Obesity and Nature's Thumbprint: How Modern Waistlines Can Inform Economic Theory

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Background

The modern prevalence and negative consequences of obesity suggest that many people eat more than they should. Smith examined the biological underpinnings of mammalian feeding behavior in an attempt to reconcile this "self-control problem" with the "rational choice" tradition of neoclassical economics. Medical, genetic, and molecular evidence suggest that overeating is a manifestation of the fundamental mismatch between ancient environments—in which preferences for eating evolved—and modern environments. Smith described the phenomenon with a model in which food preferences and expectations about food availability are generated depending on the prevailing environment in the distant past.

Methods and Findings

Smith presented a model of energy allocation as body fat and for other uses in rodents. Specifically, he considered the problem to be solved by natural selection ("Nature") when a wild rodent population faces seasonal food shortages, and considered what might be expected to happen if food security is suddenly improved. In the model (adapted from the "optimal foraging" literature), the optimal level of energy reserves is determined by variations in food availability and constrained by an exogenous endowment of energy income and a constant rate at which energy held in reserves from the previous period can be converted to other uses. Generally speaking, a foraging strategy is optimal—and therefore constitutes a solution to the fitness maximization problem—if no other available strategy results in a greater number of descendants surviving in the distant future.

According to Smith's analysis, an excess of body fat is generated during a feast (when food is plentiful), up to the point at which the associated marginal fitness cost is just offset by the marginal fitness benefit of closing the "gap" between current consumption and consumption in the ensuing famine. And likewise, the dearth of body fat during famine serves the same purpose—consumption smoothing—when food energy is scarce.

This model implies a unique solution to the fitness maximization problem, suggesting an equilibrium population of uniformly plump rodents. However, real populations exhibit considerable variation in body fat, which might arise from asymmetric information or payoffs among groups within the population. If the frequency of food shortages varies over time, behavior might be sensitive to new information regarding the risk of food shortages, and the optimal strategy will become a function of age and experience.

Suppose that in any given period food will be scarce with a certain probability, independent of the food state obtained in the previous period. Further, suppose that for any given cohort of rodents this probability is unknown at birth but constant throughout life and that it is adjusted in a Bayesian manner as experience reveals information about the true probability.[4] Over time, individual rodents are generated with a variety of prior distributions (subjective knowledge about an event) and a variety of sensitivities to new information, and only those rodents with the correct Bayesian prior and the correct interpretation of new information survive in the long run. The mechanism by which this variety arises is well known to biology: Parental traits are passed to offspring genetically; and genetic variation in traits is generated via the processes of recombination (the "mixing" of maternal and paternal genes) and—much more rarely—random mutation. When the trait is a behavioral trait, such as the propensity to overeat, the most successful rodents (i.e., those who survive in the long run) will have the correct Bayesian prior written into their genes.

[4]The Bayesian method is away of incorporating newly gained knowledge or information about an event, from an observation, for example, to update or modify prior knowledge in order to infer the future probability of the event.

In effect, Nature generates agents who make the best use of regularities in the environment. Thanks to the information provided by Nature (presumably via "feelings" of hunger and satiety), the rodent need not directly assess the fitness implications of his actions; rather, the evolutionary process favors those individuals who behave as if they were aware of the implications. If parental behavior reliably predicts famines, for example, Nature will condition feelings of hunger on parental behavior. So the rodent does not make conscious calculations of the marginal fitness costs and benefits of his choice; he need only eat when he's hungry. However, by taking advantage of regularities in the environment—which is the optimal thing to do, as long as the regularities remain—the rodents leave themselves vulnerable to sudden changes.

Now suppose that the equilibrium rodent population is taken from the environment characterized by episodes of food scarcity and placed in a laboratory environment in which the food supply is constant. In the absence of sufficient time (recall that the strategies that prevail in equilibrium are passed on genetically and thus cannot be altered within a single lifetime) and evolutionary pressure, the inherited behavioral tendencies of the rodent population will continue to dictate the behavior that was fitness-maximizing during the plentiful season. In terms of this simple example, the rodents in the laboratory might—through the process of Bayesian updating—come to behave as though the regime with the lowest probability of food scarcity applies. However, further adaptation is limited by the extent of the distribution found in the wild, under which the evolutionary equilibrium developed. Assuming that food supplies were always uncertain in the wild, the immediate consequence of placing the population in the secure laboratory environment is chronic obesity. Faced with an abundant food supply, the rodents choose a high level of body fat, as would have been optimal when food supplies were variable. The obesity in the laboratory constitutes a state of disequilibrium in the sense that preferences no longer serve to maximize Darwinian fitness; yet it is stable in the sense that preferences cannot be altered within a single generation.

