GLUTTONY AND SLOTH: SIGNS OF TROUBLE OR EVIDENCE OF BLISS?*

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In a model of rational agent choice in which agents value consumption and leisure as well as health, we establish that individuals, unconstrained by concerns of income or time, can and will choose levels of consumption and leisure that exceed their physiological optima. By how much they exceed the optima depends on a variety of factors, most importantly, the utility cost (benefit) of achieving health. Observed positive long-run trends in adult weight, brought on by higher levels of consumption and lower levels of physical activity, often interpreted as a public health crisis in the making, can be explained by these factors. But, rather than the trend suggesting crisis, it suggests only optimal responses to altered, and perhaps improved, circumstances. While individuals today, all else equal, may weigh more than those a generation or two ago, they also may be happier.

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I. INTRODUCTION

"Eat less, exercise more!" is the mantra repeated over and over to the American public. But, is the message getting through? According to the external measure of weight, Body Mass Index (BMI), the international standard used by the medical profession, nearly sixty-five percent of adult Americans were considered to be overweight and thirty-one percent were obese in 2000. This is up from forty-five percent and thirteen percent, respectively, in 1960 (Health, United States 2003). There is no indication this trend will change as obesity rates continue to rise in the US and in the rest of the world as well.

Medical professionals and health policy experts are concerned about these trends to such a degree that they refer to obesity as a new health epidemic or health crisis in the US – often likened to tobacco use. This clearly calls for a better understanding of the underlying causes that have led to the increases in overweightness and obesity. Since such a sharp increase in weight has come in a relatively short period of time, it is not likely to be solely attributed to a change in genetics. Thus, a better understanding of policies should be considered in regard to people's weight and health.

Lack of health knowledge should not be at issue since, in recent decades, information regarding the direct effects of obesity on health has become widely accessible through public health initiatives and the dissemination of medical research. Instead, it may be that individuals are, in fact, informed regarding the external measure of weight advocated by the medical profession for healthful living, yet still make choices that lead to a weight different from the medically prescribed weight. Indeed, many health professionals involved in the issue believe this to be the case. For example, an expert from the American Cancer Society is quoted in *USA Today* as saying "We have to stop blaming the individual. Obesity is a result of the combination of the individual choices we make and the setting we live in. The measures that produce the greatest benefit are the ones that change the environment." (Hellmich 2003).

We concur with the implied sentiment that health is a function of individuals' choices, which depend on the constraints they face. However, before drawing conclusions about desired policies, we think that a closer scrutiny of individuals' decisions and constraints is warranted. Thus, we propose a model of rational agent choice in which agents value consumption and leisure as well as health. The purpose of the model is twofold. First, it will shed light on why the so-called epidemic has come about. And second, it allows an evaluation of types of policies that should be used to address the problem of overweightness and obesity.

We examine three cases. In the first case, agents' income and work activities do not impose binding constraints on their choices of food consumption or leisure. That is, income earned is sufficient to provide for a high level of food consumption so that changes in income do not affect the chosen amount of food consumption. And, time spent away from work is sufficient to assure a level of leisure that is also not sensitive to marginal changes in the amount of time spent at work. This case illustrates the interaction among one's choices of consumption, leisure, and health. One can think of this state as an approximate representation of many peoples' lives in the modern, developed world, especially the US.

In the second case, agents' incomes and work activities impose binding constraints on food consumption and leisure. Consequently, additional income would be used on food expenditures (rather than other goods), and work hours are so long that the net marginal benefit of leisure is substantial. This situation can be thought of as being common a few generations ago for many individuals in developed countries and the US, and is still common across most of the world today. This case is considered largely as a benchmark, as it illustrates the recent trends in weight gain across the population in the US and elsewhere.

The third case considered goes to the heart of the discrepancy between what people are perceived to want to do in an affluent society, and what they actually do. It is relevant as an extension to the first scenario, and is presumably the case that sheds the most light on the ubiquity of the mantra quoted at the outset: we consider psychological costs that are often thought to be present in attempts at altering one's lifestyle. Specifically, agents are assumed to enter the planning period with accustomed levels of food consumption and leisure in excess of their unconstrained optimal levels. Altering one's behavior – in particular, reducing food consumption or leisure – is assumed to be costly. Hence, the most relevant constraints are no longer the income or time constraints, but constraints to the flexibility that humans have in adjusting their lifestyles.

In the model – despite utility being strictly increasing in consumption, health, and leisure – there is an interior, optimal food consumption-leisure pair that lies in the set of feasible allocations: *agents can obtain bliss*. At this utility optimum, agents' food consumption and leisure exceed their physiological optima: people are overweight. While agents may not be overweight in the case in which they are constrained in their choices by income or free time, they will be much less happy when facing these constraints. Finally, if agents face costs to reducing their consumption and leisure downwards towards bliss relative to their accustomed levels, they may assess the costs of achieving the blissful state not to be worth the benefits. Although they realize that they would be better off eating less and exercising more: *agents choose to remain gluttonous and slothful*.

We examine how exogenous forces, such as improvements in medical science, improvements in exercise technology, etc., affect agents' food consumption and leisure choices. We then examine under what conditions agents with supra-optimal initial conditions – food consumption and leisure that is "excessive" – will choose to change their behavior, by how much they will change it, and how policies designed to help agents achieve bliss (or some other physiological optimum) affect these changes.

The paper is structured as follows. In the next section the extant economics literature on obesity is discussed. In Section 2 the general model is laid out and the three cases discussed above are examined. Included in this is a motivation for why (rational) agents may find themselves in states of excessive consumption and leisure; a fully dynamic model in which agents choices may lead to supra-optimal consumption is outlined in Appendix A. Section 3 contains the conclusion with a discussion of policy implications.

II. Background

While obesity is quickly displacing smoking as the number one public health concern, there is relatively little research that has examined the economics of obesity. This is somewhat surprising given the rapid increase in the share of overweight and obese individuals worldwide and the attention given to it in the public health and policy arenas. According to the external measure of weight, Body Mass Index (BMI), an adult is considered overweight with a BMI of 25-29.9 and obese with a BMI of 30 or more.[1] Prevalence of overweightness and obesity (BMI > 24.9) in the US in the last 20 years has increased dramatically from 46 percent in 1980 to 64.5 percent in 2000 (NHLBI 1998; Health, United States 2003).[2] Along with the increase in prevalence come increased costs of obesity. A recent study by Finkelstein, Fiebelkorn and Wang (2003) suggests that annual medical spending attributable to overweightness and obesity is 9.1 percent of all US national health expenditures ($92.9 billion in 2002 dollars). These estimates are in line with those from previous studies (Wolf and Colditz 1998; Sturm 2002). Yet, they do not include any indirect costs attributable to overweightness or obesity, such as increased morbidity or mortality and the value of lost output, which Wolf and Colditz estimate at slightly less than the direct costs.

[1] Body Mass Index is measured as weight in kilograms divided by height in meters squared.

[2] It is worth noting that in the mid 1990s there was a shift in the official measure of overweightness previously used as the benchmark. This may have somewhat exaggerated the seeming rapid increase in prevalences. Prior to the release of clinical guidelines on overweightness and obesity by the National Heart, Lung, and Blood Institute (NHBLI) in 1995, the measure that was used to establish overweightness (without the distinction of overweightness vs. obesity) was based on the National Health and Nutrition Examination survey (NHANES) epidemiological measure of the 85th percentile of BMI. As such, adult men were considered overweight with a BMI of 27.8 or greater and adult women with a BMI of 27.3 or greater (NHBLI 1998). That said, weight has been trending upward for over 150 years (Cole, 2003).

Given the increase in obesity and the magnitude of its direct and indirect costs, it is worth a thorough examination from an economic perspective.

Several explanations of obesity have been put forth, either in the context of theoretical models or empirical tests. These include hypotheses that obesity is a result of technological change that has made production of food cheaper and time spent at work more sedentary, the rise in the number of restaurants, addiction to calories, reduction in smoking, changes in rate of time preference, and biological or evolutionary changes. Indeed, it is likely that the relationships of these and still other factors are determinants of obesity.

Both Philipson and Posner (1999) and Lakdawalla and Philipson (2002) argue that the long-run trend in weight and obesity is primarily due to technological change. Technological change increases an individual's weight by making home and market production "easier" or more sedentary, so that the calorie expenditure per hour of production is lower. Technology also lowers the real price of food via agricultural innovation. However, Philipson (2001) suggests that even with the lower price of food the amount of calories consumed has not dramatically increased. So, in the face of a growing number of obese individuals, if calorie intake has not generally increased, then it must be that expenditures of energy have decreased. This is particularly true of energy expended at work. And while there are leisure substitutes, such as going to the gym for a workout, they find evidence that leisure calorie expenditure does not make up for reduced calorie expenditure at work.

