Anthropometric versus income measures of the standard of living: Issues of theoretical consistency

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Abstract

Background: Secular changes in anthropometric measures, such as height, are regularly used to infer secular changes in the economic well-being. The existence of a positive correlation between change in height and change in historical real incomes has enabled the use of change in average height as a proxy for economic growth and decline. However, the correlation is not universal. In some historical circumstances, average height fell when real income rose. This paradox calls for careful examination of the relationship between measures of economic well-being.

Aim: The essay uses the fundamentals of utility theory to articulate the theoretical relationship between anthropometric measures and income measures of economic well-being, and to identify areas where additional theoretical work would be beneficial.

Conclusion: In order to be consistent with utility theory, a measure of overall economic well-being must capture any increase in new options available to people, including new options that arise from changes in relative prices. Anthropometric measures do not meet this criterion. When inputs into net nutrition of children become more expensive relative to other goods, lower levels of net nutrition for children may be consistent with higher levels of overall economic well-being. While anthropometric measures remain important measures of the health outcomes for populations, they cannot be interpreted as measures of overall economic well-being for all populations in history.

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I. Prologue

Time magazine summarized the position of scholars studying anthropometrics or auxology thus: 'The evidence of auxologists - who cross the disciplines of economic history, pediatrics, biology and sociology - is that average height reflects how well, or badly, a population is doing - its diet, wealth, quality of housing, levels of population, disease and stress - and is a far better measure of a nation's standard of living than such conventional indicators as gross national product or per capita income.' A paragraph later the author stated, 'There is no suggestion [in the anthropometric literature] that big is beautiful or better or that smart Davids won't continue to outdo lumbering Goliaths (Usher 1996, 64).'[1] The author seemed unaware that he had reported a contradiction, namely that height both was and was not a superior measure of the standard of living. We believe that this contradictory assessment is indicative of a more general state of confusion over how height and other anthropometric measures relate to the standard of living. In this essay we point to areas where work is needed to articulate the relationship more clearly.

II. Introduction

Over the last three decades, the study of human height has become prominent research agenda in economic history. Its thrust has been to use changes in anthropometric measures as an alternative to conventional economic measures of the standard of living, such as a substitute for changes in per capita real income (Floud 1992, 1994, Floud and Wachter 1982, Floud, Wachter, and Gregory 1990, Fogel 1986, 1989, 1993, Fogel, Engerman, and Trussell 1982, Fogel, et al. 1983; Komlos 1987, 1989, 1992, 1994b, Margo and Steckel 1982, Steckel 1979, 1983, 1986, 1992, 1994, 1995, Tanner, Whitehouse, and Takaishi 1966). Because data on human height exist for populations and periods where data on real income are lacking or unreliable, anthropometric research promises to allow comparisons of the standard of living over longer periods of time and across more disparate populations than has been possible up to now.

We argue that this promise has been prematurely made. It is not clear that the anthropometric measure is either superior to or a consistent proxy for the economic measure. We make an exploratory examination of the conditions under which an anthropometric measure might proxy the economic measure of the standard of living. We suggest some empirical tests of these conditions in order to refine our understanding of the circumstances under which anthropometric measures might be used to gauge the standard of living.

Our concerns are theoretical and interpretive rather than empirical. The collection of data by anthropometric researchers has been a success. Anthropometrics is a well-established research strategy for measuring an important aspect of the human condition - specifically health, the determinants of health, and the impact of health on society. While measurement, sampling, and estimation techniques have been debated, these debates are relatively minor.[2] The proliferation of studies over the last two decades has allowed scholars to construct a nearly continuous series of heights from the present to

1710 for Americans of European and African descent, to the mid-eighteenth century for Britons and east-central Europeans, and to the late eighteenth century for several other European nationalities (Coclanis and Komlos 1995, Dye 1995, Floud and Wachter 1982, Floud, Wachter, and Gregory 1990; Fogel 1986, 1993, Fogel, Engerman, and Trussell 1982, Friedman 1982, Grubb 1999, Harris 1994, Johnson and Nicholas 1995, Kirby 1995, Komlos 1987, 1989, 1994a, 1994b, Mokyr and O'Grada 1994, 1996, Murray 1993, Nicholas and Oxley 1993, Nicholas and Steckel 1991, Riggs 1994, Sokoloff and Villaflor 1982, Steckel 1979, 1983, 1986, 1992, 1994, 1995. Recent work on skeletal evidence promises to extend the anthropometric records even further back in time (Steckel 2002, Steckel, Sciulli, and Rose 2002, Steegmann 1986). In short, the anthropometric literature has done an admirable job of charting how the human body has changed over time.

How changes in the human body relate to changes in the standard of living has received less critical scrutiny. The rhetoric presumes a clear and direct connection between how the body performs and the standard of living. The presumption grew out of work in biological science. Biologists demonstrated that the terminal height, the age at which terminal height is reached, and the age-specific velocity of growth in height measure the impact during childhood of the absorption of nutrients minus the energy claims made by metabolism, exertion, climatic conditions, and disease. Differences in height, therefore, can be used to measure differences over time and across populations in the **n**utrition-**e**xertion-**c**limate-**d**isease **e**nvironments of **c**hildren (the NECDEC). Clearly, such anthropometric measures can have economic determinants. But the NECDEC is not the same as the standard of living, as we will show. Nor is there an obvious or direct correspondence between secular changes in the NECDEC and secular changes in the standard of living.

We identify several problems of interpretation of anthropometric measures. First, while pointing out and constantly cautioning that height measures net nutrition and not gross nutrition, scholars proceed

to the conclusion that differences in nutrition are the source of measured differences in height.[3] Additionally, anthropometric research has only recently begun to address the exertion-climate-disease part of the NECDEC; in the main the published literature treats exclusively nutrition. The difficulty of measuring the exertion-climate-disease part of the NECDEC and directly incorporating it into anthropometric analysis does not explain the nutrition-centric conclusions. We argue that the need to assert a connection between economic and anthropometric measures of the standard of living has led scholars to focus on adult nutrition because the food intake of adults has a direct connection to the decisions of individuals in the market place. By contrast, the connection between economic decisions of adults and disease, climate, and the food intake of children is not so direct.

