The Effects of Age and Birth Cohort on Dietary Quality in the United States

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Abstract

Secular trends in health outcomes related to dietary quality have changed substantially over the past three decades. The objective of this study is to decompose changes in dietary quality over 1977-2008 into the biological effects of age, contemporaneous effects of time period and group membership effects related to birth cohort. Dietary quality is measured by the Healthy Eating Index-2005 (HEI-2005). Using an Age-Period-Cohort (APC) model, findings suggest HEI-2005 scores follow a U-shaped trajectory over the typical American's lifetime (aged 2-79 y), with the lowest scores observed during early-to-mid adulthood (20-50 y, HEI $\simeq$ 54). Period effects largely increase throughout the sample period over 1977-2008. By examining over 100 birth cohorts (1898-2005), results show that those born in the first half of the 20th century have similar levels of dietary quality. However, following the end of the second World War, a substantial decrease in HEI-2005 scores is observed for those born between 1950 and 1990. Although recent cohorts in the 1990's and early 2000's have yet to fully age, preliminary estimates suggest dietary quality may be on the rebound. While nutritional and epidemiological studies tend to focus on secular trends (or period effects) this study suggests cohorts play an important role in characterizing changes in dietary quality.

Key Words: Diet quality, nutrition, Age Period Cohort.
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1. Introduction

Recent research linking diet quality and health outcomes is nigh on overwhelming. In particular, dietary quality is associated with lower risks of coronary heart disease, stroke and diabetes (Chuive et al., 2012), cardiovascular disease (Nicklas, O'Neil and Fulgoni, 2012), breast cancer (Shahril et al., 2013), colorectal cancer (Reedy et al., 2008) and prostate cancer (Bosire et al., 2013), as well as increased cognitive ability in middle-aged adults (Ye et al., 2013) and healthier lipid profiles in low-income women (Shah et al., 2010).[1] All the while, secular trends for health outcomes associated with diet are bidirectional: the prevalences of obesity, hypertension, type II diabetes, and gestational diabetes have all increased over the past twenty-to-thirty years (Ogden and Carroll, 2010; Egan, Zhao and Axon, 2010; CDC, 2011; Getahun et al., 2008) while the incidence of colorectal cancer and the 10-year predicted risks of cardiovascular and coronary heart disease have decreased (Cheng et al., 2011; Ford, 2013; Lopez-Jimenez et al., 2013).

A myriad of factors, such as advances in medicine and changes in lifestyles (Lakdawalla and Philipson, 2009), have been studied as contributing factors to changes in prevalences and risks of diet-related outcomes. Lifestyle factors, such as food choices, are generally thought to follow secular movements (Briefel and Johnson, 2004), as well as the biological effects of aging (Akbaraly et al., 2013). Contrarily, the effect of birth cohort, or the accumulation of different personal histories, in relation to overall dietary quality has been less studied.

Understanding and improving dietary quality has been a longstanding policy initiative of the U.S. Federal government. In 1977, the Federal Government issued its first official recommendations: the Dietary Goals for Americans (USDA, 2008). These recommendations later became the Dietary Guidelines for Americans (DGA) in 1980 and are now in their seventh incarnation, the 2010 DGA. Most recently, major informational campaigns have included the *Food Guide Pyramid* released in 1992 (subsequently updated in 2005 as the *MyPyramid* and in 2011 as the *MyPlate*) and the 1994 nutrition label mandate.

The purpose of the current study is to disentangle observed secular trends in dietary quality over the past thirty years into two other time-varying but distinct factors: age effects, or changes

[1] All of the aforementioned studies used adherence to the 2005 Dietary Guidelines for Americans via the Healthy Eating Index-2005 (HEI-2005) as one metric; three of these studies (Chuive et al., 2012; Reedy et al., 2008; Ye et al., 2013) additionally used one or more of the following measures of dietary quality: Alternate Healthy Eating Index, Mediterranean Diet Score, and Recommended Food Score. Finally, Chuive et al., (2012) demonstrate that individual components of dietary indices are also associated with lower risks of coronary heart disease and diabetes.

in diet over one's lifetime, and birth cohort effects, or changes in diets of individuals who have experienced similar personal histories due to a common birth year. Documenting the relationship between birth cohort and overall diet quality is important. For example, it has been shown that today's younger generation is less likely to drink milk (or smaller amounts of milk) as compared to the older generation (Gustavsen, 2013; Stewart, Dong and Carlson, 2012), possibly leading to a further decline in calcium intake. Similarly, fruit and vegetable intake has also been found to be decreasing among younger cohorts in the United States (Stewart and Blisard, 2008). As a result, overall dietary quality in the U.S. may suffer, especially as younger cohorts age. With the increased availability of highly processed foods, the rising popularity of fast foods, and a decreased emphasis on home-prepared meals, culinary skills are being lost from one generation to the next. In other words, it is plausible that a deterioration of dietary quality amongst younger cohorts could begin to eclipse any gains in overall dietary quality from the aging population that has been previously observed (Beatty, Lin and Smith, 2012). Therefore, improving our understanding of age and cohort effects on diet quality has far reaching implications for both policymakers and practitioners moving forward.

2. Data

This study uses nationally representative data from four U.S. individual food intake surveys: the 1977-78 Nationwide Food Consumption Survey (NFCS, n=40,679), the 1989-91 Continuing Survey of Food Intakes by Individuals (CSFII, n=14,140), the 1994-96 CSFII (n =14,516), and the continuous waves of the National Health and Nutrition Examination Survey (NHANES, 2001-08, n=32,934). Details of each survey can be found in previously published material (Rizek, 1978; USDA-ARS, 1991, 1997, 2008).

The dietary intake component in each of the four surveys was overseen by the U.S. Department of Agriculture (USDA) and used similar sampling methods, survey methodologies, and dietary collection protocols. This study excludes the 1998 CSFII supplement for children aged 2-9 because the methodological approach described below necessitates that individuals of all ages be observed in each survey period.

Respondents reported 24-hour dietary intakes in all four surveys, as well as detailed demographic information. Proxy and adult-assisted recalls were administered for children under the age of 12. Day-one dietary recalls were conducted in-person by trained interviewers in each survey. Although a second day of intake was obtained in all surveys except the 2001-02 NHANES, we use only day one intakes in order to maintain cross-survey consistency. The 1999-2000 NHANES survey was excluded because USDA dietary-intake methodology had yet to be adopted (Dwyer et al., 2003).

The sample consists of 102,296 individuals aged 2-79 reporting complete dietary intakes for day-one recalls. Young children and infants under the age of two are not included because the dietary index used in this study was not designed for this subpopulation (Guenther, Reedy, and Krebs-Smith, 2008). The upper bound on the range of ages was chosen because the 2007-08 NHANES top-codes individuals at age 80.

2.1. Dietary Quality

Dietary quality is measured using the Healthy Eating Index-2005 (HEI-2005).[2] The HEI-2005 was designed to measure compliance to the 2005 Dietary Guidelines for Americans, the U.S. Government's official recommendations for healthful eating (Guenther et al., 2008a), and has been validated as a measure of overall dietary quality (Guenther et al., 2008b). In short, the HEI-2005 is the sum of 12 components based on the consumption of key foods or nutrients. Each component assigns a score ranging from 0 to 5 (total fruit, whole fruit, total vegetables, dark green/orange vegetables and legumes, total grains, whole grains), 0 to 10 (milk, meats and beans, oils, saturated fat, sodium) or 0 to 20 for the percentage of calories from solid fats, alcoholic beverages, and added sugars (SoFAAS) creating a maximum score of 100. Table 1 contains details of scoring.

