Farm Commodity Policy and Obesity

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ABSTRACT. Many commentators have claimed that farm subsidies have contributed significantly to the "obesity epidemic" by making fattening foods relatively cheap and abundant and, symmetrically, that taxing "unhealthy" commodities or subsidizing "healthy" commodities would contribute to reducing obesity rates. This paper makes three contributions. First, we review evidence from the literature on the impacts on food consumption and obesity resulting from subsidies applied in the past to production or consumption of farm commodities. Second, we develop and present new arguments and preliminary evidence on the impacts of past government investments in agricultural R&D on food consumption and obesity—through research-induced increases in agricultural productivity and the consequences for prices, production, and consumption of farm commodities. Third, we consider and compare the economic efficiency of hypothetical agricultural research policies (changing the orientation of agricultural research investments) versus hypothetical agricultural commodity subsidies and taxes as alternative mechanisms for encouraging consumption of healthy food or discouraging consumption of unhealthy food, or both.

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1. Introduction

In this paper we examine the links between farm policies—including farm commodity programs and public agricultural research and development (R&D)—and farm commodity prices in the United States, and the implications of farm policy-induced commodity-price changes for food prices, food consumption, and obesity. We conclude that U.S. farm subsidy programs have had negligible effects on the prices paid by consumers for food and thus negligible influence on dietary patterns and obesity, consistent with some previous work by economists on the issue (e.g., Cutler, Glaeser, and Shapiro 2003a, 2003b; Miller and Coble 2007), but contradicting the mainstream view presented in the media (e.g., Pollan 2003). In contrast, however, through their effects on agricultural productivity, agricultural R&D policies have had substantial impacts on farm commodity prices and may have had much more significant impacts on consumption and obesity. In real terms, the prices of major agricultural commodities have fallen by 50 percent or more since 1950, and agricultural R&D has been credited as the primary engine for those changes (e.g., Alston, Pardey and Beddow 2009). We examine the potential for R&D-cum agricultural productivity-induced changes in commodity prices to contribute to obesity, and consider the potential for alternative R&D policies to be established with a view to reducing the future prevalence of obesity among Americans.[1]

2. Motivation and Background

Obesity is a big business. The prevalence of overweight and obesity has increased rapidly in the United States—the average American adult added 9–12 pounds

[1] U.S. agricultural R&D has substantial international spillover effects on agricultural technology (e.g., see Alston 2001). If research-induced productivity gains contribute significantly to social costs of obesity, U.S. agricultural R&D might have negative international spillovers costs from obesity to count against the positive spillover benefits reported in some of the literature on

during the 1990s (Ruhm 2007)—and the related health concerns are priority issues for the U.S. government and the medical community. This phenomenon is not unique to the United States. The proportion of the adult population classified as overweight or obese is particularly high in the United States but is growing rapidly throughout much of the world (World Health Organization, 1997; International Obesity Task Force, 2005). Obese and overweight Americans generate large additional direct and indirect health care expenses. In his "Call to Action to Decrease Overweight and Obesity" the U.S. Surgeon reported that, in 2000, the total cost of obesity was estimated to be $117 billion ($61 billion direct and $56 billion indirect). Without endorsing these particular estimates, we note that these costs will increase with increases in the U.S. prevalence of obesity, especially severe obesity, which is projected to continue to rise (e.g., see Ruhm 2007).

The U.S. government has a stated objective of reducing obesity but the appropriate policy is not clear. One option is to implement ever-more-vigorous public education programs. Another option is to revise the food and nutrition programs administered by the USDA to encourage healthier diets of participants.[2] Various proposals have been raised and some have been subjected to analysis by economists.[3] Further options include regulatory or fiscal instruments that attempt to discourage less-healthy and encourage more-healthy consumption choices. For instance, some writers have speculated about banning certain types of advertising, taxing foods with high fat or high sugar content, or subsidizing healthier foods such as fresh fruit and vegetables, and

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agricultural research benefits. We reserve this point (which we owe to Joanna Parks) for future research.

[2] These programs include the Food Stamp Program, the Special Supplemental Program for Women, Infants, and Children (the WIC Program), and the School Lunch Program, among others.

[3] For instance, proposals for a more-healthy Food Stamp Program have been analyzed by Mullally et al. (2007) and Guthrie et al. (2007). The Food Stamp Program may have contributed to an increase in obesity among participants, though the evidence is mixed with differential results between men and women, and the effects found are generally small (e.g., see Baum 2007; Chen, Yen, and Eastwood 2005; Gibson 2003, 2004; Kaushal 2007; Ver Ploeg, Mancino, and Lin 2006,

economists have analyzed some of these possibilities. One popular idea is that American farm subsidies contribute significantly to obesity and that reducing these subsidies will go a long way towards solving the problem (e.g., Pollan 2003).

The idea that farm subsidies have contributed significantly to the problem of obesity in the United States has been reported frequently in the press, and has assumed the character of a stylized fact.[4] It is conceptually possible that farm policies contribute to lower relative prices and increased consumption of fattening foods by making certain farm commodities more abundant and therefore cheaper. However, several economic studies have found these effects to be small or nonexistent. Section 3 of this paper reviews this and other U.S. and international evidence about the effects of farm commodity subsidies on food prices and obesity.[5]

A related idea is that other farm bill policies, such as public agricultural R&D, have contributed to obesity by making farm commodities cheaper and more abundant. For this to be true, public agricultural R&D must have made farm commodities that are important ingredients of relatively fattening foods significantly more abundant and less expensive. Second, the lower commodity prices caused by R&D must have resulted in significantly lower costs to the food industry, cost savings that were passed on to consumers in the form of lower prices of relatively fattening food. Third, food consumption must have changed significantly in response to these policy-induced

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2007). Even if the current program has not caused obesity, a revised program may contribute to reducing obesity, but the analysis to date has generally not been favorable to the idea.

[4] Examples abound. For instance, in November 2007 alone, articles were published Nicole Gaouette, in the Los Angeles Times http://www.latimes.com/news/science/la-na-farmbill25nov25,1,6084664.story?coll=la-news-science&ctrack=1&cset=true, Amanda Paulson in the Christian Science Monitor http://www.csmonitor.com/2007/1116/p03s01-uspo.html, Michael Grunwald in Time magazine, http://www.time.com/time/magazine/article/0,9171,1680139,00.html, and Michael Pollan in the New York Times http://www.nytimes.com/2007/11/04/opinion/04pollan.html?incamp=article_popular.

[5] This part of the paper draws significantly (at times verbatim) on Alston, Sumner, and Vosti (2008).

changes in the relative prices of more- versus less-fattening foods. Section 4 of this paper gives attention to that issue.

In the 2008 Farm Bill the U.S. government introduced the Specialty Crops Research Initiative, mandating funding of $50 million per year for FY 2009-12 and authorizing additional annual appropriations of $100 million for a new program of competitive research grants. In the Farm Bill debate, arguments for enhanced funding for specialty crops research emphasized concerns with competitiveness and the fact that specialty crops producers mostly do not receive other subsidies (a point that was at times connected to discussions about proposed revisions to farm program provisions that prevented planting of specialty crops on program base acres).[6] Implications for health and nutrition were also often raised as part of the case although the arguments were not developed in much detail. In Section 5 we develop a stylized model in which we illustrate the implications of R&D policies in a world in which food consumption entails costs of health-care system externalities. Section 6 concludes the paper.

3. Farm Subsidies, Fat Taxes and Thin Subsidies – A Review of Findings

In principle, taxes and subsidies applied to food commodities or products could be used to align the private marginal cost with the marginal social cost of excess food consumption, and hence, weight outcomes. Several proposals have been raised including eliminating farm subsidies on particular commodities that are used as inputs into unhealthy food production (e.g., corn), taxing food products or characteristics of food products that are deemed unhealthy (e.g., snack foods, fat content), and subsidizing

[6] Ultimately the 2008 Farm Bill did not eliminate the provision that specialty crops could not be grown on base acres. However, a new 2008 Farm Bill Pilot Program will allow farmers to switch acres to cucumbers, green peas, lima beans, pumpkins, snap beans, sweet corn and tomatoes as long as these crops are grown under contract for processing in 2009-2012 crop years. Growers in Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio and Wisconsin will be eligible to participate in this program.

food products or characteristics of food products that are deemed healthy (e.g., fruits and vegetables, dietary fiber content).

The popular press has frequently depicted subsidies favoring commodities used in unhealthy food products as an important contributor to rising obesity (Alston, Sumner and Vosti 2008). In particular, Pollan (2003, 2007, 2008) has claimed that subsidies on commodities like corn and wheat have led to lower prices of high-calorie, processed foods. He has asserted that the subsidy-induced decline in the prices of high-calorie, processed foods versus low-calorie, less-processed foods, has been a primary contributor to the overconsumption of such foods, and subsequent increases in obesity rates. He has pointed to the correlation between increased subsidies to corn farmers and obesity rates in the United States between the 1970s to the present as proof of this effect.