Cutler, Glaeser and Shapiro (2003) find that, as a result of technological change, food has become only slightly cheaper in monetary terms but much cheaper in terms of time spent preparing food and cleaning subsequently. This is due to both the relatively inexpensive mass preparation and technology available to aid in consumption (e.g. microwave) as illustrated by time use data. The result of such technology is an increase in the amount and variety of food such that caloric intake has increased. Another hypothesis that is tested by Chou, Saffer and Grossman (2002) focuses on the increase in the number of restaurants, as it relates to changes in the labor market, specifically the increase in the number of women working who traditionally have done much of the food preparation for their families. Thus, with more time spent in the market there is less time available for home food preparation and exercise. As such, more commercially prepared foods, often with relatively higher caloric content, are consumed.

The rational addiction model à la Becker and Murphy (1988) in the context of obesity suggests that past caloric intake provides increased marginal utility of calories consumed and, thus, has a positive impact on current and future calorie consumption. Thus, if individuals expect a long run decrease in the price of the addictive good then a large increase in the consumption of that good might be expected. Cawley (2002) finds some evidence that calories may be addictive. However he concludes that it is not the only explanation for obesity but may explain why individuals respond so strongly to other factors such as changes in prices and incentives (such as choosing medical vs. behavioral interventions).

Other alternative or complementary explanations have been put forth in trying to explain the obesity rates that we currently observe. It has been suggested that the rate of time preference has increased significantly so that agents discount the future health risks associated with current, possibly unhealthy, consumption leading to increased obesity (Levy 2002; Komlos, Smith and Bogin 2002). Alternatively, individuals may have time inconsistent preferences or varying rates of time preference (Gruber and Koszegi 2001; Frederick, Lowenstein, O'Donoghue 2002). There is also at least one study (Smith 2002) that explores why people have a tendency to eat more than is possibly healthy (i.e., increased prevalence of obesity) in the context of biological or evolutionary preferences for eating as opposed to a problem of self-control.

Lastly, Levy (2002) presents a model of rational, non-addictive eating whereby individuals recognize that they face a trade-off between satisfaction from eating and the risk to life from being overweight or underweight according to the physiological optimum. He finds that even when there is no divergence between the physiologically optimal weight and other physiological, psychological, environmental or socio-cultural motivations, the steady state still results in overweightness. Further, when socio-cultural norms of appearance are present, peer effects work to lower the stationary weight of overweight individuals relative to what it would otherwise be.

Similar to Levy, our model begins from the foundation of individual rational choice. However, his model and the other models to date address only one or two of the elements that have been discussed as explanations of obesity, e.g., social norms, technological change, and time preference. We develop a comprehensive model that brings together and enhances several of the elements in previous work. The unified framework allows us to examine why individuals choose behaviors that lead to weights that are greater than their medically desired optima, and why these behaviors are optimal even in the face of changes such as sedentary time at work or food prices. In addition, our model provides a basis for a constructive discussion of policy.

In fact, there has been much discussion regarding potential policy interventions. However, it has been somewhat disjointed, so a model that takes into consideration several factors is useful. For example, individuals may face a lower cost for medical intervention relative to the cost of behavioral change. In reality the incentives that health insurers establish likely exacerbate this due to their willingness to pay for medical interventions, e.g., prescription drugs for high blood pressure, but most do not give payment for behavioral change, e.g., joining a gym to encourage physical activity (Finkelstein, Fiebelkorn and Wang 2003; Peltzman 2002). Also key for any policy recommendations is an understanding of how the individuals view their choices so that we can understand why health interventions may or may not be successful. For example, are peer effects at work or are there externalities to obesity? Keeler (1989) suggests that there are positive external costs (costs to the government and to other individuals) of physical inactivity that are linked to obesity; however, are these actually externalities? Absent such externalities, if the internal costs of changing behavior for individuals are so large and individuals do not choose to adjust behavior of their own accord, on what grounds is there a role for government intervention?

III. THE MODEL AND OPTIMAL CHOICE

Agents' preferences are defined over food consumption, c; an alternative (composite) good, m; leisure, ℓ; and health, h. Agents divide their time between work and free time. Free time is used either for leisure or health producing exercise, e_f. Time at work is either spent in work related exercise, e_w, or in sedentary activities, s_w. The sedentary activities take time but have neither a leisure nor an exercise (i.e., health) benefit. Agents buy food and alternative goods with their income, I. They plan over a single period horizon having entered the planning period with accustomed or habitual levels of food consumption, $\overline{c}$, and leisure, $\overline{\ell}$. Reducing one's food consumption or leisure below the accustomed levels is costly in utility terms, but increasing food consumption or leisure beyond accustomed levels is not.

Agents' preferences are captured by the following utility and behavioral adjustment cost functions:

$$U(c,\ell,h,m)-k(c,\ell\,|\,\overline{c},\overline{\ell}).$$

U is strictly increasing and concave in all its arguments, with $\lim_{x\to 0} U_x = \infty$ for $x = c, \ell, h$. The cost function k takes on positive values only if current consumption or leisure falls below accustomed levels of consumption and leisure. We consider (gross) utility to be captured by U, and refer to *net* utility when we are considering utility net of adjustment costs k.

In order to capture the relevant relationships between choices through closed-form solutions, consider the following quasi-linear form for preferences

$$U(c,\ell,h,m)-k(c,\ell|\overline{c},\overline{\ell}) = c^{\alpha}\ell^{\beta}h^{\nu} + m - [\zeta(\min\{c,\overline{c}\}-\overline{c})^2 + \xi(\min\{\ell,\overline{\ell}\}-\overline{\ell})^2 + \kappa 1_{x<\overline{x}}].$$

Here κ is a fixed cost of behavioral change (the disutility associated with the mere thought of having to diet or exercise more, e.g.); and $1_{x<\overline{x}}$, $x = c, \ell,$ is an indicator function taking the value of 1, whenever consumption or leisure falls below accustomed levels, and 0 otherwise.

Agents have an initial health stock, h_0, and produce health using exercise, *e*, which takes place at work or in one's free time, so $e = e_w + e_f$. Health is degraded by deviations of consumption or leisure from their physiologically optimal values, denoted by $\hat{c}$ and $\hat{\ell}$. For expositional ease, let,

$$h = h_0 + \theta e - \lambda(c - \hat{c})^2 - \gamma(\ell - \hat{\ell})^2;\ \theta, \lambda, \gamma > 0.$$

Agents maximize their utility subject to their time constraint,

$$\ell + e_w + e_f + s_w = 1,$$

and their budget constraint,

$$pc + m = I.$$

Here the composite good *m* serves as the numeraire and *p* denotes the relative price of food consumption.

Given that preferences are not fully characterized independent of past choices (the adjustment costs affect preferences over different combinations of leisure and consumption), we examine an agent's decision in this environment in three steps.

First, we determine the agent's optimal consumption-leisure pair, suppressing adjustment costs and assuming that the income and time constraints are such that marginal changes in income do not alter food consumption and marginal changes in work hours, or the composition of work activities, do not directly affect leisure activities. This establishes the existence of an interior optimum in consumption and leisure, which we refer to as "bliss." We compare bliss to the physiologically optimal consumption-leisure pair and examine the functional relationship between bliss and the agent's optimal level of health.

Second, we consider the agent's problem assuming income levels are below the threshold needed to obtain bliss and the requirements of work make the bliss level of leisure unobtainable – resulting in "limbo."

Third, we reconsider the initial analysis, in which bliss is within the feasible set, but assume that the accustomed levels of consumption and leisure exceed their bliss levels and adjustment costs are not zero. We demonstrate that the choice thus constrained by adjustment costs, "gluttony and sloth," does not result in bliss. Finally, we examine how the forces militating against adjustment affect gluttony and sloth.

A. Bliss

Assume the cost of adjustment is zero regardless of one's past consumption and leisure choices.[3] Then an agent chooses *c,* ℓ , *h,* and *m* to maximize

$$c^{\alpha}\ell^{\beta}h^{\nu}+m,$$

subject to the time, budget, and non-negativity constraints, as well as the health function:

$$h=h_0+\theta e-\lambda(c-\hat{c})^2-\gamma(\ell-\hat{\ell})^2.$$

Since the marginal benefit from health becomes arbitrarily large for sufficiently low levels of health, and excessive consumption or leisure can reduce one's health to arbitrarily small levels, the health function effectively limits the relevant choice set available to an agent in the consumption-leisure space (see Figure 1).