Early anthropometric studies showed a coincidence of trends between anthropometric measures and real income.[4] The coincidence gave scholars confidence that anthropometric measures could be substituted for real income measures in time periods and economies where data on real income was lacking or unreliable. The initial coincidence of trends also left little need to develop a theoretical connection between anthropometric and economic measures of value. This confidence was shaken by the anthropometric evidence for nineteenth-century populations, which revealed substantial divergence between the anthropometric and real income measures of the standard of living. These findings cannot be explained away as isolated incidents or as anomalous events, because divergence occurred in a number of countries in Europe as well as in America, and in different decades in different countries (Floud, Wachter, and Gregory 1990, Fogel 1986, 1989, Fogel et al. 1983, Johnson and Nicholas 1995, Komlos 1987, 1989, 1993a, Nicholas and Steckel 1991, Steckel 1992, 1994, 1995, Steckel and Haurin 1994).[5]

The phenomenon of the divergence between anthropometric and real income measures of the standard of living during the nineteenth century has not been satisfactorily resolved. Empirical research

has proceeded, while the validity of a key assumption of anthropometrics has been ignored. Without the assumption that height (or the NECDEC) is a positive, monotonic function of real income, anthropometric measures cannot be substituted for real income measures. If the assumption is set aside, anthropometricians must demonstrate that their measures are theoretically superior to real income measures of the standard of living. As it stands, scholars appear to hold a dualistic belief that anthropometric measures are the same as, but also fundamentally different from and superior to, real income measures of the standard of living. The following assessment of the British standard of living during the early nineteenth century seems a typical defense of anthropometric measures,

> A striking feature, to me, of the recent contributions to the debate is the juxtaposition of the evidence of rising real wages after 1820 beside the lack of evidence for what workers and their families were getting out of the increased wages before midcentury: no increase in food consumption, no increase in longevity or nutritional status, no improvement in housing. The infant mortality results presented here for the sample parishes in the heartland of the Industrial Revolution provide support for the view that clear evidence of significant improvement in the daily lives of English workers and their families is lacking before the middle of the century (Huck 1995, 547).

The author appears to be arguing that workers suffered no increase in consumption as their real wages rose, thus consuming under their budget constraints.[6]

The contrast between anthropometric and economic measures of the standard of living has been shaped, in part, by the subtle mischaracterization of the economic measure of the standard of living. The economic standard is not per capita real GNP, wages, or income, as a reading of the literature or popular press would lead one to believe. Real income, however measured, is merely an empirical tool

for gauging the change in the true standard of living. The true standard of living is utility, or happiness, gained from consumption. Consumption, in turn, is defined broadly as any good, activity, or state of being that humans can acquire. Economic theory establishes the conditions under which observable changes in real income can be used to infer changes (increases or decreases) in utility. It should be noted that economic theory recognizes the necessity of establishing only one 'standard' of living. The fundamental attraction of utility theory is that it allows for the possibility that people may make utility-enhancing trade-offs across any goods, activities, or states over which they have the ability to choose. Anthropometrics has not shown under what conditions changes in anthropometric measures can be used to infer changes (increases or decreases) in utility.

We address the following question: Can anthropometric and economic measures of the standard of living be made theoretically consistent with each other regardless of whether or not their competing estimates of the standard of living track each other or diverge? We begin by exploring the connection between how the body performs, the NECDEC, and the standard of living as presented in the literature.

III. The 'biological standard of living' gambit

There are two general ways to conceive of the NECDEC's connection to the standard of living. It can be treated as just another good in the consumption basket used to calculate real income indices, that is, treated in the same way as art, alcohol, fruit, tobacco, toilets, and so on. Alternatively, the NECDEC can be treated as fundamentally different from the goods in the consumption basket that comprise real income indices. The anthropometric literature in recent years has been moving toward the latter treatment. The literature uses the term 'biological standard of living' (BSL) to suggest that the NECDEC is fundamentally different from the conventional economic measure of the standard of living.[7]

If the NECDEC is treated as one of many goods in the consumption basket, then living standards could always be driven by the consumption of other goods. But if we adopt the BSL interpretation of the NECDEC, the divergence between economic and anthropometric measures of the standard of living during the nineteenth century is not a source of contradiction because the two measures are fundamentally different. But the BSL cannot simultaneously be *incomparable* and *superior* to the conventional economic measure of the standard of living. Moreover, how the BSL fundamentally differs from the economic measure of the standard of living, and how it is connected to happiness or utility, is unclear.

The assumption underlying the BSL is that there is not one standard of living but many standards of living. This is a dangerous gambit. It suggests that there are as many standards of living as there are measurable human conditions, activities, and goods consumed. This opens the door to a cornucopia of living standards all with a legitimate claim to measuring *the* standard of living. If we retain the BSL, then we must also accept as equally legitimate the concepts of the suicide-rate standard of living, the murder-rate standard of living, the political-prisoner-torture-rate standard of living, the tobacco standard of living, and so on. Like the BSL, these measures can diverge from real income measures of the standard of living, as well as diverge from the BSL. For instance, the first two of the measures mentioned above would place Portugal and India on a higher standard of living than Sweden and the U.S., which is the opposite of what either anthropometric or real income measures would find. We are then left with many standards vying for attention because not all give the same answer all the time to the question of whether living standards are improving or deteriorating. If measures yield contradictory findings, but are regarded as equally legitimate, then they are useless as measures of *the* standard of living. There is no meaningful way to talk about *the* standard of living.

