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THE LONG-RUN GROWTH IN OBESITY AS A FUNCTION OF TECHNOLOGICAL CHANGE

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ABSTRACT

This paper analyzes the factors contributing to the worldwide long-run rise in obesity and the effects of public interventions on its continued growth. The growth of obesity in a population results from an increase in calorie consumption relative to physical activity. Yet in developed countries, obesity has grown with modest rises in calorie consumption and with a substantial increase in both dieting and recreational exercise. We consider the economic incentives that give rise to a growth in obesity by stimulating intake of calories while discouraging the expending of calories on physical activity. We argue that technological change provides a natural interpretation of the long-run growth in obesity despite a rise in dieting and exercise, that it predicts that the effect of income on obesity falls with economic development, and that it implies that the growth in obesity may be self-limiting.

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SECTION 1: INTRODUCTION

Obesity is typically treated as a problem of public health or personal attractiveness. It is those things but it is even more an economic phenomenon. More than many physical conditions, obesity is avoidable by behavioral changes, which economists expect to be undertaken if the benefits exceed the costs. Investigating whether the economic benefits and costs of obesity can fruitfully be used to explain its variations across time and populations is the principal task of this paper.

In ordinary language, "obesity" is a pejorative term, as the related term "overweight" makes even clearer. In a rational-choice model, however, there is no such thing as being "overweight." Weight is the result of personal choices along such dimensions as occupation, leisure-time activity or inactivity, residence, and, of course, food intake. Being either fat or thin may therefore be as desirable from the individual's standpoint as adhering to the norms of weight set by doctors and the public health community. It has been known by the medical profession and widely disseminated to the public since at least the 1960s (see Ippolito and Mathios, 1995) that obesity impairs health and longevity. It is currently estimated that mortality due to non-optimal levels of exercise and food intake is second only to tobacco consumption in the number of deaths that could be prevented by behavioral change (McGinnis and Foege, 1993). Yet the percentage of obese people, commonly if rather arbitrarily defined as those who are more than 20 percent above their medically determined "ideal" weight, has been growing worldwide.[1] In the 1980s, the percentage of Americans more than twenty percent above their "ideal" weight increased from about 25 percent to about 33

[1] The most comprehensive estimates of worldwide obesity are found in the so-called MONICA study (see *Obesity: Preventing and Managing The Global Epidemic*, World Health Organization, Geneva, 1997, p. 19).

percent.[2] Almost 60 percent of Americans do not exercise enough from the standpoint of controlling their weight (NIH, 1995). The increase in obesity has given rise to demands for public intervention, mainly in the form of education programs, to reduce obesity through better diet and more exercise.

We argue that there are important financial reasons for this long-run growth in obesity. Technological change has both lowered the cost of consuming calories and raised the cost of expending calories, thereby contributing to the rise in obesity in two ways: it has lowered both the real price of food and the physical expenditure of calories per hour worked both in market and household production. The technologically induced rise in obesity enables a natural interpretation of such puzzling phenomena as the growth of obesity during a period in which there has been little or no increase in calorie consumption and, indeed, a rise in recreational exercising and in dieting.

Technological change caused the price of calories to fall because food prices have declined while at the same time the amount of physical exertion required when supplying labor has also fallen. In an agricultural or industrial society, work is strenuous; in effect, the worker is *paid* to exercise. What is more, in such a society, in which public welfare is ungenerous, the cost of not exercising through work could be dire—it could include starvation. Technological change has freed up time from producing food, enabling a reallocation of time to producing other goods and eventually to producing services. In a postindustrial and redistributive society, such as that of the United States today, most work entails little exercise and not working does not cause a reduction in weight, because food stamps and other welfare benefits are available to people who do not work. As a result, people must *pay* for undertaking,

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[2] VanItallie (1996), p. 891 (tab. 2) documents an age-adjusted increase in the prevalence of overweight among persons 20 to 74 years of age from 25.4 percent to 33.3 percent between 1976–1980 and 1988–1991. See also Kuczmarski et al. 1994.

rather than be paid to undertake, physical activity. Payment is mostly in terms of foregone leisure because leisure weight control must be substituted for job weight control.

The jogging and gym revolution and the limiting of calorie consumption as a result in part of deliberate dieting can thus be interpreted as substitutions brought about by technological changes in market and household work. But despite these off-the-job substitutions which operate to limit the rise of obesity, overall obesity can rise as a result of a shift to sedentary nature work. Indeed, the technological change explanation of increased obesity is almost inevitable; since calorie consumption has not risen substantially, physical activity must have fallen for obesity to rise.

The income gains associated with technological progress may make obesity growth *self-limiting* when the sedentary effects of such progress are outpaced by the effect of rising income in increasing the demand for thinness. The peculiar impact of income gains on weight is due to the non-monotonic effect of weight on utility which drives many of our results. When being healthier means gaining weight, richer individuals will weigh more, so there will be a positive relation between income and weight. On the other hand, when being healthier means losing weight, richer individuals will weigh less, so there will be a negative relation between income and weight. A positive relation between income and health (see, e.g., Grossman, 1973) therefore implies a non-monotonic inverted U-shaped relation between income and weight. Consistent with this there is considerable evidence that obesity today falls with income and education in rich countries (see, e.g., Jeffery et al., 1991) and rises with income in poor countries. Being close to one's ideal weight is what is valued, and demand for this good rises with income. If income increases the demand for thinness in the conditions of a technologically advanced society, economic development will dampen the weight-increasing effect of income within countries, and economic growth will cause an initial period of weight gains followed by weight reductions.

