Do you want fries with that?

An exploration of serving size, social welfare, and our waistlines

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Abstract

In the debate over increasing obesity rates, fingers are often pointed at "big food" and their marketing practices. It is noted that restaurant meals are often larger than home-cooked meals and that portion sizes in restaurants have dramatically increased over the past few years. We investigate the issue by considering "socially optimal" -- rather than decentralized profit maximizing -- portions in restaurants to see whether welfare maximizing strategies may also be waistline-increasing. We demonstrate that "socially optimal" restaurant meals are larger in size than average home-cooked meals and, while many agents chose to "super-size", the option of super-sizing actually alleviates the size discrepancy between home-cooked and restaurant meals. Moreover, "socially optimal" portion sizes at home and in restaurants increase with relative reductions in the marginal costs and/or relative increases in the fixed costs of meal preparation. Given this cost structure, when offered fries a greater proportion of the population will answer with an enthusiastic "yes"!

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I. Introduction

"Do you want fries with that?" is the mantra of the fast-food burger joint. It is also the direct descendant of the "Anything else?" at the baker's, the "May I interest you in these lovely pork chops, madam?" at the butcher's, or, "Wouldn't you like a nice bunch of grapes?" at the green grocer's. But, while those were looked on as polite questions made to elicit preferences or to bring the order to a close only when the customer was ready, the question of fries has been imbued with evil intent. Big food, like big tobacco, has conspired to make us eat more by offering us fries or the option to super-size our orders (May, 2003). And we don't have to look any farther than the bulging waistlines of the adult American population to establish their success. Or do we?

In this paper we examine an individual's demand for food at an instant in time, for example at lunch, and analyze a social planner's decision to provide an optimal serving size that maximizes the welfare of consumers. Consumers face different degrees of hunger, and so choose the consumption bundle, that is, the meal, that best fits their appetites. The social planner takes the distribution of individuals and their degrees of hunger as given and chooses the size of the meal that maximizes the utility across the population. That socially optimal meal is larger than the average sized one resulting from individual choices. Should the social planner choose two rather than a single meal (which can be characterized as a standard and a super-sized meal), then all agents' *ex ante* utility is increased. Choice makes everyone better off, but the technological constraints on choice and the need to best serve the average customer make people fatter. Goodwill, rather than evil intent, is the culprit.

II. The view from the popular press

Open any newspaper or magazine or turn on the television or radio and you are immediately confronted with articles and op-ed pieces on the increasing trend in childhood and adult obesity and the ostensible culprit – the purveyors of fast and snack foods (*Economist*, 2003). Fast food companies, such as McDonald's and Burger King, have been sued. Although the *Pelman vs. McDonald's* case was thrown out of court, the judge, Robert Sweet, suggested a way to pursue the claim that would be more likely to prove successful. John F. Banzhaf III, Professor of Law at George Washington University Law School has refocused his energies away from big tobacco, where he was one of the most successful anti-tobacco litigants, and onto big food. His web page (http://banzhaf.net/obesitylinks) is dedicated to this campaign. Marion Nestle, Professor of Nutrition at NYU, argues in her much quoted book, *Food Politics* (2002), that advertising by big food is both to promote their products and to induce consumers to eat more. Clearly, if implicitly, they, not we, are to blame. This being the case, fat taxes have been suggested both in jest, i.e., taxing people based on their weight (Rauch, 2002), and as a serious proposal to alter individual's eating habits via the price mechanism, e.g., by taxing fatty foods at a higher rate (Nestle, 2002; BBC, 2000; Jones, 2003). Also, states and school districts are restricting the sales of sodas (Los Angeles Times, 2003), offering instead milk, juice or water.

While the idea that no publicity is bad publicity may be apt in some circumstances, big food has taken notice of the onslaught and has responded. Kraft Foods is reducing the serving size of its prepackaged one-serving meals and snacks, Hershey's is offering sugar free chocolates, McDonald's, Wendy's, and their ilk are offering salads and other lower fat meals in addition to their usual fare, and/or opening more health conscious fast food restaurant alternatives. Similarly, a recent KFC advertising campaign sings the praises of how few carbohydrates and how much protein their fried chicken contains, in a nod to the Atkins (2002) diet, and McDonald's has stopped offering super-seized meals (Carpenter, 2004). These responses to the market struck some as panic (Ayers, 2002), suggesting guilt rather than hard-nosed competitive responses. But, market research has found that when consumers are offered lower calorie options and reduced portion sized meals, they do opt for them, and then replace the saved calories in appetizers or desserts (Fonda, 2003; May, 2003).

