural production in the United States, and that the impacts are likely to have been more important for vegetable crops than perennial fruit crops (Johnson *et al*., 2006; Young *et al*., 2007). Hence, border measures and planting restrictions are expected, in some capacity, to have increased consumer prices of horticultural products. Therefore, based on this information we consider relatively small, and negative, CSMs for fruit and vegetable commodities. The CSMs are set equal to 6% for vegetables and melons, and 4% for fruits and tree nuts; CSMs for vegetables and melons are larger, given the higher tariff rates reported and the influence of the planting restrictions.

Similar to horticultural crops, CSEs or CTEs are not reported in the fish and aquaculture category, yet significant expenditures have been applied to U.S. fisheries (Cox and Schmidt 2003; Sharp and Sumaila 2009). Sharp and Sumaila (2009) showed that the average annual subsidy for fisheries was $713 million (ranging from $680 million to $760 million) between 1996 and 2004, and that approximately 40% of these expenditures was used for research and development activities. Over the same time period the annual value of landings averaged $3.46 billion (NMFS 2011). We excluded government expenditures for research and development because the CSMs for the other farm commodities also excluded these expenditures. Hence, we set all CSMs for fish and aquaculture equal to 12.4% in 1992, 1997, and 2002.

The second CSM listed in Table II, denoted CSM_B, is equal to CSM_A augmented with an allocation of total cross-commodity support: we assigned a portion of the total cross-commodity transfers to each of the ten commodities based on their shares of consumption expenditure

(OECD, 2010). The resulting commodity-specific measure corresponds to the measure plotted in Figure 1 for aggregate CSEs, which also included cross-commodity support.

The third CSM, denoted CSM_C, is based on the reported CTEs and constructed in a fashion comparable to CSM_A and CSM_B (i.e., some commodities are aggregated and adjustments are made to the horticulture and fish categories). Because the CTEs were reported by a different source than the CSEs, we do not include the cross-commodity support in the calculation of CSM_C. CSM_C corresponds to the aggregate measure of consumer support as measured by the CTEs plotted in Figure 1.

3. MODELLING THE EFFECTS OF AGRICULTURAL POLICIES ON PRICES AND CONSUMPTION FOR FOOD

We develop an equilibrium displacement model to simulate the effects of removing agricultural policies, as measured by the calculated CSMs, on consumption and prices of food in selected time periods. This type of model is commonly used by applied economists to study a wide range of research topics, most notably in studies that examine the changes in prices and quantities resulting from small changes in supply and demand conditions. Muth (1964) provided the original derivations for the one-output, two-input model that could be used to examine determinants of output supply and input demand, in a vertical market structure. Floyd (1965) applied a variant of the same model to analyze farm policies, and Gardner (1975) used an equivalent model to examine the transmission of price changes between the market for a farm commodity and a corresponding retail food products. Wohlgenant (1982) and Wohlgenant (1989) developed variations of Gardner's (1975) model to examine marketing margins on farm commodities for one food product produced using multiple farm commodities.[3]

Wohlgenant (2001) provided a survey on models of marketing margins used in equilibrium displacement models, and highlighted that the linkages between markets for farm commodities and retail products are generally modeled assuming that one farm commodity and one or more marketing factors are inputs into the production of a particular FAH. For example, the farm commodity beef is the primary ingredient for the retail food product beef. However, FAFH and combination FAH products (e.g., soups, frozen dinners) incorporate multiple farm commodities. Under the assumption of fixed proportions, the price transmission between farm commodities and both combination FAH products and FAFH would certainly be less than the price transmission between farm commodities and non-combination FAH products because the farm commodity cost represents a smaller share of the retail value of FAFH and combination food products. Since FAFH and combination foods now constitute 35% and 13% of personal consumption expenditures on food, respectively, and are increasingly becoming a large source of daily caloric intake in the United States, it is necessary to include these categories of food in the analysis.

The model introduced here extends a system compromising one output product with L inputs, as presented by Wohlgenant (1982), to N output products with L–1 farm commodities and one composite marketing input (representing an aggregate of labor, materials, energy, capital and other inputs used in the food processing, manufacturing, and marketing sector, in conjunction with farm commodities). A model disaggregated in this fashion is necessary to represent the impacts of policies applied differentially to individual farm commodities, as they affect the cost of food and thus food prices and consumption.

The market equilibrium for this system can be expressed in terms of N demand equations for food products, N total cost equations for food product supply, L supply equations for input commodities and $L \times N$ equations for competitive market clearing. The market equilibrium for this system is expressed as:

(1) $Q^n = \mathrm{Q}^n(\mathbf{P}, A^n), \forall n = 1,.., N,$

(2) $P^n = \mathrm{c}^n(\mathbf{W}), \forall n = 1,.., N,$

(3) $X_l = \sum_{n=1}^{N} \mathrm{g}_l^n(\mathbf{W})Q^n, \forall l = 1,..., L,$

(4) $X_l = \mathrm{f}_l(\mathbf{W}, B_l), \forall l = 1,.., L.$

Equation (1) represents the demand for nth food product in which the quantity demanded, Q^n, is a function of an $N \times 1$ vector of product prices, $\mathbf{P}$, and an exogenous demand shifter, A^n, which subsumes the effects of changes in total consumer expenditure and other exogenous shifters on product demand.[4] Equation (2) is based on the assumption of constant returns to scale at the product industry level and competitive market equilibrium, where the price of the nth product is set equal to the marginal cost of producing product n, $\mathrm{c}^n(\mathbf{W})$, which is a function of an $L \times 1$ vector of commodity prices, $\mathbf{W}$.[5] Equation (3) is the Hicksian demand for commodity l, X_l, which is derived by applying Shephard's lemma to the total cost functions of the N products (i.e., $\partial C^n / \partial W_l = \mathrm{g}_l^n(\mathbf{W})Q^n$), and then summing across the N product industry demands for commodity l. Equation (4) is the supply function for commodity l, which is a function of all of the commodity prices and an exogenous supply shifter, B_l.

Totally differentiating equations (1) to (4), and converting to elasticity form yields equations for proportionate changes in quantities and prices of retail products (i.e., $\mathrm{E}Q^n = \mathrm{d}Q^n/Q^n$ and $\mathrm{E}P^n = \mathrm{d}P^n/P^n$ where d is the total differential operator) and farm commodities (i.e., $\mathrm{E}X_l = \mathrm{d}X_l/X_l$ and $\mathrm{E}W_l = \mathrm{d}W_l/W_l$) in equations (5) to (8):

(5) $\quad \mathrm{E}\,Q^n = \sum_{k=1}^{N} \eta^{nk}\, \mathrm{E}\,P^k + \alpha^n, \forall n = 1,..,N,$

(6) $\quad \mathrm{E}\,P^n = \sum_{l=1}^{L} \frac{\partial \mathrm{c}^n(\mathbf{W})}{\partial W_l} \frac{W_l}{P^n} \mathrm{E}\,W_l, \forall n = 1,..,N,$

(7) $\quad \mathrm{E}\,X_l = \sum_{n=1}^{N} SC_l^n \sum_{m=1}^{L} \left(\eta_{lm}^{n*}\, \mathrm{E}\,W_m + \mathrm{E}\,Q^n\right), \forall l = 1,...,L,$

(8) $\quad \mathrm{E}\,X_l = \sum_{j=1}^{L} \varepsilon_{lj}\, \mathrm{E}\,W_j + \beta_l, \forall l = 1,...,L,$

where

(9) $\quad \eta^{nk} = \frac{\partial \mathrm{Q}^n(\mathbf{P}, A^n)}{\partial P^k} \frac{P^k}{Q^n}$ is the Marshallian elasticity of demand for retail product n with respect to retail price k,

(10) $\quad SC_l^n = \frac{X_l^n W_l}{X_l W_l}$ is the share of the total cost of commodity l used in the production of retail product n (farm commodity use share),

(11) $\quad \eta_{lm}^{n*} = \left(\frac{\partial \mathrm{g}_l^n(\mathbf{W}) Q^n}{\partial W_m}\right) \frac{W_m}{X_l^n}$ is the Hicksian elasticity of demand for commodity l in industry n with respect to commodity price m,

(12) $\quad \varepsilon_{lj} = \frac{\partial \mathrm{f}_l(\mathbf{W}, B_l)}{\partial W_j} \frac{W_j}{X_l}$ is the elasticity of supply of commodity l with respect to commodity price j,

(13) $\quad \alpha^n = \frac{\partial \mathrm{Q}^n(\mathbf{P}, A^n)}{\partial A^n} \frac{A^n}{Q^n} \mathrm{E}\,A^n$ is the proportional shift of demand for retail product n in the quantity direction,

(14) $\quad \beta_l = \frac{\partial \mathrm{f}_l(W_l, B_l)}{\partial B_l} \frac{B_l}{X_l} \mathrm{E}\,B_l$ is the proportional shift of supply of commodity l in the quantity direction.

This system can be modified to accommodate policy shocks such as the introduction of subsidies or taxes on farm commodities. Let s_l be the subsidy rate on commodity l, and $W_{S,l}$ and $W_{D,l}$ be the seller and buyer prices of l, respectively, so that

(15) $\quad W_{S,l} = (1 + s_l) W_{D,l}.$

The total differential of (15), expressed in terms of proportionate changes and evaluated to represent the introduction of s_l from a base of no subsidy, is

(16) $\quad \mathrm{E}\,W_{S,l} = s_l + \mathrm{E}\,W_{D,l}.$

Substituting (16) into (8) yields

$$\text{(17)} \quad \mathrm{E}X_l = \sum_{j=1}^{L} \varepsilon_{lj} \, \mathrm{E}W_{D,l} + \sum_{j=1}^{L} \varepsilon_{lj} s_l + \beta_l.$$

Several simplifications can also be made to the system. First, since $\partial c^n(\cdot) / \partial W_l = X_l^n / Q^n$, equation (6) can be rewritten as

$$\text{(18)} \quad \mathrm{E}P^n = \sum_{l=1}^{L} SR_l^n \, \mathrm{E}W_l, \forall n = 1,.., N,$$

where $SR_l^n = X_l^n W_l / P^n Q^n$ and is the share of total cost for retail product n attributable to commodity l (farm-retail cost share). Second, the share-weighted Hicksian elasticity of demand for commodity l with respect to the price of commodity m is

$$\text{(19)} \quad \eta_{lm}^{*} = \sum_{n=1}^{N} SC_l^n \eta_{lm}^{n*}.$$

Equation (7) can be rewritten using (19):

$$\text{(20)} \quad \mathrm{E}X_l = \sum_{m=1}^{L} \eta_{lm}^{*} \, \mathrm{E}W_m + \sum_{n=1}^{N} SC_l^n \, \mathrm{E}Q^n, \forall l = 1,..., L.$$