In advocating the BSL, anthropometricians seem to assume that their measures capture the core

value of life in a way that cannot be captured by any other measure. The BSL becomes a superior measure of value. In effect, the economic measure of value is replaced by a physical measure of value, in this case height. As such, it is similar to the crude Marxian theory of value, where all value is measured in physical units of labor effort. Although the appeal of this replacement is powerful because it satisfies a desire for a direct, universal, and objective measure of value that is easily estimated, the underlying assumptions appear empirically dubious. If we agree that height is the supreme measure of value, then we must be willing to assert that people would never knowingly trade off better nutrition for anything else. We think this is wrong, and we present a more detailed critique of this line of rationalization in the next section.

Economic theorist and development economist Partha Dasgupta (1993) offers a system of analysis that treats anthropometric and real income measures as fundamentally different. His empirical technique has been adopted recently by anthropometricians (Costa and Steckel 1997). Dasgupta advocates ranking living standards across countries by combining the rankings of anthropometric measures, educational measures, political and human rights measures, with real income rank using the Borda rule. Dasgupta's empirical work supports his belief that the government has the knowledge, resources, and responsibility to provide basic health and education services to the destitute: 'Health and education would seem to be an embodiment of positive freedoms, whereas income contributes to the enjoyment of these freedoms' (Dasgupta 1993, 76). In order to adopt Dasgupta's formulation of welfare that treats items in the NECDEC as different from income, one must explicitly adopt his theory of the social contract. The choice of such a formulation is political, not theoretical or empirical, as it implies a belief that a central authority could (or should) have provided a different (presumably better) anthropometric outcome in the past. At any rate, an explicit argument for the adoption of Dasgupta's formulation for specific historical circumstances has not been clearly made.[8]

Alternatively, the NECDEC can be treated in the same way as other goods and activities. The task then is to assign it a weight in the amalgamation of the cornucopia of 'standards of living' in order to assess its impact on the overall standard of living. This path makes the BSL interpretation of the NECDEC redundant because it is identical to what utility and rational choice theory in economics does when it constructs a real income measure of the standard of living.[9]

By dropping the BSL interpretation of the NECDEC, scholars would be free to concentrate on describing the "biological quality of life"—a term recently used by some anthropometricians in place of the BSL. Knowing about "nutritional status" or about "health levels" is as useful to scholars, policy makers, and the general public, as is knowing about suicide rates, teenage-pregnancy rates, and fiber-optic-cable-access rates.[10]

In the development of the concept of the BSL, the conventional economic measure of the standard of living has been subtly mis-characterized. No one would dispute the fact that per capita real GNP, wages, or income do not measure all facets of human happiness. This fact is then used to open the door to alternative measures of the standard of living, such as the BSL. The error in the argument is that economic theory never held that real GNP, wages, or income measure human happiness. Only utility measures human happiness. Economic theory establishes the conditions under which observable changes in real GNP, wages, or income can be used to infer changes (increases or decreases) in utility (the standard of living). The problem that remains to be tackled is to establish under what conditions anthropometric measures can be used to infer changes in utility.

IV. Treating the NECDEC as an ordinary good

The alternative to the BSL interpretation of the NECDEC is to place it in the consumption basket with all other goods used to calculate real income indices. Although anthropometric measures

could not be substituted for the conventional economic measure of the standard of living, under certain conditions anthropometric measures might still be considered a highly reliable proxy of living standards. When real income measures cannot be constructed, anthropometric measures might be second best. There are several variants of this approach. In this section we treat the variants with the most extreme underlying assumptions first, and then move on to variants with less radical underlying assumptions.

A) The NECDEC as a heavily weighted good in the consumption basket

i) The no-choice position

The underlying assumption of the no-choice position is that the NECDEC dominates the consumption basket. The assumption rests on the proposition that the NECDEC is so important to human welfare that no rational person would ever trade it for another good. If there is no possibility of trade-offs between the NECDEC and other goods, then there is no possibility that the standard of living could be driven by the consumption of goods other than the NECDEC.[11] The assumption requires that people behave in an absolutely risk-adverse, safety-first way. They have no choice regarding food and nutrition, always securing enough of those goods before proceeding to other consumption. The assumption is tantamount to arguing that nutrition is not an endogenous choice variable in utility maximization, but more like an exogenous resource constraint in society's production possibilities.

If the no-choice position is accepted, then changes in anthropometric measures capture changes in the standard of living, but if and only if people are on the edge of subsistence. Anthropometric measures can be used to measure the standard of living if one assumes societies are always in Malthusian crisis. This position equates the concept of 'enough to eat' with 'high-quality nutritional intake.' Surely it is true that faced with imminent starvation people will choose food over all else, but once enough food is ingested to prevent imminent starvation, the question of whether people will trade-off long-term nutrition for other goods is not addressed by the literature.[12]

Some anthropometricians argue that the weight of the NECDEC in the consumption bundle must be high because food is a large share of budgets. Food, however, is not nutrition. How much people actually spend on food, whether it is 60 or 70 or 80 percent of real income, is irrelevant. What matters is not the cost of the food actually consumed, but the feasibility of the least-cost high-nutrition diet. A defense of the assumption that the NECDEC should receive a weight of one in the basket might be to calculate the least-cost high-nutrition diet. Comparing calculations of the least-cost high-nutrition diets (Stigler 1945 and Kahn 1992) with what people in Britain and North America ate (Shammas 1990 and Fogel 1989) indicates that the least-cost high-nutrition diet was within the budget constraint of those populations. People exercised considerable latitude in making utility-enhancing trade-offs between nutrition and other dimensions of food consumption. Moreover, what matters is not the share (or change in the share) in real income of the least-cost high-nutrition diet, but whether that share exceeds 100 percent of real income, thus truly forcing people to substitute out of a high-nutrition diet.

