MARITAL STATUS AND OBESITY: CAUSE AND EFFECT

by

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ABSTRACT

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Obesity is an increasingly prevalent nutritional disorder among children and adolescents as well as adults and has now become a very important public health issue in most developed countries. The prevalence of obesity varies with socioeconomic and marital status. Marital status is related to morbidity and mortality, with married people, especially married men, healthier and at lower risk of death than unmarried men. The relationship between marital status and obesity, however, is not well established. To explore the origin of these associations, I study the effects of marital status and several socioeconomic variables on body mass index (BMI, kg/m^2) and obesity. At the same time, I allow for reverse causality from obesity to marital status. To obtain consistent estimates of these effects, I apply ordinary least squares models and bivariate probit models with correlated errors to data from National Longitudinal Survey of Youth (NLSY 79). This survey is designed to represent the entire population of American youth in 1979. My results reveal that married men have significantly larger values of BMI and are more likely to be obese than men who never married or divorced, even when demographic and socioeconomic variables are held constant. By contrast, marital status is not significantly associated with obesity of BMI among women. These findings, which take account of reverse causality from weight to marital status, suggests that marital status appears to influence obesity among men, but not among women.

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I. Introduction

1. Obesity as a Global Epidemic: General Problem

We are unanimous in the belief that obesity is a harmful or detrimental factor for the human health and well being. In medicine, obesity is regarded as a major determinant of many non-communicable diseases (NCDs) and is also believed that it induces non-insulin-dependent diabetes mellitus (NIDDM, Type-II diabetes), coronary heart disease (CHD), stroke, hypertension, gallbladder disease, breast, endometrial and colon cancers, musculoskeletal disorders, osteoarthritis, some respiratory problems, and even premature death (World Health Organization (WHO) Press Release/46, 1997).[1] And a number of recent studies have documented that obesity reached epidemic proportions not only in U.S. but also in most developed and even less developed countries and now is threatening to become a global epidemic. Statistics reveal that the prevalence of obesity (defined as a body mass index ≥ 30 kg/m^2) has increased in varying degrees, not only in the United States, but also in United Kingdom and elsewhere in Europe, as well as in countries as diverse as Australia, Kuwait, India and China.[2] According to the classification scheme established by WHO,[3 4]

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[1] Because hypertension, diabetes, and hypercholesterolemia are biologic effects of obesity and are intermediate steps in the causal pathway linking obesity to increased mortality due to cardiovascular disease and several cancers, it is not easy to control for these variables in the primary analysis.

[2] In U.S., the prevalence of obesity increased from 12.0% in 1991 to 17.9% in 1998 (A.H. Mokdad *et al.*). Also the crude prevalence of overweight and obesity (body mass index ≥ 25.0) for age 20 and older was 59.4% for men, 50.7% for women and 54.9% for overall in U.S. (K. M. Flegal *et al.* (1998)). According to the estimate

more than 50% of adults in U.S. are classified to be overweight (defined as a body mass index ≥ 25 kg/m^2) and almost 22% are obese, equivalent to approximately 13.5 kg (30 lbs) overweight.[5] And about 3% of U.S. adults have a BMI of 40 kg/m^2 or more. And the entire U.S. adult population would be overweight within a few decades if this trend persists. This striking increase is still present even among the children and adolescents.[6]

On a simple level, the culprit of obesity among the population can be the genetic factors. Although a lot of advanced researches highlighted the role of molecular genes as a dominant factor of obesity, our genes have not changed significantly during the past two decades.[7] It may well explain the cross-sectional differences among the people with endowment heterogeneity. But, it's not clear how it would identify the rapid change in obesity over time.

Another one is an environmental factor that promotes behaviors that may lead to

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from the 1999-2000 National Health and Nutrition Examination Survey (NHANES), however, the obesity problem has become more serious with over 64 percent of U.S. adults are either overweight or obese (see K.M. Flegal *et al.* (2002)). In U.K., it has increased from 9% in 1980 to 13% in 1991. And according to the WHO MONICA study, with which the data from 1983 to 1986 on the prevalence of obesity in Europe are most comprehensive. The distributions of the body mass index values seem to be homogeneous over Europe despite large socioeconomic and cultural differences among the countries (see Seidell (1995) for detailed information).

[3] World Health Organization, *Obesity: Prevention and Managing the Global Epidemic* (WHO, Geneva, 1998).

[4] But the variations in the prevalence of overweight and obesity among and within countries can be a function of differences in ethnicity, health and socioeconomic status, assessment methodology, and the definition of overweight and obesity.

[5] Flegal *et al., op cit.*

[6] Almost 25% of U.S. children are overweight or obese (see Troiano and Flegal (1998) for detailed information).

obesity. Several studies indicate that the quality of life may be compromised in obese people because of the impaired physical and psychosocial functioning. Obesity can arise when energy intake is larger than energy expenditure. Therefore, the behaviors that the environment fosters may be correlated with the obesity. According to *the Report of the Surgeon General*, low level of physical activity is associated with an increasing trend of obesity,[8] and we know that our current environment is discouraging physical activities. The technological improvement and advancement of media and transportation have decreased the need for physical activities of the people.[9] A great portion of population already lives a sedentary life mainly due to the appeal of television, video games, and more frequent use of computers in homes as well as in workplaces.[10] A sedentary lifestyle needs lower energy intake and causes obesity unless food intake is limited. In this context, many recent studies

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[7] See Koplan *et al.* (1999).

[8] U.S. Department of Health and Human Services, *Physical Activity and Health: A Report of the Surgeon General,* U. S. Department of Health and Human Services, Atlanta: Georgia, 1996.

[9] According to Cutler *et al.*(2003), however, authors argue that the startling increase in the rate of obesity in the United States is primarily a result of increased food consumption, rather than reduced physical exercise. Through technological improvement in food production and transportation, people could save time costs in consuming food and this lowered time costs have led to increased food consumption.

[10] Mass media and scholarly journals have cited that the relationship between TV watching and obesity of the children. In here, two primary mechanisms by which television viewing contributes to obesity have been suggested: reduced energy expenditure from decreasing physical activity and increased food intake, either during watching TV or as a result of food advertisement (See "Study Finds TV Linked to Obesity in very Young." *The Washington Post*, June 2, 2002. And see T. N. Robinson (1999) for detailed information). Besides, American people watch television much more than Europeans, partly because American television offers much more variety than European. The U.S. is the world's leading innovator in "passive" entertainment, which is highly sedentary. Also, it is true that for average American about half of the leisure time is spent in watching the television (see Robinson and Godbey (1997) for further analysis).

tried to relate the several socioeconomic status (SES) to the variations of body fatness, but there is no solid relationship understood between SES and obesity. In addition, the causal relationship between social status and body weight may be bi-directional. Put it differently, there may be a reverse causality between them; obesity may affect social status and vice versa. Low SES and economic constraints may restrict behavioral options like an access to healthy foods or physical exercise. Furthermore, some specific factors such as low income or wage level, unemployment, and social isolation or low self-esteem may increase the probability of weight changes.[11] Since obesity is negatively valued especially in an affluent society, it is likely that obesity and overweight lead to social and economic disadvantages. Negative attitudes about the obese people have led to the stigmatization of obesity and low self-esteem. There apparently must be a stigma attached to unattractiveness which may be extended to obesity given that being thin has become a prerequisite for being considered attractive. This stigma manifests itself in many situations which can be summarized by noting that the obese people are frequently teased and maligned because of their appearance. It may cause social discrimination and difficulties in job market and marriage market in terms of lower likelihood of being hired or of mating, dating and getting married than the

[11] Ruhm (2000) argues that Body Mass Index (BMI) shows the pro-cyclical fluctuation because in economic downturns individuals have more time to exercise or consume healthy diets, reducing the probability of being overweight. Also lowered income due to unemployment can lower the daily intake of dietary fat.

people with the recommended body mass index.[12] Also it may hamper socioeconomic advancement in almost every aspect no matter what the cause of obesity is. Obesity can be a signal as with other signaling activities and this implies that there may be overinvestment in thinness from a social view point: thinner people are preferred in many situations simply because they look healthier, more attractive, more productive and more reliable than the heavier people,[13] [14] because thinness implies a degree of self-control, self-discipline or will power (Brownell, 1991).