Furthermore, assuming fixed factor proportions reduces much of the complexity in the simulation model and is an appropriate description of substitution patterns for agricultural commodities in a short- to medium-run time horizon.[6] With this assumption, the Hicksian elasticity of demand between two factor inputs l and j in product n is zero (i.e., $\eta_{lj}^{n*} = 0, \forall\, l,j = 1, ..., L, \forall\, n = 1, ..., N$), which implies:

$$\text{(21)} \quad \mathrm{E}X_l = \sum_{n=1}^{N} SC_l^n \, \mathrm{E}Q^n, \forall l = 1,..., L.$$

Lastly, the assumption of exogenous commodity prices (i.e., representing the case where the U.S. food industry faces a perfectly elastic supply of farm commodities, including supply from storage and reflecting the influence of international trade) implies that equation (8) becomes

$$\text{(22)} \quad -\mathrm{E}W_l = \overline{\beta}_l + s_l, \forall l = 1,..., L,$$

where $\overline{\beta}_l$ is a proportionate shift in supply of commodity l in the price direction.[7]

To simplify the notation, we present equations (5), (18), (21) and (22) in matrix notation. Letting **EQ**, and $\mathbf{EP}^S$ be $N \times 1$ vectors of proportionate changes in quantities and producer prices of retail products, respectively, and **EX**, and $\mathbf{EW}_D$ be $L \times 1$ vectors of proportionate changes in quantities and buyer prices of commodities, respectively, the system is

$$\text{(23)} \qquad \begin{bmatrix} \mathbf{I}^N & \mathbf{-\eta}^N & \mathbf{0} & \mathbf{0} \\ \mathbf{0}^N & \mathbf{I}^N & \mathbf{0} & \mathbf{-SR} \\ \mathbf{-SC} & \mathbf{0}^{\mathrm{T}} & \mathbf{I}_L & \mathbf{0}_L \\ \mathbf{0}^{\mathrm{T}} & \mathbf{0}^{\mathrm{T}} & \mathbf{0}^{\mathrm{T}} & \mathbf{-I}_L \end{bmatrix} \begin{bmatrix} \mathbf{EQ} \\ \mathbf{EP}^S \\ \mathbf{EX} \\ \mathbf{EW}_D \end{bmatrix} = \begin{bmatrix} \boldsymbol{\alpha} \\ \mathbf{0} \\ \mathbf{0} \\ \overline{\boldsymbol{\beta}} + \mathbf{s}_L \end{bmatrix},$$

where the parameters are defined above. Using matrix block inversion, the solutions for **EQ**, $\mathbf{EP}^S$, **EX** and $\mathbf{EW}_D$ are:

$$\text{(24)} \qquad \begin{bmatrix} \mathbf{EQ} \\ \mathbf{EP}^S \\ \mathbf{EX} \\ \mathbf{EW}_D \end{bmatrix} = \begin{bmatrix} \mathbf{I}^N & -\boldsymbol{\eta}^N\mathbf{SR} \\ \mathbf{0}^N & -\mathbf{SR} \\ \mathbf{SC} & -\left(\mathbf{SC}\boldsymbol{\eta}^N\mathbf{SR}\right) \\ \mathbf{0}^{\mathrm{T}} & -\mathbf{I}_L \end{bmatrix} \begin{bmatrix} \boldsymbol{\alpha} \\ \overline{\boldsymbol{\beta}} + \mathbf{s}_L \end{bmatrix}.$$

We use this model to simulate how changes in the measures of agricultural support for the ten farm commodities discussed earlier in this article affect the prices and consumption of seven FAH products (cereals and bakery products, meat, eggs, dairy products, fruits and vegetables, other foods, and nonalcoholic beverages), a composite FAFH good, and alcoholic beverages. Converting simulated changes in food consumption to changes in caloric intake is not straightforward. The consumption mix of various food products changed between 1992, 1997 and 2002, and the caloric composition differs among the various food products. In the next section we review the steps taken to convert changes in food consumption to caloric intake, and discuss how the results from our simulation model can be used to assess the likely changes in obesity patterns that would have resulted from alternative farm policies.

3.1. Impact of food consumption on calorie consumption and weight

A key component in our analysis is that we translate the simulated changes in quantities of retail food products—given exogenous changes in the CSMs—into changes in caloric consumption and weight. We calculated the average daily food and calorie intake for a nationally representative sample of individuals aged 18 and older using 24 hour dietary recall data from three national surveys of food consumption: the Continuing Survey of Food Intakes by Individuals (CSFII) 1989-91 (USDA-ARS, 1993), the CSFII 1994-96, 1998 (USDA-ARS, 2000), and the 2001-02 National Health and Nutrition Examination Surveys (CDC, NCHS 2003).[8] Respondents were initially asked to recall what they consumed in the past 24 hours, and a follow-up over-the-phone interview was conducted to collect an additional day of dietary intake data. We included only the first day of dietary recall data in our analysis.

Data in the surveys categorize foods based on the USDA food classification system, which includes the following food categories: dairy, meats, eggs, beans, seeds and nuts, cereals and bakery products, fruits, vegetables, fats, sweets, nonalcoholic beverages and alcoholic beverages. We aggregated the food categories so that they closely match the food products included in our simulation model; we were also able to identify whether the food consumed was FAH or FAFH, based on survey questions. We make two assumptions in order to use average daily calorie consumption for each food group reported in the CSFII and the NHANES. First, we assume that calories consumed are approximately equal to calories purchased; this is a conservative assumption in the sense that it means our estimates are likely to provide an upper-bound estimate of the magnitude of the effects of agricultural policies on caloric consumption.

Second, USDA food codes that represent combination foods, which are difficult to identify as one of our nine food categories, are classified as other foods. For example, if a sample respondent reported consumption of a turkey sandwich (USDA food code 2750431) rather than its constituent parts (i.e., turkey, bread, and so on), then this food is considered to be in the category of other foods, which contains prepared meals and appetizers. Table III shows the food intake and caloric intake patterns for the nine food categories in the three time periods.

Tracking changes from CSMs to food consumption and then to caloric intake is complex. The dynamic relationship between calorie intake and body weight is even more complex, and we make some simplifications in this aspect of our analysis. An individual who loses weight will need fewer calories to maintain the lower body weight. Consequently, given a fixed reduction in daily energy intake, an individual's weight will decrease but eventually will settle at a new steady state, which can take several years to achieve. Textbooks and academic articles that address the potential impacts of food price policies on weight (e.g., Whitney, Cataldo, Rolfes, 1994, Chouinard *et al*., 2007; Smith, Lin, and Lee, 2010) often use a multiplier of 3,500 calories per pound of fat tissue. We employ the same multiplier in our calculations that convert changes in annual calorie consumption into changes in steady-state body weight. Although this simplification may not capture all of the idiosyncrasies that describe the links between caloric intake and human weight, it does allow us to provide a consistent approach for measuring the effects across the CSMs in the three time periods, and allows us to better understand the relationship between agricultural policies and obesity.[9]

3.2. Parameterization of the model

Our simulation model requires parameters to describe (i) measures of consumer support for agricultural commodities, (ii) food quantity-to-calorie conversion rates, (iii) elasticities of demand for food products, (iv) farm-retail cost shares, and (v) farm-commodity cost shares. Measures of consumer support (which enter the model through the exogenous shock, s_l) and calorie conversion rates are summarized in Tables II and III. Below we provide more detail for the demand elasticities (denoted $\boldsymbol{\eta}^N$ in the simulation model), farm-retail cost shares (denoted **SR** in the model), and farm-commodity cost shares (denoted **SC** in the model). Because we examine the effects of agricultural policies in three time periods, we also develop values for the relevant parameters and policy wedges that are representative of the three time periods.

The results from simulation analysis of the type we employ here are conditioned by modeling assumptions and parameterization, and it is reasonable to ask if the results are sensitive to parameter values, especially the elasticities of demand. A corollary question is: what confidence can we place in the derived estimates of impacts of policy change on food consumption, calories, and obesity, given the observed precision in our estimates of the elasticities? To gauge the sensitivity of our results to errors in estimation of the elasticities of demand for food products, we conducted a stochastic simulation. We estimated the joint distribution of $\boldsymbol{\eta}^N$, the elasticities of demand for food products, using Monte Carlo integration (Chalfant, Gray and White 1991; Piggott 2003) based on a vector of parameter estimates ($\hat{\boldsymbol{\gamma}}$) with its associated covariance matrix ($\hat{\boldsymbol{\Sigma}}$) from Okrent and Alston (2011).[10] We randomly drew vectors of demand system parameters from a multivariate normal distribution with mean $\hat{\boldsymbol{\gamma}}$ and covariance matrix $\hat{\boldsymbol{\Sigma}}$ and computed the implied matrix of demand elasticities, evaluated at the mean of the sample data for prices and quantities. Those draws of parameters and the corresponding elasticities that satisfied curvature and monotonicity conditions were then used to solve the price transmission model, and compute the implied changes in calorie consumption and body weight, holding all other parameters constant. The solutions were used to generate empirical posterior distributions for the effects of interest, and we report the means from the posterior distributions and standard deviations around those means. Table IV shows that the simulated own-price elasticities of demand are all negative and statistically significant, and range between –0.51 and –0.98; in addition, all the food products have at least one statistically significant cross-price relationship.

We estimated the farm-retail product and farm-commodity shares (**SR** and **SC**, respectively) for the three time periods using the Benchmark Input-Output Detailed Use Tables (after redefinitions) for 1992, 1997 and 2002 (U.S. Department of Commerce, Bureau of Economic Analysis 1997, 2002 and 2007).[11] The cost shares of commodities and marketing inputs in the retail cost of each food product are listed in Table V. The cost share of marketing inputs is relatively low for food products that involve little processing. For cereals and bakery, beverages, and FAFH we see that the cost share for the marketing input exceeds 90%, and therefore policies that apply to farm commodities used in these products will have a relatively small impact. Farm-retail product shares calculated by the USDA-ERS (2008) for several products—including cereals and bakery products, beef, pork, poultry, eggs, dairy, fresh fruits, fresh vegetables, processed fruits and vegetables, and fats and oils—are very similar to those reported in Table V. The results in Table VI show that the share of total commodities used in FAFH increased between 1992 and 2002 while the share of commodities used in the FAH categories decreased over time.

