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HOW HAVE AGRICULTURAL POLICIES INFLUENCED CALORIC CONSUMPTION IN THE UNITED STATES?

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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 US agricultural policies on prices and quantities of 10 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 US agricultural commodities in 1992, 1997, and 2002 and quantify the effects on US 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 10 agricultural commodities using information about government expenditures on agricultural commodities from various sources. Our results indicate that—holding all other policies constant—removing US subsidies on grains and oilseeds in the three periods would have caused caloric consumption to decrease minimally whereas removal of all US 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.

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KEY WORDS: agricultural policy; caloric intake; consumer support; food consumption; obesity; simulation model

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 1960–1962, 13.4% of US adults were obese, and by 2007–2008, 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 *et al*. (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 *et al*. (2004) examined the influence of various socio-economic and cultural factors on obesity, and their econometric results indicated that increasing obesity was driven primarily

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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 *et al*., 2004; Cash *et al*., 2005; Schroeter *et al*., 2008; Allais *et al*., 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 do they present 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 *et al*. (2007), Ludwig and Pollack (2009), and Popkin (2010) have attributed the growth in US 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 such as *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 Report to the President, 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 non-existent 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 *et al*., 2006; Alston *et al*., 2008; Beghin and Jensen, 2008).

In this article, we examine the consequences of US 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 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 *et al*., 1999), and it is important to consider the effects on both food at home (FAH) and FAFH in such analysis. Our research presents a

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

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novel approach for measuring the caloric effects of agricultural policies on consumption of seven 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 US 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 14 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 15 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 whereas positive CTE values imply a consumer tax. To make the two alternative measures more clearly comparable, we multiplied the CTEs by -1, to convert it 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 *et al*., 2008). However, aggregate measures of consumer support, like those shown in Figure 1, do not capture the effects for individual agricultural commodities or the complex interactions between markets for agricultural commodities and markets for the food products that use these commodities as ingredients.

We report 5-year average values of the CSEs and the CTEs for 15 commodities in three periods in Table I. Both the CSEs and the CTEs show that consumers of milk and sugar were taxed significantly across the three 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

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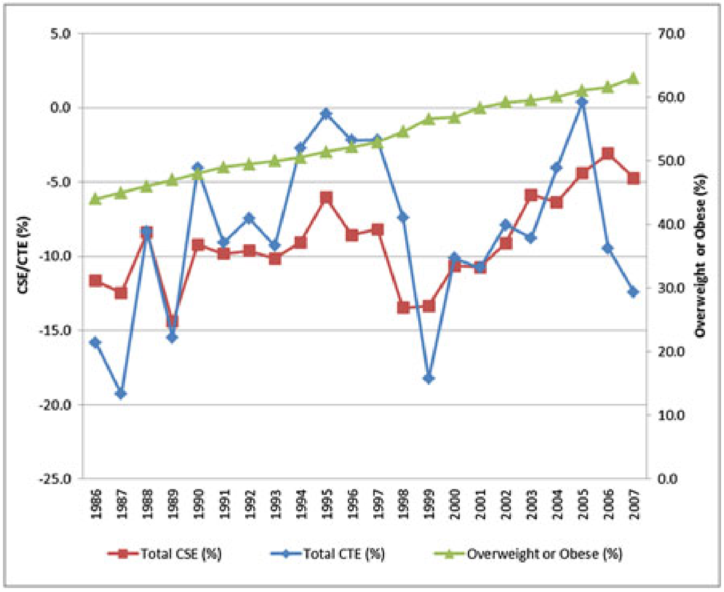

Figure 1. Consumer support estimate (CSE), consumer tax equivalent (CTE), and the rate of obesity in the United States (1986 to 2007). We multiply the reported CTEs by −1.0 so that they represent rates of consumer support rather than rates of consumer taxes. Sources: Anderson *et al*. (2008), CDC (2009), and OECD (2010)

