# Welfare-Enhancing Technological Change and the Growth of Obesity

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There has been concern about the dramatic growth in obesity seen in developed countries. This paper advances the view that a neoclassical interpretation of weight growth that relies on changing incentives does surprisingly well in explaining the observed trends, without resorting to psychological, genetic, or addictive models.[1]

Although the recent rise in obesity has attracted attention, weight growth is not a recent phenomenon (Dora Costa and Richard Steckel, 1995). Weight has been rising consistently over the past 150 years, particularly during the immediate post-World War II period. As Figure 1 illustrates, the secular growth in weight has been accompanied by modest growth, or even *declines,* in calorie intake (Judith Jones Putnam and Jane E. Allshouse, 1999). This suggests the importance of both rising food intake and declining physical activity. The calorie and weight trends have coincided with a decline in the relative price of food, of around 0.2 percentage points annually, from 1950 to 2000 (Lakdawalla and Philipson, 2002).

To explain these trends, this paper argues that *welfare-improving* technological change has simultaneously lowered the cost of calories and raised the cost of physical activity by making agricultural production more efficient and work more sedentary. When home or market production involves manual labor, the worker is *paid* to exercise; in advanced economies, people *pay* to exercise, primarily in terms of forgone leisure. Leisure-time exercise, such as jogging or gym activities, must be substituted for job-based exercise. Technological change on both the supply side (through agricultural innovation) and the demand side (through more sedentary household and market work) lead to weight growth, falling relative food prices, but ambiguous food consumption trends, because both food supply and demand fall.

Welfare-enhancing technological change also has new implications for the effect of income on weight. Growth in earned income that results from more skilled, sedentary work raises weight, even though growth in unearned income might raise the demand for thinness. This helps explain why richer people are thinner than poorer people within countries where workplace technologies are more uniform, even though richer and more technologically advanced countries are fatter than poorer ones. This theory also produces different implications for price than its competitors, such as a change in the psychology of food consumption, growth in the demand for fast food, genetically induced eating, or changing social norms. These alternatives emphasize rising demand for food, which implies rising food prices.

We develop the implications of the idea that economic progress (as income growth, food price declines, and sedentary work) leads to weight gain when people behave efficiently. To make concrete the point that obesity is a side effect of progress, we offer an empirical example of how lower food prices (a result of technological change) improve nutrition. Objective blood-test-based data suggest that lower food prices correlate with markedly improved nutrition in the United States. This relationship is often expected for developing countries, but less so for developed ones.

Our results suggest the difficulty of improving welfare by "rolling back" obesity to earlier levels, because obesity is a side effect of welfare-enhancing progress. The case of food prices and nutrition bears this out: raising food prices through taxation may reduce weight (cf. Marion

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[1] See Philipson and Richard Posner (1999) and Lakdawalla and Philipson (2002) for elaboration of the discussion here.

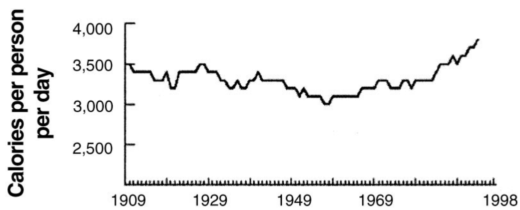


FIGURE 1. LONG-RUN CHANGES IN CALORIC CONSUMPTION, 1909–1998

*Notes:* USDA Economic Research Service.

Nestle, 2004), but it can have significant negative effects on nutrition and health.

## I. Technological Progress and Weight

Suppose period utility depends on food intake $F$, other consumption $C$, and weight $W$, according to $U(F, C, W)$. $U$ rises in food and other consumption but is non-monotonic in weight. The individual has an ideal weight, $W_0$, in that she prefers weight gain when below weight $W_0$, but weight loss when above. Let strenuousness of home or market work be $S$. The weight transition equation is

$$W' = (1 - \delta)W + g(F, S)$$

where $\delta < 1$, and $g$ is continuous, concave, increasing in food consumption, and decreasing in strenuousness. The associated value function $\nu$ is

$$(1) \quad \nu(W) = \max_{F,C,W'}\{U(F, C, W) + \beta\nu(W')\}$$

subject to $pF + C \leq Y$ and $W' = (1 - \delta)W + g(F, S)$, where $Y$ is income and $p$ the food price. The first-order and envelope conditions are

$$(2) \quad U_F(F, Y - pF, W) + \beta\nu'(W') \times g_F = pU_C(F, Y - pF, W)$$

$$\nu'(W) = U_W(F, Y - pF, W) + \beta\nu'(W')(1 - \delta).$$

The first-order condition implies that the marginal utility of consumption equals the overall marginal utility of food, which equals the marginal utility of eating plus the marginal value of the weight change induced by eating. The envelope condition implies that the long-run marginal value of weight equals the marginal utility of current-period weight plus the discounted future marginal utility of weight. These imply that steady-state weight and food, $W^*(S, p, Y)$ and $F^*(S, p, Y)$, are decreasing in $p$. Steady-state food intake $F^*$ rises with strenuousness $S$, but still steady-state weight $W^*$ falls with $S$. When strenuousness rises, it is harder to stay fat. This lowers the cost of food but raises the cost of weight, with predictable results.