4. RESULTS

We conducted eighteen simulation experiments to better understand how agricultural policies, as captured by our three CSMs, influenced caloric intake in the United States. We simulated the economic effects of removing only policies applied to grains and oilseeds, and of removing all policies applied to agricultural commodities, including border policies, in each of the three selected time periods (i.e., 1992, 1997, and 2002). Agricultural policy reform discussions in the United States and elsewhere are driven, in part, by the negotiating agenda of the WTO. In the Uruguay Round of the WTO and in current negotiations, member countries have proposed to reduce domestic support, import tariffs, and export subsidies across all agricultural commodities (Josling and Tangermann 1999; Sumner 2003; WTO 2011). Even though it is unlikely that the United States would introduce policy reform to grain and oilseed markets while leaving other policies in place, we examine this scenario given the attention that such subsidies have received.

In addition, agricultural policy reform is not likely to occur in isolation in the United States; rather, any major change in U.S. policy for any particular group of farm commodities is more likely to occur in conjunction with comparable changes made by other WTO member countries or as an element of a bilateral agreement. If U.S. policy changes are made concomitantly with changes in other countries that apply similar trade-distorting policies, the impacts on prices paid by U.S. consumers are likely to be smaller than if the U.S. policy changes were made in isolation (for instance, if the United States and other countries all eliminated their border restrictions on sugar and dairy products, the world market price would increase, offsetting to some extent the decrease in U.S. consumer prices that would be associated with the elimination of U.S. import restrictions, holding policies in all other countries constant). Thus, our analysis is conservative in the sense that it provides an upper-bound estimate of the effects of U.S. policies.

The model generated empirical distributions for the changes in prices and quantities of the agricultural commodities and food categories. The empirical distributions are used to calculate the mean and a 90% confidence interval for each of the variables across 1,110 iterations.[12] We used the simulated food consumption changes to develop an empirical distribution for the changes in caloric intake patterns. All of the changes simulated here are relative to the consumption patterns observed in the dietary intake data in the specified years. Because we assume that the impact of policy change would be transmitted mostly to consumers with relatively little of the incidence being borne by other market participants, our results are likely to be at the high end of the feasible range. Below we focus on the simulated changes in food consumption and the calculated changes in caloric intake across the nine food categories.

The top portion of Table VII reports the simulated percentage changes in food consumption for the three CSMs in the three time periods in response to the removal of U.S. agricultural policies for grains and oilseeds, leaving all other policies in place. For CSM_B and CSM_C consumption of cereals and bakery, eggs, other foods, and FAFH would have decreased with the elimination of support in grain and oilseed markets, and dairy consumption would have increased because of substitution effects; however, the simulated effects are quite small overall. The lower portion of Table VII shows the caloric implications from removal of agricultural support for grains and oilseeds across the nine food categories. We report the mean annual changes in total per capita caloric consumption and weight, and provide the 90% confidence intervals for these changes in Table VII. Because the range of values in the 90% confidence interval does not change the major thrust of our results, we focus on the central values in our discussion below. Changes in total energy consumption are measured in calories per adult, per year. Positive changes indicate that removing agricultural policies would cause caloric consumption to increase; conversely, negative changes indicate that removing agricultural policies would cause caloric consumption to decrease.

Grain and oilseed policies as measured by CSM_A had a positive but diminishing effect on consumption of calories during the three periods, ranging from 285 additional calories consumed per adult per year in 1992 to 0 calories in 2002. The commodity-specific CSEs for oilseeds and food grains were 0 and –3.4 percent in 1992, respectively and both fell to 0 in 2002, which implies that food produced from oilseeds and grains was taxed at a greater rate in 1992 than in 2002. Simulations using CSM_B, which is also based on the CSEs but includes cross-commodity transfers, yielded a slightly different caloric outcome. Using this measure of consumer support, the removal of policies for grains and oilseeds in 1992, 1997 and 2002 would have caused annual consumption per adult to decrease by 804 calories in 1992, 1,500 calories in 1997, and 1,136 calories in 2002. Here, we treat the cross-commodity support as providing a subsidy for all food categories, which contributes to caloric consumption. Hence, eliminating CSM_B, which includes this cross-commodity support as well as support for grains and oilseeds, would have caused a reduction in caloric intake. Likewise, removing policies applied to oilseeds and grains as measured by CSM_C, which is based on the CTEs, would have caused a decrease in calorie consumption of between 995 calories and 1,419 calories per adult per year; this is equivalent to a weight reduction of between 0.28 and 0.41 pounds per adult. The simulation based on CSM_C indicates that grain and oilseed policies had their largest impact on caloric intake (and therefore obesity) during the period 1995–1999. Removing these policies in the more-recent time period, 2000–2004, would have led to a smaller decrease in caloric consumption.

The CSMs based on CSEs represent the value of government transfers to consumers as a share of the total value of consumption, and do not represent the price effects of agricultural policies. Furthermore, because cross-commodity policies may not directly affect market prices for farm and food products, it may be more appropriate to model such policies as income transfers to food consumers. Therefore, even though previous research has employed CSE measures as a way to characterize the effects of agricultural policies on prices, we argue that using CTE measures, as captured by CSM_C in our analysis, may provide a better understanding of the link between agricultural policies and obesity rates in the United States. Overall, the findings in Table VII suggest that grain and oilseed policies, the policies that are most often linked to obesity, have had a positive yet modest effect on caloric intake and the effect appears to have peaked in the late-1990s.

Following the format used in Table VII, the results in Table VIII show the consumption and caloric effects of removing all agricultural policies in the three different time periods, as implied by the three alternative CSMs. The top portion of Table VIII shows the simulated changes in consumption of the nine food categories, and the bottom portion shows the simulated changes in caloric intake and weight. Simulated results using CSM_A (including commodity-specific CSEs only) indicate that removing all agricultural policies would have caused caloric consumption to increase; an average U.S. adult would have consumed 4,771 more calories in 1992, 4,583 more calories in 1997, and 4,021 more calories in 2002 if the policies were removed. However, because CSM_A does not include the subsidies for grains and oilseeds that are in CSM_C, the simulation results using CSM_A most likely underestimate the negative effect of agricultural policies on consumption of food products that use grains and oilseeds as ingredients. The results from the simulation using CSM_B (which includes commodity-specific and cross-commodity CSEs) for all commodities indicate a more modest increase in calorie consumption with removal of agricultural policies in the three periods: an increase in consumption per U.S. adult of 2,495 calories per year in 1992, 1,967 calories per year in 1997, and 1,952 calories per year in 2002. As previously noted the cross-commodity support is treated in the CSE calculation like an additional subsidy applied to all commodities. Therefore when we simulate the effects of removing all agricultural policies, including cross-commodity (i.e., using CSM_B), the measured responses are smaller. The simulation based on CSM_C, shows that the removal of agricultural policies would have caused consumption to increase by 3,410 calories per year for an average U.S. adult in 1992, which implies an increase in body weight of 0.60%; and an increase of 3,061 calories per adult per year in 2002, which implies an increase in body weight of 0.49%. Because the CTEs are constructed specifically to measure distortions to incentives for consumers of agricultural commodities, whereas CSEs are not designed for this purpose, the simulation results based on CSM_C better represent the likely effects from the elimination of agricultural policies in the United States.

Although the results in Table VIII are somewhat mixed, the caloric effects are in every case larger in size than their counterparts from simulations of eliminating only subsidies on grain and oilseed commodities, and opposite in sign. However, in Table VIII all of the 90% confidence intervals for the effects of removing all subsidies, based on CSM_C, include zero; the measured effects are not statistically significantly different from zero (unlike the simulated effects of eliminating subsidies on grains and oilseeds in Table VII, for which none of the 90% confidence intervals includes zero, even though the mean effects are comparatively small). In what follows we discuss the mean values of these posterior distributions, while acknowledging that the estimates are measured imprecisely such that, as well as being absolutely small, the measured effects are not statistically significant.

Across the three different measures of support, the mean estimates indicate that removing all policies would have caused a reduction in consumption of cereals and bakery, meats, eggs, other foods, and non-alcoholic beverages, and an increase in consumption of dairy, fruits and vegetables, and FAFH. On balance, the removal of all agricultural policies would have caused per capita food consumption and caloric intake to increase by between 1,952 and 4,771 calories annually.[13] The results are largest for CSM_A and smallest for CSM_B; bracketing the preferred measures based on CSM_C. The results in Table VIII provide additional evidence that the relationship between agricultural policies and obesity peaked in the period between 1995 and 1999, and that it has diminished over time. In addition, we also ran a set of simulations using elasticities that are double and half of the posterior mean values (reported in Table IV) used to calculate the results in Table VII and Table VIII. Results from these additional simulations show that large changes in elasticities have some effect on the magnitude of our results, increasing or decreasing the impacts roughly in proportion to the changes in elasticities, but do not change the general thrust of our results.

Our results indicate that U.S. agricultural commodity policies, for the most part, have not made food commodities significantly cheaper and have not had a significant effect on caloric consumption. Based on the simulations using CSM_C, eliminating U.S. grain and oilseed subsidies alone would have led to a small decrease in annual per capita caloric consumption—simulated to range between 995 and 1,846 calories per adult per year in the 1990s and early 2000s. This effect is in the direction suggested by many commentators, but much smaller than most of them would have expected. In contrast removing all farm subsidies, including those provided indirectly by trade barriers, would have led to an increase in annual consumption per adult in the range of 3,061 to 3,860 calories, depending on the size of the policy-induced price wedges to be removed. This effect is in the opposite direction from what most pundits have claimed for farm subsidies. Regardless of which measures of agricultural support we use in our simulations, we find that agricultural policies have had fairly small impacts on total caloric consumption, and thus have had little impact on obesity. In addition, our research also provides evidence that the impact of agricultural policies on obesity rates diminished between 1990 and 2004.

5. CONCLUSION

This article provides a careful examination of the linkages between farm policy, food prices, and obesity in the United States. With a few exceptions, farm subsidies have had relatively small and mixed impacts on prices and quantities of farm commodities in the United States. Given the relatively small share of the cost of commodities in the cost of retail food products, the effects in markets for food products are even smaller. Our specific simulation results across a range of scenarios show that removing farm policies for grains and oilseeds alone would have led to a small decrease in caloric consumption. Therefore, the removal of grain and oilseed policies alone appears to be a way to reduce caloric consumption in the United States. But this is an unlikely scenario given the current discussions concerning global agricultural policy reform under the auspices of the WTO. Eliminating all farm subsidy policies, including trade barriers, would cause consumption of some food products to decrease, but would also cause consumption of other food products to increase, and most likely would lead to an increase in overall caloric consumption.