We conclude by considering public interventions to reduce obesity.[3] There have been dramatic warnings about an international obesity "epidemic," but a rational-choice perspective casts doubt on the case for public interventions designed to reduce obesity. If health is not everything in life, rational people will of course eat more and exercise less than medical science advises them. In particular, people may prefer their high-paying sedentary jobs to more physically demanding ones with less pay. When preferences and technology determine obesity as in our analysis, public education campaigns about what are already well known ways to limit weight gains are likely to have little effect. The issue is not information but incentives; everyone *knows* how to loose weight, either you eat less or exercise more, but few want to pay the price, in effort, expense, or forgone pleasure, of doing it.

There is a difference between an individual's being overweight in a medical sense, which from a rational-choice perspective does not demand public intervention, and the population's being overweight in a social Pareto-inferior way, implying that people would be willing to pay others to lose weight. But, some public interventions may actually cause both measures of excess weight to increase. Interventions in the cigarette and food markets are examples. Anti-smoking measures may increase obesity and by doing so reduce the health benefits of these measures, because smoking is a method of weight control and so the heavy taxes and regulations aimed at smokers may induce people to be overweight in a Pareto sense. The food-stamp program may raise the incidence of obesity among lower-income persons compared to when a low income

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[3] For a comprehensive call for international intervention, see *Obesity: Preventing and Managing The Global Epidemic*, World Health Organization, Geneva, 1997. For the United States, see publications by e.g., the initiative *Healthy People 2000* (www.health.gov/healthypeople), or The President's Council on Physical Fitness, the agency in charge of efforts to combat obesity in the United States.

reduced food consumption. Although it appears that it is unlikely that obesity generates negative externalities large enough to justify government intervention to reduce its prevalence,[4] in any event such measures should be analyzed in light of a sound understanding of how private behavior has induced the observed growth in obesity.

There has been little economic analysis of the forces contributing to obesity, although the question is related to, yet distinct from, other human capital issues in health.[5] This is unfortunate because obesity is a major health and public finance issue. More Americans are obese than smoke, use illegal drugs, or suffer from obesity-unrelated ailments; and obesity is a substantial risk factor in most highly prevalent serious diseases, including heart disease, cancer, and diabetes, and therefore affects major public programs such as Medicare and Social Security. Obesity affects wages as well as the overall demand for and supply of health care; and Americans spend in the aggregate many billions of dollars each year trying to lose weight through dieting or exercise.

SECTION 2: OBESITY AND TECHNOLOGICAL CHANGE

The Determination of Weight with Exogenous Physical Activity

We first consider the individual's choice of weight holding physical activity constant. This case captures that part of one's physical activity that cannot be reduced or avoided if one wants to undertake certain daily tasks. Weight is affected by the intake and expenditure of calories, according to the function W(F,S), where F is the intake of calories ('food') and S denotes the calories used in physical activity, so that $W_F \geq$

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[4] However, Keeler et al. (1989) find that sedentary life-styles impose external costs because insurers are forbidden to differentiate in their premiums fully among the insured of different health risks.

[5] See, e.g., Grossman (1972), Arthur (1982), Ehrlich and Chuma (1992), Rosen (1988, 1994), Philipson and Becker (1997), and Cawley (1999). Wolf and Colditz (1988) provide estimates on the direct and indirect costs of obesity in the US.

0 and $W_S \leq 0$. The cause of a growth in obesity in a population must be that calorie consumption exceeds calorie expenditure. The growth rates of obesity and calorie expenditure may thus both be negative if the reduction in physical activity exceeds the fall in calorie consumption. We assume that changes in weight diminish with the levels, $W_{FF} \leq 0$ and $W_{SS} \geq 0$, and that calorie intake and expenditure are complementary; the more calories are spent, the more valued is calorie intake; $W_{FS} \geq 0$. Utility U(W(F,S),F,C) is defined over weight, food consumption and alternative consumption, C. An important property of the utility function is that it is *non-monotonic* in weight. Specifically, it has an inverted U-shape. There is an ideal weight W_0 that the individual does not prefer to be above or below, holding other consumption constant. W_0 is the weight that would be chosen if achieving one's preferred weight was without cost. We assume that this ideal weight does not depend on the level of consumption of other goods and that there is diminishing marginal utility of consumption of both food and alternative goods, $U_{FF}, U_{CC} \leq 0$. We also assume that gaining weight is more valued the more underweight a person is while losing weight is more valued the more overweight a person is. That is, the inverted U-shaped function over weight is concave as well; $U_{WW} \leq 0$.

A person's ideal weight W_0 may or may not correspond to the weight that maximizes health or longevity, although it is likely to be influenced by concern with these factors. Being "overweight" is a subjective, as opposed to objective, property; very thin girls may prefer to lose weight. Even people who would, ceteris paribus, prefer to be at the weight that minimizes the adverse health consequences of being overweight that are emphasized by the public health community might choose not to be.