Thus, assuming that income is sufficiently high so that additional money is spent only on the composite good, and time spent at work is sufficiently little so that additional free time is used for exercise and only indirectly affects leisure choices, the agent's problem reduces to one of maximizing utility with consumption and leisure constrained only by their implications for health. Consequently, the first order (sufficient) conditions,

$$\begin{gathered}\alpha c^{\alpha-1}\ell^{\beta}h^{\nu}-2\nu\lambda c^{\alpha}\ell^{\beta}h^{\nu-1}(c-\hat{c})-p=0,\\ \beta c^{\alpha}\ell^{\beta-1}h^{\nu}-\nu c^{\alpha}\ell^{\beta}h^{\nu-1}[\theta+2\gamma(\ell-\hat{\ell})]=0\end{gathered}$$

imply a bounded optimal consumption-leisure pair, (c^*,ℓ^*) : bliss.

[3] Or, suppose that an agent's past consumption and leisure have been so little that no adjustment downward need be considered.

PROPOSITION 1 (IS GLUTTONY AND SLOTH BLISS?): *If neither the income nor the time use constraints bind on agents' choices of food consumption and leisure, the bliss levels of consumption and leisure (blissful consumption and blissful leisure) will exceed the physiologically optimal levels.*

The proof follows directly from first-order conditions.

Since agents care for more than survival, food consumption and leisure give pleasure even at levels that are above the physiologically optimal levels.[4,5] Thus, while utility is enhanced by being healthier, being healthier comes at the cost of foregoing utility enhancing consumption and leisure – a choice many agents may not find worth making.[6] Bad health, therefore, does not, in and of itself, signal that an individual is not taking good care of himself. Rather, it signals that the benefits of improving one's health are not worth the costs. Equivalently, good health alone neither assures nor signifies well-being.[7]

An immediate implication of the analysis is that if public policy concerning optimal weight and consumption is based on the physiologically optimal level of consumption, all agents will have the tendency towards measured overweightness. Since those measures take only health and not well-being into consideration, they are inherently inaccurate guides for policy. The difference is best understood when considering the relationship between health and blissful consumption.

[4] Smith (2002) offers a biological explanation for excessive food consumption, noting that over the broad sweep of human history, humans have been subject to periods of feast and famine. In feast times agents would consume more than required (for contemporaneous health reasons) to prepare for the possibility of future famines. Those who did not would not survive the famine, and over the millennia their genes would be removed from the gene pool.

[5] Levy (2002) also finds that optimal consumption exceeds the physiologically optimal level.

[6] Wolf and Colditz (1998) use revealed preference theory to estimate by how much people are willing to reduce their health in order to increase food consumption and leisure.

[7] See Bednarek, Pecchenino and Stearns (2003).

Bliss is not immutable. It depends on one's physiologically optimal levels of consumption and leisure and the characteristics of the health production function. These may vary both across individuals and over time in an economy, and are to some degree possibly subject to public policy. How bliss changes gives insights both into how individuals differ at a point in time and over time. To determine this, totally differentiate the first-order conditions to derive the following comparative static results (complete derivations are relegated to Appendix B).

LEMMA 1 (BLISS AND THE PHYSIOLOGICAL OPTIMUM): *Agents for whom the physiologically optimal levels of consumption or leisure are higher have higher blissful consumption and spend more time at blissful leisure. That is,*

$$dc^*/dx,\ d\ell^*/dx > 0; \quad x = \hat{c},\ \hat{\ell}.$$

The physiologically optimal levels of consumption and leisure for one individual may not be those for another, and what is physiologically optimal at one time may not be at another time. Thus, if one were to compare two individuals of the same height, build, and sex, one could see great variation in their bliss levels of consumption and leisure, provided that their physiologically optimal levels of consumption and leisure differ, say, due to genetic differences.

Alternatively, if over time the physiologically optimal levels rise, agents in an economy could become heavier and lazier, as externally measured by the medical profession. This would not necessarily imply a reduction in average well-being that could be overcome by increased activity and reduced consumption, but rather the external evidence of agents making optimal responses to changing conditions.

LEMMA 2 (BLISS AND IMPROVED HEALTH): *Agents with high initial health stocks, or for whom the benefit of exercise is higher, have higher blissful consumption and spend more time at blissful leisure. That is,*

$$dc^*/dy,\ d\ell^*/dy > 0; \qquad y = h_0, \theta$$

Thus, *ceteris paribus*, the naturally healthy choose to eat more and spend more time at leisure than their less healthy peers. Consequently, advances in the public health of an economy that improve the initial healthiness of the population at large or increase the effectiveness of exercise should be accompanied by positive secular trends in food consumption (although perhaps not weight if exercise is more effective) and leisure. Casual empiricism would confirm these trends.

If such medical or technological advances are available to some, but not others, for example to the relatively wealthy but not the poor, then, all else equal, the negative correlation between weight and income could be a result of access to a better health technology. This, however, does not imply that the poor should mimic the behavior of the rich, as this would surely lower their well-being.

LEMMA 3 (BLISS AND DEVIATIONS FROM THE PHYSIOLOGICAL OPTIMUM): *Agents for whom the health costs of consumption or leisure are higher have lower blissful consumption and spend less time at blissful leisure. That is,*

$$dc^*/dz,\ d\ell^*/dz > 0; \qquad z = \lambda, \gamma$$

The determinants of the costs of not eating enough or of eating too much, or of inadequate or excessive inactivity depend, in part, on the wonders of modern medicine. If, for example, high cholesterol is correlated with being overweight, then one could reduce one's cholesterol by losing weight, or, alternatively, by taking a medication that lowers cholesterol without the necessity of losing weight. Such medication makes the cost of deviating from the physiologically optimal level of consumption lower, and blissful consumption higher. That is, people are willing to pay for such medication, even though the same "health" result is obtainable through change in behavior (a revealed-preference indication of the existence of adjustment cost functions as will be seen in Part C). If improvements in medicine reduce the costs of unhealthy behaviors, those behaviors can become less and less unhealthy even with no change in blissful consumption.[8]

It is worth noting that for the agent's decision it is irrelevant whether the properties of the health function are scientifically proved and thus objective, or merely perceived and thus highly subjective. (Although one may argue that in the latter case there is room for learning, and thus further adjustments to the bliss levels of consumption and leisure.) Consequently, the choices made by agents who may attain bliss are a function of both medical knowledge and their own education. This, too, may explain differences in overweightness between different income groups, wherever income and education correlate.

B. Limbo

The analysis of bliss suggests why one may find a tendency for people to have less-than-healthy lifestyles and be overweight. However, the discrepancy between blissful consumption and the physiological optimum does not explain the secular trends towards less healthy lifestyles and overweightness. This can only be accounted for in an economically meaningful way if agents face changes in the environments in which they optimize, as opposed to experiencing changes in their preferences over consumption, leisure, health, or, for that matter, their time preferences.

The nature of the change in the environment is clear from the analysis of bliss: it was assumed that the income and time constraints did not preclude attaining bliss. However, this

[8] See also Peltzman (2002).

assumption will have been violated in the past in modern economies, and is surely not tenable in much of the world today.

PROPOSITION 2A (LIMBO AND INCOME): *Agents whose incomes are low compared to the relative price of food, so that they cannot obtain bliss, $pc^* > I$, may be healthier than their wealthier, blissful peers.*

The proof follows from the budget constraint.

At low levels of income (or relatively high food prices) all income is spent on food, and food consumption necessarily falls below bliss levels. As bliss levels exceed the physiologically optimal levels, agents may be healthier at these lower levels of income. They are, nevertheless, less happy than their wealthier peers.

The obvious corollary to the proposition is, of course, that as incomes rise, or food becomes relatively less expensive, consumption approaches bliss levels and thus will exceed physiologically optimal levels: a trend towards overweightness is observed.

Both rising real incomes and a decline in real food prices (largely due to technological advances in production) are well-established phenomena in those countries where obesity trends are observed (Ladkawalla and Phillipson, 2002). Moreover, this result is also broadly consistent with the findings of Chou, Grossman and Saffer (2002). However, provided that current consumption is not constrained by bad habits acquired in the past (see Subsection C, below), the changes that we observe are individually optimal, and thus should not by themselves be interpreted as undesirable, as Chou, *et al.* seem to imply.

This result does not imply that higher income individuals will necessarily be heavier than their lower income peers. Thus, two agents with identical preferences, both with incomes sufficient to afford their bliss levels of consumption c^*, may nonetheless differ in their food consumption choices because the agents may differ fundamentally (say in their rates of metabolism, or other health parameters) or because one entered the planning period with bad habits (see Subsection C, below).

Note, finally, that as income constraints slackened one would expect to observe an increase in serving sizes of food items, including restaurant meals, as a market response to the changes in income and food prices. Thus, an increase in the portion sizes at restaurants may simply be a response to changes in consumer demand rather than a "conspiracy" of the food industry to entice people to overindulge (Nestle, 2002).

Consider now changes in work patterns over time.