The trend in Figure 1 suggests a direct link between measures of consumer support and obesity in the United States between 1986 and 2007, and in general, our simulation results support this notion. However, we also find that reductions in obesity from removing measures of consumer support for grains, oilseeds, and meats would be outweighed by the increase in obesity from removing consumer support for sugar and dairy, and this support is not captured in Figure 1. In addition, the net effect of agricultural policy on caloric intake decreased between 1990 and

2004. In other words, contrary to common claims in the popular media, farm policies have more likely slowed the rise in obesity in the United States—but any such effects are small. Compared with other factors, the policy-induced differences in relative prices among various farm commodities have played only a tiny role in determining excess food consumption and obesity in the United States, and these effects have been shrinking over time.

This article contributes towards a better understanding of the link between agricultural policy, caloric intake levels, and obesity patterns using detailed data about policy measures, commodity to food parameters, nutrient information, and consumption patterns for a representative basket of food products that includes FAH and FAFH. Our research highlights three interesting issues that are important when examining the implications of agricultural policies on caloric intake patterns in the United States. First, although the overall estimated impact is relatively small, the caloric responses to removing CSMs are not trivial for all food products included in our analysis. For example, removing all agricultural policies would have caused caloric consumption of dairy products to increase by as much as 10,050 calories and consumption of FAFH to increase by as much as 3,521 calories per adult per year. Second, the total caloric response to removing agricultural policies across food categories would be positive—in other words, in aggregate agricultural policies have discouraged food consumption and mitigated the effects of other factors that have encouraged obesity. Third, agricultural support had a stronger link to caloric intake in 1992 than in 2002. The dampening effect on consumption from agricultural policies appears to diminishing over time, and this result holds under all three CSMs in our analysis. It reflects both a decline in the distortions in farm commodity prices and decreasing relative importance of farm commodities in total food costs.

Farm commodities have indeed become much more abundant and cheaper generally over the past 50 years in the world as a whole as well as in the United States, but not because of subsidies. This abundance mainly reflects the effects of technological innovations and increases in farm productivity, which has alleviated hunger and poverty throughout the world while at the same time reducing pressure on the world's natural resources. If cheaper and more abundant food has contributed to obesity, then we should look to innovations in production agriculture rather than farm subsidies as the fundamental cause. Even so, it would be a mistake to seek to oppose and slow agricultural innovation with a view to reducing obesity rates. The challenge for policymakers is to find other—more effective and more economically rational—ways to reduce the social consequences of excess food consumption while at the same time enhancing consumption opportunities for the poor and protecting the world's resources for future generations.

Footnotes

[1] Articles in the popular press often draw links between U.S. farm policies and increased rates of obesity (e.g., Bittman, 2011; Harrison, 2011).

[2] U.S. border measures also exist for a wide range of processed fruits and vegetables and in some cases these are significant barriers. For example, the U.S. tariff applied to frozen concentrated orange juice is approximately 33% (Brown, Spreen, and Lee 2004). However, these measures are not included in the CSEs or CTEs and we do not explicitly include agricultural policies applied to frozen concentrated orange juice or other highly processed fruits and vegetables in our analysis.

[3] Similarly, Gardner (1987), Piggott (1992), Alston, Norton, and Pardey (1995), and Alston and James (2002) used variations of the two-input, one-output model to examine the impact of various farm policies on consumer prices and consumption.

[4] Superscripts on variables denote products, and the subscripts denote the farm commodities and composite marketing input. For the rest of this article, the term 'commodities' refers to both farm commodities and the composite marketing input.

[5] Suppose the technology for the industry producing product n can be expressed as a total cost function in which the total cost of producing the nth retail product, C^n is a function of an $L \times 1$ vector of prices of farm commodities and the marketing input, $\mathbf{W}$ and the quantity of the product, Q^n, i.e., $C^n = c^n(\mathbf{W})Q^n$. Under the assumption of constant returns to scale, the average cost per unit of product n is equivalent to its marginal cost (i.e., $C^n / Q^n = c^n(\mathbf{W})$), and, under the further assumption of competitive market equilibrium with no price distortions, marginal cost and average cost are equal to the retail price, P^n.

[6] An anonymous reviewer noted that the assumption of fixed factors of production may be too restrictive when discussing the effects of farm policies in sweetener markets where, historically, manufacturers have substituted away from sugar and into high fructose corn syrup (HFCS) in response to artificially high sugar prices. Indeed, if sugar and HFCS were allowed to be substitutes in food production, most likely the effect of removal of farm policies applied to sugar and corn on consumption of retail food products and hence calorie consumption, as reported in this analysis, would be dampened. However, since the retail-farm cost share for sugar is very small it is unlikely that allowing for substitution between sugar and corn commodities will have a large impact on overall caloric consumption. See Beghin and Jensen (2008) for more details.

[7] Note that $\varepsilon_{l,Bl} = \varepsilon_{ll}(\partial W_l / \partial B_l)(B_l / W_l)$, or $\beta_l = \varepsilon_{ll}(\overline{\beta}_l)$. Hence, (17) becomes

$$(24) \qquad \mathrm{E}X_l = \sum_{j=1, j\neq l}^{L} \varepsilon_{lj}\left(\mathrm{E}W_j + s_j\right) + \varepsilon_{ll}\left(\mathrm{E}W_l + \overline{\beta}_l + s_l\right).$$

The limit of this equation as $\varepsilon_{ll} \to \infty$ is

(25) $$\lim_{\varepsilon_{ll}\to\infty}\left[\frac{1}{\varepsilon_{ll}}\left(\mathrm{E}X_l-\sum\nolimits_{j=1,j\neq l}^{L}\varepsilon_{lj}\left(\mathrm{E}W_j+s_j\right)\right)\right]=0=\mathrm{E}W_l+\overline{\beta}_l+s_l.$$

[8] Data from the food recall surveys sample individuals in northern states in the summer and individuals in southern states in the winter. Diets can be highly seasonal and vary geographically across the United States, and this may influence the results from analyses that use such data (Curtin and Mohadjer, 2010).

[9] The relationship between caloric consumption and obesity is clearly much more complex than this use of a simple, fixed multiplier would suggest, with significant nonlinear and dynamic aspects; nevertheless, such treatments are common in models of obesity and policy. In the analysis of this paper, we are simulating a change in policy of the type that would typically be implemented on an enduring basis. The resulting changes in consumption would therefore be continuing, and the consequent annual changes in bodyweight would be cumulative. We abstract from the detail of these difficult dynamics in our analysis, which is explicitly comparative static in nature. However, we deal with them effectively through our use of multiplier that is consistent with the steady-state impacts of policy changes. A small number of studies have estimated the change in steady-state weight for a permanent change in caloric consumption, which is a relevant concept for our context. Hall, *et al.* (2009) developed a formula (equation (14, p. 5), which implies that an increase in consumption of 220 kcal per day would be consistent with an increase in body weight of 10 kg (which translates approximately to 10 kcal per day per pound increase of steady state-body weight). Hall and Jordan (2008) reported tables of multipliers such that, for a 115 kg man or a 90 kg woman, a permanent decrease in consumption of 100 kcal per day would result in a steady-state weight loss of 6.4 kg, which translates to 7.1 kcal per day per pound. The figure of 3,500 kcal per pound is equivalent to 9.6 kcal per day per pound, which falls between the estimates from Hall, *et al.* (2009) and Hall and Jordan (2008). See, also, Hall, *et al.* (2011).

[10] Okrent and Alston (2011) estimated a demand system (the National Bureau of Research Model, Neves 1987) for the nine food categories using annual data on Personal Consumption Expenditures and Fisher-Ideal price indexes between 1960 and 2009 (U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, 2010). They found their estimates (a) were broadly comparable to others in the food demand literature, in terms of the magnitudes and plausibility of the elasticities, and (b) provided generally more accurate predictions of past changes in quantities based on past changes in prices and total expenditure.

[11] The Benchmark Input-Output Accounts are published every five years with the most recent publication reflecting the 2002 Economic Census estimates. Hence, our analysis is restricted to years 1992, 1997 and 2002. The 2007 Benchmark Input-Output Accounts will be published in 2012.

[12] We calculated the 10 percent confidence intervals using the percentile method (Cameron and Trivedi 2005, p. 365). The estimated caloric changes from the 1,110 draws were ordered and the lower and upper 5 percentiles were reported as the lower and upper bounds of the confidence interval.

[13] As a rough estimate, removing U.S. tariffs applied to frozen concentrated orange juice would likely lead to an additional increase in consumption of 0.53 calories per day per adult, or 192 calories annually. This calculation is based on four assumptions (i) the average annual consumption of frozen concentrate orange juice in the United States is 1,168 calories per adult, (ii) the tariff rates is 33%, the (iii) demand elasticity is – 0.5, and (iv) no substitution between frozen concentrated orange juice and other beverage products.