### A. *The Relationship between Income and Weight*

The total effect of income on weight includes the pure effect of unearned income and the effect of income earned through the labor market. The unearned-income relationship may be inverted U-shaped (cf. Lakdawalla and Philipson, 2002): $F_Y^* > 0$ and $W_Y^* > 0$ for the poor while $W_Y^* < 0$ and $F_Y^* < 0$ for the rich. Both food and health are normal goods. Therefore, increases in income promote food demand, but they also depress food demand as people like to be thin and healthy.

The effect of earned income accounts for the impact of strenuous exercise, or lack of it, in work. Define $S(Y)$ as the level of strenuousness associated with income $Y$. When work is sedentary, $S'(Y) < 0$. The total effect of income on weight is

$$\frac{dW^*}{dY} = W_Y^* + W_S^* S_Y(Y).$$

When work is sedentary, earning income through the labor market raises weight by more than unearned income. The earned and unearned income effects explain both the non-monotonic relationship between income and weight within countries and the positive relationship across countries. Differences in technology are smaller within countries (where the non-monotonic unearned-income effect dominates) than between countries (where the positive earned-income effect dominates).

### B. *The Time-Series Behavior of Weight*

The theory illuminates the three trends mentioned earlier: in food intake, food prices, and weight. Denote by $F(t) \equiv F^*(S(Y(t)), p(t), Y(t))$ and $W(t) \equiv W^*(S(Y(t)), p(t), Y(t))$ the time path of steady-state food consumption and weight. Sedentary technological change is growth in $Y$ and reduction in $S$ and $p$. The equilibrium steady-state price $p(t)$ is determined by

$$(3) \quad F^*(S(Y(t)), p(t), Y(t)) = Z(p(t); A(t))$$

where the supply of food $Z(p; A)$ depends positively on price and agricultural efficiency, $A(t)$. The price trend is

$$(4) \quad p'(t) = p_A A'(t) + [p_S S_Y + p_Y]Y'(t) = \frac{-Z_A A'(t) + (F_S S_Y + F_Y)Y'(t)}{Z_p - F_p^*}.$$

The two numerator terms reflect the supply and demand forces influencing price. Food supply expands with agricultural progress (in the first term). In the second term, income growth affects food demand. Earned-income growth through sedentary technological change lowers food demand, but unearned-income growth can have ambiguous effects. The only force promoting higher food prices is the ability of richer people to afford more food. This single force is opposed by sedentary technological change, agricultural efficiency, and the demand for health. These last three forces have dominated historical U.S. food price trends.

Weight trends are governed by similar forces:

$$\frac{\partial W^*}{\partial t} = W_p^* p'(t) + [W_Y^* + W_S^* S_Y]Y'(t).$$

Promoting weight growth are: expanding food supply, $W_p p'(t)$, and sedentary technological change, $W_S S_Y$. The term $W_Y$ reflects the total impact of unearned income growth on weight: on the one hand, higher income raises the demand for food, but on the other, income promotes health demand and weight loss. The demand for healthy weight loss is the only force promoting weight decline; it appears to have been overwhelmed historically.

## II. Food Prices and Nutrition

Obesity is an adverse side effect of progressive economic forces, such as declining food prices and the declining strenuousness of work. An example helps make this concrete: we show how lower food prices improve nutritional status, even in a developed country like the United States. This has normative implications, since Pigouvian taxes on food have been proposed as a remedy for the negative external costs of obesity (cf. Nestle, 2004). Taxing all food seems undesirable because obesity is the result of *over*-consumption, rather than consumption itself. Moreover, these results illustrate the pitfalls of taxing foods like red meat that can promote obesity but still have nutritional value.

### A. *The Measurement and Consequences of Micronutrient Deficiency*

Blood tests can provide objective evidence of micronutrient malnutrition, when properly interpreted. We focus in particular on four measures of nutritional status: Vitamin-A deficiency; Vitamin-C deficiency; insufficient serum folate; and anemia.[2] For vitamin A, fruit and milk are the most important sources. For vitamin C, fruit and fruit juice are most important. For folate, orange juice and bread (which are often fortified) are most important. Finally, meat is the most important source of dietary iron, which helps prevent anemia.

We use nationally representative data from the 1988–1994 National Health and Nutrition Examination Survey III (NHANES) for our information on micronutrient deficiencies. The NHANES contains data on demographic characteristics, as well as laboratory analysis of blood samples for 29,314 of the 33,994 NHANES participants.

[2] See Eugene Braunwald et al. (2001) for health consequences of nutritional deficiencies and normal values for adults. See Bhattacharya and Janet Currie (2001) for child normal values.