Farm subsidies can affect the rate of obesity by changing the relative prices of commodities and retail foods, and hence, the composition of food consumption, but a range of studies have demonstrated that the magnitude of this effect is likely to be small (Alston, Sumner, and Vosti, 2006, Alston, Sumner, and Vosti 2008, Beghin and Jensen 2008, Miller and Coble 2007, Schmidhuber 2004, Senauer and Gemma 2006). This finding has several elements.

First, farm subsidies increase both production and consumption of subsidized commodities by increasing the net return to farmers and lowering the market price paid by consumers. For example, if subsidies are applied more to commodities that are inputs for unhealthy foods compared to healthy foods, then the increase in the consumption of unhealthy foods can be partly attributed to the farm subsidies. Evidence from the United States and other OECD countries suggests that the effect of commodity subsidies on commodity prices is small (Alston, Sumner, and Vosti, 2008). In particular, Beghin and Jensen (2008) found that subsidies on corn have a negligible effect on the price of food products that use high fructose corn syrup (HFCS) in the United States. They attributed substantial declines in the price of corn, and hence, HFCS and food products that use HFCS to technical change rather than subsidies. In addition, since the price of sugar in the United States is considerably higher than the world price because of U.S. import restrictions, Beghin and Jensen (2008) and Alston, Sumner and Vosti (2008) both concluded that the net effect of farm policies (corn subsidies and import barriers on sugar) has been to increase the price and discourage consumption of caloric sweeteners.

Schmidhuber (2004), Loureiro and Nayga (2005) and Alston, Sumner, and Vosti (2008) showed that agricultural policies, including subsidies and trade barriers, have actually resulted in higher food costs for consumers across OECD countries. Countries with higher food costs tend to have lower rates of obesity, so if anything subsidies and trade barriers have contributed to reducing obesity, but the effects in the United States must have been very small. Other agricultural policies may have had more significant effects on obesity. Alston, Sumner and Vosti (2006, 2008) suggested that productivity gains resulting from agricultural research and development (R&D) have been much more important than commodity subsidies as a determinant of food prices. Moreover, Miller and Coble (2007, 2008) estimated that increases in total factor productivity contributed more to lowering prices of retail food products, and thus, the portion of income spent on food, than did subsidies to farmers for the United States and across OECD countries.

Second, the magnitude of the effect of the changes in commodity prices on retail prices depends on the cost share of the commodity on retail prices. Since the commodity share of the retail price of foods is generally small (i.e. approximately 20 percent) in the United States, changes in the price of commodities used in high-calorie foods may not translate into perceptible changes in the price of high-calorie food products (Alston Sumner and Vosti, 2008). Schmidhuber (2004) noted that developed countries have much higher marketing margins than less-developed countries and that policies that affect commodity prices in the presence of higher marketing margins are unlikely to have much impact on food prices, and hence, consumption. Hence, higher marketing margins for commodities have dampened the effects of policy-induced commodity price changes on retail food prices.

Third, even if policies generate a relatively larger price drop in unhealthy foods versus healthy foods, consumers may not respond much to changes in the price of food products. Several studies have explored the impact of relative prices on weight gains in the United States. Lakdawalla and Philipson (2002) argued that the expansion in the supply of food through agricultural innovation has allowed the real price of foods to decline, allowing for increases in food consumption, and thus, increases in weight. They attributed 41 percent of growth in BMI to declines in the cost of food products and 59 percent to changes in physical activity. Alternatively, Bleich et al. (2007) attributed 80 percent of the growth in BMI across OECD countries to increases in calorie supply, and found that reductions in relative food prices were associated with increased calorie supply. Huffman et al. (2006) found that an increase in the price of food leads to decreases in obesity-related mortality across OECD countries.

Further, some studies have suggested that a decline in the price of “unhealthy” foods relative to “healthy” foods has been the primary contributor to obesity. Drewnowski and Specter (2004) and Drewnowski and Darmon (2005) hypothesized that the price differential between energy-dense versus energy-dilute foods has caused individuals to substitute out of energy-dilute foods into energy-dense foods.[7] Gelbach,

[7] Energy density is defined as the amount of available dietary energy per unit of weight (expressed in kcal/g or kJ/g). Water accounts for most of the variability in energy density because it provides weight but not energy. Fiber also contributes to energy density because it provides little energy. Foods high in water and/or fiber are therefore energy dilute, or low-energy-dense. Conversely, fat provides the greatest amount of energy per gram, hence high-fat foods tend to be high-energy-dense (Newby 2006).

Klick and Strattman (2007) found that individuals do substitute between healthful and unhealthful foods when relative prices change, but this relative price effect accounts for only about 1 percent of the rise in average BMI during their sample period.[8] Assuming sugar is addictive, Miljkovic, Njange and de Chastenet (2007) found low current prices of sugar induced greater consumption of all foods today and weight gains in the future. However, under the rational addiction hypothesis, the expectation of a future increase in prices of sweet food leads to increased sugar consumption in the current period by overweight and obese people, and decreased sugar consumption in the current period by normal weight people. Chou, Grossman, and Saffer (2004) argued that food consumed at fast food and certain full-service restaurants tend to be higher in calories than foods prepared at home, and the cost of purchasing such foods has declined. They found that the real price of fast food, food at home and full-service restaurants have negative and significant effects on BMI and probability of being obese, but again, these effects are small.

Evaluations of fiscal instruments like taxes and subsidies have primarily focused on consumer responses, largely ignoring the potential role that producers play in food production. A tax or subsidy applied to specific categories of food has been suggested by several lawmakers (Adamy 2009, Chan 2008) and evaluated in the academic literature. Jacobson and Brownell (2000) and Brownell and Frieden (2009) discussed how small taxes on snack foods and sweetened beverages can generate revenues that could be earmarked for health promotion. However, both acknowledged that the magnitude of the tax revenues generated from such taxes would be decreased by substitution effects and the orientation of the supply curve for soft drinks and snacks.

[8] Their definitions of "healthy" and "unhealthy" foods are dependent upon the availability of prices from the Bureau of Labor Statistics. They defined healthy foods as all fruits and vegetables, tuna, milk and yogurt, and "unhealthy" foods as American processed cheese, bologna, butter, cola,

Kuchler, Tegene and Harris (2005) and Richards, Patterson and Tegene (2007) accounted for the substitution between snack foods by estimating and utilizing elasticities of demand and assumed the supply of snack foods is perfectly elastic. They estimated that a tax on snack products would have negligible effects on consumption but could generate substantial revenues for health education.

Schroeter, Tyner and Lusk (2008) went one step further and calculated the elasticity of weight with respect to a one percent change in price of several food products. Contrary to Chou, Grossman and Saffer (2004), they found that taxes on food away from home would lead to increases in weight for men and women in the United States. They also found that subsidies on the prices of fruits and vegetables would likely be ineffective. A tax on high-calorie or a subsidy on low-calorie soda achieved greater weight losses, but the magnitude of change was predicted to be small.

Alternatively, Cash, Sunding and Zilberman (2005) found that small subsidies to consumers for fruits and vegetables could be an economically efficient way to decrease the number of cases of strokes and heart disease caused by deficiencies in fruit and vegetable consumption. They found that the cost of fruit and vegetable subsidies per life saved would be substantially less than the value of the life saved.

Taxes and subsidies on product ingredients or nutrients have also been evaluated in the academic literature. Smed, Jensen, and Denver (2007) estimated the effects of a tax on fat and sugar content, and a subsidy on fiber content for a multiple food groups in Denmark. They found that such taxes are unlikely to reduce calorie consumption. Chouinard et al. (2007) tested whether a tax on fat content of dairy products can affect calorie consumption and weight, and calculated the deadweight losses from such a tax. Assuming the supply of dairy products is perfectly elastic, they

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cupcakes, ice cream, malt beverages, margarine, peanut butter, pork and beans, potato chips, frozen french fries, and shortening.

found a tax applied to the fat content of dairy products would decrease fat consumption, but would lead to less than a pound per person per year reduction in weight, holding all other determinants of weight constant. However, they also found that the consumer welfare losses from the fat tax on dairy products would be only slightly more than the revenue generated (-$4.48 billion versus $4.45 billion). In addition, O'Donoghue and Rabin (2006) found that taxes on unhealthy foods for a heterogeneous population, where a fraction of the population exhibits self-control problems in terms of food consumption, can actually lead to Pareto improvements in social welfare.

Finally, a value-added tax or subsidy can be applied to food products (VAT). In other words, the foods that most closely resemble products sold at the farm gate would incur lower taxes and highly processed foods would be more highly taxed. Gustavsen and Rickertsen (2006) estimated the effect of the removal of the VAT (11 percent price decrease) on fruit and vegetable consumption in Norway. They found that removal of the VAT would be likely to increase purchases of fruits and vegetables for high-consuming households but would have little effect on low-consuming households.

Taxes and subsidies can be used on commodity and retail food products to induce change in consumption patterns, and hence, weight outcomes. Evidence shows that agricultural policies like investment in agricultural R&D can be and have been effective in changing commodity and retail prices much more than commodity subsidies. Several countries including the United States have increased funding for specialty crops as a means of changing the composition of food consumption (Cash et al. 2006, Martin 2008). Most of the studies find that taxes and subsidies applied to food products or ingredients in food products will lead to decreases in calorie or fat consumption but the magnitude of these effects are small over a small time horizon. However, it is likely that changes in food consumption, and hence, obesity from most policies will occur in the long term.