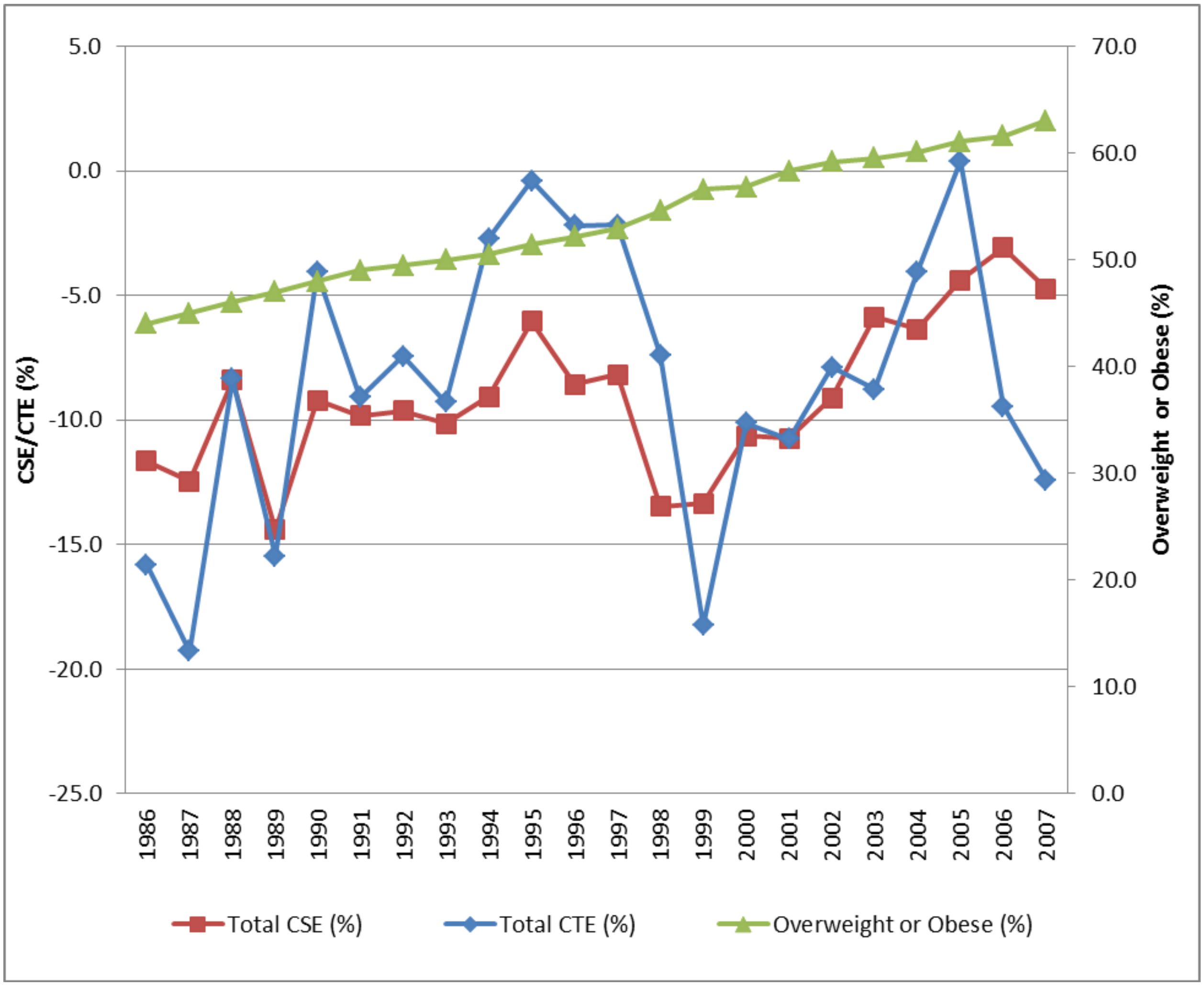

Figure 1. CSEs, CTEs, and the rate of obesity in the United States (1986 to 2007)[a]

[a] We multiply the reported CTEs by –1.0 so that they represent rates of consumer support rather than rates of consumer taxes.

Sources: Anderson et al. (2008); OECD (2010); CDC (2009)

Table I. Reported CSEs and CTEs for U.S. agricultural commodities in selected periods

Commodity	CSE (%) Negative values imply a consumer tax			CTE (%) Positive values imply a consumer tax		
	1992	1997	2002	1992	1997	2002
	Average rate for five-year period from:					
	1990 to 1994	1995 to 1999	2000 to 2004	1990 to 1994	1995 to 1999	2000 to 2004
Barley	-15.9	-0.4	0	7.4	-9.3	-11.7
Beef	-1.0	0	-0.1	-6.9	-9.6	-8.7
Cotton	-2.3	-1.5	1.0	24.6	27.8	70.0
Eggs	-7.3	-2.0	0	-1.1	-6.7	-8.8
Maize	0	0	0.4	-14.3	-15.7	-17.9
Milk	-37.4	-42.6	-37.1	38.6	55.6	40.3
Pork	-1.9	0	0	-12.4	-18.1	-19.1
Potato[a]	n/a	n/a	n/a	0	0	0
Poultry	-1.2	-0.3	-0.1	-9.1	-9.2	-9.4
Rice	-1.8	-0.1	0	-13.9	-15.9	-20.11
Sheepmeat	-1.2	-2.4	-9.0	1.2	2.6	9.9
Sorghum	0	0	0.6	-13.2	-15.3	-21.4
Soybean	0	0	0.1	-3.5	-3.4	-3.8
Sugar	-55.7	-57.6	-64.7	108.2	130.7	152.0
Wheat	-14.8	-0.3	0.1	-2.5	-17.1	-19.3
Wool	-0.9	-0.9	-1.2	0.9	1.0	1.3

[a] CSEs are provided for fourteen agricultural commodities and CTEs are provided for fifteen commodities; no CSE is provided for potatoes.

Sources: OECD (2010); Anderson *et al*. (2008)

Table II. Calculated measures of consumer support for commodities in our analysis[a]

Commodities	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
	1992	1997	2002	1992	1997	2002	1992	1997	2002
	Average percentage rate for five-year period from:								
	1990 to 1994	1995 to 1999	2000 to 2004	1990 to 1994	1995 to 1999	2000 to 2004	1990 to 1994	1995 to 1999	2000 to 2004
Oil-bearing crops	0.0	0.0	0.0	11.3	12.0	12.6	3.5	3.4	3.8
Grain crops[b]	-3.4	-0.1	0.0	7.5	11.9	12.6	11.2	15.8	18.0
Vegetables and melons	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
Fruits and tree nuts	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
Sugar cane and beets	-55.6	-57.6	-64.7	-50.7	-52.5	-60.2	-108.2	-130.7	-152.0
Other crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat[c]	-1.2	0.0	-0.2	10.0	12.0	12.4	8.2	11.5	10.7
Dairy cattle	-37.4	-42.2	-37.1	-30.3	-35.3	-29.2	-38.6	-55.6	-40.3
Poultry and eggs[d]	-2.5	-0.6	0.0	8.5	11.3	12.6	7.3	8.7	9.3
Fish and aquaculture	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4

Measures of support based on: CSE, CSE plus, CTE.

[a] Calculations for CSM_A are based on the reported CSE values for individual commodities; calculations for CSM_B are based on reported CSE values for individual commodities and also include a share of total cross-commodity support weighted by consumption; calculations for CSM_C are based on reported CTE values. For all three CSMs we aggregate support reported for grain commodities, meat commodities, and poultry and eggs; we also add support measures for vegetables and melons, fruits and tree nuts, and fish and aquaculture.

[b] Measure of support for grain crops is a five-year average weighted by value of consumption for corn, wheat, barley, and rice (OECD, 2010).

[c] Measure of support for meats is a five-year average weighted on value by consumption for beef, pork, and sheepmeat (OECD, 2010).

[d] Measure of support for poultry and eggs is a five-year average weighted by value of consumption for poultry and eggs (OECD, 2010).

Table III. Food-to-calorie parameters for nine food categories in selected years

Food category	Average Daily Intake[a]					
	1992[b]		1997[c]		2002[d]	
	Grams	Calories	Grams	Calories	Grams	Calories
Total	1,971.7	1,882.2	2,146.8	2,019.2	2,343.9	2,168.6
FAH						
Cereals and bakery	147.6	358.5	148.1	378.5	136.3	352.4
Meat	70.7	165.6	59.6	143.9	63.7	150.5
Eggs	11.5	19.9	12.3	21.9	16.2	27.7
Dairy	220.0	167.1	220.5	169.8	229.9	195.2
Fruits and vegetables	221.1	154.9	226.4	148.9	212.1	140.6
Other food	191.5	345.4	205.6	356.2	209.9	400.0
Nonalcoholic beverages	560.5	106.6	636.8	139.5	676.7	163.5
FAFH	560.7	576.6	621.6	659.7	772.5	733.4
Alcohol	60.2	29.4	101.4	48.2	160.1	72.2

[a] Average daily intake represents average amounts of food consumed by category for adults in the periods shown, based on survey information.

[b] Data taken from CSFII 1989-91 (USDA-ARS, 1993)
[c] Data taken from CSFII 1994-96, 98 (USDA-ARS, 2000)
[d] Data taken from NHANES 2001-02 survey (CDC, NCHS, 2003).

Table IV. Simulated Marshallian elasticities of demand that satisfy curvature and monotonicity for FAH and FAFH products

Elasticity of Demand for	With Respect to Price of										With Respect to Expenditure on
	Cereals and bakery	Meat	Eggs	Dairy	Fruits and vegetables	Other Food	Non-alcoholic beverages	FAFH	Alcoholic beverages	Nonfood	
Cereals and bakery	-0.98	0.07	0.02	0.11	0.17	0.43	-0.05	-0.36	-0.08	0.46	0.21
	(0.13)	(0.09)	(0.03)	(0.09)	(0.09)	(0.09)	(0.06)	(0.18)	(0.12)	(0.36)	(0.25)
Meat	0.03	-0.51	0.05	0.01	0.14	-0.09	-0.10	0.21	0.18	-0.67	0.75
	(0.05)	(0.10)	(0.02)	(0.05)	(0.05)	(0.06)	(0.05)	(0.09)	(0.06)	(0.32)	(0.31)
Eggs	0.23	0.96	-0.74	0.66	-0.48	-0.53	0.28	0.22	-0.19	0.28	-0.69
	(0.29)	(0.34)	(0.14)	(0.27)	(0.29)	(0.31)	(0.22)	(0.52)	(0.35)	(1.25)	(0.93)
Dairy	0.13	0.02	0.08	-0.94	-0.07	0.24	0.19	-0.21	0.15	-0.51	0.92
	(0.11)	(0.11)	(0.03)	(0.13)	(0.10)	(0.11)	(0.07)	(0.20)	(0.13)	(0.44)	(0.32)
Fruits and vegetables	0.18	0.28	-0.05	-0.05	-0.63	-0.12	0.12	0.12	-0.04	-0.15	0.35
	(0.10)	(0.10)	(0.03)	(0.09)	(0.13)	(0.09)	(0.06)	(0.18)	(0.12)	(0.37)	(0.26)
Other food	0.31	-0.11	-0.04	0.14	-0.09	-0.65	0.05	0.16	0.01	-0.50	0.72
	(0.07)	(0.08)	(0.02)	(0.07)	(0.07)	(0.11)	(0.06)	(0.11)	(0.08)	(0.31)	(0.26)
Nonalcoholic beverages	-0.08	-0.25	0.03	0.20	0.14	0.09	-0.78	-0.04	0.15	-0.36	0.90
	(0.08)	(0.12)	(0.03)	(0.08)	(0.08)	(0.10)	(0.10)	(0.13)	(0.09)	(0.42)	(0.36)
FAFH	-0.13	0.12	0.01	-0.06	0.03	0.07	-0.01	-0.64	-0.10	-0.17	0.89
	(0.06)	(0.05)	(0.02)	(0.05)	(0.06)	(0.05)	(0.03)	(0.17)	(0.08)	(0.22)	(0.13)
Alcoholic beverages	-0.06	0.23	-0.01	0.08	-0.03	0.01	0.08	-0.18	-0.57	-0.04	0.49
	(0.08)	(0.07)	(0.02)	(0.07)	(0.08)	(0.07)	(0.05)	(0.16)	(0.14)	(0.31)	(0.19)
Nonfood	-0.00	-0.03	-0.00	-0.01	-0.01	-0.02	-0.01	-0.02	-0.01	-0.95	1.06
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.03)	(0.02)

Notes: Simulations were based on estimates of parameters and their covariances from Okrent and Alston (2011). The means of the empirical posterior distributions of the elasticities of demand are reported and their standard deviations are in parentheses.