Neither the subjective nor any objective weight W_0 is the most preferred weight in the economic sense. With physical activity held fixed at S, the most preferred weight depends on opportunities and preferences, as in

$$\text{Max } U(W(F,S),F,C) \qquad \text{s. t.} \qquad C + pF \leq I$$

where p is the price of food or the intake of calories and I is income. Substituting in the budget constraint, the necessary condition for an interior choice of calories balances the weight effect and joy of eating against the foregone consumption of alternative goods:

$$U_W W_F + U_F = pU_C$$

The conditions for being rationally over- or underweight are rather weak; whether with respect to one's own subjective ideal weight or an objective ideal weight set by a third party such as the public health community. In other words, for many prices and incomes the preferred weight is different from the ideal weight W_0. This helps explain the number of underweight and overweight individuals and the divergence between subjective and objective obesity. The National Center for Health Statistics reports that about 44 percent of women and 25 percent of men who are classified as underweight by the medical profession considers themselves overweight (Statistical Abstract of the U.S., 1998, tab. 243).

Figure 1 below illustrates the tradeoffs involved when utility is separable in weight, food, and alternative consumption. In this case, when physical activity is exogenous, the price of calories has a negative effect on weight and income a positive effect; $dW/dp \leq 0$ and $dW/dI \geq 0$. This can easily be seen in Figure 1, as the utility loss from the foregone consumption of non-food related consumption shifts in opposite directions.

[INSERT FIGURE 1 HERE]

A more interesting feature of the model is that there are limits to how such reductions in prices or gains in income affect weight. At high incomes or low prices, weight becomes inelastic to income and price respectively. For notice that the marginal benefit (LHS) of the first-order condition will be declining and become *negative* at the caloric intake level, denoted F_M in Figure 1, that would maximize the utility from eating if food were free, yielding the upper bound on weight $W_M = W(F_M)$. Beyond this caloric level, there is a marginal cost of consuming more calories even if they are free because the utility loss from gaining weight dominates the joy of eating. More precisely, under fairly weak regularity conditions

$$\lim_{p\to 0} W = \lim_{I\to\infty} W = W_M$$

Thus, as technological change lowers the price of food, and thereby frees up time to raise income by other forms of production, weight will not continue to grow indefinitely. Obesity growth induced by income gains or price reductions is limited from above by the non-monotonic impact of weight on utility.

Non-Monotonic Income Effects on Weight

The inverted U-shaped effect of weight on utility implies that income may have an inverted U-shaped effect on weight as well when richer individuals care more about their health and hence their weight. The basic force behind an inverted U-shaped income profile of weight is some form of complementarity between consumption and weight. More precisely, the implicit function theorem applied to the first-order condition of optimal food consumption implies

$$dF/dI = [U_{WC} - pU_{CC}]/SOC$$

where the term SOC is positive when the second order condition holds. Consequently, without any complementarity, income must raise food consumption and weight because of diminishing marginal utility of consumption; $U_{WC} = 0$ implies $dF/dI \geq 0$. The weight income profile will be inverted U-shaped only when the effect of consumption on the marginal dis-utility of weight gains is relatively higher for larger incomes.

An illustrative reduced form of the type of complementarity that induces more weight concerns with a rise in income is the quasi-linear utility function of the form

$$U(W,F,C) = -(h/2)[W - W_0]^2 + fF + C$$

where h reflects the importance of weight concerns to the individual and f the value of calorie intake per se, both as measured in alternative consumption. When weight is proportional to the *net* consumption of calories, i.e.,

$$W(F,S) = F - S.$$

The optimal solution is

$$W^* = W_0 + (f-p)/h$$

That is, the individual will choose to be over- or underweight, relative to his ideal weight, if the price of calories (p) is low or high relative to his preference for food per se (f), and the degree to which he will be either overweight or underweight will fall with how much he cares about his weight (h). If how much he cares is a positive function of income, h(I), representing the positive relation between health and income, then weight rises with income whenever the population is underweight, $dW^*/dI > 0$ when $p > f$, and falls with income whenever the population is overweight $dW^*/dI < 0$ when $p < f$. In other words, the income effect on weight interacts positively with price when income raises health investments

$$d/dp[dW^*/dI] = h_I/h^2 \geq 0$$

Hence the effect of income in increasing weight should fall with economic development, because the ratio of income to costs of producing food, I relative to p, is higher in the advanced nations.

When food prices are low, people prefer, ceteris paribus, to consume calories, but their concern with being overweight limits their caloric intake. Wealthier or educated individuals care more about their weight, for health or other reasons, and so they limit their weight more. When food prices are high relative to incomes, many people are underweight because they cannot afford sufficient caloric intake, but wealthier individuals forgo other consumption in order to maintain or gain weight. So we expect technologically less developed economies, in which the share of income spent on food is large because food is expensive to produce, to exhibit a positive relation between income and weight because richer individuals care more about their health, while for the same reason we expect technologically advanced economies, in which income is high relative to the price of food, to exhibit a negative relation between income and weight (for empirical evidence, see Sobal and Stunkard 1989; Jeffrey et al., 1999). Thus in poor or early societies the obese are relatively wealthier, but in wealthy modern societies the obese are relatively poorer. So without other effects operating at the same time, such as the effect of technological change in making work, including work in the household, increasingly sedentary, income growth will tend to make the growth in obesity brought about by declining food prices self-limiting.