In the midst of this angst over ever increasing waistlines, the WHO has tried to bring some perspective to the policy debate. Instead of too much unhealthy, cheap food being available "always and everywhere" (Buckley, 2003), the major health risk worldwide is too little food. Specifically, the number one health hazard in terms of disease and death caused is underwieghtness, not its opposite (WHO, 2002). Overweightness, as a health hazard, just makes the top ten. Nevertheless, for the U.S., and increasingly so for other industrialized countries, obesity has all but been declared the number one public health concern.

III. The economics profession weighs in

The positive trend in weight began in the mid-1800s and is not, as usually depicted, a recent phenomenon (Cole, 2003; Costa 1993). What is incontrovertible, however, is that since the late 1970s portion sizes have increased both inside the home and at restaurants, where the largest servings are at fast food restaurants, the smallest at other restaurants (Nielsen and Popkin, 2003). Somewhat at odds with this finding is that while caloric intake per meal has not changed, the number of meals consumed has, ostensibly as a result of a reduction in the price of food (Cutler, Glaeser, and Shapiro, 2003). But, price elasticities of demand are inadequate to account for the increases in weight, so alternative and/or additional reasons have been suggested: more sedentary jobs (Ladkawalla and Philipson, 2002) leading to less energy usage, and the increased time cost of home preparation of food (Chou, Grossman and Saffer, 2002) causing a substitution into the relatively cheaper market prepared food. These two rationales, however, do not necessarily lead to weight gain. This is because for most workers today the sedentary nature of their jobs has been a constant rather than a mid-career change, so their physiological energy requirements have not changed and have not necessitated a change in food consumption patterns to maintain weight. Further, nothing necessitates over-eating when one eats out rather than in. Alternative reasons that may imply weight gain are provided by Bednarek, Jeitschko, and Pecchenino (2004), who find that increases in income and leisure time lead to individuals eating more and spending less time in active pursuits, and by Cutler, Glaeser, and Shapiro (2003) who find that lack of self-control leads individuals to give into temptation today while putting off the diet until a tomorrow that fails to arrive.

IV. The model

Agents are endowed with y units of income. Their preferences are defined over food consumption, c, and an alternative composite good, m. Agents' utilities are quasi-linear and concave in food consumption. Their utility from food consumption depends on how “hungry” an agent is. Specifically, an agent experiences utility from food consumption that is captured by the function $\pi U(c)$, where $U(.)$ is a standard von Neumann-Morgenstern utility function with $U' > 0$, and $U'' \leq 0$, and $\pi \in (0,1]$ measures how hungry an agent is. That is, the bigger the π, the greater the hunger, and food gives more pleasure the hungrier one is. We assume that agents know their state of hunger and π is distributed *i.i.d.* across the population according to the distribution function F.

For a given π, the agent chooses food consumption, c, and the amount of the composite good, m, to maximize

$$\pi U(c) + m, \tag{1}$$

subject to

$$y = m + e(c), \tag{2}$$

where $e(c)$ measures the expenditures made to acquire a portion of size c.

If the (per unit) price of food is fixed, then the expenditure function simply reduces to the more familiar form $e(c) = pc$. However, we use the expenditure function in order to capture the possibility of volume discounts—often encountered when increasing the order size of the purchase. Thus, we make the natural assumption that expenditures are increasing in the amount purchased, $e'(c) > 0$, but unit prices, $p = e(c)/c$ are (weakly) decreasing in quantity, $e'(c)c - e(c) \leq 0$.

The two properties attached to the expenditure function mirror actual pricing policies in restaurants. More importantly for our purposes, though, they reflect typical cost structures of production: a fixed cost of providing (any sized) portion and relatively constant marginal costs of increasing the portion size. Thus, pricing at a given mark-up above the cost of a portion yields an expenditure function with the above properties.