Finally, we must recall that the NECDEC is not the net nutrition of the general population, but only the net nutrition of children. Thus, the proper test of the no-choice position is to determine the least-cost high-nutrition diet of the children in the population, then add the least-cost, just-barely-preventing-starvation diet for adults in the population, and see if *this* cost exceeds 100 percent of the real income of parents and of society. If it does, then parents and society were truly forced to reduce the nutritional status of children thus producing a downturn in anthropometric measures of the standard of living.

We suspect the test would fail to support the anthropometricians who make arguments along these lines. Kahn (1992) estimates that the least-cost high-nutrition diet of adult American slaves, based on 4,000 calories per day, cost approximately 50 percent less than what slaves actually consumed. Slaves, out of any group in North-Western Europe and North America, should have been closest to the

least-cost high-nutrition diet because the direct utility of food consumption did not enter into the profit calculation of the plantation owner. Yet it seems that the pull of the utility value of food consumption beyond its nutritional component was powerful even among slaves.

Free populations, presumably, could exercise full control over the trade-off between a least-cost high-nutrition diet and great-tasting, utility-enhancing, but perhaps nutritionally-deficient diet. Therefore, the gap between what free populations actually consumed and the feasible least-cost high-nutrition diet may have been even greater than the 50 percent gap estimated for adult slaves. Our prediction, therefore, is that even for relatively poor populations, the least-cost high-nutrition diet for children, with the exception of rare periods of acute crisis, was generally affordable in North-western and Central Europe and in North America in the early modern era.[13] It appears reasonable that people could and did easily engage in utility-improving trade-offs between the long-run nutrition of their children and other goods. In fact, we suspect that changes in the gap between the least-cost high-nutrition diet for children and actual shares of food for children in early modern budgets may go a long way to explaining how anthropometric measures can diverge from real income measures of the standard of living.

ii) The limited trade-off position

A more mainstream position assumes that the NECDEC has a weight of almost, but not quite, one in the consumption basket. It accepts that people can engage in a utility-enhancing trade-off of nutrition for another good but argues that the scope for such trade-offs is limited. In this case, it is theoretically possible for the anthropometric and the conventional economic measures of the standard of living to diverge. Divergence, however, is statistically unlikely because of the NECDEC's dominance in the consumption bundle.

How high is the probability that anthropometric measures are a good proxy? That is an

empirical question that requires attention. Three aspects are apparent: how heavy a weight the NECDEC should be given in the consumption bundle, how much room is available for utility-enhancing trade-offs of long-term nutrition for other goods, and how likely it is that people make such trade-offs.

A first estimate of the weight of the NECDEC in consumption would be to calculate the doctor services, hospital services, drug potions, and so on spent on children as a share of family spending or of national income. We believe this share would be small in historical economies. However, if all food consumed in the population is included in the calculation, health spending would likely be a large share of income. But, again, food is not nutrition, and spending on food for the entire population overstates the cost of providing nutrition to children. So we return to the estimation of the share of the least-cost high-nutrition diet for children as an estimate of the numerator of the share of health spending in income. Given the discussion in the previous section, we think its weight will be much smaller than is commonly presumed, but the determination of the proper share of the NECDEC in the consumption basket is an avenue of research that needs to be pursued in more depth.

B) The NECDEC as a lightly weighted good in the consumption basket

Assuming that the NECDEC has a large share in the consumption basket is not strictly necessary. The anthropometric measure could be used as a reliable proxy for real income if we assume that the NECDEC, particularly its nutrition component, has a consistently positive real income elasticity of demand. If this condition is true, then whether the NECDEC is a lightly or heavily weighted good in the consumption bundle is irrelevant because it always tracks real income, and thus utility.

The exclusively positive sign of the real income elasticity of the NECDEC has sometimes been asserted but has not been shown.[14] The assertion is not obvious. For example, at extremely low incomes people may choose to increase food consumption that also increases nutrition as income rises in order to stave off the imminent risk of starvation. However, because food is not nutrition, once the

subsistence threshold is reached, further increases in income may be channeled into other utility-enhancing goods. Income increases may even permit an expansion into utility-enhancing but health-deteriorating goods, such as tobacco and alcohol. Income elasticities for nutrition, therefore, might well change from positive to negative or vice versa depending on income levels. The degree to which anthropometric measures might reliably proxy for real income measures of the standard of living may depend on the absolute and relative incomes of the population.

Next, suppose we give the NECDEC a small weight in the consumption basket and assume a positive real income elasticity. We must then allow that a lot of latitude exists for the substitution effects of relative price changes to dominate the NECDEC's positive income effect. Let us consider the case where real income is rising, which would lead to an increase in anthropometric measures of the standard of living, other things equal. But suppose at the same time the prices of tobacco, alcohol, opium, or sugar fall relative to the price of the NECDEC. Or suppose the opportunity cost of parental time increases so that the real cost of attending to the nutrition of children increases. We might observe a substitution out of nutrition-enhancement for children, despite the positive real income elasticity of the NECDEC.

The extent to which substitution effects dominate income effects and lead to a decline in the nutritional status of children during periods of rising real income will vary by particular historical circumstances. In addition, like income elasticities, the NECDEC's substitution effect may vary by income level within a society. For example, a uniform income increase may have led to a greater increase in alcohol consumption by the lower half of the income distribution than by the upper half of the income distribution, thus weakening any correspondence of the anthropometric measure with the real income measure of the standard of living.[15] More research into these possible explanations of the divergence between the measures would be fruitful.