Endogenous Calorie Usage and Physical Life Styles

We have assumed thus far a fixed level of physical activity. But the amount of physical activity is, of course a choice, and indeed a choice that is affected by such activities as occupation, housing, transportation, as well as, of course, exercise. Let I(S) denote the income that can be earned when S calories are expended. The marginal effect I_S thus measure the loss ($I_S \leq 0$) or gain ($I_S \geq 0$) in income from a more active life style. The relevant measure of income is full income, including any tradeoffs between higher-earning but more sedentary jobs, cheaper suburban housing inducing more sedentary forms of transportation (commuting versus walking), or technological change enabling more efficient but also more sedentary home or market production. The choice of intake and expenditure of calories now solves

$$\text{Max}_{(F,S)}\ U(W(S,F),F,I(S) - pF).$$

The necessary first-order conditions for an interior solution are

$$\text{d/dF:} \qquad U_W W_F + U_F = pU_C$$
$$\text{d/dS:} \qquad U_W W_S = -I_S U_C.$$

The first FOC is identical to the one discussed before, but is now also conditional on the optimal level of calorie expenditure. The second FOC implies that a necessary condition of an interior solution is that the individual is overweight if and only if he forgoes income to spend calories

$$W \geq W_0 \iff I_S \leq 0.$$

This follows from the fact that the marginal utility of weight is negative when overweight and positive when underweight. The second condition requires this marginal utility U_W to have the same sign as I_S. This has important consequences for the effect of technological change on the growth of obesity. Technological change has caused the price of calories to fall because food prices have declined and the amount of physical exertion required when supplying labor to fall also. In an agricultural or an industrial society, work is strenuous; in effect, the worker is *paid* to exercise; I_S is positive. In a modern postindustrial society, work tends to be sedentary. The consequence is that people must *pay* for undertaking, rather than be paid to undertake, physical activity; I_S has become negative.

An illustrative case is again the modified quasi-linear utility function

$$U(W,F,C) = -(h/2)[W - W_0]^2 + fF^a + C, \qquad 0 < a < 1.$$

When weight is proportional to the *net* consumption of calories as in

$$W(F,S) = F - S$$

and when the income associated with a given amount of calorie, expenditure is linear function of that activity,

$$I(S) = I_0 - I_1 S$$

The most preferred choices are

$$F^* = [(p + I_1)/af]^{1/(a-1)} \quad \& \quad S^* = [(p + I_1)/af]^{1/(a-1)} - W_0 - I_1/h$$

These induce the most preferred weight:

$$W^* = W_0 + I_l/h$$

The individual chooses to be above or below his ideal weight depending on much income he forgoes when engaging in more physical activity (I_l) and how weight conscious he is (h). As physical activity shifts from raising to lowering income, weight naturally rises, but this may well occur with no change, or even a reduction in calorie consumption

$$dW^*/dI_l \geq 0 \quad \& \quad dF^*/dI_l \leq 0.$$

For if work is less strenuous, people eat less.

Obesity and the Allocation of Time

One of the important ways in which physical activity may be related to income is through the effects of the allocation of time, and in particular labor supply, on weight. The amount of time that one works, and the character of the work, affects weight in at least two respects: the first is through increasing earned income, which we have shown has an important effect on weight; the second is through affecting the amount of calories expended on the job. However, leisure can be allocated to weight control, as through off-the-job physical activity. By reducing the number of calories expended per hour worked, technological change in the workplace has reduced the financial incentives to control weight and so has increased obesity; but this trend has been accompanied by a rise in off-the-job physical activity illustrated by increased jogging and increased use of treadmills and other exercise machines in homes or in gyms.[6] This substitution of leisure-time for work-time physical exertion has been brought about by the change in the nature of work in the

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[6] On the efficacy of leisure-time physical activity as a method of weight control, see, e.g., Haapanen et al. (1997); Williamson et al. (1993).

direction of greater sedentariness. The allocation of time is important here because consumption of calories requires money income and is thus goods-intensive, as opposed to physical activity of calories, which is time-intensive. Although one can buy food in the market, one cannot buy a given amount of physical activity, it has to be self-produced, which takes time. This might lead one to expect high-wage earners to be more obese, as they have more income to buy calories and their foregone income is higher when using leisure to expend calories. But, when labor supply has an inverted U-shape as a function of wages, because of the effect of income on leisure, the incentives for weight to rise with income maybe dominated by the negative labor supply effect of higher income. This is exemplified by the positive effect of retirement on exercise due to the abundance of leisure, e.g., by replacing work by golf.

To incorporate the allocation of time into our analysis we generalize the budget constraint to include earned income in the labor market in addition to unearned income

$$C + pF \leq wH + I$$

where w is the hourly wage and H is hours worked. The time constraint states that time is split between work, physically inert leisure (i.e., leisure that has no weight effects), and leisure devoted to off-the-job exercise:

$$H + L + E \leq T.$$

The time spent in leisure-time exercise, E, consists of active measures of weight reduction. These measures, which need not be *intended* to control weight, include smoking, taking diet pills (as distinct from eating less), and exercise.

Total physical activity (S) B given by

$$S = sH + E$$

where s is calories expended per hour of work. When technological progress "lightens" work, s falls.

The individual chooses the number of hours to work and to exercise, as well as the amount of food to consume to maximize

$$U(W(F,sH + E), I + wH - pF, F, T - H - E).$$

The necessary first-order conditions for an interior maximum are

(1) $U_W W_{SS} + U_C W = U_L$ (Labor Supply)

(2) $U_W W_S = U_L$ (Recreational Exercise)

(3) $U_W W_F + U_F = pU_C$ (Calorie Intake).