PROPOSITION 2B (LIMBO AND WORK REQUIREMENTS): *Agents who spend a substantial portion of their time at work or face extremely high work-related exercise requirements so that they cannot obtain leisurely bliss or choose not to exercise at home, may be healthier than their more sedentary peers.*

The proof follows directly from the time constraint.

At one level the argument here is similar to that made with regard to low levels of income: if free time is not sufficient to reach blissful leisure, agents will spend less time at leisure and thus may end up closer to their physiological optima, as blissful leisure goes beyond what is physiologically optimal. This may occur whenever time spent at work, $s_w + e_w$, is substantial. However, the proposition also addresses another factor, namely how the composition of time spent at work, e_w as opposed to s_w, impacts health. Thus, if work requirements entail large amounts of exercise (possibly so large that the agent ends up with a "corner solution," choosing $e_f = 0$), health may be increased regardless of the level of leisure chosen, due to the impact of the amount of at-work exercise on the health function.

Indeed, the characteristics of the average job have changed dramatically over the past century in the more economically advanced economies. While at the turn of the twentieth century most jobs required that one expend significant physical effort, a large number of jobs today are, by and large, completely sedentary (changes in the composition of time spent at work). At the same time average annual, weekly, and daily work hours have dramatically decreased (changes in the amount of time spent at work).[9]

Thus, as agents experience such changes one would expect to find increases in overweightness as leisure activities increase (due to less time spent at work), even though agents may begin using some of their free time for exercise (due to changes in the composition of time spent at work). That is, despite the fact that agents begin to jog, play tennis, go for walks, or become active in a fitness club (increases in e_f), overweightness increases over time (due to increases in ℓ beyond $\hat{\ell}$, and decreases in e caused by decreases in e_w, that are not offset by increases in e_f).

Propositions 2A and 2B are deliberately written as conditionals, since the implied antecedent (that one is healthier) need not result for all that have less income or spend more time exercising at work. Indeed, as constraints become ever more binding health deteriorates due to malnourishment and overwork – a case still prevalent throughout much of the world today.[10] However, for individuals who are constrained, increases in income and fewer requirements in terms of work hours and strenuous activities at work, health improves. Ultimately, but well before they would be able to obtain bliss, these agents would weigh less and be physiologically healthier than their blissful peers. But, they would not be as content. An increase in their income and a lessening of the physical requirements of work and total amount of time spent working would allow them to achieve bliss.

[9] See, e.g., Lakdawalla and Philipson (2002).

[10] In our framework overwork can also result if sedentary work time is excessive so that agents cannot achieve sufficient or required levels of exercise or leisure; see Shields (2002).

C. Gluttony and Sloth

The analysis to this point suggests two things. First, overweightness occurs as the result of rational utility maximization when agents face fewer constraints in their (food) consumption and leisure decisions, even when agents value good health and they are fully informed about (utility reducing) health implications of their choices. To the extent that this is the case, overweightness should not be a public policy concern in terms of "helping" individuals to improve their well-being or happiness.[11]

Second, some obvious policy measures designed to improve agents' health can actually lead to further increases in overweightness, as increases in health can shift out the bliss levels of consumption and leisure, possibly yielding greater discrepancies between optimal choices and the physiological optimum. In other words, agents trade-off improved health with increases in consumption and leisure.

Nevertheless, there appears to be a considerable amount of grief and frustration expressed by some individuals concerning their health and well-being as a consequence of their weight. A substantial amount of money is spent on various weight-loss programs that appear to have, at best, mixed success, or on medical procedures – from stomach tying and stapling to liposuction – that are designed to reduce an individual's weight. This suggests that not all is blissful in modern economies in terms of food consumption and leisure. While we do not think that over sixty percent of the population (the number of people assessed as being overweight in the US according to current government guidelines) are affected by these concerns, this appears to be an important issue for a significant part of the population. We posit that reducing accustomed levels of consumption and leisure is costly in utility terms. In the model this is captured by the behavioral adjustment cost function *k*.

[11] This does not preclude the possibility of other rationales for intervention; it merely states that one is not improving the agent's utility by urging lower consumption and more exercise.

Before considering the implications of having accustomed/habitual levels of consumption and leisure, $\overline{c}$ and $\overline{\ell}$, in excess of their bliss levels, c^* and ℓ^*, for agents who face an adjustment cost function, it is worth contemplating how rational individuals could ever end up at accustomed levels above their bliss levels. We offer four scenarios; their relative significance may vary from one individual to another and which of these is overall most important may ultimately be an empirical question that we do not address here.

1. Poor habits carried over from childhood. Lack of sufficient health knowledge by an individual's parents may lead to poor choices concerning childhood consumption and exercise habits (a childhood of fast food and video games). However, government policies concerning school lunches (dumping surplus high fat foods such as cheese, beef and peanut butter) and reduced physical education in schools may be equally important in habit formation. Also, the increasingly common practice of schools granting exclusive access to soft drink and candy distributors may be cause for concern – especially as obesity is dramatically increasing among children (Anderson, et al., 2003). In any event, it is clear that many people enter adult life (and thus the stage in their lives where they are first assumed to take full responsibility for their choices) with habitual supra-optimal levels of food consumption and leisure.

2. Idiosyncrasies of the health function. How one's health reacts to one's environment differs from individual to individual. While one may have conjectures about the parameterization of one's own health function (e.g., on the basis of family traits), ultimately, agents must learn about their health function. In the process of doing so, even cautious individuals may inadvertently overshoot their bliss levels of consumption and leisure and thus end up with supra-optimal levels. (This case is briefly formalized in Appendix A.)

3. Deterministic changes in the health function. Over time the parameterization of the health function changes. In particular, it is well known that the caloric needs of individuals decrease as they physically mature.[12] Hence, what may have been bliss (or near-bliss) levels of consumption and leisure at one point in one's life may at an older age become gluttonous and slothful. Even fully rational agents that anticipate this change in their health function will overindulge and slack off when young relative to their ideal habits in later life.

4. Unanticipated changes in medical insights. Recommendations as to what constitutes a healthy lifestyle are modified over time. For instance, the definition of obesity using the body mass index was modified in 1995 with the release of the clinical guidelines on overweightness and obesity by the NHLBI in such a way that a significant number of people who were previously considered relatively healthy (from the standpoint of weight) were suddenly classified as overweight or even obese. Similarly, in May 2003, the US government issued new guidelines concerning blood pressure that doubled the number of Americans that should change their lifestyles to account for "prehypertension" (Chobanian, et al. 2003).

Thus, even if the physiologically optimal levels (or one's perception thereof) remain unchanged, underestimating the costs of being away from them may have resulted in poor choices in the past. Hence, given past understanding of the impact of consumption and leisure on health, and, in turn, the impact of health on utility, the accustomed levels of consumption and leisure may coincide with previous (possibly merely subjective) levels of bliss. That is: ignorance *was* bliss. (The sketch of a dynamic model in Appendix A can also illustrate this scenario.)

Notice that none of these four scenarios postulate irrational or inconsistent decision-making by agents. However, all situations can be exacerbated by changes in time preferences or time-inconsistent preferences. Also, we do not consider food or leisure activities to be addictive, although the model could easily account for such phenomena should they prove to be relevant.[13]

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[12] See, e.g., USDA guidelines found in *Nutrition and Your Health: Dietary Guidelines For Americans*, 2000, 5th Edition, USDA.

[13] In the case of rational addictions, agents deliberately choose high levels of consumption, and this increases the marginal utility from further consumption. In our model, a rational agent does not find it desirable to be at consumption (or leisure) levels that exceed bliss – indeed their marginal utility from further increases in consumption (or leisure) is negative at these levels.

Having thus recognized why agents may enter the planning period with accustomed levels of consumption and leisure in excess of the bliss levels, consider now the agent's optimization problem. Given the accustomed levels, the agent must decide how much to consume and how much leisure to take, knowing that behavioral change imposes utility losses through *k* but garners utility gains through *U*. With positive cost of adjusting consumption and leisure downwards towards bliss, if the desired consumption and leisure levels together with the cost imply a reduction in net utility, the agent may continue with his accustomed levels of consumption and leisure.

PROPOSITION 3 (TRIUMPH OF GLUTTONY AND SLOTH OVER BLISS?): *Agents with accustomed levels of consumption and leisure that exceed bliss levels will not attain bliss.* The proof follows from the first-order conditions, below.