C) Children in the NECDEC

A significant problem with treating the NECDEC as a good in the consumption basket is that the NECDEC measures the effect of nutrition on children, but decisions regarding consumption are made by adults. Height data are typically available for adults, but the decisions affecting the heights measured were made while the subjects were children, predominantly by their parents. By construction, measurement of adult heights reflects nothing about the current adult standard of living. There is a large gap between the individuals making the choices in the population and the anthropometric measure of the standard of living for that population. Yet sometimes the anthropometric literature offers statements about the current nutrition-exertion-climate-disease environment of subjects, rather than more properly offering statements about the conditions prevailing when they were children. For example, consider the debate over whether exertion caused by extra work days depleted the net nutrition of workers as measured by their heights. The debate lacks relevance because, with the possible exception of older teenage boys, children were not affected by the required extra work days.[16]

More important than these oversights to the future of anthropometric research is the intergenerational nature of the NECDEC. Might adults trade-off the long-run nutritional health of children for their own current utility enhancement? History and the popular press is full of stories of such trade-offs. Consider the ritual dominance of adult males in African (and some Native American) agricultural societies; women and children eat last. Today some pregnant women risk the health of their fetuses by consuming alcohol or smoking; some school lunches are less than highly nutritious. Despite the high level of information on the risks of such activities and choices, it seems as though twenty-first century parents and policymakers sometimes do not maximize the heights of their children.

One factor that might cause this trade-off to vary over time, thus causing anthropometric and conventional economic measures of the standard of living to diverge, would be the degree to which

children are treated by parents as consumption goods rather than investment goods. In modern, developed societies where children are treated as consumption goods, parents might be less likely to trade off the long-run health of children for current parental consumption of other goods because the health of children enters directly into their utility function. Parents in the past may have been more inclined to make trade-offs in long-run health of children for parental consumption. If in earlier societies children fulfilled an investment role as captive labor in their youth and caretakers for parents in old age, the child's long-term health might have entered indirectly into the utility function of the parent. Only insofar as it was understood that nutrition reduces the susceptibility of the child to certain diseases might nutrition for the child have mattered directly to the parent. Additionally, the expected payoff to the parent of investing in high-quality nutrition for the child, and in so doing add an inch or so to the adult height of the child, would have to be discounted by 20 to 30 years, and adjusted for the risk of early death of the child and the parent from causes outside their control. At even moderate interest rates, the calculation might yield small or even negative net returns. This investment decision could also vary over time, across segments of the population, by income level, and as discount rates and forecasted risks changed. Issues of how to characterize intergenerational utility functions, how parental choices affect the nutrition of children, and how parental choices might change over time, especially as they might change in a fashion that is not monotonically related to parental income, need to be addressed in more detail.[17]

It has been argued that anthropometric measures are needed to adjust up or down the conventional economic measures of the standard of living because the economic measure is too narrow and does not adequately capture facets of the standard of living captured by anthropometric measures. For example, Costa and Steckel (1997) use anthropometrics as a calibrating device in assessing the standard of living in the U.S. in the long run. To consider the validity of this use of anthropometric

measures, the theoretical basis of the conventional economic measure of the standard of living must be reviewed.

V. The theoretical basis of the income measure of the standard of living

A) Utility and real income

The goods consumed, activities undertaken, and sources of satisfaction are numerous, varied, and unique to each individual. Economists long ago gave up trying to measure human happiness, value, or standards of living in cardinal or fixed physical units that might be objectively comparable across individuals. The labor theory of value, the last serious attempt in economics to measure human happiness or value in cardinal and fixed physical units, was abandoned by non-Marxian economics in the nineteenth century as unworkable, and replaced by the ordinal utility theory for measuring human happiness. Of course, ordinal utility theory is still the core of economic thinking today.

In economics, utility theory produces an ordinal but observable measure of the standard of living without recourse to imposing a fixed physical and universal caliper. Utility theory assumes that likes, dislikes, and the magnitude of happiness gained from choices are unique to each person fundamentally unknowable to another. Therefore, interpersonal comparison of utility or happiness is not meaningful. Utility theory in economics also assumes that everyone is a rational maximizer of utility, in other words, that individuals don't knowingly, consciously, and repeatedly choose things they dislike in place of things they like. The act of choosing x when y could have been chosen, by definition, implies that x gives the chooser more utility or happiness than y, other things equal. Finally, utility theory assumes that more of whatever it is that humans like is preferred to less, so the ability to have more of any good, other things equal, makes a person happier.

It then follows that increased happiness is an improved standard of living, and that people's

standard of living unambiguously improves when they can have more of all things they like, as long as having more of one thing they like does not entail sacrificing something else they like. These assumptions imply that, given a fixed amount of resources, a person will choose that combination of goods and activities that causes the greatest personal happiness and that all other combinations of goods and activities that could have been acquired with the initial resources must yield less utility or happiness. Because preferences are unique, the combination of goods and activities that yields the happiest outcome may be substantially different across individuals even when these individuals possess the same resources and face the same costs of acquiring the goods and activities.

To use utility theory to produce an observable measure of changes in the standard of living requires one final assumption, namely that each person's likes, dislikes, and the magnitude of joy attained from consumption must remain reasonably stable, at least over the period measured. Thus, if available resources do not change and the cost of acquiring the goods and activities does not change, then the utility measure of the standard of living does not change. Only when resources increase (or decrease) does utility or the standard of living increase (or decrease), other things constant. Changes in available resources, namely income, can therefore be used to determine whether the standard of living is changing.

Of course, relative prices often change concurrently with changes in resources or income. A change only in relative prices could lead people to change the mix of consumption, but they not be any better or worse off (have the same utility). It could also lead to being better off (having higher utility), or to being worse off (having lower utility). This is where the concept of real income comes into use. One's real income is one's purchasing power or command over real resources. Because changes in relative prices augment or subtract from an income's purchasing power, changes in relative prices must be taken into account before conclusions can be made about the utility of those changes. In other words, real

income is income adjusted for relative and absolute movements in prices. Consider the case where income is constant but prices change such that people can still purchase the same quantity and mix of goods that they purchased before the price changes. The standard of living remains unchanged. If people can purchase more of at least one good than before the price change, then they must be better off than before the price change (or they would have purchased the same bundle as before). The change in relative prices has afforded a higher utility or a higher standard of living. Alternatively, if after the price change people cannot purchase the quantity and mix of goods that they purchased before the price change, then they are worse off. There has been a decline in the standard of living.