V. The determination of optimal portion sizes

We consider three scenarios in determining the optimal portion size of meals; home cooking, eating out, and eating out with an option to "super-size."

First, we suppose that consumers can choose any desired portion size. This serves as our benchmark. Second, we consider the case in which a single given serving size is provided. We determine the socially optimal size to provide and compare it to average consumption under the benchmark case. Third, we allow for distinct (albeit limited) portion sizes, i.e., the option to "super-size" a meal, and see how consumption under this option differs from the other two scenarios.

Given these three scenarios, we then examine how they are affected by changes in the pricing rules, that is, changes in the expenditure function, assuming that the pricing function is a reflection of production costs.

Case 1 – Continuous choice; home provision of meals.

Home cooks when preparing meals need only prepare according to their current state of hunger, and can vary portion size to perfectly satisfy that hunger. This option is sometimes found in buffet style cafeterias and restaurants, where one loads up a plate that is weighed at the register and one pays a price per ounce. However, since this method is largely impractical for most restaurant meals, it is not often observed and we consider this benchmark case to be one of food preparation at home.

Substituting constraint (2) into equation (1) and choosing c to maximize

$$\pi U(c) + y - e(c),$$

the first-order condition of the agent's problem is

$$\pi U'(c) - e'(c) = 0. \tag{3}$$

The second-order condition of the agent's problem is

$$\pi U''(c) - e''(c) < 0. \tag{4}$$

If the second-order condition is satisfied, Equation (3) is solved for the optimal level of food consumption as a function of one's state of hunger, $c^*(\pi)$. A sufficient condition for the second-order condition to be satisfied is that the expenditure function reflects (constant) mark-ups above average costs and the marginal cost of food preparation is non-decreasing – a requirement that is sure to hold in all relevant instances.

Case 2 – The optimal portion size for a single portion

Suppose a social planner, like the restaurateur or the purveyor of TV dinners but unlike the home cook, cannot provide each agent with a continuous choice of meal size and thus cannot provide each consumer with his desired consumption portion. Then the planner will choose a single portion size that maximizes expected social welfare.

That is, the planner chooses the portion size b to maximize

$$\int_0^1 \left[\pi U(b) + y - e(b)\right] dF(\pi).$$

Rewriting, the planner maximizes

$$\hat{\pi} U(b) + y - e(b),$$

where $\hat{\pi}$ is the expected value of π. The first-order condition of the planner's problem is

$$\hat{\pi} U'(b) - e'(b) = 0, \tag{5}$$

which is solved for b^*.

Proposition 1: The social planner's optimal portion size is larger than the average portion size of the consumer with continuous choice. That is,

$$E(c^*(\pi)) < b^*.$$

Proof: Equation (3) implicitly defines c^* as a function of π, say $G(c,\pi) := \pi U'(c) - e'(c) = 0$. By the Implicit Function Theorem

$$c'' = \frac{d^2 c^*}{d\pi^2} = -\frac{d}{d\pi}\frac{G_\pi}{G_c} = -\frac{G_{\pi\pi}G_c - G_{c\pi}G_\pi}{G_c^{\ 2}} = \frac{U''U'}{G_c^{\ 2}} < 0$$

so, $c(\pi)$ is concave. Hence, $E[c^*(\pi)] < c^*(E\pi)$. But $c^*(E\pi) = b^*$. ■

Thus, the planner will always choose a portion size that is larger than the average portion chosen by the population at large. This is because the utility loss of having too little food is much higher at the margin than the utility loss (in terms of forgone consumption of *m*) of having too much. Hence, the planner will be more willing to err on the side of abundance rather than paucity, and profligacy rather than abstemiousness is the path to higher expected utility. Once food is prepared and purchased, the consumer has the option of not eating any excess beyond the decentralized full information optimum (i.e., the home production choice of $c^*(\pi)$), that is, there is free disposal. However, since the marginal value of greater consumption remains positive, and sunk costs are sunk, the agent will eat the entire meal.