Table V. Farm-retail cost shares

Year	*Farm Commodity/ Input*	Cereals and bakery	Meat	Eggs	Dairy	Fruits and vegetables	Other food	Nonalcoholic beverages	FAFH	Alcoholic beverages
		Food Category								
1992	Oilseeds	0.004	0.000	0.000	0.000	0.000	0.075	0.000	0.003	0.000
	Food grains	0.074	0.000	0.000	0.000	0.000	0.026	0.000	0.005	0.011
	Vegetables and melons	0.000	0.000	0.000	0.000	0.238	0.010	0.000	0.007	0.000
	Fruits and tree nuts	0.001	0.000	0.000	0.000	0.233	0.014	0.047	0.004	0.013
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.001	0.000
	Other crops	0.001	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.003
	Beef and Hogs	0.000	0.349	0.000	0.000	0.000	0.002	0.000	0.028	0.000
	Dairy farming	0.000	0.000	0.000	0.316	0.000	0.000	0.000	0.016	0.000
	Poultry and Eggs	0.000	0.106	0.759	0.000	0.000	0.001	0.000	0.010	0.000
	Fish	0.000	0.052	0.000	0.000	0.000	0.001	0.000	0.008	0.000
	Marketing inputs	0.920	0.493	0.241	0.684	0.529	0.847	0.953	0.918	0.973
1997	Oilseeds	0.000	0.000	0.000	0.000	0.000	0.081	0.000	0.005	0.000
	Food grains	0.085	0.000	0.000	0.000	0.002	0.030	0.000	0.009	0.009
	Vegetables and melons	0.000	0.000	0.000	0.000	0.236	0.014	0.000	0.006	0.000
	Fruits and tree nuts	0.001	0.000	0.000	0.000	0.224	0.024	0.060	0.004	0.024
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.001	0.000
	Other crops	0.001	0.000	0.000	0.000	0.001	0.009	0.002	0.001	0.003
	Beef and Hogs	0.000	0.282	0.000	0.000	0.000	0.003	0.000	0.028	0.000
	Dairy farming	0.000	0.000	0.000	0.296	0.000	0.000	0.000	0.017	0.000
	Poultry and Eggs	0.000	0.123	0.738	0.000	0.000	0.008	0.000	0.014	0.000
	Fish	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.011	0.000
	Marketing inputs	0.913	0.543	0.262	0.704	0.538	0.817	0.939	0.905	0.964
2002	Oilseeds	0.000	0.000	0.000	0.000	0.000	0.062	0.000	0.003	0.000
	Food grains	0.059	0.000	0.000	0.000	0.003	0.034	0.000	0.004	0.016
	Vegetables and melons	0.000	0.000	0.000	0.000	0.272	0.017	0.000	0.002	0.000
	Fruits and tree nuts	0.003	0.000	0.000	0.001	0.206	0.018	0.029	0.002	0.021
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.001	0.000
	Other crops	0.001	0.000	0.000	0.000	0.000	0.021	0.004	0.001	0.002
	Beef and Hogs	0.000	0.263	0.000	0.000	0.000	0.003	0.000	0.014	0.000
	Dairy farming	0.000	0.000	0.000	0.274	0.000	0.001	0.000	0.010	0.000
	Poultry and Eggs	0.006	0.092	0.685	0.002	0.001	0.004	0.000	0.005	0.000
	Fish	0.000	0.064	0.000	0.000	0.004	0.000	0.000	0.007	0.000
	Marketing inputs	0.931	0.580	0.315	0.723	0.514	0.826	0.967	0.953	0.960

Source: Authors' calculations based on 1992, 1997 and 2002 Benchmark Input-Output Detailed Use Table after redefinitions (USDC-BEA 1997, 2002, 2007).

Table VI. Farm-commodity cost shares

Year	*Farm Commodity/ Input*	Cereals and bakery	Meat	Eggs	Dairy	Fruits and vegetables	Other food	Nonalcoholic beverages	FAFH	Alcoholic beverages
		Food Category								
1992	Oilseeds	0.026	0.000	0.000	0.000	0.000	0.860	0.000	0.114	0.000
	Food grains	0.485	0.000	0.000	0.000	0.000	0.295	0.000	0.177	0.043
	Vegetables and melons	0.000	0.000	0.000	0.000	0.735	0.085	0.000	0.180	0.000
	Fruits and tree nuts	0.005	0.000	0.000	0.000	0.653	0.106	0.107	0.095	0.033
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.889	0.000	0.111	0.000
	Other crops	0.058	0.000	0.000	0.000	0.021	0.607	0.001	0.161	0.152
	Beef and Hogs	0.000	0.785	0.000	0.000	0.000	0.004	0.000	0.211	0.000
	Dairy farming	0.000	0.000	0.000	0.743	0.000	0.000	0.000	0.257	0.000
	Poultry and Eggs	0.000	0.656	0.137	0.000	0.000	0.008	0.000	0.199	0.000
	Fish	0.000	0.660	0.000	0.000	0.000	0.011	0.000	0.329	0.000
	Marketing inputs	0.088	0.080	0.001	0.055	0.034	0.143	0.049	0.493	0.056
1997	Oilseeds	0.000	0.000	0.000	0.000	0.000	0.842	0.000	0.158	0.000
	Food grains	0.435	0.000	0.000	0.000	0.006	0.263	0.000	0.269	0.027
	Vegetables and melons	0.001	0.000	0.000	0.000	0.739	0.108	0.000	0.153	0.000
	Fruits and tree nuts	0.002	0.000	0.000	0.000	0.571	0.153	0.129	0.095	0.051
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.842	0.000	0.158	0.000
	Other crops	0.045	0.000	0.000	0.000	0.015	0.672	0.038	0.162	0.066
	Beef and Hogs	0.000	0.742	0.000	0.000	0.000	0.008	0.000	0.251	0.000
	Dairy farming	0.000	0.000	0.000	0.692	0.000	0.002	0.000	0.306	0.000
	Poultry and Eggs	0.000	0.603	0.122	0.000	0.000	0.038	0.000	0.237	0.000
	Fish	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.408	0.000
	Marketing inputs	0.087	0.087	0.001	0.052	0.035	0.134	0.052	0.499	0.052
2002	Oilseeds	0.000	0.000	0.000	0.000	0.000	0.854	0.000	0.146	0.000
	Food grains	0.382	0.000	0.000	0.000	0.013	0.382	0.000	0.166	0.057
	Vegetables and melons	0.000	0.000	0.000	0.000	0.834	0.113	0.000	0.053	0.000
	Fruits and tree nuts	0.011	0.000	0.000	0.004	0.682	0.135	0.066	0.052	0.049
	Sugar cane and beets	0.000	0.000	0.000	0.000	0.000	0.854	0.000	0.146	0.000
	Other crops	0.019	0.000	0.000	0.000	0.000	0.767	0.043	0.143	0.028
	Beef and Hogs	0.000	0.821	0.000	0.000	0.000	0.009	0.000	0.170	0.000
	Dairy farming	0.000	0.000	0.000	0.770	0.000	0.005	0.000	0.225	0.000
	Poultry and Eggs	0.025	0.647	0.152	0.007	0.002	0.027	0.000	0.139	0.000
	Fish	0.000	0.682	0.000	0.000	0.019	0.003	0.000	0.297	0.000
	Marketing inputs	0.078	0.085	0.001	0.049	0.033	0.119	0.043	0.547	0.044

Source: Authors' calculations based on 1992, 1997 and 2002 Benchmark Input-Output Detailed Use Table after redefinitions (USDC-BEA 1997, 2002, 2007).

Table VII. Effects of grain and oilseed policies on food and calorie consumption

Food category	Elimination of consumer support measure based on:								
	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
	1992	1997	2002	1992	1997	2002	1992	1997	2002
	Percentage Change in Consumption by Food Category								
FAH									
Cereals and bakery	0.22	0.01	0.00	-0.17	-0.49	-0.25	-0.62	-1.07	-0.72
Meats	-0.01	-0.00	0.00	-0.04	-0.03	-0.02	0.01	0.04	0.03
Eggs	-0.01	-0.00	0.00	-0.41	-0.46	-0.50	-0.10	-0.09	-0.26
Dairy	-0.06	-0.00	0.00	0.33	0.43	0.40	0.25	0.34	0.37
Fruits and vegetables	-0.03	-0.00	0.00	-0.01	0.02	-0.03	0.09	0.15	0.05
Other foods	-0.02	-0.00	0.00	-0.48	-0.53	-0.55	-0.08	-0.04	-0.21
Nonalcoholic beverages	0.01	0.00	0.00	0.05	0.05	0.08	-0.00	-0.02	0.04
FAFH	0.04	0.00	0.00	-0.06	-0.16	-0.09	-0.13	-0.24	-0.16
Alcoholic beverages	0.04	0.00	0.00	-0.08	-0.14	-0.16	-0.12	-0.18	-0.24
	Annual Change in Per Capita Caloric Intake (kcal) by Food Category								
FAH									
Cereals and bakery	284	10	0	-221	-671	-318	-810	-1,472	-927
Meats	-6	0	0	-25	-14	-13	8	21	19
Eggs	-1	0	0	-30	-37	-51	-7	-7	-27
Dairy	-34	-1	0	198	269	286	150	213	264
Fruits and vegetables	-20	-1	0	-7	13	-17	49	79	28
Other foods	-31	-1	0	-603	-683	-799	-106	-58	-313
Nonalcoholic beverages	3	0	0	21	26	49	0	-9	25
FAFH	86	4	0	-129	-379	-232	-264	-580	-425
Alcoholic beverages	4	0	0	-9	-24	-43	-13	-32	-62
	Change in Total Per Capita Annual Caloric Consumption and Steady-State Weight[a]								
Consumption (kcal)	285	11	0	-804	-1,500	-1,136	-995	-1,846	-1,419
	(206, 368)	(8, 15)	(0, 0)	(-1,154, -465)	(-2,013, -981)	(-1,617, -656)	(-1,286, -709)	(-2,352, -1,346)	(-1,892, -941)
Weight (lb)[b]	0.08	0.00	0.00	-0.23	-0.43	-0.32	-0.28	-0.53	-0.41
	(0.06, 0.11)	(0, 0)	(0, 0)	(-0.33, -0.13)	(-0.58, -0.28)	(-0.46, -0.19)	(-0.37, -0.20)	(-0.67, -0.38)	(-0.54, -0.27)
Weight (%)[c]	0.05	0.00	0.00	-0.14	-0.26	-0.18	-0.17	-0.32	-0.23
	(0.04, 0.07)	(0, 0)	(0, 0)	(-0.20, -0.08)	(-0.35, -0.17)	(-0.26, -0.11)	(-0.23, -0.12)	(-0.40, -0.23)	(-0.31, -0.15)

[a] The means from the empirical posterior distributions of percentage changes in quantities of foods consumed, caloric intake and changes in body weight are reported, and the numbers in parentheses represent the 90% confidence intervals for the means.
[b] The calculation here assumes that additional consumption of 3,500 kcals per year adds one pound to steady-state body weight (Whitney, Cataldo, Rolfes 1994; Hall et al. 2011).
[c] Average body weight of an adult individual was 162.0 pounds in the CSFII 1989-91 (USDA-ARS, 1993), 166.3 pounds in the CSFII 1994-96, 98 (USDA-ARS, 2000), and 176.3 pounds in the NHANES 2001-02 survey (CDC, NCHS, 2003). Body weight is self reported in both CSFII whereas body weight is measured in the NHANES.