Smith then offered empirical evidence from a variety of fields, such as behavioral endocrinology, nutritional anthropology, and behavioral ecology, to support his model of obesity and why we might expect limits to conscious control over the behavior. In our evolutionary history, such conscious control would at best have been useless, and at worst resulted in starvation. In the language of probability theory, the prior distribution we are born with precludes flexibility; such flexibility would have been harmful to our ancestors, and the preferences they have passed on will continue to haunt us for generations to come. Human evolution has proceeded more slowly than recent advances in modern agriculture and transportation technology. Thus, the actual probability of starvation and the probability implied by our genes are now distinctly mismatched.

Discussion

A close examination of the biological underpinnings of the self-control problem suggests a fundamental flaw in the First Fundamental Theorem of Welfare Economics.[5] Specifically, because preferences necessarily imply a probability distribution over outcomes, a market economy may fail to yield an efficient allocation when the prevailing probability distribution differs from that implied by the preferences of consumers. Allowance might be made, on feasibility grounds, for some error on the part of consumers, but when the error is systematic—as appears to be the case with obesity—then a market failure of a new sort is implied. It is one thing to suggest, as the "stable disequilibrium" of the preceding model does, that, in modern environments, consumers may fail to maximize individual fitness in the biological, Darwinian sense. But it is another thing entirely to suggest that consumers should try to maximize fitness—or that welfare economists should encourage them to do so.

[5]The First Fundamental Theorem of Welfare Economics holds that, under certain conditions, in a perfectly competitive market economy, any competitive equilibrium is Pareto optimal. As noted earlier, a Pareto optimum refers to a situation where there is no way to reallocate resources so you can make someone better off without making someone else worse off.

Today's consumers are faced with a very real tradeoff between short-term pleasure and long-term health, and we have no a priori reason to expect that they should be particularly good at making this choice. However, improving the health and welfare of the general population might—in light of the evidence that obesity appears to be exacerbated by poverty, and malnutrition early in life—consist of such antiobesity measures as strengthening the social safety net or providing prenatal care to expectant mothers and proper nutrition to at-risk children.

Perhaps a more fundamental problem for welfare economics is the question of measurement. The equivalence between individual choice and individual welfare commonly assumed in welfare economics allows for estimating and comparing the impacts of various policies through the simple observation of human behavior. Weakening this equivalency—with the qualification that behavior is individually optimal only when subjective probabilities are equivalent to actual probabilities—poses a difficult problem for policy analysts. The other social sciences have long been skeptical of the choice/welfare equivalence in economics, and a number of alternative measures of well-being have been devised that deserve the attention of economists (e.g., Kahneman, 1999; Larson and Fredrickson, 1999).

The author's central thesis is that "overeating—the most prominent of self-control problems—is best viewed as a manifestation of the difficult problem of energy homeostasis faced by our ancestors." This thesis is widely accepted, but on its own, it does not have implications for welfare economics or for policy. Smith should be mindful of the "Naturalistic Fallacy," that what is by nature is what should be, which may not be necessarily so.

He also suggests that "body fat might be a function not only of season, but also of social status and wealth and there is evidence that this is true in natural environments." The idea that body fat is a function of season, social status, and wealth but is genetically programmed is novel. However, it may not be widely known or accepted as an explanation for obesity among low-income Americans.

Smith claims "the evidence supporting a biological basis for the self-control problem has the troubling consequence of undermining a foundational tenet of welfare economics." As a rebuttal, welfare economics has long recognized that choice and well-being are different. The First Welfare Theorem states, "An equilibrium produced by competitive markets will exhaust all possible gains from exchange." Having a biological basis for decisions about food does not weaken this.

Finally, the author suggests that "today's consumer is faced with a very real tradeoff between short-term pleasure and long-term health." However, this argument has shifted away from "Nature's Thumbprint." The policy implications do not rely on the paper's principal contribution; they are not closely tied to genetics. Smith's article can be viewed as an introduction for economists to the biology of weight regulation.

Future Research

Smith's findings may have important implications for the theory and practice of welfare economics. The unanswered question, if these claims are taken at face value, is whether this approach might be applicable to other realms of economic behavior. If his thesis turns out to apply to body fat and little else, then what he has to offer would be another anomaly for the growing list of behavioral phenomena that do not comfortably fit into a neoclassical framework. But other examples, upon further investigation, will likely be found of cases in which people seem to be acting on the basis of biased subjective probabilities.