Agents trade-off the benefit of increasing their health with the cost of changing their behavior. If the fixed costs of behavioral change, κ, are too large, agents will not adjust their behavior at all. Otherwise the trade-off leads to a decrease in consumption and leisure activities below the accustomed/habitual levels. Rewriting the first-order conditions,

$$c^{\alpha}\ell^{\beta}h^{\nu}\left[\frac{\alpha}{c}-\frac{2\nu\lambda(c-\hat{c})}{h}\right]-p=2\zeta(\min\{c,\bar{c}\}-\bar{c})\leq 0$$

$$c^{\alpha}\ell^{\beta}h^{\nu}\left[\frac{\beta}{\ell}-\frac{\nu[\theta+2\gamma(\ell-\hat{\ell})]}{h}\right]=2\xi(\min\{\ell,\bar{\ell}\}-\bar{\ell})\leq 0.$$

The right-hand-side terms of the equality are negative whenever the agent chooses to adjust his behavior, since the agent will never choose higher consumption and/or leisure as this would move him farther from bliss, and thus reduce his overall utility (but would not impose costs of adjustment). See Figure 1. The bracketed left-hand-side terms are zero if the agent is at bliss.

Since the bracketed terms are decreasing in c and ℓ, for the equality to hold, the optimal levels of consumption and leisure when agents face transaction costs exceed their bliss levels. Gluttony and sloth triumph over bliss.

D. Virtue vs. Vice

While agents whose accustomed levels of consumption and leisure are supra-optimal may reduce their consumption and leisure, these reductions only push them in the direction of bliss. How strong the pull of gluttony and sloth is and how much one is willing to suffer to obtain bliss depends upon one's past choices, one's capacity for suffering, and the ultimate joy envisioned. That is, it depends on the accustomed/habitual levels of consumption and leisure and on the parameters of the adjustment cost and health functions. Clearly, there will be many paths towards bliss, not one true path.

The relationship between one's increase in gross utility due to improved health and one's willingness to change (i.e., decrease) one's levels of consumption and leisure are captured in the following lemma.

LEMMA 4 (THE COMFORTS OF CONSTANCY): *The greater is the fixed cost of behavioral change κ, or the marginal adjustment cost of consumption ζ or leisure ξ, the smaller is the net benefit of moving towards bliss.*

Although the difficulty of overcoming an addiction is well understood, the difficulty of breaking habits formed over a lifetime is not. The costs of behavioral change are many: changing the food you buy and prepare and how you prepare it, your eating habits more generally (whether you eat out or in), your leisure activities that involve eating, with whom you spend your time (since social pressures may be high and resistance weak).[14]

The same difficulties apply to exercising more. One has to alter one's schedule to accommodate the increase in exercise, and then one has to learn how to exercise effectively: relabeling a leisure activity as exercise is not adequate. Clearly, the lower the costs of adjustment, the more one adjusts. But, if the fixed costs are high enough, habits will prove too strong to break. Absent a magic wand that can costlessly transport the agent into a state of bliss, the hard work of getting there makes bliss not worth obtaining.

Of course, one's willingness to change one's behavior not only depends on the costs of doing so, but also on the benefits one hopes to reap.

LEMMA 5 (THE ALLURE OF BLISS?): *Given accustomed/habitual levels of consumption,* $\bar{c}$ *(leisure,* $\bar{\ell}$*), the benefit of approaching the bliss level of consumption,* c^* *(leisure,* ℓ^**) is decreasing*

a. in the physiologically optimal level of consumption, $\hat{c}$ *(leisure,* $\hat{\ell}$*);*

b. in the initial level of health, h_0*; and*

c. in a diminished impact of deviations from the physiological optimum, λ *(*γ*), on health.*

Moreover, given accustomed/habitual levels of consumption and leisure, $\bar{c}$ *and* $\bar{\ell}$*, the benefit of approaching the bliss levels of consumption and leisure,* c^* *and* ℓ^**, is decreasing*

d. in the effectiveness of exercise, θ*.*

[14] There is substantial cross-sectional evidence for the US that the poor are more likely to be overweight than the rich. In the context of our model, this could be the case since while both rich and poor in the United States today are largely unconstrained by income in their food consumption (they are not in limbo), the poor may be more likely to enter the planning period with supra-optimal weight because of a lack of health knowledge and the consequent bad habits, possibly formed in youth. Similarly, it may be argued that the cost of adjusting behavior is higher for lower income individuals for socio-economic reasons.

The motivation to change one's behavior is directly related to the health benefit of doing so. Good health need not imply low levels of consumption and leisure. If it does not, then the net benefits of being thin and active are low and agents will forgo changing their behavior much (part a). Similarly, the better one's health at the onset of the planning period, the less one chooses to alter one's behavior (part b). Why might high consumption and leisure not be unhealthy, and why might one's initial health be high? It could be a result of public health initiatives or medications that, for example, lower one's blood pressure or reduce one's cholesterol. But, if one's blood pressure and/or cholesterol are lower, the incentives to lose weight and exercise more are weakened. Modern medicine that enables unhealthy behaviors may be the ally rather than the enemy of gluttony and sloth. As such, modern medicine is nevertheless utility increasing, even if it facilitates the persistence of "sin."

If the health benefit to change is substantial, that is, the cost of being away from one's physiological optimum is high, then agents will choose to eat less and exercise more. However, if the health benefit is low, or perceived to be low, perhaps because of the high quality and low cost of medical care that can substitute for more expensive behavioral change, the net benefit of losing weight and exercising is inadequate to generate such "good behavior" (part c). Consequently, should a physician tell a patient that he would be healthier if he were thinner and more active, the patient could wholeheartedly agree, but still not have an adequate incentive to become healthier since health and happiness are not equivalent states of being.

Finally, when there are increased gains to exercising, one might think that agents would make use of this and exercise more, thus cutting back more on leisure. However, this overlooks the agent's inclination to make trade-offs. As health improves with exercise the marginal utility of leisure increases so that an agent will substitute some leisure for exercise. In fact, given the improvement in health, agents also need not forgo as much consumption. That is, agents will substitute leisure as well as consumption for some of the improvements in health (part d).

In sum, the one-prescription-fits-all (*"Eat less, exercise more!"*) approach to improvements in health and well-being does not fit at all. And many a medical advance can be viewed not only as improving health, but also as facilitating gluttony and sloth. Consequently, in order to assist agents' achievement of bliss – and thus (only) indirectly health – measures that may reduce the costs of adjusting behavior may be more effective than measures designed to directly increase health.

IV. POLICY AND CONCLUSIONS

Individuals, unconstrained by concerns of income or time, can and will choose levels of consumption and leisure that exceed their physiological optima. By how much they exceed the optima depends on a variety of factors, most importantly, the utility cost (benefit) of achieving health. Observed positive trends in adult weight, brought on by higher levels of consumption and lower levels of physical activity, often interpreted as a public health crisis in the making, can be explained by these factors. But, rather than the trend suggesting crisis, it suggests only optimal responses to altered, and perhaps improved, circumstances. While individuals today are heavier than those a generation or more ago (Cole, 2003), those free of bad habits are also assuredly happier.

Attempts by the medical profession and public health officials to promote physiologically "optimal" weights rather than the higher optimal weights resulting from individual utility maximization (recalling Proposition 1) may be costly, misguided, and stress-inducing policies with very low social welfare benefits. Thus, policy makers may need to rethink the rationale for their promotion of the physiological optimum. Is it promoted because there are externalities associated with obesity or is it to correct for other policies that may exacerbate the discrepancy between physiologically optimal and the accustomed levels of food consumption and leisure, e.g.

relatively unhealthy school lunches, soda and candy vending machines in schools, etc.? In this context, recent trends in childhood obesity rates are particularly troubling, and may call for action. Whatever the public policy motivation, policies should promote better health and the achievement thereof, not optimal weights.

Indeed, the most effective tools in increasing agents' health and well-being may be those that reduce the incidence of supra-optimal levels of consumption and leisure. The prescription for this may be easier to find when it is tied to behavior adopted in childhood due to habits formed at school, but it is much more difficult when it comes to agent's experiencing changes to the expected health functions. In particular, it is this area where the one-size-fits-all prescriptions may be particularly misdirected – as idiosyncratic differences in health requirements and maintenance (and hence optimal prescriptions) may vary substantially from one individual to the next.

Even so, when agents, for whatever reason, find their consumption and leisure patterns to be "excessive," they must decide whether or not to change their behavior by weighing the costs and the benefits of doing so. If one can buy an improvement in health via cheap medical care rather than expensive behavioral change, the medical care option will be followed. Of what does this medical care consist? It is largely prescription drugs that reduce the adverse effects of being overweight and not getting adequate exercise, such as drugs to reduce high blood pressure, drugs to reduce cholesterol levels, drugs to control the blood sugar levels of diabetics, etc.[15]

Clearly, a medical doctor would face a moral dilemma if she failed to prescribe the sure medical treatment to alleviate the medical conditions suffered by a patient, prescribing instead the behavioral change that would achieve the same or a better end, and the patient's condition worsened as a result of the doctor's orders not being followed. Thus, doctors routinely prescribe medication while only recommending behavioral change, and are encouraged to do so by the

[15] While drugs can treat conditions caused by overweightness and obesity, overweightness and obesity themselves are not amenable to drug therapy. See Inoue, Zimmet, et al. (2000).

structure of our health care system (which generally subsidizes medical care, but is much weaker in supporting behavioral change). For this practice to be reversed, the relative cost of behavioral change will have to fall significantly. Thus, behavioral change needs to be facilitated more – recent changes to the tax code allowing some deductions for health club memberships may be the first steps in this direction.