2. Objectives of the Study

In a marriage market, physical appearance would be lucre and a virtue especially for women. Women are therefore more motivated by appearance in dietary behaviors than men.

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[12] Economic theory refers to these situations as "cosmetic discrimination," a simple distaste for overweight employees or mates. It can be measured as a coefficient of discrimination. Another way to interpret these is that an individual's degree of obesity may be perceived by his or her prospective employers or mates as a proxy variable for some unobservable potentials including life expectancy, future productivity and its related characteristics (see Gary S. Becker for a fuller discussion).

[13] McLean and Moon, however, argue the existence of so called "portly banker" effect which implies among mature men, however, large size may generate a "non-verbal signal" of power, strength, dignity, or capability which commands respect from co-workers, employees, and even customers. And Loh also finds that overweight males earned about the same as nonobese males. But the reported earnings functions of the Loh's study do not account for occupation effects (see McLean and Moon (1980) and Loh (1993) for detailed information).

[14] Pagán and Dávila report that women pay a penalty for being obese, but overweight males sort themselves into jobs to offset this penalty or to take advantage of potential weight-related effects via occupational mobility. They also argue that individuals may gain weight in occupations with high levels of stress and little physical activity. In terms of hedonic model, therefore, the individuals prone to obesity may choose occupations in service sector because this occupation affords them a higher wage in compensation for accepting a higher level of stress (See Pagán and Dávila (1997) for detailed information).

For men, however, there may be some more aspects that also make themselves attractive in the marriage market. Since the future productivity and potentials can be evaluated through their current income levels, occupations, education level on top of their physical appearance, those mediating factors are also drawing attention from the opposite sex. Therefore, these differences in the importance of thinness can explain gender differences in the relationship between marital status and obesity.

Men may remain thin before marriage but have a lower incentive to keep slim once they entered the marriage life compared to the married women, whose motivation may continue even after marriage. So, married men are more likely to be obese than their unmarried or previously married counterparts. It is rather paradoxical from the empirical studies that married men have lower mortality or morbidity and have a relatively longer life expectancy than unmarried or previously married men[15] because obesity is a risk factor for mortality and morbidity and married men are more likely to be obese.

There are several possible explanations about this epidemiological paradox. Despite the existence of obesity, its risk for diseases can be offset by the preventive and beneficiary

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[15] Marriage provides a well-defined social role and it regulates and controls the individual's daily affairs and behaviors. Thus, the married avoid risky behaviors and conduct a healthier life style. Also their role obligations prevent and limit the degree to which they can get involved in illness behaviors, adopt the sick role, and be exempt from daily functioning. So, the married are more socially integrated and their behaviors are more regulated than those of the unmarried counterparts. And their health advantage could be explained in these terms.

effects from marriage. Several studies are supporting this interpretation by denoting that married men are more likely to engage themselves in a variety of healthy behaviors such as avoiding taking risks, avoiding substance abuse, taking regular exercises and getting adequate cares. And a concurrent explanation says that obesity may not be as serious a risk factor for mortality and morbidity as other conditions that are influenced by marriage, and therefore even though married men are more obese risk factors like smoking or drinking alcohol would outweigh the impact of obesity. These two extremely different approaches about obesity and marriage are important to figure out.

To my knowledge, little has been done so far concerning this side of the relationship between marital status and obesity. Many studies revealed that obese people may have lower probability of getting married in marriage market, but the work on marital status as a cause of obesity has not been done that much. This study, therefore, is putting more weights on the second aspect of marriage and obesity, although both of them will be discussed in this paper.[16]

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[16] Cross-sectional data cannot definitely distinguish causation and selection models in marriage market between obesity and marital status. But it is a plausible assumption that in this cross-sectional analysis marital causation model is operating dominantly for the following reason. Since over 90% of people eventually marry, it suggests that selection does not necessarily prohibit marriage but that the stigmatization of obesity may influence how

II. Mechanism of Obesity

Although it is increasingly apparent that obesity is a complex and multidimensional phenomenon, there is little consensus about conceptualizing the determinants of obesity so far. A myriad of studies, however, have revealed that the body weight changes resulted directly from the change in energy balance. A weight gain is coming from the positive energy balance and weight loss is from the negative energy balance. If the consumed calories are bigger than the expended ones in a given time period, it will be accumulated in the body. Therefore, the positive energy balance can be achieved by either an increase in energy intake or a decrease in energy output; the negative energy balance is achieved by the converse.

It is known that the one and only source of energy intake is the food consumption. Energy output, however, derives from several sources such as fundamental metabolism,[17] the thermal effect of food, and physical activities including the lifestyle, and so on.[18] Like any other system, the human body obeys the laws of thermodynamics, so an excess of energy

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easily people marry and how desirable a mate they attract.

[17] A study reports that the metabolic rate of the 4-year-old children of obese parents was 10% lower than that of children of nonobese parents, even though the children were the same height and weight (Griffiths and Payne (1976)). It suggests that the difference could account for the later development of obesity in children of obese parents, even on a caloric intake that did not differ from that of the children of normal weight parents.

[18] Carefully controlled laboratory studies have found exquisitely precise relationships between changes in energy balance and changes in body weight (Garrow (1978)). But, these studies are mainly short-term laboratory investigations.

intake over expenditure will lead to storage or accumulation of energy in the form of adipose. A major problem studying obesity, however, is the apparent lack of relationship between food intake and body weight in adults even when the effects of physical activity and environment are controlled. It may be due to the underreporting of food intake by some obese people. Also, people have a tendency to report higher than their actual height and lower than their actual weight, which will lead to reporting error that may bias coefficient estimates in obesity studies.[19] But even though the food intake and energy expenditure are carefully and accurately measured, the relationship between energy intake and body weight is weak.[20] Therefore, the new understanding of metabolic system in obesity helps explain this weak linkage between the two. A study found that infants with lower energy expenditure had become overweight at age 1, whereas those with higher expenditure had not. These early differences in caloric expenditures seem unlikely to have arisen from environmental factors. It seems more probable that they are of genetic origin and that the lowered energy expenditure may be at least one means by which a genetic predisposition to obesity is

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[19] NLSY (National Longitudinal Survey of Youth) and BRFSS (Behavioral Risk Factor Surveillance System) are containing self-reported weight and height, which may bias the coefficient estimates. Cawley (2000) raises the issue to capture the reporting error by regressing the true value of the variable on its noisy reported value (see Cawley for detailed information).

[20] Mean energy intake and fat consumption in industrialized countries have declined substantially as prevalence of obesity has escalated (see Brownell *et al.* (1992), Prentice *et al.* (1995), and Seidell (1997) for detailed information).

expressed (Roberts *et al.*, 1988)[21] and also the genetic heterogeneity may lead to racial or ethnic differences in height, body circumference, and frame.

Environmental factors are another important one determining the amount of body fat, but the rearing environments appear to have no significant effects in adults (Stunkard *et al.*, 1986; Price *et al.*, 1987). Rather, the adult environments are the most important non-genetic determinants of obesity in adults. Thus, recent studies have been focusing on the roles of socioeconomic status on body weight especially in adults.

III. Measuring Overweight and Obesity

1. Some Arguments

Overweight and obesity are recently considered major health problems worldwide. A body mass index (BMI) of ≥ 25 has been classified as overweight and of ≥ 30 as obesity. However, national and epidemiologic data on overweight and obesity are not based on actual measures of body fat because of the difficulty of collecting such data from large groups and especially from the groups with obese people.