As shown in table 1, the HEI-2005 is a density measure (the ratio of an individual's component intake to their total calorie intake) rather than quantity based. Therefore, by design the HEI-2005 measures the *relative* quality of foods consumed, independent of total calories (and of energy expenditure). Although at first glance this may seem to be a limiting factor, it is important and necessary to analyze the relative *quality* of foods consumed across individuals of all ages and calorie needs. This makes the HEI-2005 an appropriate index for measuring overall dietary quality for all individuals found in a very diverse U.S. population.

To calculate the HEI-2005 for U.S. food intake surveys, we use the USDA's MyPyramid Equivalents Database (MPED). The MPED is a "recipe database" that deconstructs the thousands of foods and food mixtures reported by survey respondents into MyPyramid serving equivalents (i.e., standardized portion units per 100 edible grams of food). For example, when a respondent reports eating two slices of pepperoni pizza, we can use the MPED to determine how many servings of grains, vegetables and meat are in every 100 grams, as well as the amount of saturated fat and oils.

Currently, the USDA has released two versions of the MPED and an addendum (Friday and Bowman, 2006; Bowman, Friday and Moshfegh, 2008; Koegel, Kuczynski and Britten, 2013). MPED version 1.0 (Friday and Bowman, 2006) can be linked to the 1994-96 CSFII and the 2001-2002 NHANES. MPED version 2.0 (Bowman, Friday and Moshfegh, 2008) was designed for the 2003-2004 NHANES. HEI-2005 values can be calculated for the 2005-08 NHANES by using the MPED 2.0 and a supplementary addendum database (Koegel, Kuczynski and Britten, 2013).

[2]Future work will use the HEI-2010. Note however that the 2005 and 2010 versions have many similarities (see NCI, 2013a).

2.2. Back-dating the HEI-2005

In order to measure long-run changes in overall diet quality, a consistent measure must be used. However, for the 1977-78 NFCS and 1989-91 CSFII no officially released MPED exists. To address this issue, this study constructs HEI-2005 values for the 1989-91 CSFII by using MPED 1.0 values. Of the 4,077 unique foods reported on day one by individuals in the 1989-91 CSFII, 4,013 (98.4 percent) of these foods are also found in the MPED 1.0. The remaining 64 foods were matched to closely related foods as shown in appendix table A.1. The method of matching similar foods to one another to create a servings database has also been used by the National Cancer Institute (NCI, 2013b).

A similar approach to linking MPED 1.0 values to the 1977-78 NFCS was undertaken. Because the food coding scheme changed between the 1977-78 NFCS and 1989-91 CSFII, a linking database is first used to convert each 1977-78 food code to a corresponding 1989-91 food code value (Moshfegh, 1986). NFCS respondents reported 3,415 unique foods on day one, and 3,357 (98.3 percent) of these foods had an exact match to a MPED 1.0 value. The remaining 58 foods were matched to closely related foods. See appendix for details of matching.

Nutrient values for calories, saturated fat, carbohydrates, sodium, and alcohol for each food in the 1977-78 NFCS were obtained from the USDA Nutrient Database for Standard Reference version 16-1, which corresponds to the 1994-96 CSFII. This was necessary due to advances in food science methodologies when determining nutrient values, especially saturated fats, per 100 grams of food.

3. Descriptive Measures and Empirical Motivation

We begin our analysis by plotting HEI-2005 scores for each of the four survey waves by age and by cohort (figure 1).[3] Panel (a) of figure 1 shows that diet quality generally follows a U-shaped, or check-shaped, pattern over the lifecycle. That is, scores fall dramatically during childhood and adolescence, reaching their lowest levels in the latter-half of the teenage years. This "bottoming-out" of dietary quality is maintained through early-to-mid adulthood before rebounding on an upward trajectory over the rest of one's life. We can also infer from figure 1 that diet quality has been increasing over the sample period 1977-2008 for all age groups, an observation that has been previously documented (Beatty et al., 2012; Popkin, Zizza, and Siega-Riz, 2003).[4]

[3] To facilitate visual appeal in figure 1, we aggregate periods by survey as noted in the legend. Additionally, in panel (a) individuals are grouped into the following age groups, which further segments the Institute of Medicine's age classifications for Dietary Reference Intakes (IOM, 2011): 2-3, 4-5, 6-8, 9-10, 11-13, 14-15, 16-18, 19-22, 23-26, 27-30, 31-35, 36-40, 41-45, 46-50, 51-55, 56-60, 61-65, 66-70, 71-75, and 76-79. In panel (b), cohorts are grouped in the following fashion: the first cohort covers 1898-1904; cohorts born between 1905 and 1999 are grouped quinquennially; the last cohort covers 2000-2005.

[4] Mean HEI-2005 scores for the 1977-78 NFCS, 1989-91 CSFII, 1994-96 CSFII and 2001-08 NHANES are as follows (standard errors in parenthesis): 46.78 (0.20), 49.52 (0.31), 50.12 (0.31), and 51.37 (0.25), respectively.

In panel (b) of figure 1, we can see that each successive cohort appears to have diminishing dietary quality; although the most recent cohorts begin to have higher-quality diets, they are also the youngest individuals observed in each survey. Of course, trends in both panels of figure 1 are conflated by the omitted factor. In panel (a) we can not disentangle the effect of age and birth cohort across each survey: a 40-year old individual in 1977 belongs to the same birth cohort as a 52-year old in 1989. The confounding effect is perhaps more obvious in panel (b) because we do not observe all birth cohorts in every sample. The 1950 birth cohort, for example, has widely differing dietary scores within each survey period because each birth cohort is confounded by age. Put differently, individuals in the 1950 birth cohort have ages ranging from 27 to 45 years old, depending on the survey period.

As demonstrated by figure 1 and is well-known (Fienberg and Mason, 1978; Mason et al., 1973), a key empirical difficulty in identifying *Age*, *Period* and *Cohort* (APC) effects is that the three are conflated. That is, all individuals in a given period who are of the same age are also in the same cohort. More specifically, age equals period minus birth cohort, which introduces perfect collinearity.

In this study, we apply an APC model to individual level data over nonconsecutive periods covering 1977-2008. For the 1989-91 and 1994-96 CSFII, annual data can be analyzed separately by using the annualized weights provided in the surveys. As such, our sample covers 11 periods consisting of 78 ages and 108 cohorts. Table 2 offers details of sample sizes for various age and cohort ranges by period. In the empirical estimation we use ungrouped ages and cohorts. In the next section, we outline an estimable function that provides a solution to APC identification problem.

4. Methods

The methodological objective of this study is to decompose changes in dietary quality into three time-related aspects:

$$HEI_i = \beta_A \left(Age_i\right) + \beta_P \left(Period_i\right) + \beta_C \left(Cohort_i\right) \tag{1}$$

where,

- *Age* is accumulation of years in an individual's life in a given time period and captures the physiological and social aspects of age.
- *Period* captures contemporaneous effects such as prices and policies in place in a given time period. Period effects affect all individuals simultaneously.

- *Cohort* captures group membership of individuals that were born in roughly the same time period. Birth cohorts age together and experience similar broad social phenomena at the same age. For example, individuals who are part of two different birth cohorts may have been exposed to very different information about what constitutes a healthy diet over their lifetimes.