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

	CSE (%), negative values imply a consumer tax			CTE (%), positive values imply a consumer tax		
	1992	1997	2002	1992	1997	2002
	Average rate for a 5-year period					
Commodity	1990 to 1994	1995 to 1999	2000 to 2004	1990 to 1994	1995 to 1999	2000 to 2004
Barley	−15.9	−0.4	0.0	7.4	−9.3	−11.7
Beef	−1.0	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	0.0	−1.1	−6.7	−8.8
Maize	0.0	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	0.0	−12.4	−18.1	−19.1
Potato[a]	n/a	n/a	n/a	0.0	0.0	0.0
Poultry	−1.2	−0.3	−0.1	−9.1	−9.2	−9.4
Rice	−1.8	−0.1	0.0	−13.9	−15.9	−20.1
Sheep meat	−1.2	−2.4	−9.0	1.2	2.6	9.9
Sorghum	0.0	0.0	0.6	−13.2	−15.3	−21.4
Soybean	0.0	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

CSE, consumer support estimate; CTE, consumer tax equivalent.
Sources: OECD (2010), Anderson *et al*. (2008).
[a]CSEs are provided for 14 agricultural commodities, and CTEs are provided for 15 commodities; no CSE is provided for potatoes.

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

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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 these commodities.

Another important difference between the CSEs and the 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 such as food stamps, school lunch, and the 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 \$26.2bn in 2007, of which approximately 50% funded the School Lunch Program, 27% supported the Food Stamp Program, and 20% financed the Special Supplemental Nutrition Program for Women, Infants, and Children. 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 10 agricultural commodity groups in three periods. Table II shows the values for the three CSMs for 10 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).

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

	Measures of support based on								
	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
	1992	1997	2002	1992	1997	2002	1992	1997	2002
	Average percentage rate for a 5-year period								
Commodities	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
Oilseeds	0.0	0.0	0.0	11.3	12.0	12.6	3.5	3.4	3.8
Food grains[a]	−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
Sugarcane 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
Beef and hogs[b]	−1.2	0.0	−0.2	10.0	12.0	12.4	8.2	11.5	10.7
Dairy farming	−37.4	−42.2	−37.1	−30.3	−35.3	−29.2	−38.6	−55.6	−40.3
Poultry and eggs[c]	−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

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 food grains, beef and hogs, dairy farming, and poultry and eggs; we also add support measures for vegetables and melons, fruits and tree nuts, and fish and aquaculture.
CSE, consumer support estimate; CSM, consumer support measure; CTE, consumer tax equivalent.
[a]Measure of support for food grains is a 5-year average, weighted by value of consumption for corn, wheat, barley, and rice (OECD, 2010).
[b]Measure of support for beef and hogs is a 5-year average, weighted by value of consumption for beef, pork, and sheep meat (OECD, 2010).
[c]Measure of support for poultry and eggs is a 5-year average, weighted by value of consumption for poultry and eggs (OECD, 2010).

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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 in two ways. First, we aggregated some of the 15 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.

Consumer support estimates 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 0. 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 US 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 on 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 for 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, on the basis of 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 CSEs or CTEs for horticultural crops, CSEs or CTEs are not reported for the fish and aquaculture category, yet significant expenditures have been applied to US fisheries (Cox and Schmidt, 2003; Sharp and Sumaila, 2009). Sharp and Sumaila (2009) showed that the average annual subsidy for fisheries was \$713m (ranging from \$680m to \$760m) between 1996 and 2004 and that approximately 40% of these expenditures was used for research and development activities. Over the same period, the annual value of landings averaged \$3.46bn (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 10 commodities on the basis of 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.

[2]US border measures also exist for a wide range of processed fruits and vegetables, and in some cases, these are significant barriers. For example, the US tariff applied to frozen concentrated orange juice is approximately 33% (Brown *et al.*, 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.

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3. MODELING THE EFFECTS OF AGRICULTURAL POLICIES ON PRICES AND CONSUMPTION OF 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 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 corresponding retail food products. Wohlgenant (1982, 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. Because 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

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

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

$$X_l = \sum\nolimits_{n=1}^{N} \mathrm{g}_l^n(\mathbf{W}) Q^n, \forall l = 1, \ldots, L, \tag{3}$$

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

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,

[3]Similarly, Gardner (1987), Piggott (1992), Alston *et al.* (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.