In the past, there was no universally accepted definition of obesity, but rather a

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[21] In the late 1980s and early 1990s, researchers try to figure out the roles of genes of body fat. Stunkard *et al.* (1986) find that there is a strong relationship between the weight class of the adoptees and the BMI of their biologic parents and no relationship with the BMI of their adoptive parents. Also Stunkard *et al.* (1990) suggest the substantial genetic relationship which fully accounts for the familial resemblance in BMI, whereas little or

collection of descriptive statements such as an "excess accumulation" or an "abnormally high percentage" of body fat. Such definitions are difficult to quantify methodologically because those are subjective in their interpretation. Metropolitan Life Insurance Company of New York has developed one of the most commonly used indirect measures. This relative weight method was based upon the standard weights for heights along with acceptable ranges of weight (Table 1) in its periodic Build Studies in 1983. These standards are developed for individuals in their late teens and early twenties, and are defined as the weight for which the mortality rate is minimized. So, an individual should be classified as being obese as long as his or her weight exceeds this standard by a given percent, the most common cutoff being 20 percent. In the United States, a BMI of 27.8 for men and 27.3 for women has been proposed as a definition for obesity based upon the value at the 85th percentile for body mass index data from the National Center for Health Statistics (NCHS). Basing a definition on a BMI value at a specific percentile level does not clarify the issue because the percentile level will vary with distribution of BMI values in the population and the BMI value will not correspond to a similar percentile level in a different population group. In 1997, the World Health Organization (WHO) developed a classification system for overweight and obesity based upon grades of body mass index values related to increasing the risk of comorbidity (Table

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no influence of childhood environments on BMI.

2): a BMI of between 25 and 29.9 is defined as overweight and a BMI of ≥ 30 as obesity. The increasing risk of comorbidity with a high BMI was in reference to the relationship between a high BMI and a corresponding high level of body fat. According to the WHO classification of overweight and obesity, data from the MONICA Study indicated that 10 ~ 30% of persons of European heritage around the world are obese; these data groups are 15 years old. In fact, in some non-western countries, overweight and obesity are now a more serious problem than malnutrition.

The currently available national and epidemiological prevalence data on overweight and obesity are not based on actual measures of body fat simply because it is difficult to collect such data from large groups and especially from the groups with obese people. But the continually rising obesity prevalence among children as well as adults in the United States and many other countries around the world has highlighted the need for accurate and reliable methods to assess levels of body fat. It is difficult to monitor and treat obesity without some easily acceptable assessment method or index and a reference population.

2. Measuring Obesity

Anthropometric measurements are commonly used to describe body size, shape, and the level or degree of body fat. Changes in size and composition of body that may occur with weight gains and losses associated with maturation, pregnancy, aging, and disease can alter the accuracy of anthropometric measurements to predict a given relationship or outcome in any statistical models.

Weight is the most obvious measure for describing overweight and obesity. Generally speaking, most people with high body weights tend to have high amounts of body fat. Weight has been combined with stature or height squared in the body mass index as a descriptive index of overweight and obesity, which is independent of a person's stature.[22] The main advantages of using BMI are that extensive national and epidemiological reference data are available, it has established direct relationships with body fat and with morbidity and mortality, and it is highly predictive of future risks for overweight and obesity. Weight and body mass index are very useful in monitoring the treatment of overweight and obesity because they are both sensitive to positive progress in response to treatment. Weight is easily monitored and tracked at home and also a weight change of only about 3.5 kg is sufficient to produce a unit change in BMI.

The use of BMI, however, as an index of obesity is not applicable to all the people. Principally its use has been in adults, but it is now being used in children and the elderly as well. Even though the correlation between a high BMI value in childhood or adolescence

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[22] Body Mass Index (BMI) is a better measure of obesity than weight alone because it corrects for changes in

and corresponding morbidity has not been clearly determined, high percentile levels of BMI in childhood have been linked to very significant levels of risk for obesity in adulthood.[23] [24]

The waist-to-hip ratio (WHR) is another popular index to describe adipose tissue distribution in the human body. WHRs higher than 0.85 are generally considered indicative of a masculine or central distribution of fat. According to this categorization, most men with a WHR higher than 1.0 and women with WHR higher than 0.85 are at increased risk for cardiovascular disease, diabetes, and several cancers. Central body fat is mainly associated with increased deposition of intra-abdominal adipose tissue, although increased subcutaneous abdominal adipose tissue is involved also. The waist-to-hip ratio is rather an imperfect index of intra-abdominal adipose tissue, and the use of the waist or abdominal circumference alone can provide much the same information. Abdominal thickness is another measure that has received notoriety because of supposed relationships with levels of abdominal obesity. This measurement makes sense conceptually in the sense that a large abdomen should be a thick abdomen. However, there has been a lack of consistency in standardizing this measurement.

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heights.

[23] For example, a girl with a BMI at the 85th percentile at age 12 has a risk (30-40%) of having a BMI at the same level at age of 35. And, a BMI at the 95th percentile, the corresponding adult risk is between 40 and 80% (See Guo *et al.* (1994) for detailed information).

[24] In elderly, the loss of muscle mass known as sarcopenia can cause an elderly person of normal weight and BMI to be obese because of an increased high percentage of body fat. Obesity is not an uncommon problem among the elderly.

Standardized anthropometric techniques are crucial for comparisons among both clinical and research studies.

Skinfolds are the most common anthropometric method for measuring subcutaneous fat thickness, of which the key to this approach is the implicit assumption that the degree of fat within the skin is directly proportional to the degree of general body fat. But they are not very useful in many overweight and obese adults because the availability of skinfold calipers capable of larger measurements would not be a significant improvement because of the physical difficulty of picking up a very large skinfold on an obese adult. We do not know the real distribution of subcutaneous fat measurement simply because of the measurement limitation of skinfold calipers. And the statistical relationships of skinfolds with the percentage of total body fat are often not as strong as that of BMI in both children and adults.[25]

IV. Socioeconomic Status (SES) and Obesity

The current epidemic of obesity is caused in large part by the environment that induces excessive food intake and discourages physical activities. And now, obesity is socially constructed and associated with socio-cultural norms of beauty, health and normality.

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[25] See Roche *et al.* (1981) for detailed information.

In most pre-industrialized societies, plumpness was considered more attractive and productive whereas in post-industrialized societies thinness in body shape has become a symbol of beauty, credibility, health, and even wealth. The possibility that the socioeconomic status (SES) might be associated with physical appearance or body weight was first raised by the institutional school economist Thorstein Veblen over one century ago in his investigation that thinness became an ideal of feminine beauty in "chivalric or romantic times" when it served as a status symbol of an emerging leisure class.[26]

In this vein, recent obesity studies have been focusing on the roles of socioeconomic variables, simply because the understanding biological factors, however, cannot fully capture the human obesity epidemic without any consideration of cultural, societal, and psychological effects. Thus, much of recent works report the possibility of these factors in the interactions with genetic and biological factors and the influences imposed by particular environments.[27] According to them, one of the most striking facts about obesity is known

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[26] "... In the conventional scheme of those days ladies of high degree were conceived to be in perpetual tutelage, and to be scrupulously exempt from all useful work. The resulting chivalric or romantic ideal of beauty takes cognizance chiefly of the face, and dwells on its delicacy of the hands and feet, the slender figure, and especially the slender waist. ... It has already been noticed that at the stages of economic evolution at which conspicuous leisure is much regarded as a means of good repute, the ideal requires delicate and diminutive bands and feet and a slender waist. These features, together with the other, related faults of structure that commonly go with them, go to show that the person so affected is incapable of useful effort and must therefore be supported in idleness by her owner. She is useless and expensive, and she is consequently valuable as evidence of pecuniary strength......" (Thorstein Veblen. *Theory of the Leisure Class*, Fairfield, NJ: Kelly, 1899. Ch. 6)

[27] See Sobal *et al.* (1989).

that the significant inverse relationship between obesity and SES especially in the developed countries: obesity is likely to contribute to social and economic disadvantages because obesity is negatively valued in affluent societies. Obese people tend to be discriminated in most societies and they may be less competitive in socioeconomic advancement. And low educational attainment and health-related problems attributable to obesity can further lead to the difficulties in employment or marriage and economic problems. Obviously, there are at least three possibilities for this association: prevalence of obesity influences SES, SES influences obesity or at least one unobservable factor may exist to influence both obesity and SES. And it would be probable that a common factor or factors influence both obesity and socioeconomic status greatly complicates the attribution of obesity.