One approach would be to calculate each individual's total HEI-2005 score (HEI_i) and estimate equation (1) directly. However, individual components of the HEI-2005 are of separate interest, and more importantly, we can recover parameter estimates for the total HEI score by simply summing over all components. Let hei^c be the cth component of the HEI-2005 such that $\sum_c hei^c = HEI$. We specify an APC model for each of the 12 components as,

$$\log E\left(\frac{c_i}{k_i}\right) = \beta_A^c\left(Age_i\right) + \beta_P^c\left(Period_i\right) + \beta_C^c\left(Cohort_i\right) \tag{2}$$

where c_i is individual i's total component intake and k_i is his or her total kilocalorie (kcal) intake. To recover each component's estimated age, period and cohort effect such that coefficient estimates fall within their respective ranges as outlined in table 1, the estimates must first be transformed due to the log-linear specification. We then weight the transformed estimate by the maximum score and divide by the 2005 DGA recommendation.

For example, let c be the total fruit component, which is given a weight of $w = 5$ (i.e., represents up to 5 percent of the total HEI-2005 score). The 2005 DGA recommends consuming $r = 0.8$ ounce equivalents of fruit for every $k = 1,000$ kcal consumed. The vector of age coefficients, for example, for the cth component of the HEI-2005 is calculated as $\widehat{hei}_A^c = \frac{w}{r}\exp(\hat{\beta}_A^c)$. We can then sum over the 12 components to get the total HEI-2005 age effect, $\sum_c \widehat{hei}_A^c = \widehat{HEI}_A$. This same process holds for period and cohort effects.

4.1. Estimation

The exact linear dependence of $cohort = period - age$ produces a singular design matrix $\mathbf{X}$ of less-than full-rank when estimating equation (2) using standard regression techniques. Several approaches to estimating each of the three effects, with only two pieces of information, have been proposed over the past 80 years (Manson and Wolfinger, 2002). It must be noted that no unique solution exists to the linear APC problem; one must impose a constraint to estimate equation (2) (e.g., Hanoch and Honig, 1985) or use alternative methods, such as the maximum-entropy principle (Browning, Crawford, and Knoef, 2012). This study uses a method introduced by Yang, Fu and Land (2004), which is referred to as the "Intrinsic Estimator."[5]

[5] As noted elsewhere (e.g., Browning, Crawford, and Knoef, 2012; Powers, 2013) the Intrinsic Estimator is not an estimator per se, but rather an estimable function that provides a "solution" to the APC identification problem.

Yang et al. (2004) propose a principle components regression as a solution to the APC identification problem via the Intrinsic Estimator (IE). The geometric representation of this approach has been aptly described elsewhere (Yang et al., 2008). Fu (2000) shows that the IE can also be estimated using a ridge estimator (or penalized regression) where in the limit the shrinkage penalty approaches zero. The two approaches of Yang et al. (2004) and Fu (2000) are approximately equal in the limit. This study forgoes the principle components and ridge regression techniques and uses an OLS estimator that employs a Moore-Penrose inverse of $\mathbf{X}'\mathbf{X}$ denoted as $\mathbf{X}^{+}\mathbf{X}$ (Fu and Hall, 2006).

We follow Powers (2012, 2013) and estimate equation (2) via maximum likelihood estimation. The log-likelihood function is

$$\log L = \sum_{i=1}^{N} c_i \mathbf{X}\beta^c - k_i e^{\mathbf{X}\beta^c}. \tag{3}$$

Optimization is achieved iteratively by applying the Moore-Penrose inverse to the Hessian matrix of $\log L$ with respect to β^c in each step. The algorithm employed here is a Newton-Raphson (Powers, 2012).

4.2. Inference

Because the HEI-2005 is the sum of 12 ratios (total nutrient/food intake per 1,000 calories), a direct method for calculating standard errors is not readily available. A bootstrapping method that accounts for the complex, multi-stage survey design is therefore used to calculate standard errors and 95-percent confidence intervals (Rao, Wu, and Yue, 1992). To automate the bootstrapping process, the Stata package `bsweights` (Kolenikov, 2010) is used to construct 1,000 balanced replicate weights for each individual in the sample.

5. Empirical Results

Our main results are concerned with the total HEI-2005 score, as this score represents overall dietary quality. Because individual components of the HEI-2005 are of their own interest and have been found to be correlated with various health outcomes (Chuive et al., 2012), we report these estimates in appendix figures A.1-A.3. Although we do not extrapolate on the interpretation of individual components here, we will make reference to them.

A key feature of the HEI is that components represent two broad categories: "Adequacy" components (those that should be increased) and "Moderation" components (those that should be decreased). Higher intakes of Adequacy components yield a higher score, whereas decreasing consumption of Moderation components increases the score. This is in line with the position of the Academy of Nutrition and Dietetic Association that all foods can be part of a healthful diet – there are no “bad” or “good” foods, but rather those that should be consumed to an adequate degree and those that should be consumed in moderation (Freeland-Graves and Nizke, 2013). To this end, we report APC effects for the total HEI-2005 score, the Adequacy HEI-2005 score (components 1-9) and the Moderation HEI-2005 score (components 10-12) in figures 2-4.

5.1. Age Effects

As shown in the top panel of figure 2, healthy eating over the lifecycle of a typical American largely mirrors results found in panel (a) of figure 1. The APC model, however, allows us to interpret the results as the relationship between age and diet quality, net of period and cohort effects.

Between the ages of 2 and 16, the quality of diet drops substantially. The transition from early childhood into adolescence is a time of growing independence with respect to food decisions (Whitney and Rolfes, 2002) and healthy eating is often of low priority (Neumark-Sztainer et al., 1999). The drop is largely due to decreased consumption of Adequacy components. Upon closer inspection of the individual components, we can see that the decrease in diet quality is mainly due to reductions in fruit and milk consumption. Moderation scores generally increase over the lifecycle.

Focusing on dietary quality for adults, we can see that the total HEI remains relatively stable throughout early-to-mid adulthood (HEI $\simeq$ 54). This period of life is characterized by major changes in lifestyle as individuals become more independent, leave home to enter the labor force or post-secondary school, and begin to establish their own set of characteristics (Arnett, 2000). As individuals transition out of mid-adulthood, dietary quality begins to rebound, possibly due to a greater awareness of the relationship between diet and health, and to reductions in household size (e.g., empty nesters), which increases economies of scale.

5.2. Period Effects

The structural or period effect on overall diet quality shows a steady increase over 1977-2008. The period effect from the APC model represents the change in the grand mean after conditioning on age and cohort effects. In the 1977-78 period, we estimate a conditional mean HEI-2005 score of 51.6. Over the next 30 years, diet quality increased by 17.0% before reaching its current score of just over 60. When examining the individual components, we can see that much of the increase is due to increased consumption of oils and decreased consumption of saturated fats.

Adequacy and Moderation scores also increased over the sample period, although at different rates over different time periods. Over 1977-1989, Adequacy scores increased by about 8.5%, whereas Moderation scores where slightly lagging at 7.1%. The most recent twenty-year time period (1989-2008) saw larger increases in Moderation scores (18.7%) as compared to Adequacy scores (5.2%). Beatty et al., (2012) found that reformulation played a role in explaining some of the improvement in HEI-2005 scores over 1989-2008. Given that a lion's share of reformulation has occurred within the Moderation components, it is likely that food formulation has contributed to increases in HEI-2005 scores, although future research should more thoroughly investigate this hypothesis.