The logic of utility theory is important to measuring living standards because utility theory allows for the possibility that people can achieve a higher standard of living even if they do not consume more of all goods. In fact, a change in relative prices can lead people to increase the consumption of the relatively cheaper good, decrease the consumption of the relatively more expensive good, and still achieve a higher standard of living.[18] Any proxy for the standard of living that relies on increases or decreases in the consumption of one good or a few goods, such as the NECDEC, is inconsistent with utility theory.[19] Proponents of such a proxy must deny that people can make utility (happiness) enhancing trade-offs between the goods in question and other goods when the relative prices of other goods fall. In other words, people who hold that the NECDEC measures the standard of living must deny that people can substitute away from nutrition if the relative price of other goods falls, and as a consequence be happier. It is because real income measures of the standard of living account for changes in relative prices that real income measures are theoretically superior to anthropometric measures of the standard of living.[20]

B) Anthropometric adjustments to real income measures of the standard of living

Can anthropometric measures serve as an adjustor to real income measures? The argument

asserts that the growth or decay in real income might need to be adjusted upwards or downwards to account for changes in the 'biological quality of life.' Thus, the anthropometric measure of the standard of living might be used as a valuable bias-adjustment tool. The reasoning behind this claim is the assertion that real income does not take into account the value of the biological quality of life (Floud 1994, Komlos 1994c, Steckel 1992, 1995).

If the NECDEC is driven by food intake or nutritional choices, then anthropometric measures should not be used to adjust real income. (Some cases where the NECDEC is not driven by nutritional choices are treated in the next section.) While nutrition is a choice variable, it is not one specific good in the consumption bundle. There is no single and separate good called 'nutrition.' Instead, nutrition is an attribute of the goods that are chosen. Some goods, such as oatmeal, have nutrition-enhancing attributes. Some goods, such as tobacco, have nutrition-detracting attributes. Some goods may be nutritionally neutral. As an indirect outcome of consumption of other goods, nutrition is built in to the utility of these other goods already, and therefore need not be measured separately. Suppose income increases or relative prices fall and individuals increase their consumption of known health-degrading goods, such as substituting alcohol, tobacco, and recreational drugs for the nutritional care of children. The act of choosing reveals that the choosers are happier, that they have more utility. They reveal by their choices that they experience a higher standard of living by trading off the health of their children for other goods. The anthropometric measure that shows that nutrition or health has fallen by this choice tells us nothing additional. The decline in health of children cannot be enough to make people worse off over all; it cannot indicate a lower standard of living, or by definition people would not have chosen the combination of goods that resulted in the lower anthropometric measure.[21]

Mis-specification of the economic standard of living fosters the impression that real income measures need to be adjusted for all sorts of conditions, such as the biological quality of life. Casual talk

of real income or GNP as though it is the standard of living, rather than an interpretation of real income in terms of the utility concept that lies behind it, tends to lead to misuse of standard-of-living assessments by introducing a cardinal dimension to its interpretation. There is no theoretical basis for cardinal comparisons using the economic—utility—measure of the standard of living. When real income is carelessly used to compare standards of living across time and space, it is open to all sorts of claims that it is biased and needs to be adjusted. But there is nothing in economic theory or in anthropometric measures that indicates exactly what bias exists. Thus, even when real income is used incorrectly as a cardinal measure of the standard of living, adjustment devices are not useful.

The standard of living as measured in economic theory is an ordinal issue only. Utility theory ranks choices and combinations of goods ordinally only. A doubling of all goods consumed does not double utility. The assumptions that would have to be added to utility theory to introduce elements of cardinal comparisons, such as proportionality between utility and the quantity of goods chosen and strictly homothetic utility functions, have been consistently rejected in economics as theoretically and empirically untenable. The principle of declining marginal utility is well accepted. Therefore, all that can be said is that when real income is higher or lower, then utility is correspondingly higher or lower and so the standard of living is higher or lower. How much higher or lower can never be said.

VI. Disease and climate versus nutrition: Policy implications of historical anthropometrics

Interpretations of the anthropometric evidence focus on nutritional changes and downplay the exertion-climate-disease portion of the NECDEC. The interpretations have led scholars to debate the idea that the Industrial Revolution improved standards of living. In this section we show that focusing on disease and downplaying nutrition leads to the conclusion that the Industrial Revolution was an even more powerful economic engine than real income estimates indicate. The difference in conclusions

indicates that more work needs to be done on the possible causes of falling heights during some periods.

The exact role of the exertion of children beyond metabolism may be impossible to determine, so setting that factor aside may be understandable. Disease and climate, however, are clear and important parts of the NECDEC. While disease and climate as causal factors behind anthropometric measures are usually mentioned, the tendency in the literature to ignore their role may be because they are predominately exogenous forces.[22] While there are nutrition-sensitive diseases and individuals can make disease-sensitive choices such as moving from the countryside to a large city, in general disease - especially infectious disease - is an unexpected shock that sweeps through the population and is largely outside the control of the individual and society. This is especially true for pre-twentieth century societies where knowledge about how most diseases were transmitted and about how to detect disease vectors was limited.