Gortmaker *et al.* (1993) report the evidence for the influence of obesity on SES especially in adolescence and young adulthood basing on a longitudinal survey of a national probability sample of 10,039 subjects 16 to 24 years old in 1981 who were examined in that year and again in 1988 when they turned 23 to 31 years. Their study finds that overweight during adolescence has very important socioeconomic and psychological consequences after controlling for some mediating variables, which are greater than those of many other chronic physical conditions.[28] Furthermore, it is much more serious for women: obese women may

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[28] Gortmaker *et al.* report that persons with other chronic physical conditions do not have lower socioeconomic

be more penalized in society than obese men. Overweight and obesity differ from many other chronic conditions in its visibility. Unlike other attributes such as color of skin or sex, weight is considered to be under voluntary control, so that obese people are responsible for their current condition and for changing with a desirable one. Adolescents may be much more sensitive to weight-related mistreatment such as weight-teasing and rejection of dating because self-esteem would be a crucial part of identity formation in adolescence. Teasing frequency and teasing effect are significantly associated with dissatisfaction about the body and they may lead to self-destructive eating disorders such as anorexia nervosa and bulimia nervosa and mental depression. And obese adolescents who do not meet contemporary standards of body shape are likely to have a lower probability of courtship and more difficulty in arranging dates and establishing intimate relationships, thus, stigmatization of obese adolescents may be an important influence on needs to be thin to become attractive.[29]

The evidence that obesity influences socioeconomic status in no way contradicts the idea that socioeconomic status (SES) influences obesity, and the study of Gortmaker *et al.* also confirms this opposite directional causality. Earlier studies of parental socioeconomic

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attainment or a lower likelihood of marriage, or at least that the largest effects are limited to those with severe impairments.

[29] Recently the proportion of women students in colleges and universities of U.S. has been rising up to 57%, which makes it much more difficult for overweight 'women' students to have a dating opportunity ("Where the boys aren't." *U.S. News & World Report*, vol.126 Issue 5 (February 8, 1999): 46).

status such as educational attainment and earnings have reported that it was strongly related to the obesity prevalence in adult life. Furthermore, the strongest evidence of the causal effect of parental socioeconomic status on overweight and obesity of their children should be the adoption study,[30] in which there was a negative relation between SES of adoptive parents and the body mass index of adoptees, but no significant effect between the body mass index of the adoptive parents and that of the adoptees. The easiest way to explain these findings is that the relation between obesity and socioeconomic status is bidirectional: each influence is at work. There is a complicated mechanism, however, meaning that a third factor may influence both obesity and socioeconomic status. A good culprit is heredity, so the adoption study revealed that the socioeconomic status of biological parents influenced that of offspring with whom they had even no contact at all, probably through genetic contributions to IQ. Also, this study proved that the socioeconomic status of the biological parents influenced the body mass index of the adult adoptees, even when the investigators controlled for the mediating variables of the adoptees.[31]

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[30] See Sørensen and Price (1990) for detailed information.

[31] See Sørensen, Price, and Stunkard (1989) for detailed information.

V. Theoretical Perspectives on Marriage and Obesity

Marriage is understood as a fundamental social institution that provides a basic role in the lives of most people. Marriage provides a well-defined social role and regulates and controls the individual's daily lives and behavior.[32] And it is obvious that marital status is related to social integration through the attainment of valued social roles and statuses and through the fulfillment of social expectations. At a certain age, being "married" is the socially preferred status and the socially valued role. Failure to acquire or maintain this status is sometimes understood as a failure to live up to social norms and expectations. Also a family is considered a political, economic, and educational unit as well as a child-rearing one from a joint production and joint consumption within a family. Generally speaking, one of the most important roles a person in a marriage life is that of spouse for his or her partner. It basically takes huge length of time and effort on courtship and mating in the process of spousal choices, and they would be demarcated from marital role after the wedding rituals with which lots of rights and duties are imposed. Some rights and duties of the marital role can influence behaviors and life style relevant to weight gain or obesity such as eating and activity patterns. Also personal and/or social values and norms which are associated with marital roles are correlated with preferred body shape.

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[32] See Anson (1989) for more literature review.

For there to be a marriage, it is obvious that a man and a woman must be available in a marriage market. The desire to get a better physical attractiveness to the potential mates is the primary reason that people are concerned about their physical appearance. Mainly unmarried people try to avoid being overweight or obese in the marriage market. In the sense, additional costs will be incurred from the obesity to offset the disadvantages in the marriage market and these costs will grow bigger with lower spouse availability in a given area.[33] Theoretically and empirically, marriage depends upon exogenous market conditions; imbalance in the relative availability of men and women has significant effects on their comparative status and power, on norms of sexual behaviors, and on marriage rates, and childbearing practices. To understand marriage, what is important is the sex ratio among unmarried people who are at a marriageable age. Guttentag and Secord (1983) raise this issue with "availability ratio." In terms of this ratio, the increasing shortage of males for females in the prime marriageable ages has been shown to relate to increasing age of marriage, increasing percentages of singles, declining marital fertility, rising rate of divorce, rising female employment and higher female earnings in the contemporary United States.[34] In 1980, unmarried white women under 24 had an ample number of males from which to

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[33] According to Angrist (2002), the empirical results suggest that high sex ratios led to a large positive effect on the likelihood of female marriage by increasing the bargaining power of women in the marriage market, but a large negative effect on female labor force participation.

choose, but for such women over 25 the number of men shrank rapidly.[35]

Lower availability ratio will contribute to high rates of out-of-wedlock childbearing and cohabitation, low marriage rates and high fragility of marriage, and low levels of male parental investment. We can relate these facts to Becker's theory that women have big incentive to become more "efficient" or "competitive" – attractive to marriageable men in the marriage market. Men may penalize obese or overweight women to compensate for their "distaste" for those people. Their preferences may arise from the prejudice or lack of knowledge about the attractiveness and productivity of the obese people. Also, people may statistically discriminate against obese individuals simply because they may believe that obesity and overweight serve as a strong proxy for factors like higher expected health care costs[36] or shorter life expectancies. Therefore, people in the marriage market are less likely to be obese due to stigmatization, rather they try to lose weight to draw more attention from their potential partners by spending money in the fitness centers or health clubs.[37]

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[34] Guttentag and Secord (1983).

[35] Goldman *et al.* (1984).

[36] Recent estimates suggest that obesity accounts for 5.7% of US total direct health care costs, but these estimates have not accounted for the increased death rate among obese people. Therefore, it is required to check whether the direct health costs attributable to obesity are offset by the increased mortality rate among obese individuals (See Allison *et al.* (1999) for detailed information).

[37] Young people also go to these places to meet and date because gyms and health clubs are very sexy places. For this purpose, they can go to bars and night clubs where potential mates are hanging around ("The Bridget Jones Economy." *The Economist*, February 2002).

The marital role will provide support and resources which may influence eating and exercise habits. In that sense, there are two theoretical perspectives to consider the relationship between marital status and obesity. Obesity can affect the entry into the marital role, or by contrast, marital status influences obesity. These two models are not mutually exclusive, and both of them may operate separately or interactively. It is important to note that these two models may predict opposite results: marital choice model suggests that non-married people will be heavier with a causation model mentioning that married people will be heavier in modern cultures.