5.3. Cohort Effects

The cyclical effect of birth cohort observed in figure 4 offers a new insight into the evolution of dietary quality in the United States. It is important to note that the very earliest cohorts (those born before 1925) and the most recent cohorts (those born after 1975) are not observed in every sample period. This is typical in APC analyses, but it is worth mentioning that the end points are not fully representational of all ages. Nevertheless, the heart of the matter is concerned with those born in mid-twentieth century.

Following the second World War (post-1945) the food environment changed rapidly. Concurrently, home environments changed substantially as children were being born into more homes with dual-working spouses. The family meal structure also changed rapidly for Baby Boomers and beyond.

The overall trend in cohort effects across Adequacy and Moderation scores mainly mirror each other. That is, for pre-1955 birth cohorts, both Adequacy and Moderation scores were nondecreasing. For individuals born in the late-1950's to early 1990's, we can see a much more steady drop in both Adequacy and Moderation scores. Although recent cohorts in the 1990's and early 2000's have yet to fully age, preliminary estimates suggest dietary quality may be on the rebound; future monitoring and research for these individuals is necessary.

6. Discussion

FORTHCOMING...

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Tables and Figures

Table 1: Healthy Eating Index-2005 standards for scoring.

	Score				
Component	0	5	8	10	20
Total fruit	0	$\longrightarrow$ $\geq$ 0.8 cup eq/1000 kcal			
Whole fruit	0	$\longrightarrow$ $\geq$ 0.4 cup eq/1000 kcal			
Total vegetables	0	$\longrightarrow$ $\geq$ 1.1 cup eq/1000 kcal			
Dark green/orange veg./legumes	0	$\longrightarrow$ $\geq$ 0.4 cup eq/1000 kcal			
Total grains	0	$\longrightarrow$ $\geq$ 3.0 cup eq/1000 kcal			
Whole grains	0	$\longrightarrow$ $\geq$ 1.5 cup eq/1000 kcal			
Milk	0			$\longrightarrow$ $\geq$ 1.3 cup eq/1000 kcal	
Meats and beans	0			$\longrightarrow$ $\geq$ 2.5 oz eq/1000 kcal	
Oils	0			$\longrightarrow$ $\geq$ 12 g/1000 kcal	
Saturated fat	$\geq$ 15		$\longrightarrow$ 10	$\longrightarrow$ $\leq$ 7% of energy	
Sodium	$\geq$ 2.0		$\longrightarrow$ 1.1	$\longrightarrow$ $\leq$ 0.7 g/1000 kcal	
Calories from SoFAAS[a]	$\geq$50				$\longrightarrow$ $\leq$ 20% of energy

Source: Recreated from Guenther et al. (2008a).

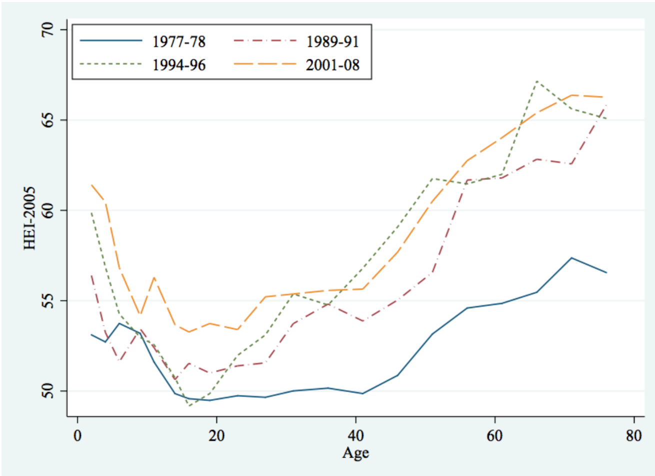
[a]Solid Fat, Alcohol, and Added Sugar

Table 2: Period Observations by Age and Cohort

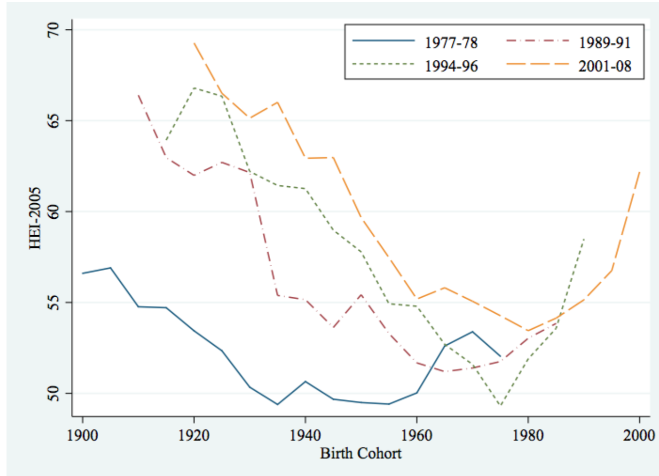
	1977[a]	1989	1990	1991	1994	1995	1996	2001[a]	2003[a]	2005[a]	2007[a]	Total
Age												
2-5	3,646	388	367	352	847	718	618	856	763	902	832	10,289
6-10	4,963	442	376	427	424	399	418	935	754	851	918	10,907
11-15	5,593	372	341	395	355	326	370	1,389	1,208	1,204	790	12,343
16-22	5,616	477	404	424	432	285	379	1,406	1,372	1,356	824	12,975
23-30	4,428	634	609	638	431	310	485	720	612	775	633	10,275
31-40	4,179	713	744	807	605	476	687	807	719	785	957	11,479
41-50	3,474	524	513	595	609	563	597	828	707	752	882	10,044
51-60	3,680	425	413	421	513	664	507	650	566	600	871	9,310
61-70	2,987	442	456	397	441	556	480	578	603	562	798	8,300
71-79	2,113	363	285	396	331	454	236	500	553	451	665	6,347
Cohort												
1898-1909	2,736	0	0	0	0	0	0	0	0	0	0	2,736
1910-1919	3,388	363	244	300	137	153	53	0	0	0	0	4,638
1920-1929	3,752	486	497	442	432	533	332	375	289	153	117	7,408
1930-1939	3,466	423	413	425	494	632	498	629	650	519	691	8,840
1940-1949	4,751	545	513	573	602	614	578	649	582	605	921	10,933
1950-1959	6,195	724	744	804	579	541	655	818	665	696	879	13,300
1960-1969	10,788	755	727	780	585	421	636	825	716	774	918	17,925
1970-1979	5,603	740	627	665	613	414	541	882	792	871	876	12,624
1980-1989	0	744	743	863	880	725	783	2,499	1,957	1,663	929	11,786
1990-1999	0	0	0	0	666	718	701	1,992	1,782	2,055	1,635	9,549
2000-2005	0	0	0	0	0	0	0	0	424	902	1204	2,530
Total	40,679	4,780	4,508	4,852	4,988	4,751	4,777	8,669	7,857	8,238	8,170	102,269

[a] 1977 = 1977-78; 2001 = 2001-02; 2003 = 2003-04; 2005 = 2005-06; 2007 = 2007-08.