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where the price of the nth product is set equal to the marginal cost of producing product n, $c^n(\mathbf{W})$, 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 N products (i.e., $\partial C^n / \partial W_l = g_l^n(\mathbf{W})Q^n$) 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)–(4) and converting them to elasticity form yields equations for proportionate changes in quantities and prices of retail products (i.e., $EQ^n = dQ^n/Q^n$ and $EP^n = dP^n/P^n$, where d is the total differential operator) and farm commodities (i.e., $EX_l = dX_l/X_l$ and $EW_l = dW_l/W_l$) in Equations (5)–(8):

$$EQ^n = \sum\nolimits_{k=1}^{N} \eta^{nk} EP^k + \alpha^n, \forall n = 1, \ldots, N, \tag{5}$$

$$EP^n = \sum\nolimits_{l=1}^{L} \frac{\partial c^n(\mathbf{W})}{\partial W_l} \frac{W_l}{P^n} EW_l, \forall n = 1, \ldots, N, \tag{6}$$

$$EX_l = \sum\nolimits_{n=1}^{N} SC_l^n \sum\nolimits_{m=1}^{L} \left(\eta_{lm}^{n*} EW_m + EQ^n\right), \forall l = 1, \ldots, L, \tag{7}$$

$$EX_l = \sum\nolimits_{j=1}^{L} \varepsilon_{lj} EW_j + \beta_l, \forall l = 1, \ldots, L, \tag{8}$$

where

$\eta^{nk} = \dfrac{\partial Q^n(\mathbf{P}, A^n)}{\partial P^k} \dfrac{P^k}{Q^n}$	is the Marshallian elasticity of demand for retail product n with respect to retail price k,	(9)
$SC_l^n = \dfrac{X_l^n W_l}{X_l W_l}$	is the share of the total cost of commodity l across all industries used by retail product n (farm commodity share),	(10)
$\eta_{lm}^{n*} = \left(\dfrac{\partial g_l^n(\mathbf{W})Q^n}{\partial W_m}\right) \dfrac{W_m}{X_l^n}$	is the Hicksian elasticity of demand for commodity l in industry n with respect to commodity price m,	(11)
$\varepsilon_{lj} = \dfrac{\partial f_l(\mathbf{W}, B_l)}{\partial W_j} \dfrac{W_j}{X_l}$	is the elasticity of supply of commodity l with respect to commodity price j,	(12)
$\alpha^n = \dfrac{\partial Q^n(\mathbf{P}, A^n)}{\partial A^n} \dfrac{A^n}{Q^n} EA^n$	is the proportional shift of demand for retail product n in the quantity direction,	(13)
$\beta_l = \dfrac{\partial f_l(W_l, B_l)}{\partial B_l} \dfrac{B_l}{X_l} EB_l$	is the proportional shift of supply of commodity l in the quantity direction.	(14)

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

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

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

[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, that is, $C^n = c^n(\mathbf{W})Q^n$. 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.

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

Substituting Equation (16) into Equation (8) yields

$$\mathrm{E}X_l = \sum\nolimits_{j=1}^{L} \varepsilon_{lj} \mathrm{E}W_{D,l} + \sum\nolimits_{j=1}^{L} \varepsilon_{lj} s_l + \beta_l. \tag{17}$$

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

$$\mathrm{E}P^n = \sum\nolimits_{l=1}^{L} SR_l^n \mathrm{E}W_l, \forall n = 1, \ldots, N, \tag{18}$$

where $SR_l^n = X_l^n W_l / P^n Q^n$ 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

$$\eta_{lm}^{*} = \sum\nolimits_{n=1}^{N} SC_l^n \eta_{lm}^{n*}. \tag{19}$$

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

$$\mathrm{E}X_l = \sum\nolimits_{m=1}^{L} \eta_{lm}^{*} \mathrm{E}W_m + \sum\nolimits_{n=1}^{N} SC_l^n \mathrm{E}Q^n, \forall l = 1, \ldots, L. \tag{20}$$

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 food production in a short-run 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 0 (i.e., $\eta_{lj}^{n*} = 0, \forall l, j = 1, \ldots, L, \forall n = 1, \ldots, N$), which implies

$$\mathrm{E}X_l = \sum\nolimits_{n=1}^{N} SC_l^n \mathrm{E}Q^n, \forall l = 1, \ldots, L. \tag{21}$$