4. Agricultural R&D and Commodity Prices

In real terms agricultural commodity prices trended down significantly during the past 100 years, reflecting growth in supply of agricultural products outstripping growth in demand that was fueled by increases in population and per capita incomes. The long-term trend in deflated prices has been remarkable. Over the 55 years between 1950 and 2005, in real terms commodity prices fell at an average annual rate of 1.6 to 2.5 percent; over the 30 years between 1975 and 2005, at an average rate of 2.6 to 3.9 percent per year (Alston, Beddow, and Pardey 2009). Alston, Beddow and Pardey (2009) attributed these trends in prices primarily to growth in farm productivity—in terms of crop yields, broader partial productivity measures, and multifactor productivity measures—which they ascribed primarily to public and private investments in agricultural R&D.

Evidence on Returns to R&D and R&D Lags

Alston, Andersen, James and Pardey (2009) modeled state-specific U.S. agricultural productivity for the period 1949-2002 as a function of public agricultural research and extension investments over 1890-2002. The results supported relatively long research lags (an overall lag length of 50 years with a peak impact at 24 years but with most of the impact exhausted within 40 years), with a very substantial share of a state's productivity growth attributable to research conducted by other states and the federal government. The authors found that U.S. public agricultural R&D, whether undertaken by state or federal government, yielded very handsome returns.

Table 1 summarizes the results from the preferred model, showing the distribution of own-state and national benefits from state-specific and federal investments in agricultural research and extension in the United States, expressed in terms of benefit-cost ratios and internal rates of return. The results show that marginal increments in investments in agricultural research and extension (R&E) by the 48 contiguous U.S. states generated own-state benefits of between $2 and $58 per research dollar, averaging $21 across the states (the lower benefit-cost ratios were generally for the states with smaller and shrinking agricultural sectors, especially in New England). Allowing for the spillover benefits into other states, state-specific agricultural research investments generated national benefits that ranged between $10 and $70 per research dollar across the states, with an average of $32. The marginal benefit-cost ratio for USDA intramural research was comparable, at $18 per dollar invested in research.

[Table 1: *Benefit-Cost Ratios and Internal Rates of Return to U.S. Agricultural R&D*]

The benefit-cost ratios in Table 1 are generally large, and might seem implausibly large to some readers. In fact, however, these ratios are consistent with internal rates of return at the smaller end of the range compared with the general results in the literature as reviewed by Alston et al. (2000a), and as discussed by others (e.g., Evenson 2002; Fuglie and Heisey 2007). Specifically the estimates of own-state "private" rates of return ranged from 7.4 to 27.6 percent, with an average of 18.9 percent per annum across the states and the estimates of national "social" rates of return ranged from 15.3 to 29.1 percent, with an average of 22.9 percent per annum across the states, and the rate of return to USDA intramural research was 18.7 percent per annum.

Relative Prices of Specialty Crops, Other Crops, and Livestock

While all food commodity prices have trended down in real terms, the movements have been uneven, with important differences among commodity categories.[9] Figure 1, panel a shows the nominal prices for the main product categories. The prices of specialty crops have grown both absolutely and relative to field crops and

[9] Alston and Pardey (2008) reviewed past trends in prices in the context of their analysis of the economics of R&D on specialty crops, and material presented in this section is drawn mainly from their analysis.

livestock products, which have had fairly static nominal prices for the 20 years prior to 2004 in spite of general cost inflation.[10] Figure 1 Panel b shows the same price series deflated by the implicit price deflator for gross domestic product (representing prices generally in the economy). Figure 2 shows the corresponding average annual rate of change in deflated output prices for the period 1950-2004. Prices received by farmers for all crop categories trend down relative to prices paid by consumers for all goods and services. Associated with these price changes have been substantial increases in quantities produced and consumed. The increase in consumption could be accounted for by the lower real price or growth in demand, or a combination of the two. The increase in production in spite of lower real producer prices indicates that supply must have increased.

[Figure 1: *Nominal and Relative Prices of Specialty Crops, 1949-2004*]

[Figure 2: *Real Movement in Prices of Specialty Crops, 1949-2004*]

A first impulse may be to assume that, since prices have fallen faster for other products (i.e., field crops and livestock), the rate of growth in productivity and increase in supply must have been comparatively slow for specialty crops. However, such an interpretation may not be justified. More-specific interpretations are possible if we have more information. For instance, if we know the elasticity of supply, we can partition changes in production into those associated with changes in prices and those associated with shifts in supply; and if we know the price elasticity of demand, we can partition changes in consumption into those associated with changes in prices and those associated with shifts in demand.

[10] As discussed by Alston, Sumner, and Vosti (2006), some of these price increases for specialty crops might reflect premia for changes in quality, variety, or seasonal availability, which might not have been fully addressed in the indexing procedure. This possibility is a subject for continuing research, and is set aside for the time being.

Here, we are mainly interested in the supply side. The indexes of prices and quantity for the different categories of output grew at different rates over the period 1949 through 2004, as summarized in Table 2. The indexes all started at 100 in 1949. By 2004 the quantity indexes had reached 212 for livestock (i.e., the index grew by 112 percent), 278 for field crops, 262 for vegetables, 283 for fruits and nuts, and 742 for nursery and greenhouse marketing. In contrast, the corresponding price indexes were 307 for livestock, 190 for field crops, 489 for vegetables, 519 for fruits and nuts, and 534 for nursery and greenhouse marketing. Dividing by the GDP deflator, which had grown from 1.0 in 1949 to 6.69 in 2004, the corresponding real price indexes were 45.9 for livestock, 28.4 for field crops, 73.1 for vegetables, 77.5 for fruits and nuts, and 79.8 for nursery and greenhouse marketing. Suppose, for the sake of argument, that the relevant elasticity of supply is $\varepsilon = 1.0$. A real price index of 45.9 for livestock in 2004 indicates a price decrease of 55.1 percent since 1949, which given $\varepsilon = 1.0$, ceteris paribus, would imply a 55.1 percent decrease in quantity supplied. Subtracting the price-induced change in quantity supplied (– 55.1 percent) from the overall observed growth in quantity (112 percent) implies an increase in livestock supply of 167.1 percent (i.e., 112 – (– 55.1) = 167.1 percent). Table 2 reports the corresponding computations for each category of production using an elasticity of supply of either $\varepsilon = 1.0$ or $\varepsilon = 0.5$.

[Table 2: *Growth in Production and Prices for Agricultural Products, 1949–2004*]

Considering the estimates made using an elasticity of $\varepsilon = 1.0$, the computed growth rates of supply of vegetables as well as fruits and nuts fall in between those of livestock and field crops. Only greenhouse and nursery is outside the typical range for livestock and other crops. When we use an elasticity of $\varepsilon = 0.5$ instead, the differences in the computed growth rates of supply are reduced. In either case, with the exception of nursery and greenhouse, which has been growing much faster but from a very small base, supply of specialty crops has been growing at a rate similar to that for the supply of U.S. agricultural products generally. Thus there is not a prima facie case to suggest that specialty crops have been technological orphans. Of course, we have not identified the source of the growth in supply, and it might be mostly from increases in acreage and capital investment in fruit and nuts and other specialty crops, and mostly from new technology in field crops, but whether that is so remains a matter of speculation for now.

Some authors have attributed at least some of the rising obesity in the United States to the relatively slow decline in real prices of specialty crops. Whether these relative price movements are attributable to relatively slow growth in supply or relatively fast growth in demand for specialty crops, the price changes themselves will have contributed to the observed consumption patterns. In particular, they will have contributed to the observed under-consumption of fruit and vegetables relative to the recommendations of health professionals—as, for instance, contained in the USDA food pyramid. In turn, it has been argued that the government should do something to reverse this pattern—to change the relative prices in favor of fruit and vegetables. One suggested approach is to tax other products, subsidize fruit and vegetables, or both (see for instance, Cash, Sunding, and Zilberman 2005). An alternative approach is to change the emphasis of agricultural R&D by increasing productivity-enhancing research into specialty crops, reducing productivity-enhancing research into other commodities, or both. In what follows we examine these alternatives using a relatively simple model of supply and demand for two categories of commodities, specialty crops and others.

5. A Stylized Model of Agricultural R&D and Commodity Prices

In the illustrative simulation model developed here consider two categories of agricultural commodities, "specialty crops" and "other." We use this model to examine the implications of subsidies on specialty crops or taxes on other commodities versus an increase in R&D on specialty crops (as introduced in the 2008 Farm Bill), perhaps at the expense of R&D on other commodities.

Commodity Policy as Public Health Policy: Some Issues

Some basic questions can be asked about whether commodity policy should ever be used as public health policy. Nevertheless, changes in commodity policies have been proposed and introduced as treatments for nutrition and health problems associated with obesity. Consequently an exploration of the potential is justified. Before embarking on that exercise, we point out some aspects that must be set aside before we can begin to conduct an analysis of food and nutrition policy in the context of a simplified model of the market for food commodities.