While trends in overweightness may be a result of reduced food prices, increased incomes, changes in job characteristics, or reduced costs of being overweight, they are ultimately the result of optimizing choices of individuals – not bad outcomes imposed on innocents. Any policy that fails to recognize the interactions of optimal choice on health is bound to fail in its stated objective and will be more costly to society overall than the benefits that may arise.

Appendix A: Stochastic Health and Dynamic Choice

We briefly sketch how accustomed levels of consumption and leisure may exceed bliss levels in a dynamic model when the agent is initially uncertain about the parameterization of the health function. This captures both the case of agents learning about idiosyncrasies in their health function as well as unanticipated health shocks.[16] For expositional ease we restrict attention to the one-dimensional case, i.e., consumption only, and give a numeric example. A dynamic version of the full model yields the same insights.

The agent maximizes utility by choosing consumption in two periods. Per-period utility is given by

$$U = c_t^{\alpha} h_t^{\beta} - (t-1)k(c_t|\bar{c})\text{ , with } h_t = h_0 - \zeta(c_t - \hat{c})^2, t = 1,2.$$

The adjustment cost function, $k(c_2|\bar{c} = c_1)$, takes on positive values if $c_2 < \bar{c} = c_1$, and is zero otherwise.

Suppose that the base level of health h_0 is the realization of a random variable H_0. Prior to first period consumption the agent knows only the distribution of H_0. Its realization, h_0, is revealed after the first period consumption decision has been made, yet it is known before the second period consumption decision is made.

In both periods the agent's consumption is restricted only by the health function. That is, the budget constraint is slack.

Normalize $\alpha = \beta = \zeta = \hat{c} = 1$ and consider bliss in the second period. At the beginning of the second period the agent knows the value of h_0. Thus, given the parameterization and the fact that bliss is independent of $k(\cdot)$, the bliss level of consumption, $c_2^*(h_0)$, maximizes

[16] In the latter case the expected health function serves as the actual first period health function.

$$U(c_2, h_2(c_2)) = c_2^{\alpha}\left(h_0 - \zeta(c_2 - \hat{c})^2\right)^{\beta} = -c_2^3 + 2c_2^2 + (h_0 - 1)c_2 .$$

Thus,

$$c_2^*(h_0) = \frac{2 + \sqrt{3h_0 + 1}}{3} .$$

Given the non-binding budget constraint, bliss is achieved in the second period only if $c_1 = \bar{c} < c_2^*(h_0)$. Otherwise the agent's second period utility is diminished due to the adjustment cost function. Indeed, the loss in (second period) utility is larger the greater is the excess of $\bar{c}\ (= c_1)$ over c_2^*. Let $\mathsf{L}(\bar{c}, c_2^*(h_0))$ denote the loss (compared to bliss levels) in second period utility implied by the adjustment cost function $k(\cdot)$. Then – assuming that there is no discounting – given initial uncertainty about h_0, the agent chooses a consumption level c_1 that maximizes

$$E\left[U\left(c_1, h_1(c_1, h_0)\right)\right] - E[\ \mathsf{L}(\bar{c}, c_2^*(h_0))\ ].$$

For simplicity let $k(\cdot)$ be such that $\mathsf{L}(c_1, h_0) = \frac{1}{5} c_1 \Pr\{\bar{c} > c_2^*\}$, which has the desired properties of the expected loss function. Suppose, lastly, that H_0 is distributed uniformly on [5/3, 11/3] so that $F(h_0) = \frac{3h_0 - 5}{6}$. Then,

$$\Pr\{\bar{c} > c_2^*(h_0)\} = \Pr\left\{h_0 < 3c_1^2 - 4c_1 + 1\right\} = \max\left\{0, \frac{9c_1^2 - 12c_1 - 2}{6}\right\}.$$

Thus, the agent's first period choice of c_1 maximizes

$$-c_1^3 + 2c_1^2 + \frac{5}{3}c_1 - \max\left\{0, c_1 \frac{9c_1^2 - 12c_1 - 2}{30}\right\}.$$

The result of this maximization yields the agent's first period bliss consumption, when accounting for potential future adjustment costs associated with reducing consumption. Specifically,

$$c_1^* = \frac{24 + 2\sqrt{313}}{39} \approx 1.5 .$$

This is a reduction in consumption compared to myopic consumption (given by $c_2^*(E[h_0]) \approx 1.67$). Yet, in both periods *any* agent consumes more than the physiologically optimal level of $\hat{c} = 1$, and, if health is independent across agents, approximately ten percent of the population find themselves with accustomed levels of consumption in excess of their second-period bliss levels so that they will not achieve bliss. That is,

$$\Pr\{\overline{c} > c_2^*(h_0)\} = \Pr\left\{\frac{2+\sqrt{3h_0+1}}{3} < \frac{24+2\sqrt{313}}{39}\right\} \approx 10\% .$$

APPENDIX B: PROOFS OF LEMMAS

The first-order conditions of utility maximization for the general model at an interior optimum (m, $e_f > 0$) are

$$\alpha c^{\alpha-1}\ell^{\beta}h^{\nu} - 2\nu\lambda c^{\alpha}\ell^{\beta}h^{\nu-1}(c-\hat{c}) - 2\zeta(c-\bar{c}) - p = 0$$
$$\beta c^{\alpha}\ell^{\beta-1}h^{\nu} - \nu c^{\alpha}\ell^{\beta}h^{\nu-1}[\theta + 2\gamma(\ell-\hat{\ell})] - 2\xi(\ell-\bar{\ell}) = 0$$

Totally differentiating we have

$$\begin{bmatrix} A-2\zeta & B \\ B & D-2\xi \end{bmatrix}\begin{bmatrix} dc \\ d\ell \end{bmatrix} = \begin{bmatrix} -\nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1} + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})] \\ -\nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1} + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})] \end{bmatrix} dh_0$$

$$+\begin{bmatrix} -\nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}(1-\ell-s_w) + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})](1-\ell-s_w) \\ -\nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}(1-\ell-s_w) + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})](1-\ell-s_w) \end{bmatrix} d\theta$$

$$+\begin{bmatrix} \nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}\theta - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})]\theta \\ \nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}\theta - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})]\theta \end{bmatrix} ds_w$$

$$+\begin{bmatrix} \nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}(c-\hat{c})^2 - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})^3] + 2(c-\hat{c})\nu c^{\alpha}\ell^{\beta}h^{\nu-1} \\ \nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}(c-\hat{c})^2 - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})^2 \end{bmatrix} d\lambda$$

$$+\begin{bmatrix} -\nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}[2\lambda(c-\hat{c})] + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[4\lambda^2(c-\hat{c})^2] - 2\lambda\nu c^{\alpha}\ell^{\beta}h^{\nu-1} \\ -\nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}[2\lambda(c-\hat{c})] + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})][2\lambda(c-\hat{c})] \end{bmatrix} d\hat{c}$$

$$+\begin{bmatrix} \nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}(\ell-\hat{\ell})^2 - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})(\ell-\hat{\ell})^2] \\ \nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}(\ell-\hat{\ell})^2 - \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})^2 + 2(\ell-\hat{\ell})\nu c^{\alpha}\ell^{\beta}h^{\nu-1} \end{bmatrix} d\gamma$$

$$+\begin{bmatrix} -\nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}[2\gamma(\ell-\hat{\ell})] + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})][2\gamma(\ell-\hat{\ell})] \\ -\nu\beta c^{\alpha}\ell^{\beta-1}h^{\nu-1}[2\gamma(\ell-\hat{\ell})] + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[\theta+2\gamma(\ell-\hat{\ell})][2\gamma(\ell-\hat{\ell})] - 2\gamma\nu c^{\alpha}\ell^{\beta}h^{\nu-1} \end{bmatrix} d\hat{\ell}$$

$$+\begin{bmatrix} 2(c-\bar{c}) \\ 0 \end{bmatrix} d\zeta + \begin{bmatrix} -2\zeta \\ 0 \end{bmatrix} d\bar{c} + \begin{bmatrix} 0 \\ 2(\ell-\bar{\ell}) \end{bmatrix} d\xi + \begin{bmatrix} 0 \\ -2\xi \end{bmatrix} d\bar{\ell} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} dp$$

where

$$A = \alpha(\alpha-1)c^{\alpha-2}\ell^{\beta}h^{\nu} - 4\lambda\nu\alpha(c-\hat{c})c^{\alpha-1}\ell^{\beta}h^{\nu-1} + 4\lambda^2\nu(\nu-1)(c-\hat{c})^2c^{\alpha}\ell^{\beta}h^{\nu-2} - 2\lambda\nu c^{\alpha}\ell^{\beta}h^{\nu-1} < 0$$

$$B = \alpha\beta c^{\alpha-1}\ell^{\beta-1}h^{\nu} - \nu\alpha c^{\alpha-1}\ell^{\beta}h^{\nu-1}[\theta+2\gamma(\ell-\hat{\ell})] + \nu(\nu-1)c^{\alpha}\ell^{\beta}h^{\nu-2}[2\lambda(c-\hat{c})][\theta+2\gamma(\ell-\hat{\ell})]$$
$$-2\lambda\beta\nu(c-\hat{c})c^{\alpha}\ell^{\beta-1}h^{\nu-1}$$