Lastly, the assumption of exogenous commodity prices (i.e., representing the case where the US 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

$$-\mathrm{E}W_l = \bar{\beta}_l + s_l, \forall l = 1, \ldots, L, \tag{22}$$

where $\bar{\beta}_l$ 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 a matrix notation. Let $\mathbf{EQ}$ and $\mathbf{EP}^S$ be $N \times 1$ vectors of proportionate changes in quantities and producer prices of retail products, respectively, and $\mathbf{EX}$ and $\mathbf{EW}_D$ be $L \times 1$ vectors of proportionate changes in quantities and buyer prices of commodities, respectively; the system is

[6]An anonymous reviewer noted that the assumption of fixed-factor proportions 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 in response to artificially high sugar prices. Indeed, if sugar and high-fructose corn syrup 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, because 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 $\beta_l = \varepsilon_{ll}\left(\hat{\beta}\right)$. Hence, Equation (17) becomes

$$EX_l = \sum\nolimits_{j=1, j \neq l}^{L} \varepsilon_{lj}\left(EW_j + s_j\right) + \varepsilon_{ll}\left(EW_l + \bar{\beta}_l + s_l\right).$$

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

$$\lim_{\varepsilon_{ll} \to \infty} \left[\frac{1}{\varepsilon_{ll}}\left(EX_l - \sum\nolimits_{j=1, j \neq l}^{L} \varepsilon_{lj}\left(EW_j + s_j\right)\right)\right] = 0 = EW_l + \bar{\beta}_l + s_l.$$

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

where the parameters are defined in the preceding text. With the use of matrix block inversion, the solutions for $\mathbf{EQ}$, $\mathbf{EP}^S$, $\mathbf{EX}$, and $\mathbf{EW}_D$ are

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

We use this model to simulate how changes in the measures of agricultural support for the 10 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 non-alcoholic 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 years and older using 24-h dietary recall data from three national surveys of food consumption: the Continuing Survey of Food Intakes by Individuals (CSFII) 1989–1991 (USDA-ARS, 1993), the CSFII 1994–1996, 1998 (USDA-ARS, 2000), and the 2001–2002 National Health and Nutrition Examination Survey (CDC, NCHS, 2003).[8] Respondents were initially asked to recall what they consumed in the past 24 h, 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 according to 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, non-alcoholic 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, on the basis of survey questions. We make two assumptions in order to use average daily calorie consumption for each food group reported in the CSFII and the National Health and Nutrition Examination Survey. 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),

[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).

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then this food is considered to be in the category of other foods, which contains prepared meals and appetizers.[9] Table III shows the food intake and caloric intake patterns for the nine food categories in the three 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 *et al.*, 1994; Chouinard *et al.*, 2007; Smith *et al.*, 2010) often use a multiplier of 3500 calories per pound of fat tissue. We employ the same multiplier that converts changes in annual calorie consumption into changes in steady-state body weight in our calculations. 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 periods and allows us to better understand the relationship between agricultural policies and obesity.[10]

3.2. Parameterization of the model

Our simulation model requires parameters to describe the following: (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. In the following text, 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 periods, we also develop values for the relevant parameters and policy wedges that are representative of the three 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 as follows: 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 *et al.*, 1991; Piggott, 2003) based on a vector of parameter estimates, $\hat{\gamma}$, with its associated covariance matrix, $\hat{\Sigma}$, from Okrent and

[9] The composite dishes reported in the CSFII and National Health and Nutrition Examination Survey data are placed in the 'other food' category in our analysis. Additional information may be available to break down the composite dishes into food categories that may be more closely tied to specific commodities, but we do not expect that doing so would change the general pattern of our results (notably for the results using the CTE measure of consumer support).

[10] The relationship between caloric consumption and obesity is clearly much more complex than this use of a simple fixed multiplier would suggest, with significant non-linear 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 body weight 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 a 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) that implies that an increase in consumption of 220 kcal/day would be consistent with an increase in body weight of 10 kg (which translates approximately to 10 kcal/day/lb 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/day would result in a steady-state weight loss of 6.4 kg, which translates to 7.1 kcal/day/lb. The figure of 3500 kcal/lb is equivalent to 9.6 kcal/day/lb, which falls between the estimates from Hall *et al.* (2011) and Hall and Jordan (2008). See, also, Hall *et al.* (2011).