First, consumers do not consume agricultural commodities. A number of agricultural commodities are used primarily as ingredients in livestock feed. And even food commodities typically are substantially transformed as they are combined with other commodities and other inputs to make food—including transformations that take place within households as meals are prepared from retail food products made from farm commodities.

Second, for related reasons, those who propose taxes (e.g., on fat or calories) as instruments of public health policy usually refer to taxes on food products rather than on food commodities. A fat tax applied to food products would have an ultimate incidence on food commodities, depending on their fat content and on other factors, in ways that are difficult to infer because the food marketing chain is complex. Likewise, a tax applied to particular farm commodities would have an ultimate incidence on particular foods (and on particular nutrients) but again it is difficult to infer that incidence with any precision. The same comments apply when the instrument is agricultural R&D, and these aspects make it difficult to compare agricultural R&D policies (affecting supply of farm commodities) with taxes on retail food products, as alternative instruments for achieving particular health and nutrition outcomes.

Third, there is no clear mapping from health outcomes to particular food products, let alone to particular farm commodities. Certainly sugar and other caloric sweeteners such as high-fructose corn syrup are implicated in obesity and its consequences, but food products containing these ingredients are not necessarily unhealthy for all consumers. A policy of taxing these ingredients may well result in reduced consumption of products containing them, with favorable impacts on the general health of the population. But a tax on calories is comparatively blunt, and likely to be comparatively inefficient, as an instrument of public health policy because it will influence consumption choices not only by those consumers who were but also by those who were not generating negative externalities through the health-care system.[11]

Fourth, in our application we are aggregating all agricultural commodities into two groups: (1) specialty crops, and (2) other. Each of these groups includes dozens of different commodities, the consumption of which could contribute positively or negatively to the prevalence of obesity and consequent externalities through the health-care system, depending on a host of other factors (including everything else that is consumed as part of the diet, other lifestyle choices, in conjunction with the genetic predisposition of individuals). As an abstraction and simplification we model these two aggregates as though "specialty crops" do not entail any externalities, while the consumption of foods based on other agricultural commodities does entail a negative externality that arises

[11] Similar arguments apply to alcohol taxes that fall equally on alcohol consumers regardless of whether they do or do not generate any social problems or externalities. We can imagine a more-closely targeted instrument may be fairer and more efficient—such as heavier taxes on particular alcohol-containing products that are more-frequently associated with drink-driving, violence, or alcohol-related health problems—but designing and implementing discriminatory taxes to achieve such purposes is never simple or easy.

from impacts on human health in conjunction with a health-care system in which individual costs of illness are not borne entirely individually.

A Multi-Market Model

Figure 3 represents the market for commodity S (specialty crops) in panel a, and the market for commodity O (other farm products) in panel b. We assume that the cross-product impacts on the supply side are likely to be negligible and focus attention on the substitution between “specialty crops” and “other” food commodities on the demand side. Now, suppose, as a result of an increase in specialty crops research investments, supply of specialty crops shifts down in parallel by a fraction k_s of the initial price, from SS_0 to SS_1, in panel a. A conventional measure of the benefits from this research-induced supply shift is equal to the area behind the demand curve, DS between the two supply curves in panel a (i.e., the area I_0abI_1). This total benefit is approximately equal to the research-induced cost saving per unit times the number of units affected—i.e., $k_sPS_0QS_0$.

[Figure 3: *A Research Induced Supply Shift for Specialty Crops*]

In a typical partial equilibrium analysis, the same total amount (i.e., area I_0abI_1) is interpreted as a benefit to consumers of specialty crops equal to area PS_0abPS_1 and, under the special assumption of a vertically parallel supply shift, a benefit to producers of specialty crops equal to area PS_1bcd. But this interpretation is valid only if the prices of other goods are fixed. However, in panel b, the implication of the lower price for specialty crops is a reduction in demand for other food commodities (assuming they are substitutes), shifting from DO_0 to DO_1, and the ultimate equilibrium is at a lower price, PO_1 and quantity, QO_1.

In this case, the measure of total benefits is still valid, so long as there are no market distortions and the demand curve for specialty crops is sufficiently generally defined (specifically, the demand curve DS reflects “general equilibrium” feedback effects of induced changes in prices for other products when the price of specialty crops changes).[12] In this approach it would be double-counting to add the reduction in producer surplus accruing to producers of other products (area PO_0abPO_1 in panel b) to the total benefits measured in panel a, although this area is valid as a measure of losses to those producers given the assumption of independent supply.

Now, however, suppose the consumption of other products involves a negative externality of E per unit, invalidating a key assumption underpinning the analysis above. The conventional welfare measure that does not account for changes in the externality per unit or the number of units to which it applies is no longer valid. Assuming the externality is constant at E per unit, before and after the shift in demand for other products, the increase in supply of specialty crops has resulted in a reduction of net social costs of the externality equal to area *bcde* in panel b, equivalent to $E\ (QO_0 - QO_1)$, which is an additional benefit from the increase in supply of specialty crops. Thus the gross annual benefits from specialty crops research (GARB_S) in the presence of the externality from consumption of other products is equal to the benefit in the absence of the externality (i.e., area $I_0abI_1 \approx k_sPS_0QS_0$) minus the research-induced change in the social cost of the externality: $E\ (QO_0 - QO_1)$. In other words

(1) $\text{GARB}_\text{S} \approx k_sPS_0QS_0 - E\ (QO_1 - QO_0) > k_sPS_0QS_0.$

Conversely, the benefits from "other" agricultural research in the presence of the externality will be lower than they would be otherwise to the extent that the research-induced increase in consumption entails an increase in the social costs of the

[12] However, the areas of "consumer surplus" and "producer surplus" may no longer have individual welfare significance (see Just, Hueth and Schmitz, 1982; Alston, Norton, and Pardey 1995; Thurman 1991a, 1991b).

externality.[13] In the case of a shift down of supply of other products by a fraction k_o of the price:

(2) $\text{GARB}_\text{O} \approx k_o PO_0 QO_0 - E\,(QO_1 - QO_0) < k_o PO_0 QO_0$.

This analysis shows how the presence of a negative externality associated with consumption of other agricultural products implies smaller research benefits for other products and greater research benefits for specialty crops, everything else equal, justifying a reallocation of research resources towards specialty crops and away from other products, everything else equal. This is an intuitive result, consistent with the types of arguments made both by some proponents of the Specialty Crops Research Initiative and by others who have criticized and argued for a reduction of support for public agricultural research directed towards corn and certain other commodities (Schoonover and Miller 2006).

The qualitative argument is clear in this simplified representation (recall the issues raised above about commodity policy as an instrument of public health policy). The quantitative importance of the externality relative to other considerations is an empirical question with implications for whether any reallocation of research resources is warranted. In particular, if research that enhances supply of specialty crops or supply of other commodities would yield equal marginal private benefits (i.e., ignoring any externalities) with the current allocation, then the presence externalities as shown would justify a redirection of some resources from other research towards specialty crops research. However, when there is little basis for assuming equal benefits at the margin from specialty crops, the case for redirecting research resources is less clear.

[13] Alston and Martin (1995) demonstrated the general result that the benefits from research in the presence of a distortion are equal to the benefits from research in the absence of the distortion minus the effect of the same research on the social costs of the distortion.

Moreover, the evidence of very large benefit-cost ratios for agricultural research means (1) the externality would have to be very large to justify reducing “other” agricultural research and (2) an increase in specialty crops research would be justified even in the absence of an externality. The evidence would support an increase in research on both “other” agricultural commodities and specialty crops, with an externality argument potentially supporting a *relative* increase in specialty crops research, even if we did not have the option of using other policy instruments that could more directly address the externality associated with individuals making unhealthy consumption choices in conjunction with distortions in incentives associated with health care.

Quantitative Considerations

An algebraic counterpart of the model represented in Figure 3 can be used to make our arguments more concrete and, if information on the key parameters can be obtained, to quantify the main effects. The equations of the model include supply and demand equations for each of the two categories of goods. Thus the model is given by:

(3a) $QS = \mathrm{d}_s(PS, PO)$ – demand for specialty crops

(3b) $QO = \mathrm{d}_o(PS, PO)$ – demand for other products

(3c) $QS = \mathrm{s}_s(PS, RS)$ – supply of specialty crops

(3d) $QO = \mathrm{s}_o(PO, RO)$ – supply of other products

In these equations, d_s and d_o denote the demand functions for specialty crops and other products, respectively, both as functions of the price of specialty crops, *PS* and other products, *PO*, while s_s and s_o denote the supply functions for specialty crops and other products, respectively, each as a function of its own price (*PS* or *PO*) and its own research (*RS* or *RO*).