### B. *Food Prices*

We use data on local food prices from the American Chamber of Commerce Researchers' Association (ACCRA), which collects quarterly data on the pretax retail prices of goods in various localities, including the prices of 24 food items purchased for consumption at home. We link these data to the NHANES, which provides information on county of residence for respondents living in a metropolitan statistical area with more than 500,000 people.[3] In our analysis of nutrient deficits, we focus on the relative prices of specific foods: the log difference between the price of the food in question and a composite food price index.[4] The cheapest good is bread; the most expensive are ground beef and frozen orange juice.

### C. *Specifications*

We estimate linear probability models of how nutritional deficiencies vary with food prices. We include age, race, Hispanic, sex, family income as a percentage of the poverty line, and educational attainment (high-school graduate, college attendee, or college graduate). Since the relationship between food intake and nutritional status is medically different for children and adults, we estimate the model separately for everyone and for adults.[5]

Our key identifying assumption is the exogeneity of prices in the demand equation. This is defensible if prices are driven primarily by variation in supply. This defense has been invoked by Shin-Yi Chou et al. (2004) and is supported by Lakdawalla and Philipson (2002).

### D. *Results*

Table 1 displays the results from eight regressions, for all respondents and for adults only. Vitamin-A deficiencies are rare (about 7 percent of the population have deficient serum values). Milk prices have a strong effect on the prevalence of this deficiency in the adult population. A 10-percentage-point increase in milk's relative price, which would move price from the 25th to the 75th percentile, leads to a statistically significant 0.8-percentage-point increase in the prevalence of vitamin-A deficiency. When children are included, this effect loses significance, which is consistent with price-inelasticity for children, or the consumption of subsidized milk at school.

Vitamin-C deficiency prevalence (about 12 percent) increases strongly as relevant food prices rise. A 10-percentage-point increase in the relative price of peaches increases preva-

TABLE 1—FOOD PRICES AND NUTRIENT DEFICIENCIES

| Dependent variable (mean) and key independent variables | All ages | All adults |
|---|---|---|
| Vitamin-A deficiency (7 percent) | [*N* = 6,795] | [*N* = 4,742] |
| Price of peaches | 0.035 | −0.013 |
| | (0.036) | (0.017) |
| Price of milk | 0.056 | 0.075* |
| | (0.046) | (0.024) |
| Vitamin-C deficiency (12 percent) | [*N* = 6,059] | [*N* = 4,607] |
| Price of peaches | 0.181* | 0.212* |
| | (0.050) | (0.063) |
| Price of orange juice | 0.064† | 0.078† |
| | (0.036) | (0.044) |
| Folate deficiency (16 percent) | [*N* = 6,938] | [*N* = 4,790] |
| Price of orange juice | 0.138* | 0.196* |
| | (0.055) | (0.072) |
| Price of bread | 0.195 | 0.258 |
| | (0.122) | (0.165) |
| Anemia (10 percent) | [*N* = 7,753] | [*N* = 4,787] |
| Price of ground beef | 0.106* | 0.063 |
| | (0.051) | (0.048) |

*Notes:* Prices are by county. Standard errors (in parentheses below coefficients) are clustered by the 22 unique counties. All regressions contain age, sex, Hispanic, white, family income as a percentage of the poverty line, and a categorical variable (high-school graduate, college attendee, and college graduate) for the schooling of the respondent or family reference person.

† Statistically significant at the 10-percent level.

* Statistically significant at the 5-percent level.

[3] The ACCRA data are collected by city, which we aggregate to the county level.

[4] ACCRA supplies the expenditure weights (from the Consumer Expenditure Survey) for each good. We use these weights to aggregate the prices of all 24 goods into a composite food good.

[5] All standard errors are clustered at the county level, to reflect the use of county-level prices.

lence by 1.8–2.1 percentage points. Similarly a 10-percentage-point increase in the price of orange juice increases prevalence by between 0.6 and 0.8 percentage points.

Both orange juice and bread prices have large effects on the prevalence of folate deficiencies (about 16 percent), though only the former reaches statistical significance. For adults, a 10-percentage-point increase in orange juice price is associated with a 2-percentage-point increase in folate deficiency. When children are included, these elasticities drop but remain qualitatively similar. From 1998, the FDA required that products containing flour be enriched with folate (G. M. Shaw et al., 2004). This would have likely increased the effect of bread prices.

Anemia prevalence (about 10 percent) responds strongly to the price of ground beef. In the whole sample, a 10-percentage-point increase in relative ground beef prices is associated with a 1.1-percentage-point increase in anemia prevalence, but this seems confined mainly to children. In the regression with adults only, the anemia-prevalence elasticity is not significant.

### III. Conclusions

The theory explores how technological change can produce obesity as an unintended consequence of economic development, which reduces food prices and the strenuousness of work. The empirical analysis presents a specific example of how food-price declines can improve health and well-being, even in a developed country. From a policy perspective, these results suggest caution if Pigouvian taxes targeted at specific foods are used to address the external effects of obesity.

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