Equation (2) directly implies, for anyone who does exercise, that since "inert" (*i.e.*, weight-unaffecting) leisure presumably is valued (so that $U_L > 0$) and exercise reduces weight ($W_S < 0$), weight must, at the margin, have a negative effect on utility ($U_W > 0$); otherwise no one would exercise.[7] In other words, only overweight individuals exercise for the purpose of weight control. By the same token, for someone who does not exercise at all, the marginal effect of weight on utility must be positive since lack of exercise will lead to a weight gain. This in turn implies that in equation (1) the utility that an exercising person obtains from working an extra hour in a sedentary job is less (other things being equal) than for a nonexercising person, because the extra hour of sedentary work

[7] This is abstracts from people exercising not to lose weight but to maintain muscle tone, improve their physical appearance, and increase their cardiovascular fitness.

requires the exerciser to exercise more in order to maintain his desired weight. And in equation (3), the exerciser derives more, and the nonexerciser less, utility from consumption of other goods, since the exerciser is willing to expend resources to prevent that consumption from raising his weight.

The full effect of any parameter on the observed weight depends on how it directly affects weight, holding inputs constant, together with how it affects the inputs into producing weight. Consider the full weight effect of technological change that causes a shift to sedentary work. Let w(s) denote the wage affects earned when the calories spent per hour of work is s; then a fall in s affects weight according to

$$dW/ds = W_F(dF/ds) + W_S[sdH/ds + H + dE/ds]$$

The reduction in calories used per hour work may imply that these inputs into weight are offsetting, so that weight gains may occur although food intake is falling and off-the-job exercise is rising. In other words, we may have

$$dW/ds \leq 0 \quad \& \quad dF/ds \geq 0 \quad \& \quad dE/ds \leq 0.$$

The jogging and gym "revolution" and the fall in calorie consumption, including through dieting, is a substitution brought about by technological change at work and may offset a rise in obesity due to work-related technological change. The technological changes that lower physical activity on the job also raise productivity and hence wages, which in turn affect weight through affecting hours worked, exercise, and food consumption.

The secular shift in work from manufacturing and mining to services implies, because most services involve light work, that average weight will be higher in modern, developed nations because there is less on-the-job exercise. In addition, this reallocation has not only taken place in the market but in household production as well. Household labor-saving devices, such as dishwashers and washing machines, vacuum cleaners, prepared foods, microwave ovens, and the like, have reduced the caloric expenditures in household work.

Another possible, though speculative, factor in increased obesity is improvements in medical technology that have reduced the health detriments of obesity. In our model, this would represent a fall in the marginal utility of weight gain, U_W, because now additional weight does not change one's health, and hence utility, as much as it used to. If the utility of prevention is negatively related to the efficacy of treatment, the value of being thin as a disease-prevention method has fallen. Suppose the only adverse health effect of obesity was high blood pressure; when effective drugs for treating high blood pressure are developed (and assuming that they cost less than the adverse health effects of having high blood pressure), as they have been, the health costs of obesity fall. But against this must be weighed the effect of medical advances in increasing longevity by reducing other health risks. To take an extreme example, suppose that as a result of medical advances the average age of death of thin people increased from 70 to 80, but of obese people from 65 to 68. Then despite the increased longevity of obese people, their loss of longevity from being obese would increase, from 5 years (70 – 65) to 12 years (80 – 68).

People may respond to changes in the incentives to control obesity in different ways. As cutbacks in food consumption reduce money costs, while increasing the amount of exercise increases time costs, we are led to predict that, as we observe, most people who attempt to lose weight do so by means of reducing food intake (F) as opposed to raising physical activity (S).[8] Put simply, while both exercise and dieting impose

[8] See, e.g. Horn and Anderson (1993).

nonpecuniary costs, off-the-job exercise costs resources in the form of forgone money income, but dieting saves pecuniary resources.

At first glance it may seem that different populations have responded quite differently to the increased incentives for obesity. For example, Europeans are thinner on average than Americans (Seidell, 1995). The reasons may be economic rather than cultural. Food is cheaper in the United States than in Europe, and Europe is less suburbanized than the United States. This, plus the much higher price of gasoline in Europe than in the United States, due to steep difference in gasoline-tax rates, causes Europeans to be less sedentary in their travel. The fundamental cause may simply be higher land prices in Europe, which result in Europeans living much closer to each other and to work and shopping, at distances where walking is more efficient than driving.[9] Americans also watch television much more than Europeans, in part because American television offers much more variety than European. The United States is the world's leading innovator in passive entertainment, which is highly sedentary. Indeed, about half the leisure time of the average American is spent watching television (Robinson and Godbey, 1997)—a completely sedentary activity.[10] Other things being equal, the higher the quality of television, the higher is the opportunity cost of recreational exercise and hence the lower the demand for thinness. Television is a peculiar product because the marginal pecuniary cost of consumption is zero (except for pay-TV), and so small increases in perceived quality may lead to significant increases in amount demanded.

SECTION 4: PUBLIC INTERVENTION TO LIMIT OBESITY

[9] There is an analogy to the whether to fly or take the train; even though a plane is much faster per mile traveled, below a certain distance the train is the more time-efficient method of transportation.

[10] Except for people who use exercise machines at home or in gyms. Such machines, especially treadmills, can be used while watching television.