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

	Average daily intake[a]					
	1992[b]		1997[c]		2002[d]	
Food category	Grams	Calories	Grams	Calories	Grams	Calories
Total	1971.7	1882.2	2146.8	2019.2	2343.9	2168.6
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
Non-alcoholic 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 amount of food consumed by food category for adults in the periods shown, based on survey information.
[b]Data taken from the Continuing Survey of Food Intakes by Individuals 1989–1991 (USDA-ARS, 1993)
[c]Data taken from the Continuing Survey of Food Intakes by Individuals 1994–1996, 1998 (USDA-ARS, 2000)
[d]Data taken from the National Health and Nutrition Examination Survey 2001–2002 (CDC, NCHS, 2003).

Alston (2011).[11] We randomly drew vectors of demand system parameters from a multivariate normal distribution with mean $\hat{\gamma}$ and covariance matrix $\hat{\Sigma}$ 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 to 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 periods using the Benchmark Input–Output Detailed Use Tables (after redefinitions) for 1992, 1997, and 2002 (USDC-BEA, 1997, 2002, 2007).[12] 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, policy-induced changes in farm commodities used as ingredients 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

[11]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 (USDC-BEA, 2010). They found the following: (i) their estimates were broadly comparable to others in the food demand literature, in terms of the magnitudes and plausibility of the elasticities, and (ii) these provided generally more accurate predictions of past changes in quantities based on past changes in prices and total expenditure.

[12]The benchmark input–output accounts are published every 5 years with the most recent publication reflecting the 2002 Economic Census estimates. Hence, our analysis is restricted to the years 1992, 1997, and 2002. The 2007 benchmark input–output accounts will be published in 2012.

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

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

Table V. Farm–retail cost shares

		Food category								
Year	Farm commodity/input	Cereals and bakery	Meat	Eggs	Dairy	Fruits and vegetables	Other food	Non-alcoholic beverages	FAFH	Alcoholic beverages
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
	Sugarcane 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 and aquaculture	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
	Sugarcane 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 and aquaculture	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
	Sugarcane 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 and aquaculture	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

FAFH, food away from home.
Source: Authors' calculations based on 1992, 1997, and 2002 Benchmark Input–Output Detailed Use Tables after redefinitions (USDC-BEA, 1997, 2002, 2007).

in Table V. The results in Table VI show that the share of total commodities used in FAFH increased between 1992 and 2002 whereas the share of commodities used in the FAH categories decreased over time.

4. RESULTS

We conducted 18 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 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). Although it is unlikely that the United States would introduce

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Table VI. Farm commodity cost shares

		Food category								
Year	Farm commodity/input	Cereals and bakery	Meat	Eggs	Dairy	Fruits and vegetables	Other food	Non-alcoholic beverages	FAFH	Alcoholic beverages
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
	Sugarcane 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 and aquaculture	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
	Sugarcane 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 and aquaculture	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
	Sugarcane 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 and aquaculture	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

FAFH, food away from home.
Source: Authors' calculations based on 1992, 1997, and 2002 Benchmark Input–Output Detailed Use Tables after redefinitions (USDC-BEA 1997, 2002, 2007).

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 US 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 US policy changes are made concomitantly with changes in other countries that apply similar trade-distorting policies, the impacts on prices paid by US consumers are likely to be smaller than if the US 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 US consumer prices that would be associated with the elimination of US 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 US 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

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interval for each of the variables across 1110 iterations.[13] 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. In the succeeding discussion, 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 periods in response to the removal of US 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 body 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 the following discussion. 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% 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. With the use of 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, 1500 calories in 1997, and 1136 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 and 1419 calories per adult per year; this is equivalent to a weight reduction of between 0.28 and 0.41 lb 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 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, although 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.

[13]We calculated the 10% confidence intervals using the percentile method (Cameron and Trivedi, 2005, p. 365). The estimated caloric changes from the 1110 draws were ordered, and the lower and upper 5 percentiles were reported as the lower and upper bounds of the confidence interval.

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

	Elimination of CSM based on								
	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
Food category	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
Meat	−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 food	−0.02	−0.00	0.00	−0.48	−0.53	−0.55	−0.08	−0.04	−0.21
Non-alcoholic 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	−1472	−927
Meat	−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 food	−31	−1	0	−603	−683	−799	−106	−58	−313
Non-alcoholic 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	−1500	−1136	−995	−1846	−1419
	(206, 368)	(8, 15)	(0, 0)	(−1154, −465)	(−2013, −981)	(−1617, −656)	(−1286, −709)	(−2352, −1346)	(−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)

CSE, consumer support estimate; CSM, consumer support measure; CTE, consumer tax equivalent; FAFH, food away from home; FAH, food at home.