Consequently, the average amount of food intake may very well increase as an individual shifts consumption habits from home food production to restaurant meals (or

TV dinners). However, far from being a reflection of a conspiracy of "big food" against consumers, it may merely reflect the optimal provision of standardize portions.

Case 3 – Super-sizing

We now consider the case of two meal sizes over which the consumer can choose—a "standard" portion size and a "super-sized" option. We proceed in two steps. First, we analyze a consumer's choice, given two meal sizes, and then we discuss the optimal meal sizes from the vantage point of the social planner.

Define W_i as the utility an agent receives given meal a_i, that is

$$W_i = \pi U(a_i) + y - e(a_i), \qquad i = 1,2,$$

so

$$\frac{\partial W_i}{\partial a_i} > 0 \text{ for } a_i < c^* \text{ and } < 0 \text{ for } a_i > c^*.$$

The agent chooses between a_1 and a_2 to solve $\max[W_1, W_2]$.

For any feasible pair of as, there will be a type of agent, π^c, such that the agent is indifferent between the two meals, given the portion sizes and the associated expenditures. For that type of agent $W_1 = W_2$, which implies that

$$\pi^c = \frac{e(a_2) - e(a_1)}{U(a_2) - U(a_1)} > 0, \qquad (6)$$

for an interior solution.

Consider now the optimal meal sizes. Given the agent's expected utility for a given value of π, the agent's *ex ante* expected utility is given by

$$EW(a_1,a_2)=\int_0^{\pi^c}\left[\pi U(a_1)+y-e(a_1)\right]dF(\pi)+$$

$$\int_{\pi^c}^{1}\left[\pi U(a_2)+y-e(a_2)\right]dF(\pi).$$

Assuming, for the sake of closed form solutions, a uniform distribution of π across the population, the social planner's problem is to choose a_1 and a_2 to maximize

$$EW(a_1,a_2,\pi^c(a_1,a_2)=\left\{.5\pi^c U(a_1)-e(a_1)\right\}\pi^c+$$
$$\left\{.5(1+\pi^c)U(a_2)-e(a_2)\right\}(1-\pi^c)+y.$$

Letting a subscript denote the partial derivative, the first-order (sufficient) condition of the planner's problem, with respect to a_1 and a_2, respectively, are

$$\left\{.5\pi^c U'(a_1)-e'(a_1)\right\}\pi^c+.5\pi_1^c U(a_1)\pi^c+\left\{.5\pi^c U(a_1)-e(a_1)\right\}\pi_1^c+.5\pi_1^c U(a_2)(1-\pi^c)-$$
$$\left\{.5(1+\pi^c)U(a_2)-e(a_2)\right\}\pi_1^c=0;$$

$$\left\{.5\pi^c U(a_1)-e(a_1)\right\}\pi_2^c+.5\pi_2^c U(a_1)\pi^c+\left\{.5(1+\pi^c)U'(a_2)-e(a_2)\right\}(1-\pi^c)$$
$$+.5\pi_2^c U(a_2)(1-\pi^c)-\left\{.5(1+\pi^c)U(a_2)-e(a_2)\right\}\pi_2^c=0.$$

Recalling the implicit definition of π^c,

$$\pi^c U(a_1)-e(a_1)=\pi^c U(a_2)-e(a_2)\,,$$

these reduce to

$$.5\pi^c U'(a_1)=e'(a_1)$$
$$.5(1+\pi^c)U'(a_2)=e'(a_2).$$

The first-order conditions immediately yield the following two results.

First, compared to the case of a single (standardized) meal, welfare is strictly increased with the choice between two meals, i.e.,

$W(a_1*,a_2*) > W(b,b)$, for all b,

since the first-order conditions cannot be satisfied for any pair $a_1 = a_2 = b$, so the maximum under two distinct portions must be strictly greater than for the single portion.

Second, a comparison of the planner's reduced first-order conditions with the agent's first-order conditions given in Equation (3) shows that the meal sizes chosen by the planner are optimal conditioned on the segment of the population that chooses a particular meal, i.e.,

$$a_1 = c^*(E\pi|\pi < \pi^c) \text{ and } a_2 = c^*(\pi|\pi > \pi^c),$$

since $E(\pi|\pi < \pi^c) = ½\, \pi^c$ and $E(\pi|\pi > \pi^c) = ½\, (1+\pi^c)$.