Taking logarithmic differentials, the equations of the model can be expressed in terms of proportional changes and elasticities of supply and demand as follows:

(4a) $d \ln QS = \eta_{ss}\, d \ln PS + \eta_{so}\, d \ln PO$

(4b) $d \ln QO = \eta_{os} d \ln PS + \eta_{oo} d \ln PO$

(4a) $d \ln QS = \varepsilon_{ss} d \ln PS + \varepsilon_{sr} d \ln RS$

(4d) $d \ln QO = \varepsilon_{oo} d \ln PO + \varepsilon_{or} d \ln RO$

These four equations can be solved for proportional (or percentage) changes in the four endogenous variables—two quantities produced and consumed (*QS* and *QO*) and two prices (*PS* and *PO*)—as functions of the own- and cross-price elasticities of demand (η_{ss}, η_{oo}, η_{so}, η_{os}), elasticities of supply with respect to prices and research spending (ε_{ss}, ε_{oo}, ε_{sr}, ε_{or}), and exogenous increases in research spending.

Assume that the total research budget is fixed, such that any increase in the budget for specialty crops research comes at the expense of other agricultural research. Then $w_s d \ln RS = -(1 - w_s) d \ln RO$, where w_s is the share of research expenditure on specialty crops. Further, consider a 1 percent increase in spending on specialty crops research, such that $100 \times d \ln RS = 1$, and therefore $100 \times d \ln RO = -(1 - w_s)/w_s$. The solution is:

(5)
$$\begin{bmatrix} d\ln QS \\ d\ln QO \\ d\ln PS \\ d\ln PO \end{bmatrix} = \frac{1}{100 \times D} \begin{bmatrix} \eta_{ss}\left(\eta_{oo} - \varepsilon_{oo}\right) - \eta_{so}\eta_{os} & -\eta_{so}\varepsilon_{ss} \\ -\eta_{os}\varepsilon_{oo} & \eta_{oo}\left(\eta_{ss} - \varepsilon_{ss}\right) - \eta_{so}\eta_{os} \\ \eta_{oo} - \varepsilon_{oo} & -\eta_{so} \\ -\eta_{os} & \eta_{ss} - \varepsilon_{ss} \end{bmatrix} \begin{bmatrix} \varepsilon_{sr} \\ -\varepsilon_{or}\left(\dfrac{1 - w_s}{w_s}\right) \end{bmatrix}$$

where $D = \left(\varepsilon_{ss} - \eta_{ss}\right)\left(\varepsilon_{oo} - \eta_{00}\right) - \eta_{so}\eta_{os}$.

Own-price elasticities of demand are negative numbers (i.e., $\eta_{ss} < 0$, $\eta_{oo} < 0$), and under most reasonable assumptions the cross-price elasticities will be positive numbers (i.e., $\eta_{so} > 0$, $\eta_{os} > 0$) meaning that the two types of commodities are substitutes. Therefore, a 1 percent increase in research spending on specialty crops would result in an increase in production and consumption of specialty crops and a decrease in production and consumption of other products (i.e., $d \ln QS > 0$ and $d \ln QO < 0$), and the price of specialty crops would fall relative to the price of other products (i.e., $d \ln PS < 0$ and $d \ln PO > 0$).

We can use the results in equation (5) combined with equations (1) and (2) to infer approximate welfare impacts of the reallocation of research resources.[14] Combining equations (1) and (2) yields a measure of the GARB from a one-percent increase in R&D spending on specialty crops with a commensurate reduction in R&D spending on other crops such that the total spending on R&D is held constant:

$$(6) \qquad GARB \approx (\varepsilon_{sr}/\varepsilon_{ss})(PS_0QS_0)/100$$
$$- (\varepsilon_{or}/\varepsilon_{oo})[(1 - w_s)/w_s]\,(PO_0QO_0)/100$$
$$- QO_0\,E\,(\mathrm{d}\ ln\ QO)$$

In this equation the first term represents the "private" benefits from a 1 percent increase in spending on specialty crops research; the second term represents the foregone "private" benefits from "other" research that was reduced to finance the increase in specialty crops research; and the third term represents the reduction in the externality associated with the consumption of other products. This last term reflects reduced consumption of other products both as a result of doing less other research and as a result of doing more specialty crops research with its substitution effect on consumption of other products.

Equation (6) can be reduced further by substituting for $d \ln QO$ from (5) and by dividing throughout by the total value of agricultural production, and multiplying by 100, such that we express gross annual research benefits as a percentage of the value of agricultural production (*G)*:

$$(7)\ \ G \approx (\varepsilon_{sr}/\varepsilon_{ss})\mathrm{v}_\mathrm{s} - (\varepsilon_{or}/\varepsilon_{oo})\,(1 - v_s)\,[(1 - w_s)/w_s] - 100\,(E/PO_0)(1 - v_s)\,(\mathrm{d}\ ln\ QO)$$

[14] To do so we note a 1 percent increase in research spending for commodity i (where $i = o$ or s) which causes an increase in supply (quantity direction) by ε_{ir} percent is equivalent to a vertical research-induced shift down in supply by $\varepsilon_{ir} / \varepsilon_{ii}$ percent of the initial price: i.e., $k_i = (\varepsilon_{ir} / \varepsilon_{ii}) / 100$.

where $d\,ln\,QO = [-\eta_{os}\varepsilon_{oo}\varepsilon_{sr} - \{\eta_{oo}(\eta_{ss} - \varepsilon_{ss}) - \eta_{so}\eta_{os}\}\varepsilon_{or}\left(1- \ w_s\right) / w_s] / (100 \times D)$.

The sign of this expression depends on whether the private benefits from specialty crops (the first term) research plus the reduction in the externality (the third term) outweigh the foregone private benefits from other research. It is an empirical question that depends on a number of variables:

- the importance of specialty crops as a share of total output, v_s
- the importance of specialty crops research as a share of total research, w_r
- the elasticity of marginal cost with respect to research, given by the elasticity of supply with respect to research divided by the elasticity of supply with respect to price, both for specialty crops ($\varepsilon_{sr}/\varepsilon_{ss}$) and other products ($\varepsilon_{or}/\varepsilon_{oo}$)
- the externality as a fraction of the initial price of other products, E/PO_0
- the own and cross-price elasticities of demand for both products (η_{ss}, $\eta_{oo,}$ η_{so}, η_{os}) and the elasticities of supply with respect to prices and research spending (ε_{ss}, $\varepsilon_{oo,}$ ε_{sr}, ε_{or}).

6. Agricultural R&D versus Taxes and Subsidies

A subsidy on specialty crops funded by a tax on other agricultural outputs is analogous to a reallocation of existing research resources in the sense that (1) it would be self-financing, without requiring any additional taxpayer funding, and (2) it would directly and indirectly (through cross-price effects) encourage consumption and production of specialty crops and at the same time it would directly and indirectly (through cross-price effects) discourage production and consumption of other outputs. R&D lags are an important consideration. They mean that we may have to wait many years before a change in research policy implemented today has effects on production, prices, and consumption, let alone effects on obesity which has its own cumulative, dynamic characteristics. These dynamic relationships warrant their own detailed analysis, which we will set aside for the time being. This aspect has potentially important implications for the comparison between tax-subsidy policies that take effect immediately and R&D policies that take effect many years later, as discussed by Alston (2009).

Importantly, it seems likely that both specialty crops research and other research have large rates of return, with or without any allowance for externalities through the health-care system (e.g., see Alston and Pardey 2008). And it could be the case that it is not worth redirecting research resources towards specialty crops, even though doing so would reduce health-care system costs.[15] In other words, the social payoff to research into "other" agricultural commodities may be so high, externalities notwithstanding, that financing an increase in specialty crops research by reducing other research is not favored.

Even so it could be worth increasing funding of specialty crops research using taxpayer funding. A reasonable comparison, then, is between taking a given amount of taxpayer funds and using it to finance a subsidy on specialty crops or using the same money to finance an increase in research into specialty crops. This issue is similar to the case studied by Alston (2009). If agricultural R&D has a benefit-cost ratio of, say 10:1, a dollar of research spending that causes a vertically parallel supply shift has an impact equivalent to $10 of output subsidy—in present value equivalent terms. Importantly, however, while the impacts of a subsidy are clear and immediate, the impacts of research are far in the future, diffuse, and uncertain. Only those producers who adopt the resulting innovations will benefit, and under alternative assumptions about

[15] This could be so, for instance, if the private payoff is relatively low—i.e., $\varepsilon_{sr}/\varepsilon_{ss} << \varepsilon_{or}/\varepsilon_{oo}$—because of the industrial structure or agronomic features of specialty crops, as discussed by Alston and Pardey (2008).

the nature of the technological change (e.g., if it causes a pivotal supply shift) producers collectively will benefit much less.

7. Implications for U.S. Policy

The issues addressed in this paper can be viewed in terms of three types of market distortions. First, and foremost, are the distortions in incentives for individuals to economize on health care costs resulting from cost pooling through insurance and public provision of health-care services. Without this distortion, the high cost of diet-related illness alone does not constitute a case for government intervention. Second, are the distortions in agricultural production associated with farm program policies. These policies are essentially redistributive in purpose, with side effects on production and prices, and hence consumption, of food and beverages. Third, are the distortions in incentives for private provision of agricultural R&D, associated primarily with incomplete property rights over inventions, which are only partially offset by agricultural R&D policies including public agricultural R&D.