1. Marital Selection (Choice) Model

According to the marital choice model, obesity can inhibit entry into the marital role through the marriage market. Simply put, individuals who are not as socially desirable are less likely to have an opportunity to date and attract a potential mate. Most current societies like U.S. and other countries that accomplished economic development have a tendency to value thinness much more highly, whereas most traditional and pre-industrialized societies preferred fatness as a symbol of good harvest or affluence in many aspects. Therefore, the failure to meet the cultural preferences for slimness may lead obesity to be stigmatized in modern societies because obesity can play a role as a barrier for entry into the marriage role and also as a signal or proxy for some unobservable potentials including life expectancy, future productivity and its related characteristics. The marital choice model is also supported by the studies that report that eating less is regarded as more feminine. Obesity from overeating pattern may hamper success in marital choice and marriage life as well for obese women especially. Obese teenagers and college students date less often than their slim counterparts, and overweight is sufficiently stigmatizing that it carries considerable amount of cost in the dating market. This stigma manifests itself in many situations, which can be summarized by noting that the obese people are frequently teased and maligned because of their physical appearance. Physical appearance has long been considered as more important in marriage for women than men because men have relatively large number of socioeconomic factors such as occupations, income, education level, and wealth than women, which can offset or even dominate the disadvantage that result from the 'bad' appearance. Finally, assortative mating in our modern society suggests that thinner women are marrying up in socioeconomic status (SES), whereas fatter women are marrying down in SES. This implies that people are attaching very big importance to physical appearance for success in attracting potential mates in a marriage market.

2. Marital Causation Model

The marital causation model, by contrast, describes that people in the marital role can benefit much more social support than those who are not married. Once people get married, however, the marital roles may have positive effect on the weight change. Married people are more likely to be obese or overweight. The continuous spousal support can lead to obesity through diet, activity, and social values. The lifestyle of married people leads to more stable eating patterns and eating patterns may change in the direction of increased calorie consumption or larger amount of food when men got married. The gorging meal pattern has been associated with obesity among older married men and with weight gain among adolescents in a controlled intervention trial.[38] [39] And meals eaten together with other people tend to be larger than those eaten alone. Shared roles from living in a common household can require responsibilities for eating together and provide social support for married individuals as compared to the lack of such role-determined eating patterns for unmarried or previously married people.

People living alone have poorer eating patterns, which can lead to lower caloric intake. The time spent in spousal roles may incur an opportunity cost that does not allow as

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[38]Fabry *et al.* "The Frequency of Meals: Its Relation to Overweight, Hypercholesterolaemia, and Decreased G lucose-Tolerance." *Lancet, 2* (1964): 614 – 615.

[39] Fabry *et al.* "Effect of Meal Frequency in Schoolchildren: Changes in Weight-height Proportion and

much time for recreational or sporting activities for married people as for those who have no obligations. People try to have control over their weight to look attractive before they get married, and once they enter the marital role weight control may be less valued so that diet or exercise to keep slim may be de-emphasized or even abandoned. Furthermore, newly married men may lose their incentives to be sexually attractive (competitive) that they have had in the marriage market and thus allow themselves to gain weight through the release of previously inhibited weight-gain behaviors.

In fact, both of the models are acting to some extent and this may be specific to some age groups, with the choice model most applicable to younger people and the causation model more applicable to the people who have been married for substantial periods of time. In cross-sectional data across the entire spectrum of age groups, therefore, the causation model is hypothesized to predominate for the relationship between marital status and obesity, which means that people in the marriage role will be more likely to be obese than their unmarried counterparts.

3. Variables in the Marital Roles

In this obesity analysis, other variables must be controlled for the following reasons.

Skinfold Thickness." *American Journal of Clinical Nutrition 18* (1966): 358 – 361.

Firstly, it is important to insure that the channel between marital status and obesity is not a spurious one due to any predetermined variables that can influence marital status and /or obesity or set the conditions under which a relationship between marital status and obesity may occur. Secondly, it is meaningful to identify any mediating variables in the relationship using some variables that may act as mediating mechanisms through which marital status affects obesity. Thirdly, it is also an important issue to control for the social roles as well as marital status simply because stigma of obesity can be stronger for some groups. Marital status will vary by age, mainly with younger people more often being unmarried and older people more often in terminated marriages.[40] Also, body mass index (BMI) increases biologically with age, which means people gain more weights as they grow older. Likewise, obesity prevalence will vary among the racial or ethnic groups as marital patterns do. Fourth, we can identify the existence of an inverse relationship between socioeconomic status (SES) and obesity for women and mixed patterns occur for men, suggesting that gender differences as well as education level and income need to be controlled. In addition, involvement in other roles than marriage life may lead the impact of the marital role on obesity to be improved or ameliorated. In a labor market, for instance, some employment roles may demand social support and values, resources, and norms about physical appearance such as

[40] It is also possible that the termination of a marriage is accompanied by depressive symptoms that may lead to

beauty and slimness, and the roles of employees can be related to those in the marital status.

The mediating variables of interest encompass not only the diet and physical activity patterns such as smoking or exercise on a regular basis but also social variables that can possibly influence obesity. Investigation of obesity mechanism in terms of social variables including parental role, living status, and psychological or emotional feelings can provide the possible channel to obesity. People consume more resources and time to fill the role of parents. Parents have less amount of time for physical exercise and may be more exposed to snacks and fast foods from their children, which could lead to rising parental obesity and children's obesity, as well.[41] Living status has been suggested as a fundamental factor for health in terms of morbidity or mortality. Individuals who live alone are more frequently exposed to risky behaviors which can cause higher morbidity and mortality.[42] Those who live alone eat less and so that they would be expected to be less obese. People who have never been married or previously married would have less positive and stable emotional or psychological well-being than their currently married counterparts, and the problems arising

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weight-loss.

[41] Some studies also suggest that women's weight gain due to the pregnancy can lead to retaining weight even after delivery, which would operate physiologically to invite a greater parental obesity on top of any effects of the parental role (See Parham *et al.* (1990)).

[42] But, living with adult(s) in any non-marriage relationship may serve as a functional alternative to healthy effects of marriage (Anson, *op cit.*).

in emotional status tend to affect on weight change through decreased appetite.

It is well known that the physiological mechanisms in which marital status may influence obesity put together caloric intake, energy expenditure, and changes in metabolism as well. It is plausible that we expect married people eat more as part of a role obligation to their spouse. As mentioned already, energy intake and expenditure are important in manipulating body fat levels, and exercises and activities on a daily basis would be expected to be lower among the people with marital role obligations. Metabolic processes play a role in energy balance, with smoking being also an important factor upon metabolism which leads to a lower body weight among the people who smoke. Cigarette smoking can be chosen easily since it is a cheap and time-saving substitute for exercise which requires substantial periods of time and physical activities. Married people are less likely to smoke than those who are not married, suggesting that it would lead to more obesity among the people in the marital role.

A model for the operating mechanism of these variables mentioned above will provide a robust direction for this analysis. A set of antecedent variables (i.e. sex, age, ethnicity, education, and employment status, and income etc.) will influence marital status, and social mediating variables (number of children, living status, and emotional well-being, etc.) of interest in this model will demonstrate a possible track in which marital status can influence obesity. Through health-related variables, we can identify a biological effect mechanism of marriage upon obesity. Examining the model for the relationship between the marital status and obesity will permit assessment of whether a relationship actually exists and examination of the conditions under which it occurs as well. Depending upon the preexisting literature and applying a role theoretical perspective, this analysis will examine the relationship between the marital status and obesity using a nationally representative panel data of 2000 wave of National Longitudinal Survey of Youth data (NLSY 79).