Thus, increasing the number of portion sizes improves welfare and the planner maximizes average utility of consumers given their choice of serving size. But how does increasing the number of portion sizes available affect how much is consumed? As a first step note that the two optimal meals, a_1^* and a_2^*, straddle b^*, i.e.,

$$a_2^* > b^* > a_1^*.$$

This is so because $b^* = c^*(½)$ (see the proof of Proposition 1), and $a_1 = c^*(½\, \pi^c)$ and $a_2 = c^*(½\, (1+\pi^c))$. Since c^* is increasing, the result follows as $\pi^c \in (0,1)$.

In other words, as more portion sizes are offered, larger portion sizes become available. So the larger portion size is, indeed, "super-sized." However, this does not inform us concerning how average consumption is affected by offering a variety of portion sizes. For this we consider average portion sizes consumed under the three regimes, the home cooked benchmark, the single portion size, and the super-size scenarios. For the latter comparison, let Ea^* denote the average consumption when two different portion sizes are offered.

Proposition 2: Average consumption given a choice in portion size is above the average portion size of the consumer with continuous choice, yet, with only minor restrictions on the utility function, it is smaller than when only one meal is offered. That is,

$$\mathrm{E}c^* < \mathrm{E}a^* < b^*.$$

Proof: Notice that

$$\mathrm{E}a^* = \pi^c a_1^* + (1-\pi^c)a_2^* = \pi^c c^*(\tfrac{1}{2}\pi^c) + (1-\pi^c)c^*(1+\tfrac{1}{2}\pi^c).$$

For the first inequality, applying Proposition 1 to each segment of the population in turn yields

$$\pi^c c^*(\tfrac{1}{2}\pi^c) + (1-\pi^c)c^*(1+\tfrac{1}{2}\pi^c) > \pi^c \mathrm{E}(c^*|\pi<\pi^c) + (1-\pi^c)\mathrm{E}(c^*|\pi>\pi^c) = \mathrm{E}c^*.$$

For the latter inequality in the proposition, notice that if π^c equals either 0 or 1, then $\mathrm{E}a^* = b^*$, since, as noted in the proof of Proposition 1, $b^* = c^*(\mathrm{E}\pi)$ and for the uniform distribution $\mathrm{E}\pi = \tfrac{1}{2}$. However, similar to the proof of Proposition 1,

$$\frac{d^2}{d\pi^{c2}}(\mathrm{E}a^*) = \left[c^{*\prime}\left(\frac{\pi^c}{2}\right) + \frac{1}{2}\frac{\pi^c}{2}c^{*\prime\prime}\left(\frac{\pi^c}{2}\right)\right] + \left[c^{*\prime}\left(\frac{1+\pi^c}{2}\right) + \frac{1}{2}\frac{1-\pi^c}{2}c^{*\prime\prime}\left(\frac{1+\pi^c}{2}\right)\right].$$

This is positive under minor conditions on the absolute bounds of the third derivative of the utility function, so $\mathrm{E}a^*$ is concave. Hence, $\mathrm{E}a^* < b^*$ for all $\pi^c \in (0,1)$. ■

When super-sizing becomes an option, one observes larger portions being offered and consumed. However, average consumption actually decreases relative to the single portion case. Nevertheless, average consumption remains higher than in the continuous choice setting.

Changes in costs and changes in consumption

The model demonstrates that far from there being a conspiracy of "big food" or something else sinister that leads to larger portions in restaurants when compared to the average home-cooked meal, this is merely a reflection of standardized portions. Indeed, the oft maligned option of "super-sizing" alleviates this problem that may be associated with discrepancies between home-cooked meals and restaurant meals.

However, another arrow in the quiver of critics of "big food" is that portion sizes in restaurants have also increased over the last years. This is indeed the case. Nielsen and Popkin (2003) find that portion sizes have increased most dramatically at fast-food establishments and at home with the smallest increases found at sit down restaurants! Our analysis suggests this is because the cost of food ingredients (marginal cost) has dropped dramatically.