Standard public economics arguments suggest that economic efficiency would be served by applying different, separate policy instruments to address each of these three types of distortions; though, to be sure, policies directed at any one of these distortions could have implications for the others. In this framework, the application of instruments related to farm programs or agricultural R&D aiming to address public health concerns can be justified only in a second-best world in which public health policy has failed (i.e., the application of direct and more-appropriate health policy instruments has failed to correct distortions in incentives related to diet-related illness).

We may well be in that world. Some estimates suggest that the health-care system entails large externalities from excess obesity associated with moral hazard and adverse selection responses to health insurance.[16] In any event, it is an empirical question whether changing farm programs and agricultural R&D policies to influence farm commodity prices, as a mechanism for influencing consumption of food and the prevalence of obesity, would yield net social benefits. In-principle arguments raise doubts about the odds, given the remoteness of the operation of the instruments (on production and prices of farm commodities) and the target (costs of obesity-related illness). A consideration of the policies in practice reinforces these doubts.

U.S. farm subsidy policy comprises a complex set of programs that affect production costs, production, commodity prices, and farm incomes. Economists have modeled and measured many impacts of these subsidies. Nonetheless, the detailed quantitative effects of these policies on human nutrition and obesity are difficult to discern precisely. Even the direction of the effect is not clear, since commodity-specific trade policy has clearly led to higher U.S. consumer prices of several major food commodities (such as dairy products, sugar, and orange juice). But, the most important point is that, even when the direction of effects seems clear, the magnitude of the effects must be small. Farm subsidies have had small effects on most farm commodity prices and even smaller effects on consumption. U.S. farm subsidies have many critics. A variety of arguments and evidence can be presented to show that the programs are ineffective, wasteful, or unfair (e.g., see Alston 2007; Alston and Sumner 2007; Sumner 2005). Eliminating farm subsidy programs could solve some of these problems, but could not be expected to have large and favorable effects on consumer incentives to eat more-healthy diets such that obesity rates would be meaningfully reduced.

[16] Bhattacharya and Sood (2005) estimated a deadweight loss of $149 per insured person aged 25 and older per year borne by privately-insured individuals from pooling versus higher premiums for obese individuals. Across 170 million insured Americans older than 25, the total cost per year would be in the range of $25 billion per year. We are not sure how much confidence to place in the estimate but we note that it is on a similar scale to available estimates of the annual benefits from U.S. public agricultural R&D (e.g., see Alston et al. 2009).

Compared with farm program subsidies, public agricultural research policy has had much larger long-term effects on food prices and consumption in the past, and has greater potential to contribute to reducing (or increasing) rates of obesity in the future. Agricultural R&D policy, like public health policy, is an example of government failure. Available evidence clearly indicates a persistent underinvestment in agricultural R&D in spite of very significant government involvement. The opportunity cost of particular agricultural R&D investments (not counting any impacts on public health) may be in the range of $10-20 per dollar invested (e.g., Alston, Anderson, James and Pardey 2009). And the marginal returns may be very different among alternative elements of the portfolio. In these circumstances, rebalancing the existing R&D budget to favor specialty crops (at the expense of, say, corn) with a view to reducing the prevalence of obesity may involve significant net social costs. On the other hand, an increase in specialty crops R&D, without reducing other R&D, could be justified on conventional measures of benefits alone, without requiring a public health impact.

References

Adamy, J. "Soda Tax Weighed to Pay for Health Care." *The Wall Street Journal*, May 12, 2009.

Alston, J.M., 2007. “Benefits and Beneficiaries from U.S. Farm Subsidies.” AEI Agricultural Policy Series: The Farm Bill and Beyond. American Enterprise Institute, Washington, DC.

Alston, J.M., 2009. “Efficiency of Income Transfers to Farmers through Public Agricultural Research—Theory and Evidence from the United States.” *American Journal of Agricultural Economics* 91,5 (2009): (in press).

Alston, J.M., Andersen, M.A., James, J.S., Pardey, P.G., 2009. *Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending*. New York: Springer Publishers, September (in preparation).

Alston, J. M., Beddow, J.M., Pardey, P.G. “Mendel versus Malthus: Research, Productivity and Food Prices in the Long Run.” Department of Applied Economics Staff Paper No. P09-1, St. Paul, University of Minnesota, 2009a (revision in process).

Alston, J.M.,Chan-Kang, C., Marra, M.C., Pardey, P.G., Wyatt, T.J., 2000. *A Meta-Analysis of the Rates of Return to Agricultural R&D: Ex Pede Herculem*. IFPRI Research Report No. 113, Washington D.C.: International Food Policy Research Institute, 2000.

Alston, J.M., Martin, W.J., 1995. “Reversal of Fortune: Immiserizing Technological Change in Agriculture.” *American Journal of Agricultural Economics* 77(May):251-259.

Alston, J.M., Norton, G.W., Pardey, P.G. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Ithaca: Cornell University Press, 1995.

Alston, J.M., Pardey, P.G., 2008. “Public Funding for Research into Specialty Crops.” *HortScience* 43(5): 1461-1470.

Alston, J.M., Sumner, D.A., 2007. “Perspectives on Farm Policy Reform.” *Journal of Agricultural and Resource Economics* 32(1), 1-19.

Alston, J.M., Sumner, D.A., Vosti, S.A., 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(3), 313-322.

Alston, J.M., Sumner, D.A., Vosti, S.A., 2008. “Farm Subsidies and Obesity in the United States: National Evidence and International Comparisons.” *Food Policy* 33(6) (December): 470-479.

Baum, C., 2007. “The Effects of Food Stamps on Obesity.” USDA, Economic Research Service, Washington, DC, September. Available online at http://www.ers.usda.gov/publications/ccr34/ccr34.pdf.

Beghin, J., Jensen, H., 2008. "Farm Policies and Added Sugars in US Diets." *Food Policy* 33 (6)(December): 480-488.

Bhattacharya, J., Sood, N., 2007. “Health Insurance and the Obesity Externality,” National Bureau of Economic Research, working paper, No. 11529 (July).

Bleich, S., D. Cutler, C. Murray, Adams, A., 2007. "Why is the Developed World So Obese?" *NBER Working Paper* 12954.

Brownell, K., Frieden, T., 2009. "Ounces of Prevention--The Public Policy Case for Taxes on Sugared Beverages." *New England Journal of Medicine* 360(18): 1-4.

Cash, S.B., Sunding, D.L., Zilberman, D., 2005. “Fat Taxes and Thin Subsidies: Prices, Diet and Health Outcomes.” *Acta Agriculturae Scand* Section C 2, 167-174.

Cash, S., Goddard, E.W. ,Lerohl, M., 2006. “Canadian Health and Food: The Links between Policy, Consumers and Industry.” *Canadian Journal of Agricultural Economics* 54: 605-629.

Chan, S., 2008. “A Tax on Many Soft Drinks Sets Off a Spirited Debate.” *The New York Times*, December 16.

Chen, Z, Yen, S.T., Eastwood, D.B., 2005. “Effects of Food Stamp Participation on Body Weight and Obesity.” *American Journal of Agricultural Economics* 87(5), 1167-1173.

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(3): 565-587.

Chouinard, H.H., Davis, D.E., LaFrance, J.T., Perloff, J.M., 2007. “Fat taxes: Big money for small change.” *Forum for Health Economics & Obesity* 10(2).

Cutler, D., Glaeser, E. Shapiro, J., 2003a. “Why Have Americans Become More Obese?” National Bureau of Economic Research, working paper, 9446 (January).

Cutler, D., Glaeser, E. Shapiro, J., 2003b. “Why Have Americans Become More Obese?” *Journal of Economic Perspectives* 17, 93-118.

Cutler, D., Glaeser, E., Rosen, A., 2007. “Is the US Population Behaving Healthier?” National Bureau of Economic Research, Working Paper 13013, April.

Drewnowski, A.,Darmon, N., 2005. "The Economics of Obesity: Dietary Energy Density and Energy Cost." *American Journal of Clinical Nutrition* 82(1S): 265S-273S.

Drewnowski, A., Specter, S. 2004. "Poverty and Obesity: The Role of Energy Density and Energy Costs." *American Journal of Clinical Nutrition* 79(1): 6-16.

Evenson, R.E., 2002. “Economic Impacts of Agricultural Research and Extension.” Chapter 11 in B.L. Gardner and G.C. Rausser eds. *Handbook of Agricultural Economics*, *Volume 1A: Agricultural Production*. New York: Elsevier.

Fuglie, K.O. ,Heisey, F.W.. 2007. *Economic Returns to Public Agricultural Research*. USDA, ERS Economic Brief No. 10. Washington D.C.: USDA, September.

Gelbach, J., Klick, J., Stratmann, T., 2007. "Cheap Donuts and Expensive Broccoli: The Effect of Relative Prices on Obesity." *FSU College of Law, Public Law Research Paper* 261.

Gustavsen, G., Rickertsen, K., 2006. "A Censored Quantile Regression Analysis of Vegetable Demand: The Effects of Changes in Prices and Total Expenditure." *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 54(4): 631-645.

Huffman, W., Huffman, S.K., Tegene, A., Rickertsen, K., 2006. "The Economics of Obesity-Related Mortality among High Income Countries." Paper presented at the Conference of International Association of Agricultural Economists, Gold Coast, Australia, August 12-18.