VI. Literature Review

Several studies in economics and sociology have tried to figure out the impact of obesity or weight gain on the socioeconomic status (SES) even though the vast majority of the literature is dealing with the obesity in medical and nutritional sectors. Register and Williams (1990) figure out the existence of wage penalty of obesity and conclude obese women more than 12 percent less than comparable non-obese women but men have no significant effect of obesity. They use a cross sectional sample of 18- to 25-year-olds of the labor force consisting of both part-time and full-time workers from the 1982 round of the National Longitudinal Survey of Youth (NLYS). These two groups of workers are quite clearly different in their attachment to the labor force, implying that their underlying preferences are different as well. So, this empirical model treating both groups as identical may yield results that do not apply fully to either. And, if there are productivity differences between obese and nonobese workers which are not captured by the other variables in the analysis, then the measures would be biased. And, it is possible that obese and nonobese workers self-select into different types of occupations, so that occupation-specific wage premiums might be paid to the nonobese workers. We can also imagine the reverse causality such that "obesity may be due to the low economic earnings, to the extent that income level affects food and nutritional consumption behaviors." In addition, they conclude that the lower earnings associated with obesity among women may result from customer rather than employer discrimination (Becker, 1971).[43]

A study of Frieze *et al.* (1991), using a sample of 737 male and female MBA graduates from the years between 1973 and 1982, reveals that more attractive men have higher starting salaries and they continue to earn more over time. For women, however, no significant effect of attractiveness on starting salaries is found, but more attractive women earn more later on in their jobs. They rate for facial attractiveness on a 5-point scale from 1 = very unattractive to 5 = very attractive on the basis of the photographs in picture books of full-time MBA students taken at the beginning of their matriculation in an MBA program putting on business attire. They report that facial attractiveness had a positive and significant effect on a male MBA's inflation-adjusted annual starting salary. Each unit increase in his average attractiveness rating tended to raise his annual salary by $1,100. In contrast, the regression analysis for women revealed that the average attractiveness ratings did not have a significant effect on women's inflation-adjusted starting salaries. It provides evidence in support of the hypothesis that the attractiveness effects would be more consistent for men than for women and would show higher coefficients. Even though they put the weight and

[43] The fact that the significant economic implications resulting from obesity is important only for women may be attributed to several factors; our own society may impose a double standard when comparing men and women. On the other hand, men and women carry weight differently and have significantly different body fat and muscle compositions so that the effect which the measure of obesity has on appearance could differ by

height variables in their analysis, they mainly focus on the facial attractiveness on a very subjective evaluation method. Besides, the findings of their research apply to people with MBA degrees, most of whom are employed in business jobs. The practical questions like how specific these data are to this type of occupation need to be further investigated. Perhaps a matching model operates where assumptions about the characteristics of the person.

Loh (1993), following up Register and Williams(1990), examines the wage effects of height and weight in a sample of full-time young adult workers from the 1982 National Longitudinal Survey Youth Cohort and wage change between 1982 and 1985. This study has the results which are consistent with findings in other fields on the effects of physical appearance and finds that height and weight have statistically significant impacts on the wage level and wage growth of both male and female workers. He focuses on height and weight because information is available in economic data sets while more general indexes of attractiveness are not. Data on height and weight are also less subject to measurement error because they do not depend on subjective ratings from observers. Loh finds out that workers taller than the population average receive an hourly wage rate 4 to 6 percent higher than those who are shorter than average, other things held constant. For the full-time workers, however, obesity does not affect wage levels, but it lowers men's wage growth rate by

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gender (Register and Williams (1990)).

approximately 5.5 percent in the years from 1982 to 1985. Since no one can prove that these effects on wages are due to productivity differences, the explanation may point to the existence of employer discrimination meaning that employer may penalize overweight or obese employees to compensate for their "distaste" for these workers. These preferences arise from prejudice or lack of knowledge about the productivity of the obese.[44] Also he focuses on the omitted variables for the wage differences: since the average person attains his or her full adult height by age 18, which is the minimum age of workers in the data set, height and weight remain statistically significant although the magnitudes are slightly reduced. And height and weight are proxies for differences in family background. Since poorer families may have poorer diets in nutrition, the family members may be smaller on average than richer families. Or poorer families may have more obese members as long as their diet consists primarily of cheap starchy or junk foods.

Sargent and Blanchflower (1994) examine the association between obesity and stature at various ages and earnings in young men and women at age 23 years from the National Child Development Study containing all the children born in U.K. between March 3 and 9, 1958. They point the lagged relationships that women who were obese at 16 earn about 7.4

[44] Employers may statistically discriminate against overweight or obese individuals because they may believe that obesity serves as a proxy for factors such as higher probability of health risks which will incur higher expected health care costs and lack of discipline. Also, employers may be reluctant to provide firm-specific, on-the-job training to the obese workers if they feel that they reap a relatively lower return on the investment for

percent less per hour at age 23 years than their nonobese counterparts. But, no statistically significant differences are found between obese and nonobese men.[45] Even after controlling for mediating variables like social class (occupation of the head of household when the interviewee was 11 years old) and IQ scores (a test of math and reading ability administered at ages 7, 11, and 16), they report that women who were obese at age 16 suffered a similar wage disadvantage at age 23, whether or not they remained obese at age 23. It can be explained by the result that men and women who had been obese at 16 had significantly fewer years of schooling than did their nonobese peers, suggesting that events that occur around entry into the labor market may mediate this effect. Young adults enter a phase of intensive evaluation during the initial period of the participation to the labor force, and the results may be consistent with the idea that physical appearance can affect this transition from school to work.

Averett and Korenman (1996) show the income, marital status, and hourly pay differentials by body mass index (kg/m^2) in a sample of 23- to 31-year-olds drawn from the 1988 NLSY. They find the obese women have lower family incomes than the women whose weight-for-height is in the recommended range but the results for men are weaker and mixed.

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the obese workers, perhaps because of their shorter payoff periods.

[45] They find a positive relationship between height and subsequent earnings in the case of men (Sargent and Blanchflower (1994)).

They find this to be true before and after taking sister differences. Differences in economic status by BMI for women increase markedly when using an earlier weight measure or restrict the sample to persons who were single and childless when early weight was reported. They also mention the existence of labor market discrimination against obese women. Differences in the probabilities of marriage and spouse's earnings account for 50 to 95 percent of their lower economic status. Men have little evidence of an effect of obesity on family income or marriage market outcomes. Simply put, women are paying a penalty for being obese, but overweight men can sort themselves into jobs to outweigh this penalty due to relatively lower barriers they face in moving across occupations. Further, it is hypothesized that weight will be most related to occupational position in male-dominated occupations and in some occupations that involve frequent contact outside the firm. Therefore, to account for these influences, earnings functions should include occupational dummies as well as interaction terms between the occupational dummies and physical appearance variable. In the marriage market, we can explain that men have other socioeconomic and emotional factors than appearance that make themselves attractive to the potential mates.

Pagán and Dávila (1997), in the 1989 NLSY data, report that women pay a penalty for being obese, but overweight males sort themselves into jobs to offset this penalty or to take advantage of potential weight-related effects via occupational mobility. They also refer to the possibility of endogeneity of body weight[46] and argue that individuals may gain weight in occupations with high levels of stress and little physical activity. In terms of hedonic model, therefore, the individuals prone to obesity may choose occupations in service sector because this occupation affords them a higher wage in compensation for accepting a higher level of stress. But they find there are fewer overweight women in managerial and professional sector than their model predicts.

Cawley (2000) studies the relationship between body weight and the labor market outcomes for women. Applying the instrumental variable (body mass index of women's children with 6 to 9 of age ranges) method to data from NLSY, he attempts to generate consistent estimates of the effect of weight on women's labor market outcomes such as hourly wages, employment status, and sector of occupation assuming that the instrumented variable in his study is correlated with the weight of its biological mother, but uncorrelated with the mother's wage residual. He also emphasizes causality from obesity to labor market outcomes probably due to discrimination and less productivity of heavier people because they are more likely to be sick.