The public health community, and many health economists as well, have raised concern about an impending "crisis"—an international obesity "epidemic." The most commonly recommended public intervention to combat this epidemic is publicly financed education about the benefits of dieting and exercising. But few people do not understand *how* to loose weight: you simply eat less and exercise more. Rather, they do not *prefer* to lose weight. The issue is preferences and technology, not information. People may be overweight in a medical sense that differs from the actual weight desired by most people, or may even be overweight with respect to their own preferred weight, but an economically sound case for public regulation cannot be based on deviations from either of these ideals, but rather on deviations from the Pareto-optimal weight distribution in a population, that is, deviations that some people are willing to pay others to reduce or eliminate.

The question is therefore whether obesity creates negative externalities that might warrant public intervention through Pigouvian taxes or subsidies. Examples would include a calorie tax, subsidies for exercise, a tax on exercise substitutes such as driving, or subsidies for educating the public in the health hazards of being medically overweight. The first external effect to consider concerns physical appearance, a good enjoyed not only by the person himself but by others observing him. Although many people would derive benefits from increased "beauty" of strangers encountered in the streets and other public places, and beauty in our society is negatively related to obesity, the pecuniary and non-pecuniary private benefits of beauty are so great that the elasticity of weight to tax or subsidy policies would probably be small. Since, moreover, personal beauty is a positional good (one is beautiful in comparison with other people who are less good looking), an increase in the number of beautiful people harms the people who are already beautiful and so may not increase aggregate social welfare.

One potential external effect of obesity, as is true for any other health-related behavior, derives from public financing of health care.[11] It may seem obvious that since medical care is heavily subsidized, and obesity increases morbidity and mortality (see, e.g., K. Narbro et al., 1996), taxing obesity in some fashion would be bound to reduce a negative externality through tax-financed health insurance. But this ignores the fact that reducing mortality increases the fraction of the population that is elderly, and the elderly not only consume a disproportionate fraction of medical expenditures but are more heavily subsidized for those expenditures than younger people. There are tradeoffs here both between health expenditures per period and the number of periods (that is, the length of life), and between the subsidized and the non-subsidized fraction of health expenditures. Suppose that taxing obesity would reduce average per-period medical expenditures by 10 percent but increase average length of life by 5 percent; then lifetime medical expenditures would fall by approximately 5 percent. But suppose further that the percentage of lifetime expenditures subsidized would increase—because more people would be living to Medicare-eligibility age—from 20 percent to 30 percent. Then the size of the net subsidy would increase by roughly 40 percent. A further consideration is that efforts to lose weight impose their own health costs. Apart from the direct costs of diet pills and the like, there is the indirect cost of eating disorders and dangerous weight loss brought about by efforts to lose weight (see, e.g., Flynn, 1997).

A related point is that if obesity did create a negative externality, the current campaign to reduce smoking, especially so by males (Grunberg and Klein, 1998, p. 174; WHO, 1999), which has been effective, would be perverse since smoking is a method of weight control. Because of its

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[11]See e.g. Keller et al (1989). However, note that when technological change is the source of growth in obesity the same technological change raises the tax-base of publicly financed insurance.

weight-controlling effect, smoking is a substitute for exercise, and for many people a lower-cost substitute, particularly since it substitutes time for goods in controlling weight. The fall in smoking itself is unlikely to explain the rise in obesity, mainly because the effect of smoking on weight is rather small and transient (see O'Hara et al., 1998; Green and Harari, 1995; Flegal et al., 1995; and Gerace et al., 1991; Mizoue et al., 1998). But, to the extent that people do smoke to control their weight, the dangers of smoking are equivalent to the dangers of diet pills; and, consequently, we can expect cigarette producers to join with meat producers in opposing the taxing of obesity since an increase in obesity would stimulate the demand for cigarettes.

Like efforts to reduce smoking, efforts to reduce heart disease by reducing the intake of saturated fats may (paradoxically in the case of fat reduction) contribute to obesity. Foods that contain fat allay hunger pangs faster than other foods, and so people who reduce their fat intake often substitute carbohydrates that increase the eater's overall caloric intake (Brody, 1999).

Even if it were desirable to reduce weight through Pigouvian taxes or subsidies on food intake or physical activity, the weight effects of such measures would be mitigated by the complementarity between calorie intake and physical activity. In the case of exogenous physical activity and a separable utility function, applying the implicit-function theorem to the first-order condition for food intake, $U_W W_F + U_F = pU_C$, implies that physical activity raises calorie intake

$$F_S = U_W W_{FS} + U_{WW} W_F W_S / SOC \geq 0$$

where $SOC \geq 0$ when the second-order condition holds. This positive relation of calories implies that the total fall in weight as a result of a rise in physical activity is smaller than the partial effect of physical activity on weight, because food consumption rises with more activity.

$$dW/dS = W_S + W_F F_S \geq W_S.$$

This implies that public stimulation of the physical activity may not be an effective method of weight control since it also stimulates food consumption. A corrective Pigouvian tax would therefore partly be offset by reactive changes in untaxed determinants of obesity.

SECTION 5: ALTERNATIVE HYPOTHESES

In this concluding section we examine other hypotheses besides technological change, which we have emphasized, for explaining the recent growth in obesity.