Table VIII. Effects of eliminating all agricultural policies on food and calorie consumption

Food category	Elimination of consumer support measure based on:								
	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
	1992	1997	2002	1992	1997	2002	1992	1997	2002
	Percentage Change in Consumption by Food Category								
FAH									
Cereals and bakery	-1.83	-1.94	-1.83	-1.57	-1.82	-1.46	-2.80	-3.48	-2.82
Meats	-0.56	-0.81	-0.79	-2.60	-2.70	-2.55	-2.18	-2.55	-2.20
Eggs	-4.87	-5.94	-4.39	-5.08	-6.90	-5.56	-6.01	-9.02	-5.78
Dairy	10.91	11.76	9.54	9.84	10.98	8.63	11.93	16.22	11.02
Fruits and vegetables	2.18	2.29	2.32	3.11	3.14	2.99	3.29	3.62	3.26
Other foods	-0.77	-1.11	-0.72	-1.81	-2.27	-1.83	-0.97	-1.85	-1.00
Nonalcoholic beverages	-2.65	-2.84	-2.53	-3.14	-3.29	-2.83	-3.65	-4.58	-3.46
FAFH	0.97	1.09	0.73	1.05	1.05	0.89	1.12	1.46	0.94
Alcoholic beverages	-0.75	-0.69	-0.53	0.24	0.19	0.31	-0.14	-0.37	-0.13
	Annual Change in Per Capita Caloric Intake (kcal) by Food Category								
FAH									
Cereals and bakery	-2,392	-2,677	-2,348	-2,059	-2,510	-1,872	-3,663	-4,813	-3,624
Meats	-337	-424	-434	-1,570	-1,416	-1,403	-1,320	-1,338	-1,207
Eggs	-354	-475	-444	-368	-552	-562	-436	-722	-584
Dairy	6,651	7,290	6,801	6,002	6,802	6,149	7,274	10,050	7,853
Fruits and vegetables	1,234	1,242	1,189	1,757	1,706	1,535	1,857	1,967	1,674
Other foods	-972	-1,438	-1,047	-2,284	-2,957	-2,675	-1,222	-2,407	-1,458
Nonalcoholic beverages	-1,031	-1,445	-1,509	-1,222	-1,675	-1,691	-1,420	-2,332	-2,068
FAFH	2,052	2,633	1,954	2,212	2,535	2,390	2,355	3,521	2,509
Alcoholic beverages	-80	-122	-141	26	33	81	-15	-65	-35
	Change in Total Per Capita Annual Caloric Consumption and Steady-State Weight[a]								
Consumption (kcal)	4,771	4,583	4,021	2,495	1,967	1,952	3,410	3,860	3,061
	(1,187, 8,731)	(442, 9,116)	(393, 8,075)	(-1,084, 6,106)	(-2,289, 6,273)	(-1,880, 5,782)	(-619, 7,730)	(-1,961, 9,928)	(-1,374, 7,753)
Weight (lb)[b]	1.36	1.31	1.15	0.71	0.56	0.56	0.97	1.10	0.87
	(0.34, 2.49)	(0.13, 2.60)	(0.11, 2.31)	(-0.31, 1.74)	(-0.65, 1.79)	(-0.54, 1.65)	(-0.18, 2.21)	(-0.56, 2.84)	(-0.39, 2.22)
Weight (%)[c]	0.84	0.79	0.65	0.44	0.34	0.32	0.60	0.66	0.49
	(0.21, 1.54)	(0.08, 1.56)	(0.06, 1.31)	(-0.19, 1.07)	(-0.39, 1.08)	(-0.31, 0.94)	(-0.11, 1.36)	(-0.34, 1.71)	(-0.22, 1.26)

[a] The means from the empirical posterior distributions of percentage changes in quantities of foods consumed, caloric intake and changes in body weight are reported, and the numbers in parentheses represent the 90% confidence intervals for the means.
[b] The calculation here assumes that additional consumption of 3,500 kcals per year adds one pound to steady-state body weight (Whitney, Cataldo, Rolfes 1994; Hall et al. 2011).
[c] Average body weight of an adult individual was 162.0 pounds in the CSFII 1989-91 (USDA-ARS, 1993), 166.3 pounds in the CSFII 1994-96, 98 (USDA-ARS, 2000), and 176.3 pounds in the NHANES 2001-02 survey (CDC, NCHS, 2003). Body weight is self reported in both CSFII whereas body weight is measured in the NHANES.

REFERENCES

Allais O, Bertail P, Nichèle V. 2010. The effects of a fat tax on French households' purchases: a nutritional approach. *American Journal of Agricultural Economics* **92**: 228–245.

Alston JM, James JS. 2002. The Incidence of Agricultural Policy. In: Gardner BL, Rausser GC (Eds). Handbook of Agricultural Economics. Elsevier Science BV, Amsterdam, pp. 1690–1743.

Alston JM, Norton GW, Pardey PG. 1995. Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. Cornell University Press, Ithaca, New York.

Alston JA, Sumner DA. 2007. Perspectives on farm policy reform. *Journal of Agricultural and Resource Economics* **32**: 1–19.

Alston JA, Sumner DA, Vosti SA. 2006. Are agricultural policies making us fat? Likely links between agricultural policies and human nutrition and obesity, and their policy implications. *Review of Agricultural Economics* **28**: 313–322.

Alston JA, Sumner DA, Vosti SA. 2008. Farm subsidies and obesity in the United States: national evidence and international comparisons. *Food Policy* **33**: 470–479.

Anderson K, Kurzweil M, Martin W, Sandri D, Valenzuela E. 2008. Methodology for Measuring Distortions to Agricultural Incentives. Agricultural Distortions Working Paper No. 2, Development Research Group, World Bank, Washington, D.C. Available at: http://ageconsearch.umn.edu/handle/48326.

Beghin JC, Jensen HH. 2008. Farm policies and added sugars in U.S. diets. *Food Policy* **33**: 480–488.

Bils M, Klenow PJ. 2004. Some evidence on the importance of sticky prices. *Journal of Political Economy* **112**: 947–985.

Bittman M. 2011. Don't end agricultural subsidies, fix them. *New York Times*. Available at: http://opinionator.blogs.nytimes.com/2011/03/01/dont-end-agricultural-subsidies-fix-them/.

Bonnet C, Requillart V. 2011. Does the EU sugar policy reform increase added sugar consumption? An empirical evidence on the soft drink market. *Health Economics* **20**: 1012–1024.

Brown MG, Spreen TH, Lee J-Y. 2004. Impacts on U.S. prices of reducing orange juice tariffs in major world markets. *Journal of Food Distribution Research* **35**: 26–33.

Cameron AC, Trivedi PK. 2005. Microeconometrics: Methods and Applications. Cambridge University Press, New York, New York.

Cash SB, Sunding DL, Zilberman D. 2005. Fat taxes and thin subsidies: prices, diet, and health outcomes. *Acta Agriculturae Scandinavica* **C2** (3/4): 167–174.

Center for Disease Control, National Center for Health Statistics (CDC, NCHS), 2003. National Health and Nutrition Examination Survey. 2001–2002. U.S. Department of Health and Human Services, Hyattsville, MD. Available at: http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.

Centers for Disease Control and Prevention (CDC). 2009. Behavioral Risk Factor Surveillance System Survey Data. U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.

Chalfant J, Gray RS, White KJ. 1991. Evaluating prior beliefs in a demand system: The case of meat demand in Canada. *American Journal of Agricultural Economics* **73**:476–490.

Chou S, Grossman M, Saffer H. 2004. An economic analysis of adult obesity: results from the behavioral risk factor surveillance system. *Journal of Health Economics* **23**: 565–587.

Chouinard HH, Davis DE, LaFrance JT, Perloff JM. 2007. Fat taxes: big money for small change. *Forum for Health Economics & Obesity* **10**(2).

Cox A, Schmidt C. 2003. Subsidies in the OECD Fisheries Sector: A Review of Recent Analysis and Future Directions. Background Paper for the FAO Expert Consultation on Identifying, Assessing and Reporting on Subsidies in the Fishing Industry. Paris, France.

Curtin LR, Mohadjer L. 2010. Design Trade-offs for the National Health and Nutrition Examination Survey. In: Aday LA, Cynamon M (Eds). Health Survey Research Methods. U.S. Department of Health and Human Services, Washington DC, pp. 284–292. Available at: http://www.cdc.gov/nchs/data/misc/proceedings_hsrm2010.pdf

Cutler D, Glaeser E, Shapiro J. 2003. Why have Americans become more obese? *Journal of Economic Perspectives* **17**: 93–118.

Donovan J, Krissoff B. 2001. Trade Issues Facing U.S. Horticulture in the WTO Negotiations. Outlook Report No. VGS-285-01. Economic Research Service, USDA, Washington, DC.

Flegal KM, Carroll MD, Ogden CL, Curtin LR. 2010. Prevalence and trends in obesity among US adults, 1999–2008. *Journal of the American Medical Association* **303**: 235–241.

Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. 1998. Overweight and obesity in the United States: prevalence and trends, 1960-1994. *International Journal of Obesity Related Metabolic Disord*ers **22**: 39-47.

Floyd JE. 1965. The effects of farm price supports on the returns to land and labor in agriculture. *Journal of Political Economy* **73**: 148-158.

Gardner BL. 1975. The farm-retail price spread in a competitive food industry. *American Journal of Agricultural Economics* **57**: 339–409.

Gardner BL. 1987. The Economics of Agricultural Policies. MacMillan, New York, NY.

Gibson P, Wainio J, Whitley D, Bohman M. 2001. Profiles of Tariffs in Global Agricultural Markets. Agricultural Economic Report Number 796. Economic Research Service, United States Department of Agriculture, Washington, DC.