<0 under Bliss, $\gtrless 0$ under Gluttony and Sloth.

$$D=\beta(\beta-1)c^{\alpha}\ell^{\beta-2}h^{\nu}-2\nu\beta[\theta+2\gamma(\ell-\hat{\ell})]c^{\alpha}\ell^{\beta-1}h^{\nu-1}+\nu(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})]^{2}c^{\alpha}\ell^{\beta}h^{\nu-2}$$
$$-2\gamma\nu c^{\alpha}\ell^{\beta}h^{\nu-1}<0$$

By the second-order conditions

$$\Delta=(A-2\zeta)(D-2\xi)-B^{2}>0.$$

And, note, by the first-order conditions

$$\left[\frac{\alpha}{c}-\frac{2\lambda\nu(c-\hat{c})}{h}\right]>0 \text{ under Bliss, and} <0 \text{ under Gluttony and Sloth}$$
$$\left[\frac{\beta}{\ell}-\frac{\nu[\theta+2\gamma(\ell-\hat{\ell})]}{ch}\right]=0 \text{ under Bliss,} <0 \text{ under Gluttony and Sloth}$$

Proof of Lemma 1:

Under the assumption of Bliss, $\zeta=\xi=0$. Then

$$\frac{dc}{d\hat{c}}=\frac{2\nu\lambda(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\alpha(c-\hat{c})}{c}\left[\frac{\beta}{\ell^{2}}+\frac{2\gamma\nu}{h}\right]-D-\frac{\nu(\nu-1)4\gamma\lambda(c-\hat{c})^{2}}{h^{2}}\\ \quad+\frac{2\lambda(c-\hat{c})^{2}\beta(1-\beta-\nu)}{\ell^{2}h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})}{hc\ell}\end{array}\right\}>0$$

$$\frac{d\ell}{d\hat{c}}=\frac{2\nu\lambda(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\alpha\beta(c-\hat{c})}{\ell c^{2}}+\frac{2\alpha\beta\lambda(c-\hat{c})^{2}}{c\ell h}+\frac{\alpha\beta}{c\ell}-\frac{\alpha\nu[\theta+2\gamma(\ell-\hat{\ell})]}{ch}\\ \quad+\frac{[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})\alpha(1-\alpha-\nu)}{hc^{2}}\end{array}\right\}>0$$

$$\frac{dc}{d\hat{\ell}}=\frac{2\nu\gamma(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\alpha\beta(\ell-\hat{\ell})}{\ell^{2}c}+\frac{\alpha\beta}{c\ell}\frac{[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h}+\frac{2\beta\lambda(\ell-\hat{\ell})(c-\hat{c})(1-\beta-\nu)}{h\ell^{2}}\\ \quad+2\left[\frac{\alpha}{c}-\frac{2\nu\lambda(c-\hat{c})}{h}\right]\left[\frac{\beta}{\ell}-\frac{\nu\theta}{h}\right]-\frac{4\nu\theta\lambda(c-\hat{c})}{h^{2}}\end{array}\right\}>0$$

if $\frac{4\nu\theta\lambda(c-\hat{c})}{h^{2}}$ small.

$$\frac{d\ell}{d\hat{\ell}}=\frac{2\nu\gamma(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\beta(\ell-\hat{\ell})}{\ell}\left[\frac{\alpha}{c^{2}}+\frac{2\lambda\nu}{h}\right]-\frac{2\lambda\nu(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h^{2}}\\ \quad+\frac{\alpha[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})(1-\alpha-\nu)}{hc^{2}}-2A+\frac{\alpha\beta}{c\ell}\frac{2\lambda(c-\hat{c})(\ell-\hat{\ell})}{h}\end{array}\right\}>0 \;\square$$

Proof of Lemma 2:

Under the assumption of Bliss, $\zeta = \xi = 0$. Then

$$\frac{dc}{dh_0} = \frac{\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\alpha}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}\right]-\frac{\nu(\nu-1)4\gamma\lambda(c-\hat{c})}{h^2}\\&+\frac{2\lambda(c-\hat{c})\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})]}{hc\ell}\end{aligned}\right\}>0$$

$$\frac{d\ell}{dh_0} = \frac{\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\beta}{\ell}\left[\frac{\alpha}{c^2}+\frac{2\lambda\nu}{h}\right]-\frac{2\lambda\nu(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})]}{h^2}\\&+\frac{[\theta+2\gamma(\ell-\hat{\ell})]\alpha(1-\alpha-\nu)}{hc^2}\end{aligned}\right\}>0$$

$$\frac{dc}{d\theta} = \frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\alpha}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}\right]-\frac{\nu(\nu-1)4\gamma\lambda(c-\hat{c})}{h^2}\\&+\frac{2\lambda(c-\hat{c})\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})]}{hc\ell}\end{aligned}\right\}>0$$

$$\frac{d\ell}{d\theta} = \frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\beta}{\ell}\left[\frac{\alpha}{c^2}+\frac{2\lambda\nu}{h}\right]-\frac{2\lambda\nu(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})]}{h^2}\\&+\frac{[\theta+2\gamma(\ell-\hat{\ell})]\alpha(1-\alpha-\nu)}{hc^2}\end{aligned}\right\}>0 \square$$

Proof of Lemma 3:

Under the assumption of Bliss, $\zeta = \xi = 0$. Then

$$\frac{dc}{d\lambda} = \frac{-\nu(c-\hat{c})(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\alpha(c-\hat{c})}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}\right]-2D-\frac{\nu(\nu-1)4\gamma\lambda(c-\hat{c})^2}{h^2}\\&+\frac{2\lambda(c-\hat{c})^2\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})}{hc\ell}\end{aligned}\right\}<0$$

$$\frac{d\ell}{d\lambda} = \frac{-\nu(c-\hat{c})(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{aligned}&\frac{\alpha\beta(c-\hat{c})}{\ell c^2}+\frac{2\alpha\beta\lambda(c-\hat{c})^2}{c\ell h}+2\left[\frac{\alpha}{c}-\frac{\lambda\nu(c-\hat{c})}{h}\right]\left[\frac{\beta}{\ell}-\frac{\nu[\theta+2\gamma(\ell-\hat{\ell})]}{h}\right]\\&+\frac{[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})\alpha(1-\alpha-\nu)}{hc^2}-\frac{2\nu\lambda(c-\hat{c})[\theta+2\gamma(\ell-\hat{\ell})]}{h^2}\end{aligned}\right\}<0$$

if $\dfrac{2\nu\lambda(c-\hat{c})[\theta+2\gamma(\ell-\hat{\ell})]}{h^2}$ small.

$$\frac{dc}{d\gamma}=-\frac{\nu(\ell-\hat{\ell})(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\alpha\beta(\ell-\hat{\ell})}{\ell^{2}c}+\frac{\alpha\beta}{c\ell}\frac{[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h}+\frac{2\beta\lambda(\ell-\hat{\ell})(c-\hat{c})(1-\beta-\nu)}{h\ell^{2}}\\+2\left[\frac{\alpha}{c}-\frac{2\nu\lambda(c-\hat{c})}{h}\right]\left[\frac{\beta}{\ell}-\frac{\nu[\theta+\gamma(\ell-\hat{\ell})]}{h}\right]-\frac{4\nu\lambda(c-\hat{c})[\theta+2\gamma(\ell-\hat{\ell})]}{h^{2}}\end{array}\right\}<0$$

if $\frac{4\nu\lambda(c-\hat{c})[\theta+2\gamma(\ell-\hat{\ell})]}{h^{2}}$ small.