Asymmetric Information, and Obesity as a Signal

It is often argued that income was positively related to weight historically because being obese indicated a high status when not everyone could afford to eat. This is essentially an argument that weight is a signal under asymmetric information about wealth, and so provides an alternative to our hypothesis, which emphasizes food prices and the effect of changes in technology. In the nineteenth century, thinness was a signal of malnutrition and tuberculosis, and fatness a signal of prosperity; stout men and women were therefore considered handsome and stout women beautiful and sexy.[12] Of course, it may be doubted how many people actually overate in order to signal prosperity since alternative, less costly signals were available. In any event, with the virtual eradication of malnutrition and tuberculosis in the wealthy countries, and with

[12] To see this clearly, imagine that people spend 100 percent of their income on food, which is approximately true historically. Then poor people will eat less than rich and so be thinner, and weight will be a good signal of income.

expenditures on food a steadily falling percentage of household expenditures, obesity ceased to have value in signaling valued traits; instead it became a negative signal (Cassell, 1995). Today, thinness may be valued as a signal of trustworthiness, because it indicates a degree of self-control or self-discipline (Brownell, 1991, p. 4).

Note that the welfare implications of weight as a signal, as with other signaling activities, would imply today that there may be over-investment in thinness from a social standpoint, which in turn would cast doubt on the value of public programs designed to combat obesity.[13]

Since people preferred in the past to signal obesity but prefer today to signal thinness, signaling cannot be a complete explanation because it predicts that obesity should *fall* rather than rise over time. Another consideration that limits the plausibility of a signaling explanation of obesity and thinness is that weight is an imperfect signal. People differ in their genetic ability to control their weight (Bouchard, 1991; Brownell, 1991, p. 8), and so one's amount of willpower or self-discipline cannot simply be inferred from one's thinness.

Market ***versus*** *Household Production of Food*

We have pointed out that technological change in agriculture led to the reduction in food prices that made population-wide obesity even feasible, let alone desirable. In addition, market production of food hass increasingly become a substitute for household production (Haines et al., 1992), signaling a change in the share of diets *prepared*, and not onlyproduced, by the market through restaurants. It is often argued that fast food is responsible for the rise in obesity. But, we believe that fast food is a consequence of technological change, rather than an independent explanation of obesity.

The fact that food is delivered faster is a natural response to the increased value of time induced by technological change; the output foregone per meal has risen, holding the time it takes to eat constant. Technological innovations in food preparation have reduced the time it takes to consume a meal. However, in a competitive market in which consumer surplus is maximized, it seems unlikely that homemakers and restaurants would have different incentives with regard to caloric supply. It therefore seems unlikely that a rise in obesity can be blamed on the fast-food industry. More importantly, caloric intake has not increased much on average, and the fast-food industry cannot be held accountable for the reduction in physical activity.

Addiction, Genes, and Obesity

One possible reason for obesity is that eating is addictive, in the economic sense of involving inter-temporal complementarity in consumption, or that there is a large genetic component to obesity that is not influenced much by the incentives stressed here. The problem with both these explanations is that although they may well explain cross-sectional differences, it is unclear how they could explain the rapid change over time in obesity. Such change would be much slower if it were transmitted genetically; and a change in preferences over time would be an unsatisfactory explanation because it could be offered for any changes in obesity. But addictive preferences may interact with the changes in budget sets that we have argued are more important; people could not afford to act on their addictions historically, but now have the means to. However, if this is the case, the changes in budget sets are the causal force, not changes in tastes.

SECTION 6: CONCLUSION AND FUTURE RESEARCH

Our analysis suggests several avenues for future research. One would be to assess empirically the extent to which physical activity on the job has affected obesity. This can be done with available data sets (such as, in the United States, the Nutrition and Health Examination Surveys (NHANES)) by looking across occupational categories at how people have changed their food consumption and total physical activity, whether on or off the job. Such an analysis should also address the limited power of technological changes at work to explain the rise in obesity among children. One possible explanation is that children take their eating and exercise cues from their parents, another that they are watching television more, and a third that with more and more parents working outside the home the children are less monitored in the health habits.

Second, our analysis was limited in its predictions concerning gender differences in weight and the role of matching markets (the marriage and dating markets) in determining weight. If weight affects one's ability to match, we would expect unmarried people today, as consumers in the marriage market, to be thinner than married people, thereby implying that the rise in the age of marriage and the rate of divorce in recent decades has actually increased the physical health of the population. The objection to attributing too large a role to matching markets in the determination of weight is that rising divorce rates would imply a decline in obesity. In addition, rational expectations would tend to limit the value of temporary reductions in weight at the initial phase of the match.

It is empirically true and interesting that women are more concerned with their weight than men and are more likely to be dieting (Brownell, 1991, p. 4). The greater value of thinness to women than to men is reflected in studies that find a greater negative correlation between earnings and overweight for women than for men (see, e.g., Register and Williams, 1990; Averett and Koreman, 1996; and Pagán and Dávila, 1997). Since marriage can be viewed as a form of employment and each spouse as the other's employer, these studies imply that a wife's household "wage" is reduced more by obesity than her husband's household "wage" is. The reason is that men value physical atractiveness in women more than women value physical attractiveness in men (see, with specific reference to obesity, Sobal, Nicolopoulos, and Lee, 1995). Yet an unanswered question is, if thinness is more valuable to women than to men, why are more women overweight (see Rodin, 1993)?