Lakdawalla and Philipson (2002), based on the previous qualitative and theoretical

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[46] By using a Hausman specification test, Pagán and Dávila fail to reject the hypothesis that weight is uncorrelated with the error term of the wage function. But, their analysis is flawed in the sense that the IV used (family poverty level in 1988, health limitations, and indicator dummy variables about self-esteem, etc.) are also correlated with the error term in the wage function.

discussion by Posner and Philipson (1999), estimate the importance of job-related physical activity in determining the weight differences controlling for other factors such as years of formal schooling completed and income. And they could find that technological change has led to weight growth by making home- and market-production more sedentary and thus lowering food prices through agricultural innovation. By merging three different data sets such as the National health Interview Survey (NHIS), the National Health and Nutrition Examination Survey (NHANES), and the National Longitudinal Survey of Youth (NLSY), they argue that the negative effect of earned income on body mass index (BMI) is weakened if work is sedentary and try to decompose the long run growth in weight over the past few decades to find out some 40 percent of growth is from food supply expansion and about 60 percent from demand sector such as reduced physical activity.

Chou, Grossman, and Saffer (2002) reveal the relationship between regional growth in obesity and the increase in the number of fast food restaurants and other types of restaurants, and the change in price of a meal of each type of restaurant. By using 1984-1999 Behavioral Risk Factor Surveillance System (BRFSS) data, they argue that the growth of women's time price has made it more costly to monitor the calorie intake at home, which means rising prices for food preparation, consumption, and any related activities at home, and has led to growth in the demand for convenience food and fast food which is considered as unhealthy "junk" food. They also discuss that obesity among adults is related to relative price variations including price of cigarettes, clean indoor air laws, hours of work, and hourly wages by age, gender, race, years of formal schooling completed, and marital status.

VII. Data (National Longitudinal Survey of Youth 1979)

This investigation employs the 2000 wave of the National Longitudinal Survey of Youth (NLSY79) data, which was first designed in 1979. The NLSY data is very appropriate for this research for several reasons: it contains human capital variables along with the weight and height of the sampled respondents and the retention rates for the targeted individuals remaining in the data for interview have remained close to 90 percent for the past 21 years of follow-ups. And the NLSY79 is a nationally representative panel data set for the entire population with 12,686 (6,283 of whom are female) young men and women[47] who were 14 to 22 years old (who were born between January 1, 1957 and December 31, 1964) when they were first surveyed in 1979. In year 2000, these individuals turned mid thirties

[47] NLSY 79 originally consists of 6,111 respondents who are U.S. non-institutionalized civilian men and women, a supplemental sample of 5,295 minority (Hispanics and blacks) and economically disadvantaged civilian youths (non-Hispanic/non-black), both of whom are randomly selected, and a sample of 1,280 youths enlisted in one of the four branches of the army on active duty with funding from the Department of Defense and the Armed Services. Due to the funding constraints, however, some respondents in the original sample are no longer being interviewed. Since the 1984 interview, 1,079 military members of subsample were no longer eligible for interview with 201 members remain in the survey. And following the 1990 interview, all the 1,643 members of the economically disadvantaged, non-Hispanic/non-black subsample were excluded from the survey.

and forties, and have been personally interviewed for the last two decades[48]; thus the results may not generalize to the broader age group in the whole U.S. population.

At baseline, first of all, individuals were asked to report their racial or ethnical background, with which the NLSY could decompose the sample into three parts: blacks, Hispanics, and non-black/non-Hispanics. In this study, non-black/non-Hispanics are considered as whites[49] because the vast majority of the people in that group are whites, although it should be noted that this group is totally heterogeneous.

A respondent's height and weight are natural indicators of body mass index (BMI) as well as health. The NLSY recorded the self-reported height of respondents in 1981, 1982, 1983[50], and 1985. Information on height was not collected as of 1986 survey, presumably because most of the individuals are assumed to have attained adult stature. This study uses the height data in 1985 and multiplies them by 2.54/100 to get height in meters for body mass index. The height questions have been collected in a variety of formats: the 1981 question combines feet and inches into a single number, so the respondents range from 400 (i.e. four

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[48] NLSY79 has been conducted annually since 1979. Since 1994, however, interviews have been conducted every two years so far.

[49] "Non-black/non-Hispanics" included those whose race was coded "white" or "other" and who did not identify themselves as either black or Hispanic in answer to the ethnicity question. Instructions to interviewers for coding race based upon the assignment of National Opinion research Center (NORC) at the University of Chicago included (1) classifying those of Latin American descent as "non-black/non-Hispanic" unless they were obviously black or of some other non-white race and (2) coding in the "other" category those persons who were Japanese, Chinese, Vietnamese, Asian Indian, Native American, Korean, Eskimo, Pacific Islander, or of another non-black, non-white race.

feet and zero inches) to 611 (six feet and eleven inches); the 1982 and 1985 questions convert all answers into just inches; and the 1983 height questions are found under two different reference numbers: female height in feet and height in inches.

Since the weight fluctuations are much more than those of height, questions on weight are asked more frequently in 1981, 1982, 1985, 1986, 1988, 1989, 1990, and 1992 – 2000 surveys.[51] Weight in all survey years above is recorded in pounds. The weight data are normally distributed from 50 to 400 pounds in all years except 1989.[52] To convert weight in pounds into those in kilograms, we need to multiply weight in pounds by 0.4536 since 1 pound is approximately equivalent to 0.4536 kilogram.[53] Finally, Body Mass Index (BMI, also known as Quetelet's Index) is calculated as weight in kilograms over height in meters squared. Tables 3 and 4 describe the distribution of BMI among NLSY men and women by age.

Marital status information for NLSY79 respondents was available first of all from the

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[50] Height data in 1983 were collected by asking only to females who were ever pregnant.

[51] The weights for 1981 and 1982 were recorded at a time when most respondents were young (aged 17-25) and weight changes would represent the natural course of growth, so these observations were dropped.

[52] In 1989, 11 respondents marked as weighing 996 pounds. This number is not true weight but rather an out-of-range code.

[53] And women who are pregnant at the time that they report their body weight are dropped from the sample on the basis of the following two questions. First, women were asked whether they were currently pregnant at the time of interview. And second, in some years they were also asked whether they had, in retrospect, been pregnant at the time of the last interview.

responses to questions fielded during the annual or biennial surveys, and from two sets of created variables specifying marital status as of the interview date. And it was also available from an item on the marital status of each respondent as of the previous interview derived from the interviewing aid called the information sheet. The marital status of each respondent, such as whether he or she was married, widowed, divorced, separated, or never married, was collected during the 1979 survey and is available as a single variable of 'Marital Status.' From 1980 to 1987, the interviews collected change in marital status information. During the 1988 and subsequent surveys, the 'Current Marital Status' interview checks are included in the questionnaire to verify separately the marital status of respondents who report a change in their marital status since the date of last interview and respondents who do not.[54] Prior to 1988, marital status was created based on the last actual stated change in marital status. Marital status for 1988 and subsequent survey years has been created from the interview checks. Since 1980, a marital status variable has been available from each interview sheet. This variable reflects the respondent's current marital status as of the date of the last interview. Coding categories are similar to those for the created marital status variables but

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[54] Two created variables provide data on the respondent's marital status, incorporating any changes, as of each interview date. The first set of yearly created 'Marital Status' variables is constructed with coding categories of "never married," "married," "separated," "divorced," and "widowed." Although two additional categories, "remarried" and "reunited" are present within the "Marital History" section of the questionnaire, those respondents who are remarried or reunited are simply coded as "married" in the created variable series. A collapsed version of this variable that codes the respondent's status as "never married," "married spouse present." Or "other" is also available.

