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Welfare-Enhancing Technological Change and the Growth of Obesity

Darius Lakdawalla,

RAND Corporation, 1776 Main Street, Santa Monica, CA 90401, (Tel) 310-393-0411, (Fax) 310-260-8155, darius@rand.org

Tomas Philipson, and

Irving B Harris Graduate School of Public Policy, University of Chicago, 1155 E. 60th St., Chicago, IL 60637, (Tel) 773-702-9128, (Fax) 773-702-0926, t-philipson@uchicago.edu

Jay Bhattacharya*

Center for Primary Care and Outcomes Research, Stanford University, 218 Encina Commons, Stanford, CA 94305, (Tel) 650-736-0404, (Fax) 650-723-1919, jay@stanford.edu

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 foregone 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,

*Lakdawalla: RAND, 1776 Main Street, Santa Monica, CA 90407, and NBER. Philipson: Harris School of Public Policy, University of Chicago, Chicago, IL 60637. Bhattacharya: CPCOR, Stanford University, 218 Encina Commons, Stanford, CA 94305, and NBER.

NOTES

¹See Tomas J. Philipson and Richard Posner (1999) and Darius N. Lakdawalla and Tomas J. Philipson (2002) for elaboration of the discussion here.

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 US. 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 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 v is:

$$\begin{aligned} v(W) &= \max_{F, C, W'} \{U(F, C, W) + \beta v(W')\} \quad (1) \\ s.t. \quad pF + C &\leq Y \\ W' &= (1 - \delta)W + g(F, S) \end{aligned}$$

where Y is income and p the food price. The first order and envelope conditions are:

$$U_F(F, Y - pF, W) + \beta v'(W') * g_F = p U_C(F, Y - pF, W) \quad (2)$$

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

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:

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

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

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

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 US 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 US. 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 (e.g., 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

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

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.

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 pre-tax 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 (1 lb) and frozen orange juice.

C. Specifications

We estimate linear probability models of how nutritional deficiencies vary with food prices. We include: age, race, Hispanic, and sex, as well as family income as a percent 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% 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.

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

⁴ACCRA 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.

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

Vitamin C deficiency prevalence (about 12%) increases strongly as relevant food prices rise. A 10 percentage point increase in the relative price of peaches increases prevalence by 1.8 to 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%), 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 (GM Shaw et al., 2004). This would have likely increased the effect of bread prices.

Anemia prevalence (about 10%) responds strongly to the price of ground beef. In the whole sample, a 10 percentage point increase 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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References

- Bhattacharya Jay and Currie Janet. 2001 "Youths at Nutritional Risk: Malnourished or Misnourished?," Gruber J, Risky Behavior among Youths Chicago: University of Chicago Press,
- Braunwald Eugene; Fauci Anthony S.; Kasper Dennis L.; Hauser Stephen L.; Longo Dan L. and Larry Jameson J. 2001 Harrison's Principles of Internal Medicine New York: McGraw-Hill Professional Publishing.
- Chou Shin-Yi; Grossman Michael and Saffer Henry. 2004 "An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System." J Health Econ, 23(3), 565–87. [PubMed: 15120471]
- Costa Dora and Steckel Richard. 1995 "Long-Term Trends in Health, Welfare, and Economic Growth in the United States," Cambridge, MA: National Bureau of Economic Research,
- Lakdawalla Darius N. and Philipson Tomas J. 2002 "Technological Change and the Growth of Obesity," Cambridge, MA: National Bureau of Economic Research,
- Nestle Marion. 2004 Food Politics Berkeley, CA: University of California Press.
- Philipson Tomas J. and Posner Richard A.. 1999 "The Long-Run Growth in Obesity as a Function of Technological Change," Cambridge, MA: National Bureau of Economic Research,
- Putnam Judith Jones and Allshouse Jane E.. 1999 "Food Consumption, Prices, and Expenditures, 1970–97," Washington, DC: Economic Research Service, US Department of Agriculture,

Shaw GM; Carmichael SL; Nelson V; Selvin S and Schaffer DM. 2004 "Occurrence of Low Birthweight and Preterm Delivery among California Infants before and after Compulsory Food Fortification with Folic Acid." Public Health Report, 119(2), 170–3.

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Calories per person per-day

Source: USDA's Economic Research Service

Figure 1:
Long-Run Changes in Calorie Consumption, 1909–1998.

Table 1:**Food Prices and Nutrient Deficiencies**

Dependent variable (mean) Key independent variables	All Ages	All Adults
<u>Vitamin A deficiency (7%)</u>	N=6795	N=4742
Price of Peaches	0.035 (0.036)	-0.013 (0.017)
Price of Milk	0.056 (0.046)	0.075 ^{**} (0.024)
<u>Vitamin C deficiency (12%)</u>	N=6059	N=4607
Price of Peaches	0.181 ^{**} (0.050)	0.212 ^{**} (0.063)
Price of Orange Juice	0.064 [*] (0.036)	0.078 [*] (0.044)
<u>Folate deficiency (16%)</u>	N=6938	N=4790
Price of Orange Juice	0.138 ^{**} (0.055)	0.196 ^{**} (0.072)
Price of Bread	0.195 (0.122)	0.258 (0.165)
<u>Anemia (10%)</u>	N=7753	N=4787
Price of Ground Beef	0.106 ^{**} (0.051)	0.063 (0.048)

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

^{**} Significant at 5% level

^{*} Significant at 10% level.