A particularly interesting case concerns black women, a much higher percentage of whom than of white women (49.2 percent versus 33.5 percent) are overweight (VanItallie, 1996, p. 891 (tab. 2); and Chitwood et al., 1996). There are two possible economic reasons even after correction for possible genetic differences (Argyropoulos, 1998). The first is that among poor people, who in this country are disproportionately black, thinness continues to be a signal of possible poor health or bad habits—drug addicts, alcoholics, people with AIDS, and homeless people tend to be thin because of malnutrition or disease. It is therefore not altogether surprising that although there is a positive correlation in the black community between slenderness and attractiveness (see Riley, 1998; Harris, 1995; and Thomas, 1988), black women have higher weight ideals than the ultrathin ideals held by white women (Flynn, 1996). Second, the marriage market is badly stacked against black women (Mullin, 1998; Philipson and Posner, 1993, pp. 75-78). This could incite even greater efforts of some women to achieve attractiveness, but it would reduce the gains from attractiveness to those women who would have very poor marital prospects even if they invested heavily in increasing their attractiveness. When young, marriageable black men are hard to find, the matching incentive of black women to control their weight is reduced.

Finally, empirical analysis has focused up to now on changes in *average* weight over time and across populations. Given that, by definition, obesity concerns only the right tail of the weight distribution, future analysis may fruitfully address whether the average tendencies in the population mimic the behavior in that tail. It is conceivable that offsetting changes in food consumption on the bottom and top part of the distribution may mask much of the data that focus on average behavior.

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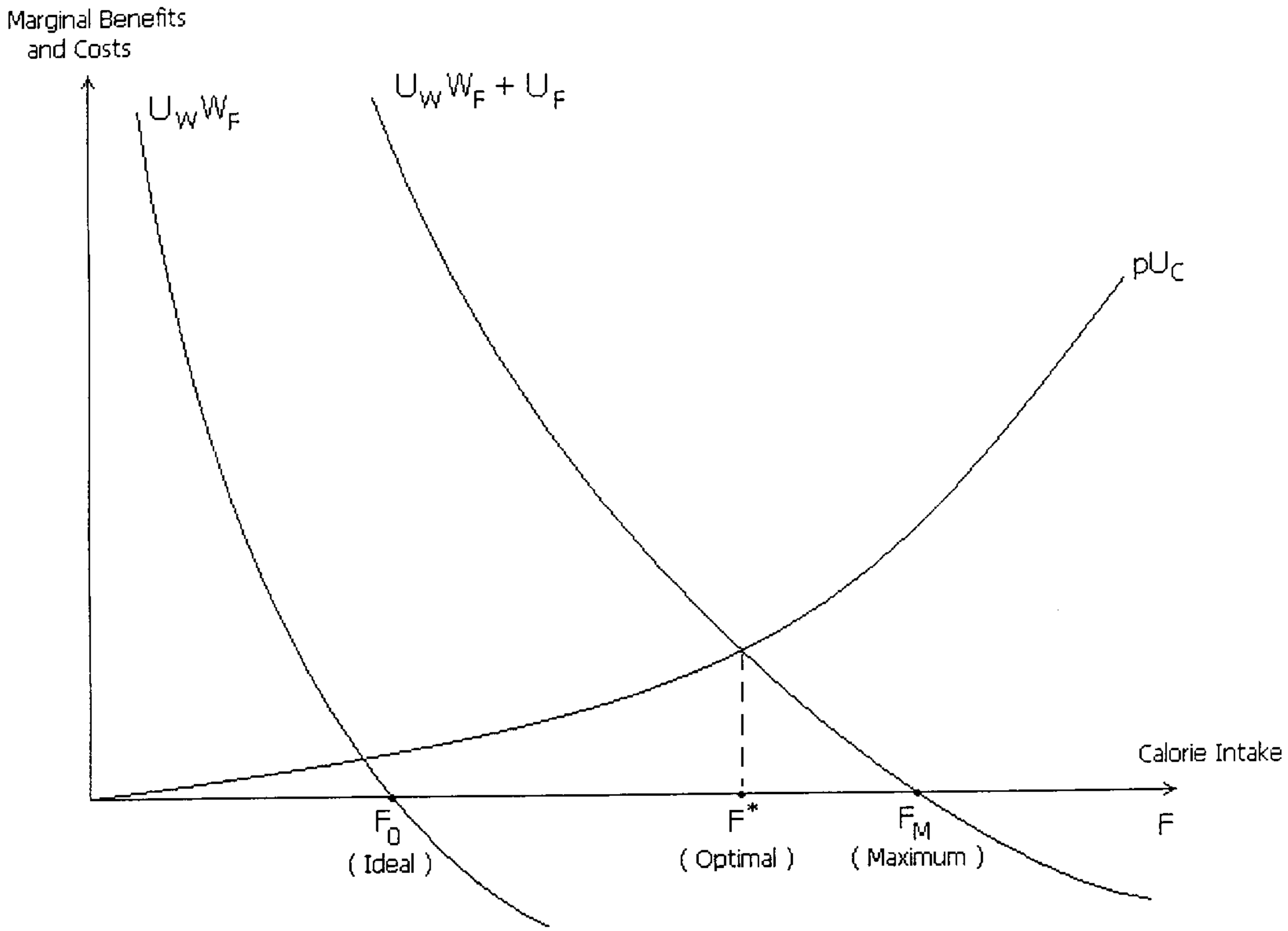

Figure 1: Ideal, Optimal, and Maximum Weight