$$\frac{d\ell}{d\gamma}=-\frac{\nu(\ell-\hat{\ell})(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\beta(\ell-\hat{\ell})}{\ell}\left[\frac{\alpha}{c^{2}}+\frac{2\lambda\nu}{h}\right]-\frac{2\lambda\nu(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h^{2}}\\+\frac{\alpha[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})(1-\alpha-\nu)}{hc^{2}}-2\mathrm{A}+\frac{\alpha\beta}{\mathrm{c}\ell}\frac{2\lambda(c-\hat{c})(\ell-\hat{\ell})}{h}\end{array}\right\}<0\;\square$$

Proof of Lemma 4:

$$\frac{dc}{d\zeta}=\frac{2(c-\overline{c})(D-2\xi)}{\Delta}>0\ \text{ since }\ c<\overline{c}$$

$$\frac{d\ell}{d\zeta}=-\frac{2B(c-\overline{c})}{\Delta}<0\ \text{ since }\ c<\overline{c}$$

$$\frac{dc}{d\xi}=-\frac{2B(\ell-\overline{\ell})}{\Delta}<0\text{ since }\ \ell<\overline{\ell}$$

$$\frac{d\ell}{d\overline{\ell}}=\frac{2(A-2\zeta)(\ell-\overline{\ell})}{\Delta}>0\ \text{ since }\ \ell<\overline{\ell}\;\square$$

Proof of Lemma 5a:

$$\frac{dc}{d\hat{c}}=\frac{2\nu\lambda(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\alpha(c-\hat{c})}{c}\left[\frac{\beta}{\ell^{2}}+\frac{2\gamma\nu}{h}+2\xi\right]-D+2\xi-\frac{(\nu-1)2\lambda(c-\hat{c})^{2}}{h}\left[\frac{2\gamma\nu}{h}+2\xi\right]\\+\frac{2\lambda(c-\hat{c})^{2}\beta(1-\beta-\nu)}{\ell^{2}h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})}{hc\ell}\end{array}\right\}>0$$

$$\frac{d\ell}{d\hat{\ell}}=\frac{2\nu\gamma(c^{\alpha}\ell^{\beta}h^{\nu})^{2}}{h\Delta}\left\{\begin{array}{l}\frac{\beta(\ell-\hat{\ell})}{\ell}\left[\frac{\alpha}{c^{2}}+\frac{2\lambda\nu}{h}+2\zeta\right]-\frac{(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h}\left[\frac{2\lambda\nu}{h}+2\zeta\right]\\+\frac{\alpha[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})(1-\alpha-\nu)}{hc^{2}}-2(A-2\zeta)+\frac{\alpha\beta}{\mathrm{c}\ell}\frac{2\lambda(c-\hat{c})(\ell-\hat{\ell})}{h}\end{array}\right\}>0$$

$\square$

Proof of Lemma 5b:

$$\frac{dc}{dh_0}=\frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\alpha}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}+2\xi\right]-\frac{(\nu-1)2\lambda(c-\hat{c})}{h}\left[\frac{2\gamma\nu}{h}+2\xi\right]\\ \qquad +\frac{2\lambda(c-\hat{c})\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})]}{hc\ell}\end{array}\right\}>0$$

$$\frac{d\ell}{dh_0}=\frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\beta}{\ell}\left[\frac{\alpha}{c^2}+\frac{2\lambda\nu}{h}+2\zeta\right]-\frac{(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})]}{h}\left[\frac{2\lambda\nu}{h}+2\zeta\right]\\ \qquad +\frac{[\theta+2\gamma(\ell-\hat{\ell})]\alpha(1-\alpha-\nu)}{hc^2}\end{array}\right\}>0\ \square$$

Proof of Lemma 5c:

$$\frac{dc}{d\lambda}=\frac{-\nu(c-\hat{c})(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\alpha(c-\hat{c})}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}+2\xi\right]-2(D-2\xi)-\frac{(\nu-1)2\lambda(c-\hat{c})^2}{h}\left[\frac{2\gamma\nu}{h}+2\xi\right]\\ \qquad +\frac{2\lambda(c-\hat{c})^2\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})](c-\hat{c})}{hc\ell}\end{array}\right\}<0$$

$$\frac{d\ell}{d\gamma}=-\frac{\nu(\ell-\hat{\ell})(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\beta(\ell-\hat{\ell})}{\ell}\left[\frac{\alpha}{c^2}+\frac{2\lambda\nu}{h}+2\zeta\right]-\frac{(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})}{h}\left[\frac{2\lambda\nu}{h}+2\zeta\right]\\ \qquad +\frac{\alpha[\theta+2\gamma(\ell-\hat{\ell})](\ell-\hat{\ell})(1-\alpha-\nu)}{hc^2}-2(A-2\zeta)+\frac{\alpha\beta}{c\ell}\frac{2\lambda(c-\hat{c})(\ell-\hat{\ell})}{h}\end{array}\right\}<0\ \square$$

Proof of Lemma 5d:

$$\frac{dc}{d\theta}=\frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\alpha}{c}\left[\frac{\beta}{\ell^2}+\frac{2\gamma\nu}{h}+2\xi\right]-\frac{(\nu-1)2\lambda(c-\hat{c})}{h^2}\left[\frac{2\gamma\nu}{h}+2\xi\right]\\ \qquad +\frac{2\lambda(c-\hat{c})\beta(1-\beta-\nu)}{\ell^2 h}+\frac{\alpha\beta[\theta+2\gamma(\ell-\hat{\ell})]}{hc\ell}\end{array}\right\}>0$$

$$\frac{d\ell}{d\theta}=\frac{(1-\ell-s_w)\nu(c^{\alpha}\ell^{\beta}h^{\nu})^2}{h\Delta}\left\{\begin{array}{l}\frac{\beta}{\ell}\left[\frac{\alpha}{c^2}+\frac{2\lambda\nu}{h}+2\zeta\right]-\frac{(\nu-1)[\theta+2\gamma(\ell-\hat{\ell})]}{h^2}\left[\frac{2\lambda\nu}{h}+2\zeta\right]\\ \qquad +\frac{[\theta+2\gamma(\ell-\hat{\ell})]\alpha(1-\alpha-\nu)}{hc^2}\end{array}\right\}>0\ \square$$

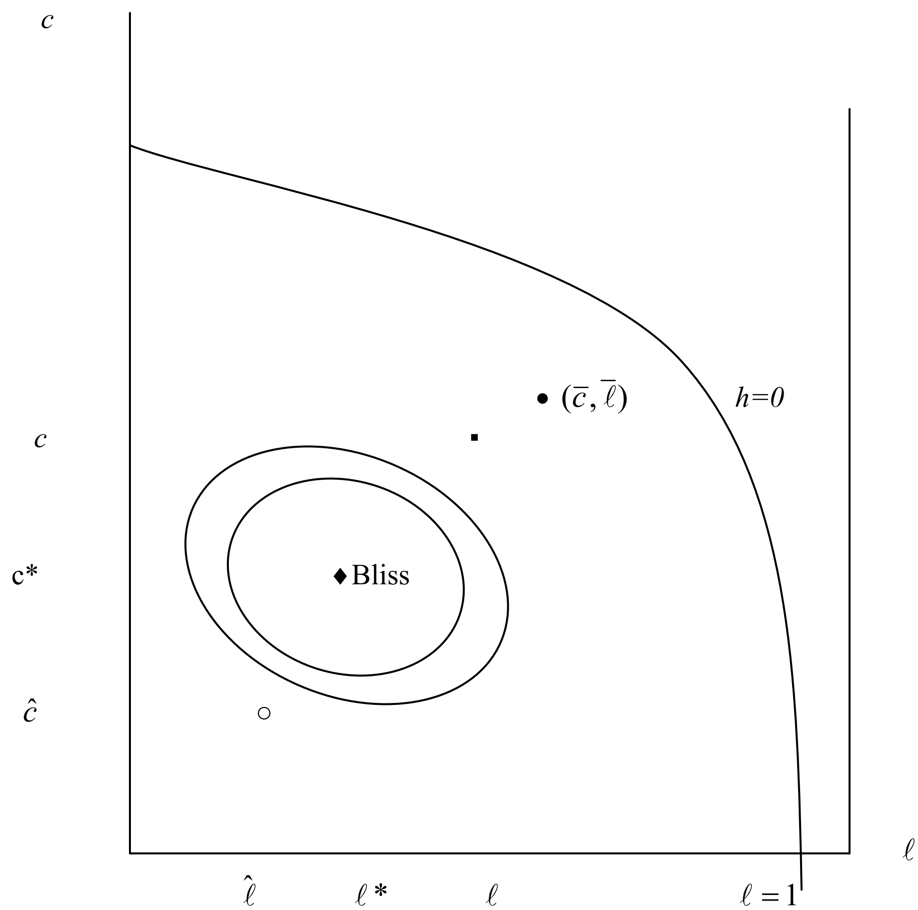

FIGURE 1
The agent's level sets in consumption-leisure space,
with *m* adjusted to account for changes in *c*.

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