Figure 1: Diet Quality by Survey Period over Age and over Birth Cohort

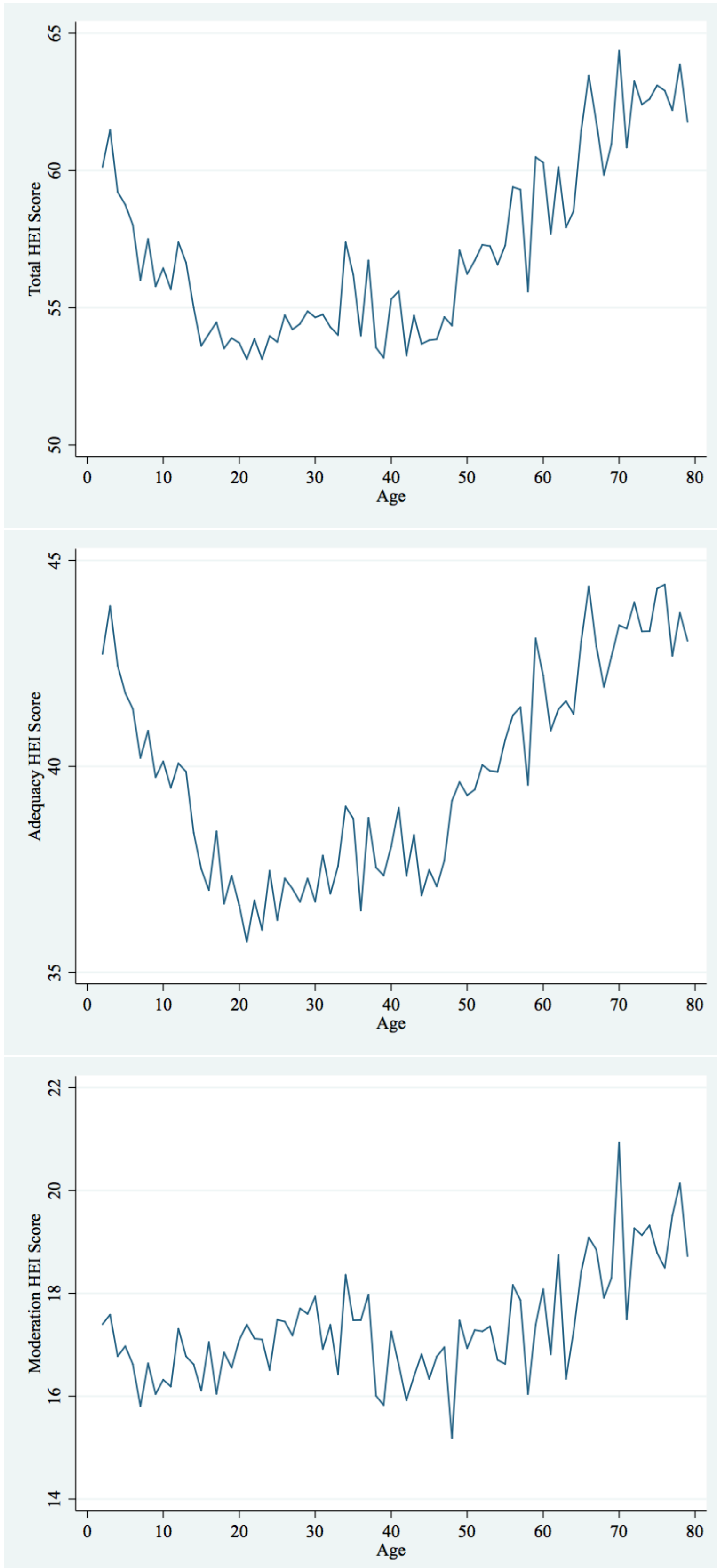


(a)



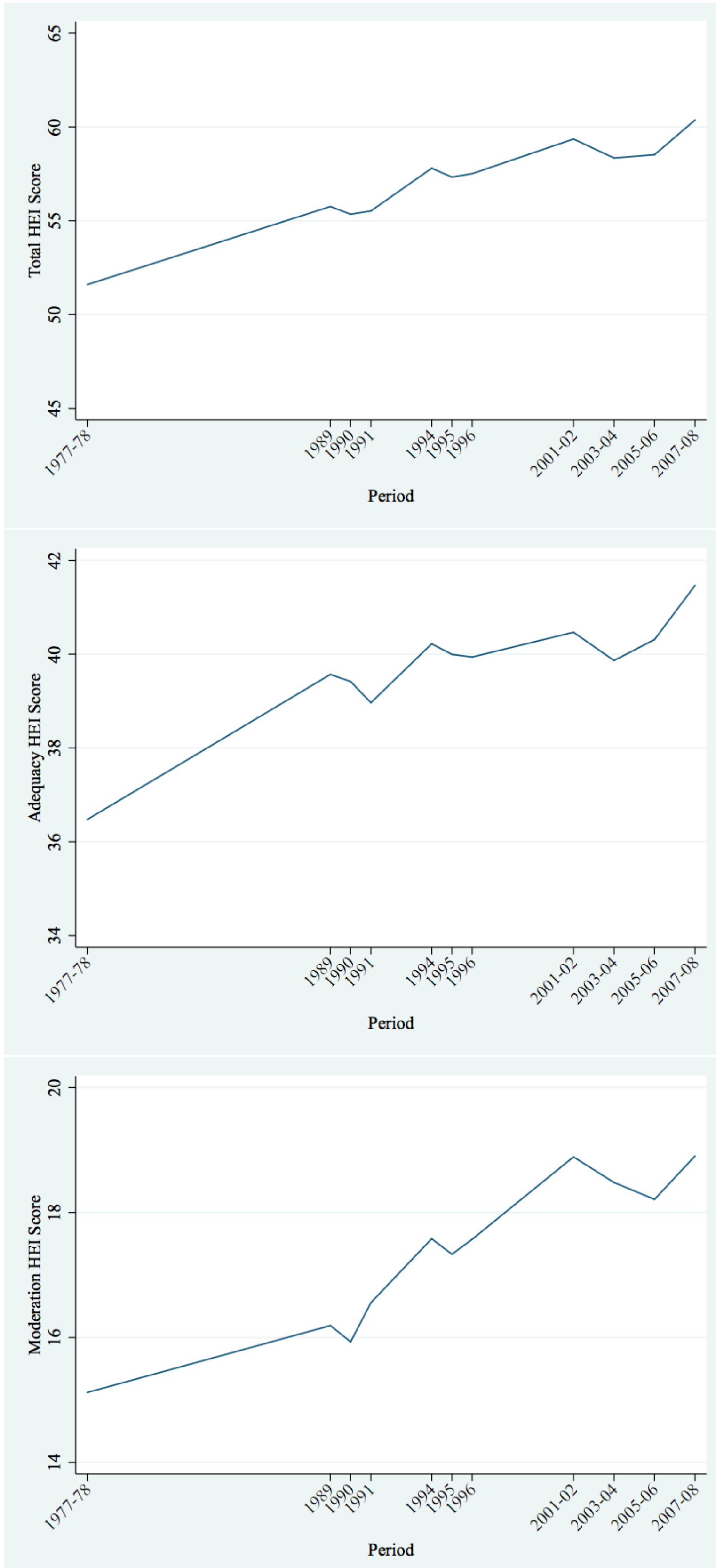
(b)