Exogenous variables such as disease and climate are not part of the utility function. Rather they are part of the resource constraint or production possibility frontier (PPF) of society, as is technology. As an exogenous variable in the PPF, improvement in technology leads to more effective resource use, greater potential output, and higher income and utility. Likewise, improvement in the disease environment automatically leads to an increase in effective resources. The number and amount of goods that can be produced per capita increases. In other words, real income increases, and society is unambiguously better off. When the disease environment deteriorates, effective resources decrease. The number and amount of goods that can be produced per capita decreases. In other words, real income decreases, and society is unambiguously worse off. The direction of utility change induced by disease shocks would be consistent with the direction of change in real income, other things equal. Thus, if the anthropometric measure of the standard of living were driven by disease or climatic shocks, it would never diverge from the real income measure of the standard of living, other things equal.[23]

Other things, however, are seldom equal. Return for a moment to the case of the nineteenth century in which heights fell while real income rose. Suppose that the unsanitary conditions of urban life led to a deterioration of the disease environment causing the decrease in height. Nonetheless real income rose. Positive technological shocks to the PPF must have more than offset the negative disease shocks to the PPF of the economy. The new interpretation is that the technological innovations of the nineteenth century in Western Europe and North America - loosely called the Industrial Revolution - had an even bigger impact on real income and living standards than the real income evidence indicates. Rather than the decline in heights being a reason to adjust the standard of living downward, as some anthropometricians might hope, in this case it is a reason for adjusting up the impact that technological improvements had to productivity.[24]

In contrast, when alternative exogenous shocks such as technology can be discounted, the climatic-disease portion of the NECDEC gives anthropometric measures an important role as a proxy for real income measures of the standard of living. Anthropometric measures of the standard of living might be particularly useful and reliable prior to the Industrial Revolution when exogenous shocks, such as technological change, were relatively small.[25] The new work in anthropometrics based on skeletal evidence from pre-nineteenth century populations, therefore, may well deliver on the initial promise of anthropometrics in providing a reliable guide to living standards (Steckel, Sciulli, and Rose 2002 and Steckel 2002).

VII. Conclusion

Anthropometrics is an important measure of health, the determinants of health, and the impact of health on society. It does not, however, measure the standard of living. When anthropometric and conventional economic measures of the standard of living diverge, such as in the evidence for the

nineteenth century, the conventional economic measure should be preferred until new research more clearly defines the relationship between anthropometric measures and real income measures of the standard of living. When conventional economic measures cannot be reliably constructed, anthropometric measures might under certain conditions proxy the standard of living. These conditions, both theoretical and empirical, need to be more adequately established.

Additionally, scholars may pursue new research avenues using cross-sectional evidence of height differences among adults. These differences, no matter what the source, indicate differences in strength, work ability, and appearance which are a critical difference in a world dominated by manual labor and service employment. For instance, height may be an important criterion used by contemporaries to assess human capital (Fogel 1989, Grubb 2000, Margo and Steckel 1982, Schultz 2002, Steckel 1995, Whaples 1995). We predict that anthropometricians will make an important contribution to in the empirical investigation of market selectivity. Anthropometrics will settle into a role other than arbiter of living standards without loss of legitimacy or prominence.

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Footnotes

1. We thank Rick Steckel for pointing out this source. The emphasis on measuring the standard of living can also be seen from the article and book titles in the anthropometric literature. See the titles in the references listed here or the more comprehensive list in Steckel 1995. Many of the articles and books that do not explicitly mention the 'standard of living' in their titles, nevertheless proclaim the measurement of the standard of living as the primary focus in their text.

2. Several the debates have occurred regarding bias and measurement. For example, Komlos (1993a) versus Floud, Wachter, and Gregory (1990, 1993) and Johnson and Nicholas (1995, 476); Komlos and Alecke (1996) versus Pritchett and Freudenberger (1992) and Pritchett (1996); Komlos (1993b) versus Grubb (1999); Komlos (1989) and Komlos and Ritschl (1995) versus Voth (1995, 1996); Komlos (1990) versus Komlos (1993a, 1993b) and the debates over how to measure military heights in Floud, Wachter, and Gregory (1990); Komlos and Kim (1990); Wachter (1981); Wachter and Trussell (1982).

3. Additionally, conclusions sometimes ignore that the findings relate to children. Some studies correlate adult height not with conditions present when the subjects were children but with contemporaneous conditions present in the adult population, such as current income, occupation, location, population density, food supply, and so on. For some specific examples see Komlos (1994b, 103); Komlos and Ritschl (1995); Riggs (1994); Steckel and Haurin (1994, 125); Voth (1995, 1996). The exceptions to this mis-specification include: Floud and Wachter (1982); Fogel (1989); Pritchett and Freudenberger (1992); Steckel (1986).

4. Steckel (1999) includes a thorough review of the literature on the correlation between income measures and average height measures. Baten and Murry (2000) offer an interpretation using individual

height data.

5. For example, see. The same problem of divergence between anthropometric and economic measures of the standard of living during the nineteenth century is produced by the peerage paradox, namely the children of the upper classes in the nineteenth century were relatively short despite their comparative wealth (Floud, Wachter, and Gregory 1990, 322-323, Fogel 1986, 480-484), by the relative tall stature of the poor Irish compared with the rich English (Grubb 1999, Mokyr and O'Grada 1994, 1996), and by the great height of Native Americans (Steckel and Prince 2001).

6. Also compare the anthropometric evidence and conclusions in Fogel (1986; 1989, pp. 354-369) and Fogel et al. (1983) with the real wage evidence and conclusions in Margo and Villaflor (1987), Margo (1992), and David and Solar (1977) for the USA during the middle of the nineteenth century. See also, Komlos (1987, 1989, 1993a, 1993b, 1994b).

7. While the advocacy of the BSL is most closely associated with the work of Komlos (1998, 1987, 1989, 1993a, 1993b, 1994c), a few other anthropometricians have also used the term (Coclanis and Komlos 1995, Steckel 1992, 1994, 1995, Steckel, Sciulli, and Rose 2002).

8. Costa and Steckel (1997, 65) note that: 'In the twentieth century, exposure to infectious disease may have been lessened by the investments in public health made between 1870 and 1930, such as the cleaning of the water supply, the establishment of sewage facilities…' They do not explore whether such public health measures were either technologically or politically feasible before the 1870. In the same volume, Engerman (1997, 31-38) provides a helpful and concise summary of measures of growth and welfare. Note also that while Dasgupta shows that changes in real national income equal changes in aggregate well- being, the general form of the proof requires that prices be household-specific shadow prices (1993, 184-188).