Gibson, D., 2003. "Food Stamp Program Participation is Positively Related to Obesity in Low Income Women." *Journal of Nutrition* 133(7), 2117-2118.

Gibson, D., 2006. "Long-Term Food Stamp Program Participation is Positively Related to Simultaneous Overweight in Young Daughters and Obesity in Mothers." *Journal of Nutrition*, 136(4), 1081-1085.

Guthrie, J., Frazao, E., Andrews, M., Smallwood, D., 2007. "Improving Food Choices: Can Food Stamps Do More?" *Amber Waves* 5(2). Available online at http://www.ers.usda.gov/AmberWaves/April07/Features/Improving.htm.

International Obesity Task Force. 2005. *EU Platform on Diet, Physical Activity and Health*. Brussels, International Obesity Task Force; 2005.

Jacobson, M.F., Brownell, K.D., 2000. "Small Taxes on Soft Drinks and Snack Foods to Promote Health." *American Journal of Public Health* 90(6), 854-857.

Johansson, R.C., Mancino, L., Cooper, J., 2006. "The Big Picture: Obesity, Consumption, and Food Production." *Agribusiness*, 22(4), 491-503.

Just, R.E., Hueth, D.L. Schmitz, A.,1982. *Applied Welfare Economics and Public Policy*. Englewood Cliffs, New Jersey: Prentice Hall.

Kaushal, N., 2007. "Do Food Stamps Cause Obesity? Evidence from Immigrant Experience." *Journal of Health Economics* 26, 968-991.

Kuchler, F., Tegene, A., Harris, J.M., 2004. "Taxing Snack Foods: Manipulating Diet Quality or Financing Information Programs?" *Review of Agricultural Economics* 27(1), 4-20.

Lakdawalla, D., Philipson, T., 2002. "The Growth of Obesity and Technological Change: A Theoretical And Empirical Examination." National Bureau of Economic Research, working paper, No. 8946, May.

Loureiro, M.L., Nayga, R.M., 2005. "International Dimensions of Obesity and Overweight Related Problems: An Economics Perspective." *American Journal of Agricultural Economics* 87, 1147-1153.

Martin, J., 2008. “USDA Announces $28.4 Millions in Funding for Specialty Crop Research.” Washington, DC, USDA, Cooperative State Research, Education and Extension.

Miller, J.C., Coble, K.H., 2007. “Cheap Food Policy: Fact or Rhetoric?” *Food Policy* 32, 98-111.

Miller, J. C., Coble, K.H., 2008. "An International Comparison of the Effect os Government Agricultural Support on Food Budget Shares." *Journal of Agricultural and Applied Economics* 40(2): 551-558.

Miljkovic, D., Nganje, W., de Chastenet, H., 2008. “Economic Factors Affecting the Increase in Obesity in the United States: Differential Response to Price.” *Food Policy* 33 (1), 48-60.

Mullally, C., Alston, J.M. Sumner, D., Townsend, M., Vosti, S., 2007. “Proposed Modifications to The Food Stamp Program: Likely Effects and Their Policy Implications.” In E. Blass ed. *Obesity: Causes, Mechanism, and Prevention*. Sunderland, MA: Sinauer Associates, Inc.

O’Donoghue, T. and M. Rabin, 2006. “Optimal Sin Taxes.” *Journal of Public Economics* 90: 1825-1849.

Ogden, C.L., Flegal, K.M., Carroll, M.D., Johnson, C.L., 2006. “Prevalence of Overweight And Obesity in the United States, 1999-2004” *Journal of the American Medical Association* 295(13), 1549-1555.

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 Magazine, April 22.

Pollan, M., 2008. "Farmer in chief." New York Times, October 9.

Richards, T., Patterson, P., Tegene, A., 2007. "Obesity and Nutrient Consumption: A Rational Addiction?" *Contemporary Economic Policy* 25 (3): 309-324.

Ruhm, C.J., 2007. “Current and Future Prevalence of Obesity and Severe Obesity in the United States.” *Forum for Health Economics and Policy* 10(2) available at http://www.bepress.com/fhep/10/2/6/

Schmidhuber, J., 2004. "The Growing Global Obesity Problem: Some Policy Options to Address It." *Electronic Journal of Agricultural and Development Economics* 12: 272-90.

Schroeter, C., Lusk, J., Tyner, W., 2008. “Determining the Impact of Food Prices and Income on Body Weight.” *Journal of Health Economics* 27(1), 45-68.

Schoonover, H., Miller, M., 2006. “Food Without Thought: How U.S. Farm Policy Contributes to Obesity.” The Institute for Agriculture and Trade Policy, Minneapolis, MN.

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.

Smed, S., Jensen, J., Denver, S., 2007. "Socio-Economic Characteristics and the Effect of Taxation as a Health Policy Instrument." *Food Policy* 32 (5): 624-639.

Sumner, D.A., 2005. "Boxed in: Conflicts between U.S. farm policies and WTO obligations." Cato Institute Trade Policy Analysis 32, December http://www.freetrade.org/pubs/pas/pas.html.

Thurman, W., 1991a. "Applied General Equilibrium Welfare Analysis." *American Journal of Agricultural Economics* 73:1508-16.

Thurman, W., 1991b. "On the Welfare Significance and Nonsignificance of General Equilibrium Demand and Supply Curves." Department of Agricultural and Resource Economics, North Carolina State University.

U.S. Surgeon General, 2001. *The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity.* Public Health Service, Office of the Surgeon General, U.S. Department of Health and Human Services, Rockville, MD.

Ver Ploeg, M., Mancino, L., Lin, B.-H., 2006. "Food Stamps and Obesity: Ironic Twist or Complex Puzzle?" *Amber Waves*, 4(1), 32-37.

Ver Ploeg, M., Mancino, L., Lin, B.-H., 2007. "Food and Nutrition Assistance Programs and Obesity: 1976-2002." Economic Research Report No. 48, USDA Economic Research Service, September.

World Health Organization, 1997. *Obesity, Preventing and Managing the Global Epidemic. Report of a WHO Consultation on Obesity*. Geneva, Switzerland, World Health Organization.

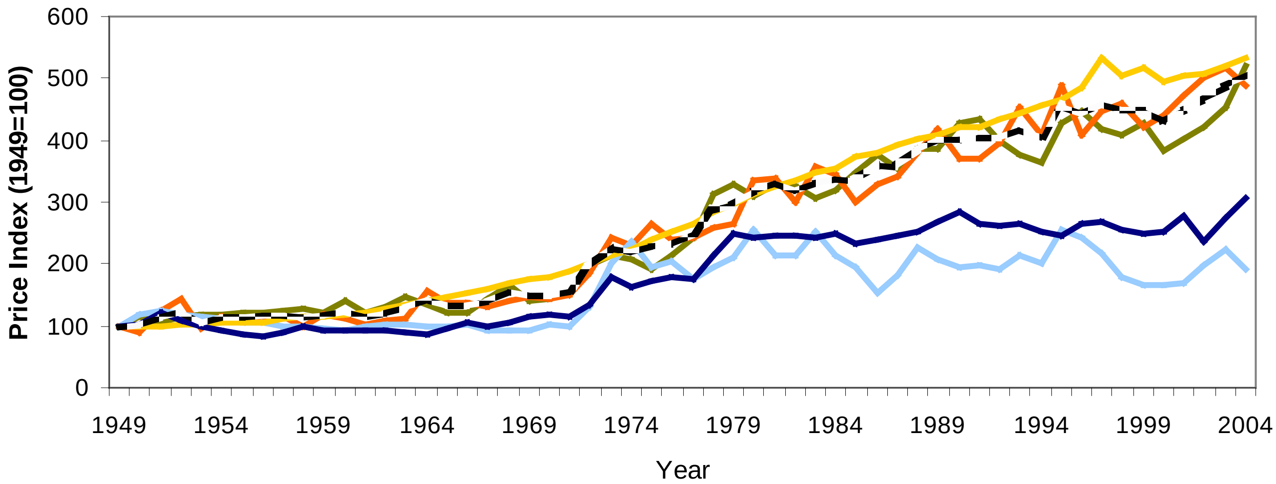
Table 1: *Benefit-Cost Ratios and Internal Rates of Return to U.S. Agricultural R&D*

Returns to	Benefit-Cost Ratio (3% real discount rate)		Internal Rate of Return	
	Own-State	National	Own-State	National
	ratio		*percent per year*	
State R&E				
48 States:				
Average	21.0	32.1	18.9	22.7
Minimum	2.4	9.9	7.4	15.3
Maximum	57.8	69.2	27.6	29.1
Selected States				
California	33.3	43.4	24.1	26.1
Minnesota	40.6	55.4	24.7	27.3
Wyoming	12.7	23.6	16.8	20.9
USDA Research		17.5		18.7