Figure 2: Age Effects



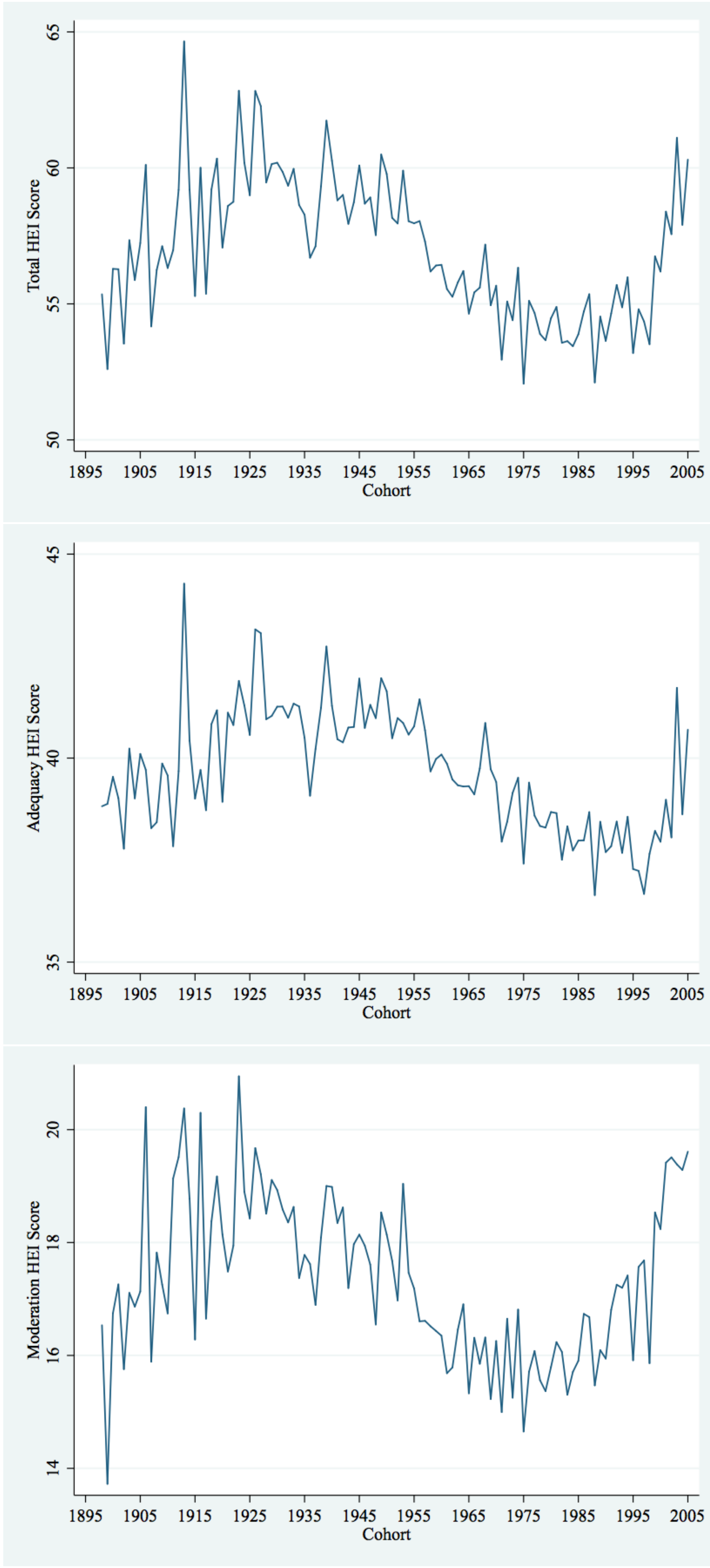
Note: Adequacy HEI is the sum of the first 9 components, and Moderation HEI is the sum of the last 3 components.

Figure 3: Period Effects



Note: Adequacy HEI is the sum of the first 9 components, and Moderation HEI is the sum of the last 3 components.

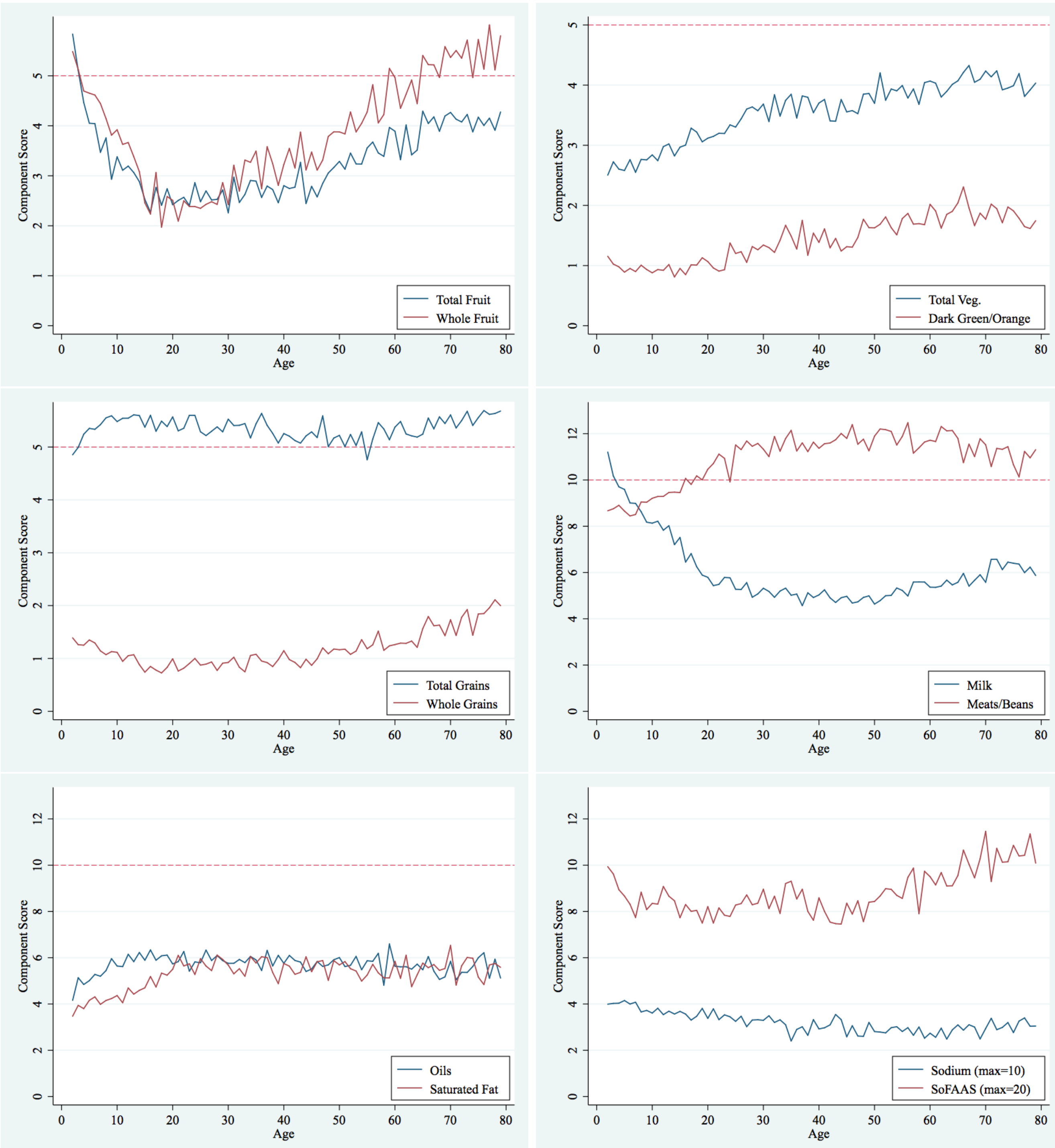
Figure 4: Cohort Effects



Note: Adequacy HEI is the sum of the first 9 components, and Moderation HEI is the sum of the last 3 components.