9. The problem of competing measures of the standard of living, and the resulting disagreement over which standard counts more, can also be seen when the popular press tries to rank the most livable cities or the best values in higher education.

10. Health and development economists have used anthropometry as a measure of the successfulness of policy specifically aimed at improving the health of children (e.g. Micklewright and Ismail 2001). This use is not at odds with utility theory, although rhetoric about the standard of living is fuzzy there as well.

11. If people always secure enough nutrition before all other goods, then anthropometric measures can tell us nothing about the standard of living in societies where incomes are high enough to secure adequate nutrition, because heights will not vary over time or across populations. Only in societies where incomes are not high enough to secure adequate nutrition before consuming anything else, can anthropometric measures tell us something about the standard of living because heights will vary positively with the ability to reach the adequate nutrition threshold.

12. This position is most closely associated with the work of Komlos (1987, 1989, 1993a, 1993b, 1994b), particularly in its Malthusian crisis variant. Komlos (1989, 107) points out the theoretical possibility that persons moving from a state of strict autarky (living like Robinson Crusoe), where they were only able to produce food and nothing else, to a developed market society where they could trade for many non-food goods, might end up consuming less food and more of other goods. As a result they could be better off in terms of utility. Komlos' application of the model is strained, however, because even Robinson Crusoe produced goods other than food. In addition, his model fails to note that food is not nutrition, and that adult production is not children's consumption. His application does not recognize that making a utility-enhancing trade-off of nutrition for other goods in response to shifts in relative prices can occur at any time and in any place, not only at points of initial market integration or

industrialization.

13. Calculating the feasible least-cost high-nutrition diet is not the same as calculating energy cost accounts, e.g. Fogel (1991, 1993), or constructing health indices, e.g. Steckel, Sciulli, and Rose (2002). Unlike the calculation of the least-cost high-nutrition diet, energy cost accounts and health indices do not incorporate the principle of opportunity cost and so are not useful for assessing the standard of living.

14. To our knowledge there has been only one attempt to estimate the historical income elasticity of demand for food; it was about 0.4 in Britain at the turn of the nineteenth century. This means that a one percent increase in income resulted in a 0.4 percent increase in food consumption (Clark, Huberman and Lindert 1995). Modern estimates based on cross-sectional data are similar (Subramanian and Deaton (1996).

15. Increasing income inequality has been used to explain movements in average height (Fogel 1986, 1989, 1991, Fogel, et al. 1983, Steckel 1983, 1992, 1994, 1995, Steckel and Haurin 1994).

16. Exceptions to this mis-specification include Floud and Wachter (1982); Fogel (1989); Pritchett and Freudenberger (1992); Steckel (1986).

17. See Schneider (1996) for an attempt to measure intergenerational consumption decisions.

18. The substitution effect appears to be large, as seen in the falling meat content of the European and US diets of the eighteenth century as reported in Komlos (1998). Komlos reports similar sensitivity to prices of foodstuffs in modern developing countries. Again, a large substitution effect, thus shorter people, does not imply lower utility.

19. Komlos (1998, 785) makes this error even though he seems to recognizing that utility could go up even if height goes down.

20. Of course, using income measures of the standard of living underestimates both production and utility. Nonmarket (household) production is not measured, and people derive utility from activities that do not include purchases, for example, a walk in the woods. This is especially clear for the case of free blacks in the antebellum U.S.: Bodenhorn (1999) can claim only that the net nutritional status of blacks was comparable to whites, not that their standard of living was good or that their utility was as high.

21. If adults underestimate the loss of future utility (or income-earning potential, or productivity) the long term results may be inefficient. Parental selfishness does not negate the logic of revealed preference, but may indicate an information problem.

22. Exceptions exist (Coclanis and Komlos 1995, Fogel 1986, 502-503, Steckel 1992, 1995, Voth and Leunig 1996, Costa and Steckel 1997, 64-65). The favorable disease environment in pre-Famine Ireland may have been an important contributor to high Irish heights (Nicholas and Steckel 1992), while unfavorable climate and a deteriorating disease environment constricted production possibilities in pre-Industrial Europe, resulting in falling stature over several centuries after the Middle Ages (Steckel 2002).

23. For a discussion of the impact of climate and disease on the economy of Europe, see Anderson (1981); Woods and Woodward (1984). For a discussion of parasitic diseases in slave populations, see Coelho and McGuire (2000) and reply by Steckel (2000).

24. See also the discussion in Fogel (1986, 503). Fogel mis-specifies the adjustment to the standard of living (whether utility increases or decreases) needed to account for disease shocks because he equates the ordinal utility measure of the standard of living with a cardinal real income measure. Adjustment to this cardinal measure is a meaningless exercise with regards to determining the ordinal ranking of utility, that is, to whether the standard of living increased or decreased.

25. The nineteenth century may not be the only period when countervailing positive exogenous shocks,

such as technological change, swamped negative disease and climatic shocks to the PPF. For example, the transition from hunter-gatherer technology to settled agriculture with domesticated animals, a change sometimes called 'The First Economic Revolution' (North 1981, 72-112), was associated with improvements in organization and in the enforcement of property rights as well as with increases in population and wealth. This transition may have also been associated with a deterioration in the disease environment as contact with domesticated animals in densely populated environments increased. Thus, it is possible that settled agriculturalists in early civilizations were both richer and shorter than the migratory barbarians who periodically sacked and conquered them. The movement to settled agriculture, like the migration from the countryside to cities in the eighteenth and nineteenth centuries, increased the overall standard of living (increased utility) despite reductions in anthropometrically measured health.