For the case of the expenditure function reflecting unit costs, the following proposition concerning home food preparation is obtained:

Proposition 3: If there is a drop in marginal costs, but not in fixed costs; e.g., food becomes less expensive, while the time costs of preparing meals remain constant or increase, portion sizes increase.

Proof: A decrease in marginal costs as well as an increase in the fixed costs of preparing food implies that volume discounts become more generous. Then $e'(c)$ decreases for all c, and the first order condition, Equation (3), is satisfied at a higher level of c^*. ■

Thus, as time costs of home food preparation increase, e.g., due to the increase in women's participation in the labor force, and as technological advances in agriculture, fisheries and raising livestock reduce the cost of producing foods, it is natural to see increased portions for meals that are prepared at home. While no one has (yet) charged home-cooks and grocery stores with a conspiracy to increase the size of the meals we consume, this charge has repeatedly been leveled at "big food." However, since portion sizes of home cooked meals have risen (Nielsen and Popkin, 2003), the idea that larger portion sizes are anything other than a response to a change in the cost of food production can be viewed as a red herring.

Indeed, there is an immediate corollary to Proposition 3 concerning portion sizes at restaurants. Thus,

Corollary 1: As volume discounts become more generous, the socially optimal portion size of restaurant meals increases.

Proof: This follows now from Equation (5). ■

If, as suggested by Chou, et al. (2003), the time cost of home preparation has indeed increased, thereby making market produced meals relatively cheaper, then individuals will choose to eat out more. And, when presented with the larger sized portions, they will eat more – by choice.

Proposition 4: The proportion of consumers who "super-size," $1-\pi^c$, is increasing in the quantity discount (the smaller the difference in expenditures between the large and small portion, $e(a_2) - e(a_1)$, *ceteris paribus*, the bigger the quantity discount).

Proof: Totally differentiating π^c yields

$$\frac{d\pi^c}{d[e(a_2)-e(a_1)]} = \frac{1}{U(a_2)-U(a_1)} > 0 .$$

Thus, as the expenditure difference falls, π^c falls, and 1- π^c rises. ■

When an agent is choosing between the small and the large meal, the cheaper the large relative to the small, the more inclined the agent is to choose the large meal even at low hunger intensity.

Volume discounts in the food industry have become larger in the recent past not as a result of reductions in the fixed costs, the costs of labor and overhead, per serving, but rather as a result of a reduction in the marginal costs of the food inputs. If restaurants in general, and fast food in particular, are subject to competitive pressures so that these reductions in cost are passed along to consumers, consumers will respond with a greater proportion ordering the larger sized meal. Consequently, π^c falls and more consumers are super-sizing, that is, saying yes to that offer of fries.

VI. Beware what you wish for

In this model a social planner, rather than a Ronald MacDonald, determines the serving sizes on offer at restaurants. We find that the planner, like Ronald, offers a serving size that exceeds the average desired serving size when compared to home-cooked meals. When providing more options, super-sizing is one of them – and this actually reduces the size discrepancy between average home cooked meals and restaurant meals.

If costs are such that there are volume discounts, as is common in the competitive food industry, those discounts are passed along to consumers in two ways: bigger portions, and more consumers demanding the biggest portion. Indeed, recent technological advances in food production yield exactly these outcomes. In the model, the social planner, not unlike big food, satisfies consumers' desires, enhances their utility, and, here's the rub, their waistlines.

The problem here is not lack of self control or self awareness, neither is it that food is not freely disposable, it is that, as long as an individual has not reached satiation, utility is increased by consuming more. And, once the sunk costs are sunk, that is exactly what most people do.

The policy response is not clear. Should firms be restricted from responding to consumer tastes and forced to give them what is "good" for them rather than what they want? Clearly, if consumer tastes were to shift toward smaller portions and low energy foods and away from the satisfyingly large portions of calorie dense foods (Prentice and Jebb, 2003), restaurants would respond or would be forced out of business. Perhaps the recent reduction in average BMI in the United States (*Economist*, 2003) heralds the onset of such a shift in tastes. If not, public policy may be hamstrung.

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