[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 3500 kcal per year adds 1 lb to steady-state body weight (Whitney *et al*., 1994; Hall *et al*. 2011).

[c]Average body weight of an adult individual was 162.0 lb in the Continuing Survey of Food Intakes by Individuals (CSFII) 1989–1991 (USDA-ARS, 1993), 166.3 lb in the CSFII 1994–1996, 1998 (USDA-ARS, 2000), and 176.3 lb in the National Health and Nutrition Examination Survey 2001–2002 (CDC, NCHS, 2003). Body weight is self-reported in both CSFIIs whereas body weight is measured in the National Health and Nutrition Examination Survey.

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 that 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 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 US adult would have consumed 4771 more calories in 1992, 4583 more calories in 1997, and 4021 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 the removal of agricultural policies in the three periods: an increase in consumption per US adult of 2495 calories per year in 1992, 1967 calories per year in 1997, and 1952 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 3410 calories per year for an average US adult in 1992, which implies an increase in body weight of 0.60%, and an increase of 3061 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 0; the measured effects are not statistically significantly different from 0 (unlike the simulated effects of eliminating subsidies on grains and oilseeds in Table VII, for which none of the 90% confidence intervals includes 0, although 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 1952 and 4771 calories annually.[14] 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 Tables VII and VIII. Results from these additional simulations show that large changes in elasticities have some effect on the

[14]As a rough estimate, removing US 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 concentrated orange juice in the United States is 1168 calories per adult; (ii) the tariff rate is 33%; (iii) the demand elasticity is −0.5; and (iv) there is no substitution between frozen concentrated orange juice and other beverage products.

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

	Elimination of CSM based on								
	CSE (CSM_A)			CSE plus (CSM_B)			CTE (CSM_C)		
Food category	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
Meat	−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 food	−0.77	−1.11	−0.72	−1.81	−2.27	−1.83	−0.97	−1.85	−1.00
Non-alcoholic 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	−2392	−2677	−2348	−2059	−2510	−1872	−3663	−4813	−3624
Meat	−337	−424	−434	−1570	−1416	−1403	−1320	−1338	−1207
Eggs	−354	−475	−444	−368	−552	−562	−436	−722	−584
Dairy	6651	7290	6801	6002	6802	6149	7274	10,050	7853
Fruits and vegetables	1234	1242	1189	1757	1706	1535	1857	1967	1674
Other food	−972	−1438	−1047	−2284	−2957	−2675	−1222	−2407	−1458
Non-alcoholic beverages	−1031	−1445	−1509	−1222	−1675	−1691	−1420	−2332	−2068
FAFH	2052	2633	1954	2212	2535	2390	2355	3521	2509
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)	4771	4583	4021	2495	1967	1952	3410	3860	3061
	(1187, 8731)	(442, 9116)	(393, 8075)	(−1084, 6106)	(−2289, 6273)	(−1880, 5782)	(−619, 7730)	(−1961, 9928)	(−1374, 7753)
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)

CSE, consumer support estimate; CSM, consumer support measure; CTE, consumer tax equivalent; FAFH, food away from home; FAH, food at home.

[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 3500 kcal per year adds 1 lb to steady-state body weight (Whitney *et al*., 1994; Hall *et al*. 2011).

[c]Average body weight of an adult individual was 162.0 lb in the Continuing Survey of Food Intakes by Individuals (CSFII) 1989–1991 (USDA-ARS, 1993), 166.3 lb in the CSFII 1994–1996, 1998 (USDA-ARS, 2000), and 176.3 lb in the National Health and Nutrition Examination Survey 2001–2002 (CDC, NCHS, 2003). Body weight is self-reported in both CSFII whereas body weight is measured in the National Health and Nutrition Examination Survey.

magnitudes, 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 US agricultural commodity policies, for the most part, have not made food commodities significantly cheaper and have not had a significant effect on caloric consumption. From the simulations using CSM_C, eliminating US grain and oilseed subsidies alone would have led to a small decrease in annual per capita caloric consumption—simulated to range between 995 and 1846 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 3061 to 3860 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 3521 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

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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 have diminished 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 have 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.

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