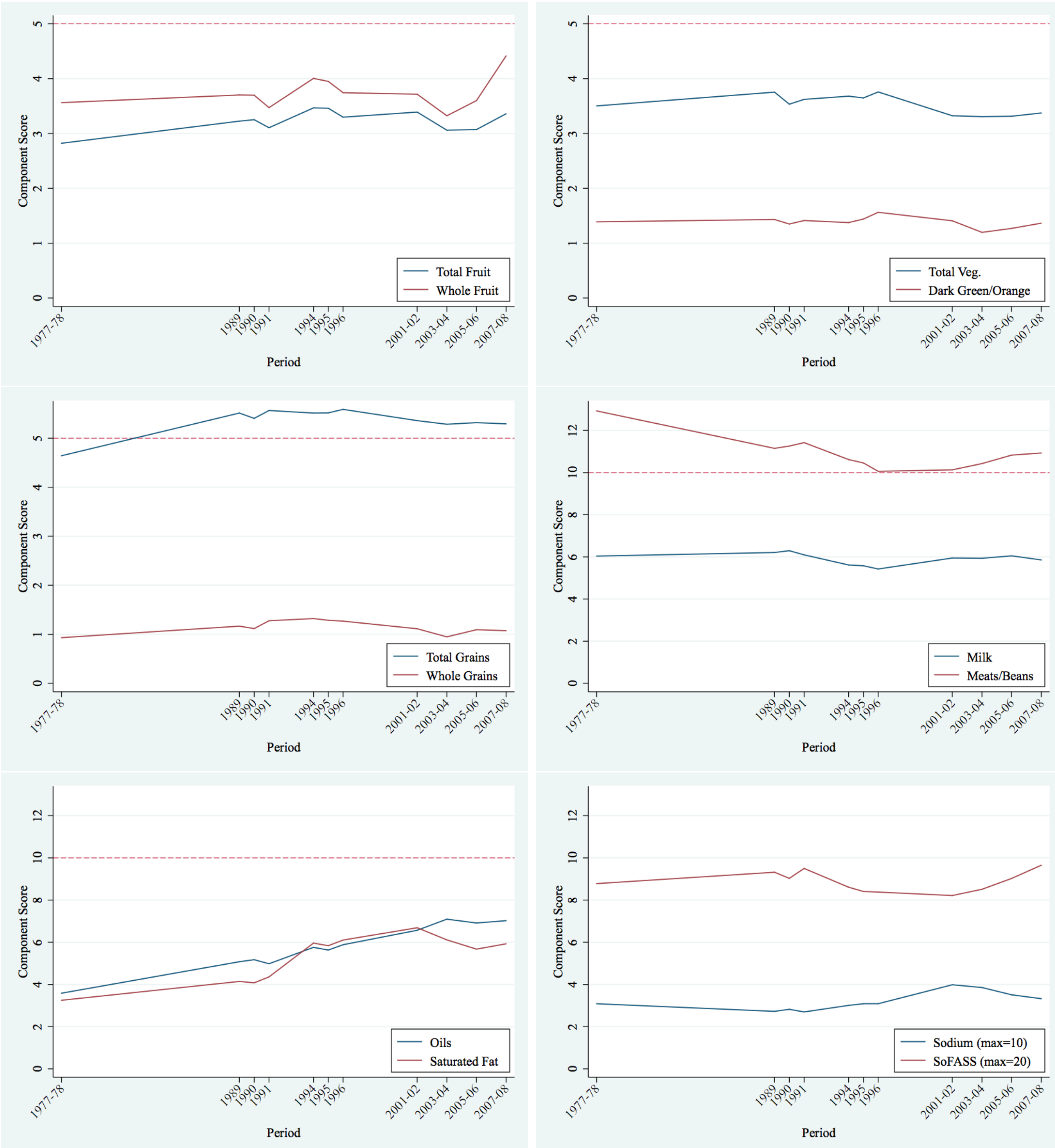
A. Appendix

Figure A.1: Age Effects - Individual HEI-2005 Components



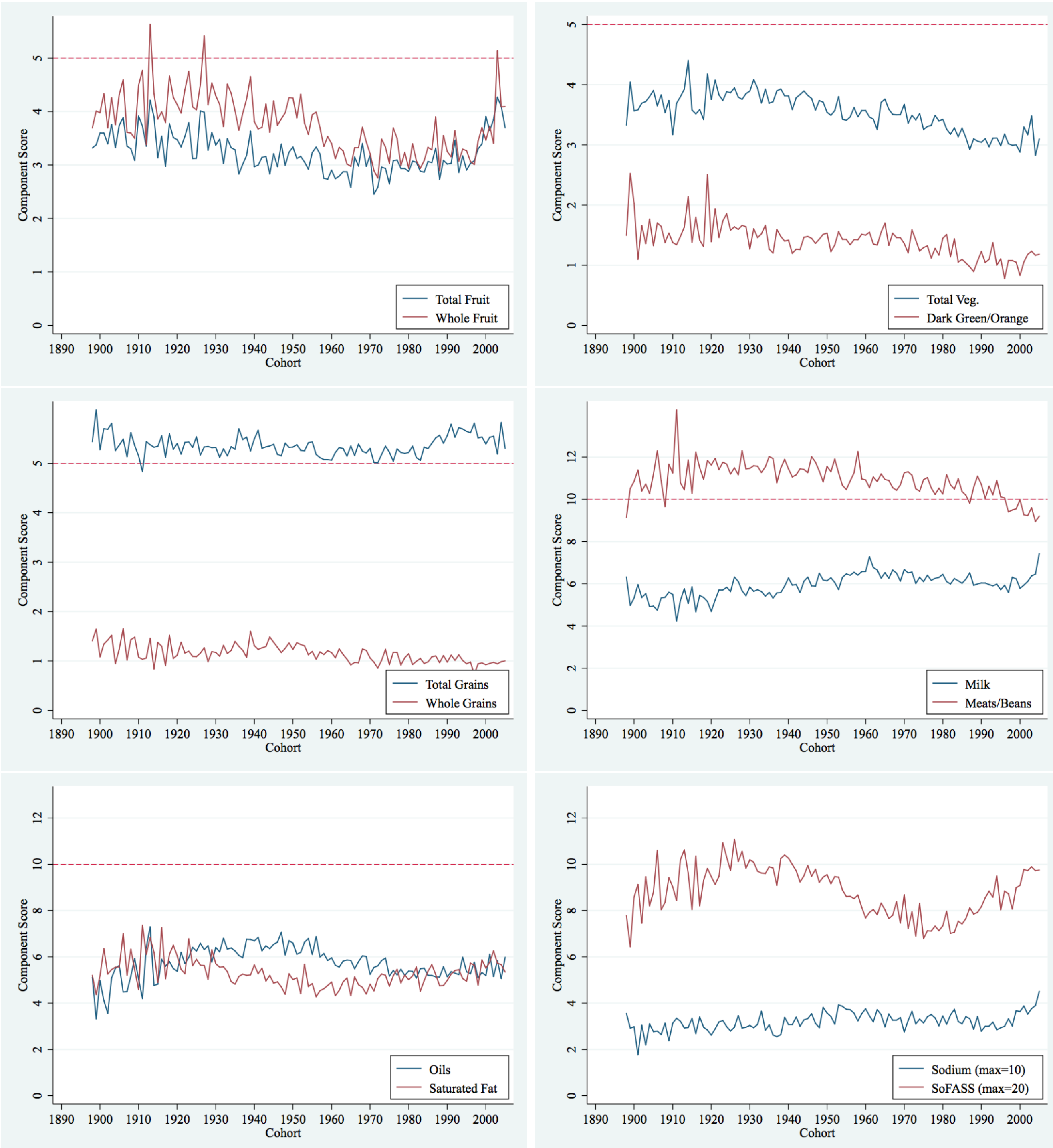
Note: The dashed line represents the maximum score, unless otherwise noted.