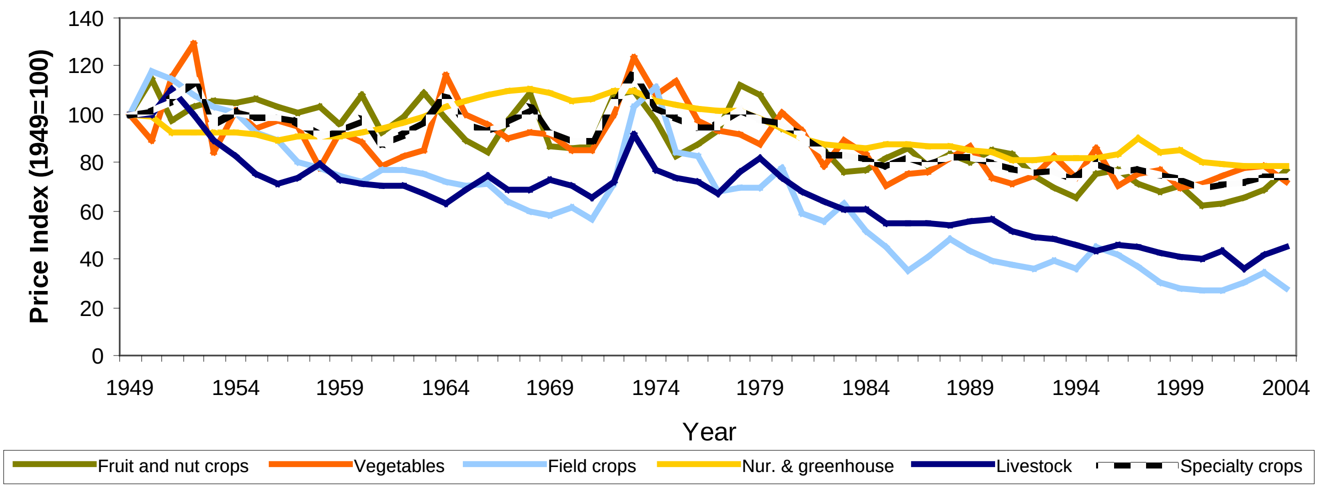
Source: Alston, Andersen, James, and Pardey (2009).

Figure 1: *Nominal Prices of Specialty Crops, Nominal and Relative Values, 1949-2004*

Panel a: Nominal Prices

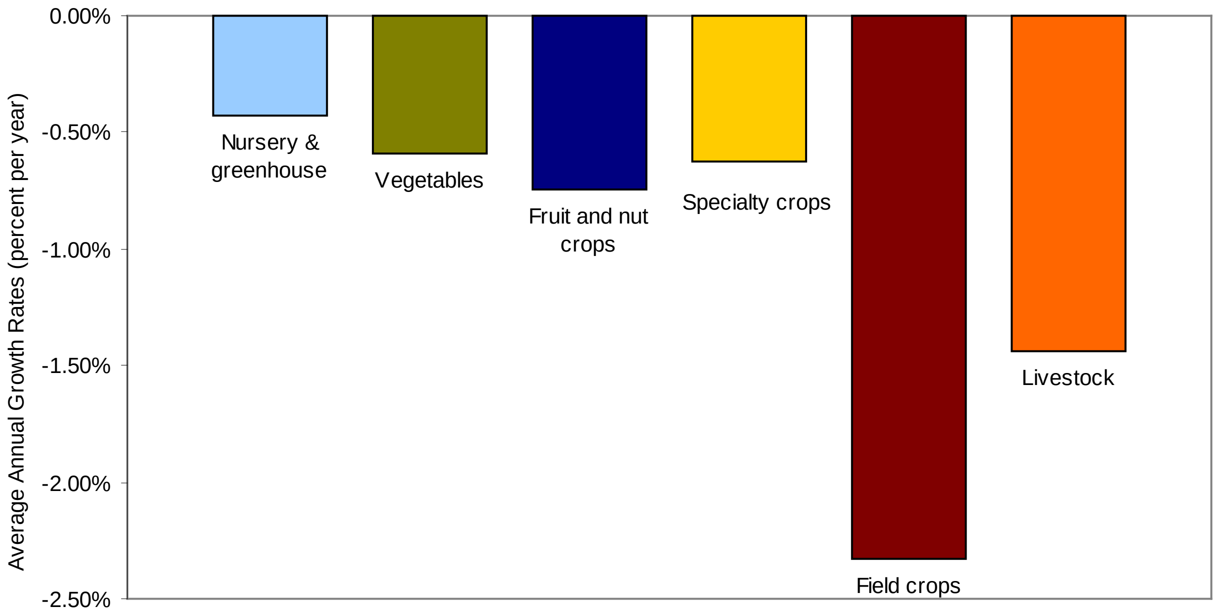


Panel b: Real Prices Deflated Using Implicit GDP Deflator



Source: Alston and Pardey (2008).

Figure 2: *Real Movements in Prices of Specialty Crops, 1950-2004*



Source: Alston and Pardey (2008).

Note: Nominal prices deflated using the GDP implicit price deflator.

Table 2. *Growth in Production and Prices for Agricultural Products, 1949–2002*

Commodity Category	Percentage Changes between 1949 and 2004 in				
	Production	Nominal Price	Real Price	Supply Growth ε = 1.0	Supply Growth ε = 0.5
Livestock	112	207	–54.1	167.1	139.6
Field Crops	178	90	–71.6	250.4	214.2
Vegetables	162	389	–27.9	189.9	176.0
Fruits and Nuts	183	419	–22.5	205.5	194.3
Greenhouse & Nursery	642	534	–20.2	662.2	652.1

Figure 3. *A Research-Induced Supply Shift for Specialty Crops*

Panel a: Specialty Crops

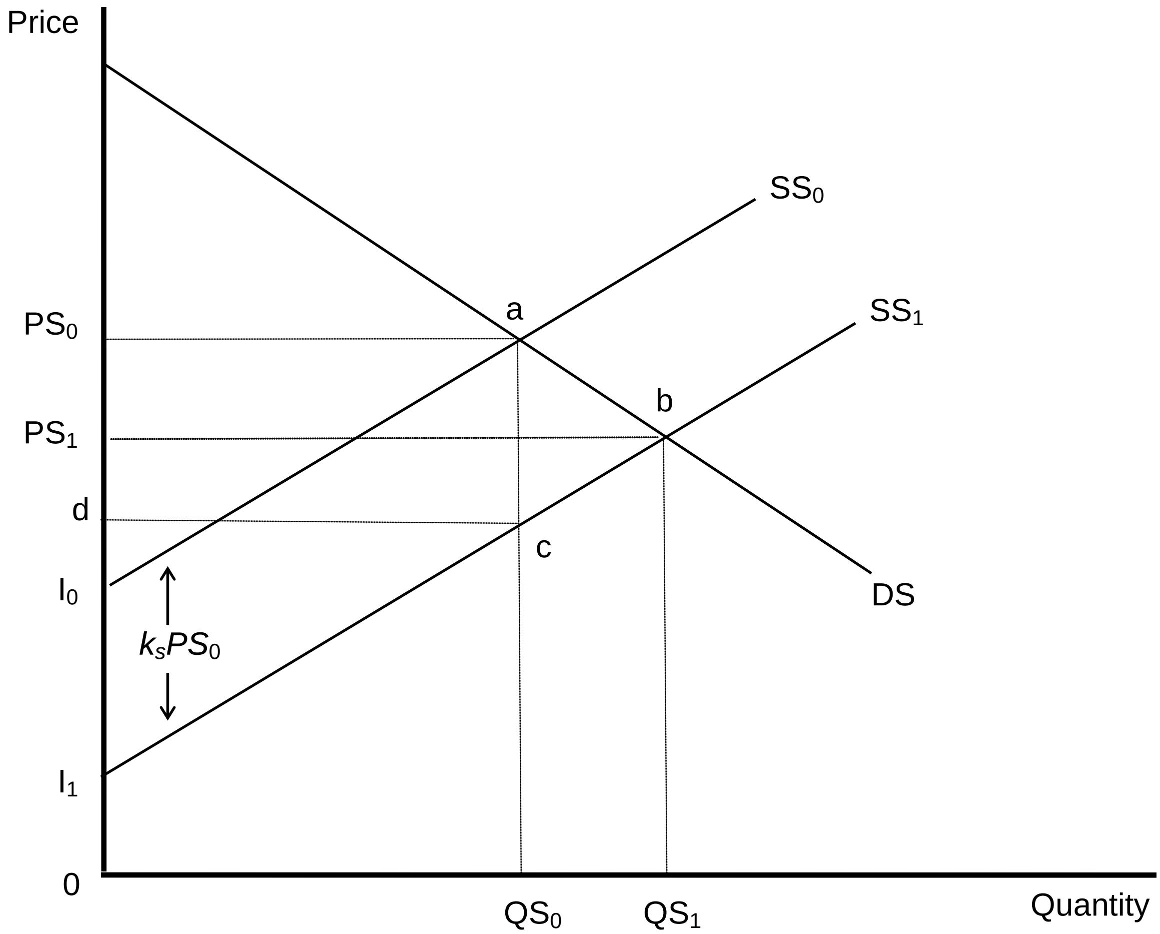


Figure 3. *A Research-Induced Supply Shift for Specialty Crops*

Panel b: Other Outputs