Hall KD, Guo J, Dore M, Chow CC. 2009. The Progressive Increase of Food Waste in America and Its Environmental Impact. *PLoS ONE* **4**: e7940 1–6. Available at: http://www.plosone.org/article/info:doi/10.1371/journal.pone.0007940.

Hall KD, Jordan PN. 2008. Modeling weight-loss maintenance to prevent body weight regain. *American Journal of Clinical Nutrition* **88**: 1495–1503.

Hall KD, Sacks G, Chandramohan D, Chow CC, Wang YC, Gortmaker SL, Swinburn BA. 2011. Quantification of the effect of energy imbalance on bodyweight. *The Lancet* **378**: 826–837.

Harrison C. 2011. ‘Time to Trim’ Winners. *Slate*.
Available at: http://hive.slate.com/hive/time-to-trim/article/time-to-trim-winners.

Johnson D, Krissoff B, Young E, Hoffman L, Lucier G, Breneman V. 2006. Eliminating Fruit and Vegetable Planting Restrictions: How Would Markets Adjust? Economic Research Report Number 30. Economic Research Service, United States Department of Agriculture, Washington, DC.

Josling T, Tangermann S. 1999. Implementation of the WTO agreement on agriculture and developments for the next round of negotiations. *European Review of Agricultural Economics* **26**: 371–388.

Karov V, Roberts D, Grant JH, Peterson EB. 2009. A Preliminary Empirical Assessment of the Effect of Phytosanitary Regulations on U.S. Fresh Fruit and Vegetable Imports. A selected paper presented at the Annual Meeting of the Agricultural and Applied Economics Association. Milwaukee, WI.

Kuchler F, Tegene A, Harris JM. 2004. Taxing snack foods: manipulating diet quality or financing information programs? *Review of Agricultural Economics* **27**: 4–20.

Lakdawalla D, Philipson T. 2002. The growth of obesity and technological change: A theoretical and empirical examination. *NBER Working Papers* 8946.

Lin B-H, Guthrie J, Frazão E. 1999. Nutrient Contribution of Food Away From Home. In America’s Eating Habits: Changes and Consequences, Frazão, E. (Ed). Agriculture Information Bulletin 750. U.S Department of Agriculture, Economic Research Service, Washington, DC.

Loureiro ML, Nayga RM. 2005. International dimensions of obesity and overweight related problems: an economics perspective. *American Journal of Agricultural Economics* **87**: 1147–1153.

Ludwig DS, Pollack HA. 2009. Obesity and the economy: from crisis to opportunity. *Journal of the American Medical Association* **301**: 533–535.

McDonald D, Nair R, Podbury T, Sheldrick B, Gunasekera D, Fisher BS. 2006. U.S. Agriculture Without Farm Support. ABARE Research Report 06.10. Australian Bureau of Agricultural and Resource Economics, Canberra, Australia.

Miller JC, Coble KH. 2007. Cheap food policy: fact or rhetoric? *Food Policy* **32**: 98–111.

Muller, M., Schoonover, H., Wallinga, D., 2007. Considering the Contribution of U.S. Food and Agricultural Policy to the Obesity Epidemic: Overview and Opportunities. Institute for Agriculture and Trade Policy, Minneapolis, MN.

Muth RF. 1964. The derived demand curve for a productive factor and the industry supply curve. *Oxford Economic Papers* **16**: 221–234.

National Marine Fisheries Service (NMFS). 2011. Fisheries Statistics Division: Annual Landings. Silver Spring, MD. Available at: http://www.st.nmfs.noaa.gov/st1/commercial/index.html

Nestle M. 2002. Food Politics: How the Food Industry Influences Nutrition, and Health. University of California Press, Berkeley, CA.

Neves PD. 1987. Analysis of consumer demand in Portugal, 1958–1981. Mémorie de maîtrise en sciences économiques, Université Catholique de Louvain, Louvain-la-Neuve.

Okrent AM, Alston JM. 2011. Demand for Food in the United States: A Review of the Literature, Evaluation of Previous Estimates and Presentation of New Estimates of Demand. Giannini Foundation of Agricultural Economics Monograph 48, Berkeley, CA.

Organisation of Economic Co-operation and Development (OECD). 2010. Producer and Consumer Support Estimates, OECD Database 1986–2009. Paris, France. Available at: http://www.oecd.org/document/59/0,3343,en_2649_33797_39551355_1_1_1_37401,00.html.

Piggott NE. 2003. Measures of precision for estimated welfare effects for producers from generic advertising. *Agribusiness* **19**: 379–391.

Piggott RR. 1992. Some old truths revisited. *The Australian Journal of Agricultural and Resource Economics* **36**: 117–140.

Pollan M. 2003. The (agri)cultural contradictions of obesity. *New York Times*, October 12.

Pollan M. 2007. You are what you grow. *New York Times*, April 22.

Popkin B. 2010. The World is Fat. Avery, New York, NY.

Schroeter C, Lusk J, Tyner W. 2008. Determining the impact of food price and income changes on body weight. *Journal of Health Economics* **27**: 45–68.

Senauer B, Gemma M. 2006. Why Is the Obesity Rate So Low in Japan and High in the US? Some Possible Economic Explanations. Paper presented at the Conference of International Association of Agricultural Economists, Gold Coast, Australia, August 12–18.

Sharp R, Sumaila UR. 2009. Quantification of U.S. marine fisheries subsidies. *North American Journal of Fisheries Management* **29**: 18–32.

Smith TA, Lin B, Lee J. 2010. Taxing Caloric Sweetened Beverages: Potential Effects on Beverage Consumption, Calorie Intake, and Obesity. Economic Research Report 100, Economic Research Service, United Stated Department of Agriculture, Washington, DC.

Sumner DA. 2003. Implications of the USA farm bill of 2002 for agricultural trade and trade negotiations. *The Australian Journal of Agricultural and Resource Economics* **47**: 117–140.

Tillotson JE. 2004. America's obesity: conflicting public policies, industrial economic development and unintended human consequences. *Annual Review of Nutrition* **24**: 617–643.

U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), 1993. Continuing Survey of Food Intakes by Individuals 1989–91. Available at: http://www.ars.usda.gov/Services/docs.htm?docid=14393.

USDA-ARS, 2000. Continuing Survey of Food Intakes by Individuals 1994-96, 1998. Available at: http://www.ars.usda.gov/Services/docs.htm?docid=14531.

United States Department of Agriculture, Economic Research Service (USDA-ERS). 2008. Agricultural Outlook: Table 8. Farm-Retail Price Spreads. Available at: http://www.ers.usda.gov/publications/agoutlook/aotables/

U.S. Department of Commerce, Bureau of Economic Analysis (USDC-BEA), 2007. 2002 Benchmark Input-Output Detailed Use Table After Redefinitions. Available at: http://www.bea.gov/industry/io_benchmark.htm#2002data.

USDC-BEA, 2002. 1997 Benchmark Input-Output Detailed Use Table After Redefinitions. Available at: http://www.bea.gov/industry/io_benchmark.htm#1997data.

USDC-BEA, 1997. 1992 Benchmark Input-Output Detailed Use Table After Redefinitions. Available at http://www.bea.gov/industry/io_benchmark.htm#1992data.

USDC-BEA, 2010. National Income and Product Accounts, Personal Consumption Expenditures and Prices, Underlying Detail Tables. Available at: http://www.bea.gov/national/nipaweb/nipa_underlying/Index.asp.

White House Task Force on Childhood Obesity Report to the President, 2010. Solving the Problem of Childhood Obesity Within a Generation. Available at: http://www.letsmove.gov/pdf/TaskForce_on_Childhood_Obesity_May2010_FullReport.pdf.

Whitney E, Cataldo C, Rolfes S. 1994. Understanding Normal and Clinical Nutrition. West Publishing Company, Minneapolis, MN.

Wohlgenant MK. 1982. The Retail-Farm Price Ratio in a Competitive Food Industry With Several Marketing Inputs. North Carolina State University Department of Economics and Business Working Paper 12, Raleigh, NC.

Wohlgenant MK. 1989. Demand for farm output in a complete system of demand functions. *American Journal of Agricultural Economics* **71**: 241–252.

Wohlgenant MK. 2001. Marketing Margins: Empirical Analysis. In: Gardner BL, Rausser GC (Eds). Handbook of Agricultural Economics, vol. 1. Elsevier Science BV, Amsterdam, pp. 934–970.

World Trade Organization, 2007. World Tariff Profiles 2006. World Trade Secretariat. Geneva, Switzerland. Available at: http://www.wto.org/english/news_e/news07_e/tariff_profiles_june07_e.htm

World Trade Organization, 2011. The Agriculture Agreement: New Rules and Commitments. Available at: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm3_e.htm

Young E, Krissoff B, Johnson D, Lucier G. 2007. Relaxing fruit and vegetable planting restrictions. *Amber Waves* **5**: 10–15.

OTHER A.E.M. WORKING PAPERS

WP No	Title	Fee (if applicable)	Author(s)
2011-11	Revealing an Equitable Income Allocation among Dairy Farm Partnerships		Dressler, J. and L. Tauer
2011-10	Implications of Agglomeration Economics and Market Access for Firm Growth in Food Manufacturing		Schmit, T. and J. Hall
2011-09	Integration of Stochastic Power Generation, Geographical Averaging and Load Response		Lamadrid, A., Mount, T. and R. Thomas
2011-08	Poor Countries or Poor People? Development Assistance and the New Geography of Global Poverty		Kanbur, R. and A. Sumner
2011-07	The Economics of Africa		Aryeetey, E., Devarajan, S., Kanbur, R. and L. Kasekende
2011-06	Avoiding Informality Traps		Kanbur, R.
2011-05	The Determinants of Minimum Wage Violation in South Africa		Bhorat, H., Kanbur, R. and N. Mayet
2011-04	Minimum Wage Violation in South Africa		Bhorat, H., Kanbur, R. and N. Mayet
2011-03	A Note on Measuring the Depth of Minimum Wage Violation		Bhorat, H., Kanbur, R. and N. Mayet
2011-02	Latin American Urban Development Into the 21st Century: Towards a Renewed Perspective on the City		Rodgers, D., Beall, J. and R. Kanbur
2011-01	The Hidden System Costs of Wind Generation in a Deregulated Electricity Market		Mount, T., Maneevitjit, S., Lamadrid, A., Zimmerman, R. and R. Thomas
2010-22	The Implications of Alternative Biofuel Policies on Carbon Leakage		Drabik, D., de Gorter, H. and D. Just
2010-21	How important are sanitary and phytosanitary barriers in international markets for fresh fruit?		Rickard, B. and L. Lei
2010-20	Assessing the utilization of and barriers to farm-to-chef marketing: an empirical assessment from Upstate NY		Schmit, T. and S. Hadcock