Figure A.2: Period Effects - Individual HEI-2005 Components



Note: The dashed line represents the maximum score, unless otherwise noted.

Figure A.3: Birth Cohort Effects - Individual HEI-2005 Components



Note: The dashed line represents the maximum score, unless otherwise noted.

Table A.1: Mapping of 1989-91 CSFII foods to MPED

1977-78 NFCS		1994-96 CSFII	
Food code	Food description	Food code	Food description
1410540	cheese, havarti	14010000	cheese, nsf
1462016	chili con queso (pepper & cheese dip)	14620150	
1466010	cheese, deep-fried (include mozzarella en caross	14660200	
2631915	shrimp, battered, fried (include fried shrimp, n	26319140	
2754040	chicken frank, plain, on bun	25210310	frankfurter, chicken
2764230	turkey w/ veg, high meat, baby, ns as to str or	27642310	turkey w/ vegetables, high meat, baby, strained
2764232	turkey w/ vegetables, high meat, baby, junior	27642310	turkey w/ vegetables, high meat, baby, strained
5112190	bread, high fiber w/ fruit &/or nuts	51122110	bread, reduced calorie,hi fiber, w/fruit/nuts,toast
5410100	crackers, ns as to sweet or nonsweet	54001000	cracker, ns as to sweet/nonsweet (incl cracker,nfs)
5620601	rice, long (no fat)	56205000	rice, cooked, ns as to type
5620860	oat bran cereal,multi-grain,cooked,inst,no fat a	56208500	oat bran cereal, cooked, no fat added
5710620	batman cereal	57100100	cereal, ready-to-eat, nfs
5710630	bigg mixx cereal	57100100	cereal, ready-to-eat, nfs
5710800	body buddies cereal, brown sugar & honey	57100100	cereal, ready-to-eat, nfs
5711250	breakfast with barbie cereal	57100100	cereal, ready-to-eat, nfs
5714200	cracklin' bran cereal	57143000	cracklin' oat bran cereal
5714900	crispy critters cereal	57100100	cereal, ready-to-eat, nfs
5715250	crunchy bran cereal	57101000	all-bran cereal
5720150	dinersaurs cereal	57100100	cereal, ready-to-eat, nfs
5722150	fruit 'n fiber w/ tropical fruit cereal	57219000	fruit 'n fiber cereal, nfs
5722200	fruitful bran cereal	57219000	fruit 'n fiber cereal, nfs
5722350	ghost busters cereal	57100100	cereal, ready-to-eat, nfs
5723550	heartwise, plain, cereal	57100100	cereal, ready-to-eat, nfs
5724200	honey & nut corn flakes	57311800	nut and honey crunch flaked cereal
5724360	hot wheels cereal	57100100	cereal, ready-to-eat, nfs
5724390	jetsons cereal	57100100	cereal, ready-to-eat, nfs
5730170	kenmei rice bran, plain, kelloggs	57101000	all-bran cereal
5730800	morning funnies cereal	57100100	cereal, ready-to-eat, nfs
5731160	nintendo cereal system	57100100	cereal, ready-to-eat, nfs
5731179	nut & honey crunch biscuits cereal	57311800	nut and honey crunch flaked cereal
5731300	nutri-grain corn cereal	57315000	nutri-grain wheat cereal
5731390	nutri-grain raisin bran	57101000	all-bran cereal
5731600	nutri-grain wheat & raisins cereal	57316100	nutri-grain almond raisin cereal
5731635	oat bran options, flakes, w/raisins,dates,nugget	57000100	oat cereal, nfs
5731636	oatbake, honey bran cereal	57000100	oat cereal, nfs

Continued on next page

Table A.1 – *Continued from previous page*

1977-78 NFCS		1994-96 CSFII	
Food code	Food description	Food code	Food description
5731637	oatbake, raisin nut cereal	57000100	oat cereal, nfs
5732000	100% natural cereal, w/ apples & cinnamon	57321000	100% natural cereal, w/ raisins & dates
5732760	quaker rice bran cereal	57101000	all-bran cereal
5740250	teenage mutant ninja turtles cereal	57100100	cereal, ready-to-eat, nfs
5740275	tiny toon adventures cereal	57100100	cereal, ready-to-eat, nfs
6120010	juice, nfs (include fresh, frozen or canned)	61210000	orange juice, nfs
6121083	orange juice, froz, w/sugar, calcium added, reco	61210630	orange juice, frozen, w/ sugar, reconst w/ water
7110101	white potato, baked, w/o peel, fat not added	71101110	white pot,baked,peel eaten,fat not added in cooking
7110102	white potato, baked, w/o peel, fat added	71101120	white pot, baked,peel eaten, fat added in cooking
7120300	white potato, chips, barbecue-flavored	71202000	white potato, chips, unsalted
7560010	soup, nfs	75651040	vegetable noodle soup, prepared w/ water
8110210	margarine, low sodium, stick or tub	81102010	margarine, stick, salted
8110300	margarine, red cal, salt / un salt, stick / tub	81102010	margarine, stick, salted
8110301	margarine, diet, salted or unsalted	81102010	margarine, stick, salted
8311270	buttermilk dressing	83210000	creamy dressing w/ buttermilk, ns low/reduced cal
8321270	buttermilk dressing, lite type	83210100	crmy drsg w/ sour crm &/ buttermilk & oil, red cal
9130101	cane syrup	83210100	cane & corn syrup
9130107	cane & maple syrup	83210100	cane & corn syrup
9130150	buttered blends syrup, reduced calorie	91301040	buttered blends syrup (incl mrs butterworth)
9130601	syrup, grenadine	91300010	syrup, nfs
9174602	royals mint chocolate candy	91746100	m & m's" plain chocolate candies
9230300	tea, ready-to-drink, ns as to added sweetener	92301000	tea, ns as to type
9230320	tea, ready-to-drink, w/ sugar	92301060	tea, ns as to type, presweetened w/ sugar
9230330	tea, ready-to-drink, low calorie sweetener	92301080	tea, presweetened w/ low calorie sweetener
9241401	soft drink,carbontd,malt(incl malta india, marti	92410310	soft drink, cola-type
9242100	soft drink, fruit-flavored, w/10% fruit juice	92510610	fruit drink (include fruit punch & fruit ade)
9242110	soft drink, fruit-flav, w/10% fruit juice, low c	92510610	fruit drink (include fruit punch & fruit ade)
9242120	soft drink, w/10% fruit juice, vitamin enriched	92510610	fruit drink (include fruit punch & fruit ade)
9310400	near beer	93101000	beer (include ale)