differ slightly across years.[55] Also prior to 1982, presence of a partner was indicated by an interview check coded "yes" if the respondent lived with at least one unrelated adult of the opposite sex. From 1982 to 1986, Version C of the *Household Interview Form*, which was completed by those who lived in their own dwelling unit or in military family housing, asked those respondents who were living with at least one unrelated adult of the opposite sex but no spouse whether they lived with a partner. Since 1987, only one version of the *Household Interview Form* has been used; all respondents not living with a spouse have been asked about opposite-sex partners. The partner variable originating from the household interview is tilted 'Currently Living as Partner with Opposite Sex Adult.' And following cohabitation information is available from the 1990 and 1992 to 2000 surveys: (1) the month and year the respondent and his/her opposite-sex partner began living together; (2) whether the respondent lived with his/her spouse before marriage; (3) the month and year the respondent and his/her spouse began living together; and (4) whether the respondent and his/her spouse lived together continuously until marriage. A household member's relationship to the respondent may be listed as "partner" in the "Household record" portion, which is filled out during the yearly household interview. This is true regardless of whether the "partner" is of the same or

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[55] In addition to these data, information is available on respondents' age at first marriage, the presence of opposite-sex partners, and the marital status of household members. The 'Age Began 1st Marriage' variable series has been created for 1982 through the present from the created 'Month/year began 1st Marriage' variables and from the 1979 date of birth.

opposite sex as the respondent. However, only opposite-sex partners are referenced during the interview for questions relating to household, income, and dating/relationship.

Cigarette smoking data were collected, during the 1984 survey, on age at first use, most recent use, and number of cigarettes smoked in the past 30 days. And the 1992 and 1994 surveys gathered information from those respondents who had smoked at least 100 cigarettes in their life on the age that they started smoking daily or the number of months or years since they had last smoked daily.

VIII. Methodology: Econometric Model

The objective of this paper is to assess the extent to which the relation between obesity or weight-gain and marital status is causal. Due to the probable structural endogeneity between the two variables that may interact, I put the structural models for obesity (O_i) and marital status (M_i) for the empirical investigation:

$$\begin{cases} O_i = \alpha_1 M_i + \alpha_2 X_i + \alpha_3 \mu_i + \varepsilon_i & (1) \\ M_i = \beta_1 O_i + \beta_2 Y_i + \beta_3 \nu_i + \eta_i & (2) \end{cases}$$

Equation (1) tells that obesity (O_i) has a functional form of marital status (M_i), observable socioeconomic variables (X_i) that determine body weight gain, and unobservable individual characteristics (μ_i) such as self-esteem or stigmatization. And equation (2) indicates the demand function for marriage with the insertion of observed individual characteristics that determine (the likelihood of) marriage (Y_i), obesity (O_i), and unobservable determinants (ν_i) such as affection and emotional motives.

The parameter we want to identify will be α_1, which is the structural effect of marital status on obesity. The reduced form of equation (3) is found from (2) by substituting equation (1) for O_i: $M_i = \beta_1(\alpha_1 M_i + \alpha_2 X_i + \alpha_3 \mu_i + \varepsilon_i) + \beta_2 Y_i + \beta_3 \nu_i + \eta_i$, and we get:

$(1 - \beta_1 \alpha_1) M_i = \alpha_2 \beta_1 X_i + \alpha_3 \beta_1 \mu_i + \beta_1 \varepsilon_i + \beta_2 Y_i + \beta_3 \nu_i + \eta_i$. Finally, it will simplify to

$$M_i = \frac{\alpha_2 \beta_1}{1 - \alpha_1 \beta_1} X_i + \frac{\beta_2}{1 - \alpha_1 \beta_1} Y_i + \frac{\alpha_3 \beta_1}{1 - \alpha_1 \beta_1} \mu_i + \frac{\beta_3}{1 - \alpha_1 \beta_1} \nu_i + \frac{\beta_1 \varepsilon_i + \eta_i}{1 - \alpha_1 \beta_1} \qquad (3)$$

, which can simplify to

$$M_i = \Pi_1 X_i + \Pi_2 Y_i + \Pi_3 \mu_i + \Pi_4 \nu_i + \beta_1 \varepsilon_i + \eta_i \quad (3)'.$$

If μ_i and ν_i determine obesity (O_i) and marriage (M_i) respectively ($\alpha_3 \neq 0$ and $\beta_3 \neq 0$), OLS will lead to biased and inconsistent estimates of the structural effect α_1 for two reasons: first, because unmeasured components of μ are likely to be correlated with marital status (i.e. statistical endogeneity); and second because marital status may be correlated with error term (ε_i) in equation (1) due to its causal dependence on obesity (i.e. structural endogeneity). Also, since obesity can be considered a detrimental factor in marriage market ($\beta_1 \neq 0$), in other words, if there is structural endogeneity, marriage may be correlated with the error term. Initially, I estimate equation (1) using a standard probit model with a parsimonious set of covariates and then with an expanded set of covariates. Estimating the basic and extended models allows us to evaluate how much of the association between marital status and obesity or weight-gain is driven by such omitted individual heterogeneity. If the magnitude of the marginal effect of obesity is highly sensitive to the inclusion of additional correlates, then it is reasonable to conclude that unobservable factors play an important role in this relationship. So the any correlation between marital status and obesity is more likely the result of selection bias rather than true causation. The importance of unobservables implies that there is something systematically different among adults who are married and also engage in specific lifestyle that can lead to weight gain or obesity. The estimated coefficients from the extended models may be considered upper bound estimates of the impact of marital status on obesity, controlling for additional selection on unobserved traits would only attenuate this effect.

If the simple comparison shows that selection on unobservable characteristics is strong, then standard probit estimates of equation (1) will be biased because it is likely that the remaining unobserved factors are confounding the relationship between marital status and obesity. For example, unobserved personality or psychological element traits such as time preference, self esteem as well as peer effects may be driving both outcomes. This problem arises often in applied health economics research. In the absence of solid natural experiments, the common procedure would be to estimate equation (1) using instrumental variables (IVs) or to jointly estimate the marital status and obesity equations using bivariate probit model.

The practical implementation of the instrumental variables estimation procedure requires valid exclusion restrictions (instruments), which is variables that predict marital status but have no direct effect on obesity. In this analysis, I attempted to follow this approach by adopting parents' marital status of respondents as instrument for marital status (marital selection) model. This instrument, however, was proved to be weak and poor predictor of marital selection. The problems associated with weak instruments and the resulting excerbation of bias are well discussed (Bound *et al.*, 1995), and thus limits the application of this approach in this case.

Therefore, we want to estimate jointly the obesity and marriage equations using a bivariate probit model, which can account for the possible correlated factors that are not observable. The bivariate probit model is based upon the assumption that the unmeasured determinants in equation (1) and (3) have a joint, bivariate normal distribution. This is an attractive feature of this model to the particular situation we want to analyze here: it is very intuitive to imagine that the "inclination" of the marital status has some relationship with the attitude of the person towards his or her physical appearance, and vice-versa. Therefore, even though the two reduced-form equations are separate univariate discrete-choice models, they can benefit from joint estimation, which establishes the bivariate model. This comes directly from the consideration of greater asymptotic efficiency in the Maximum Likelihood Estimation (MLE) context, in the case where the coefficient of correlation (ρ) is not equal to zero. If we further assume the bivariate standard normal distribution as a link function, we have the bivariate probit model with log-likelihood function. This procedure is applied if marital status (M_i) and fatness or obesity (O_i) are measured as dichotomous variables. As noted above, the appropriate specification for this type of model is the bivariate probit, a simultaneous equations model that controls for the endogeneity of two related choice. And bivariate probit model accounts for the correlation between the error terms in these two equations because of the statistical and structural endogeneity. In this bivariate probit specification all variables are observed for each individual. The model is just identified when the same vector of covariates appears in each equation. The random error terms, ε_i and η_i, may be dependent and normally distributed, such that $E(\varepsilon_i) = E(\eta_i) = 0$, $\text{var}(\varepsilon_i) = \text{var}(\eta_i) = 1$, and $\text{cov}(\varepsilon_i, \eta_i) = \rho$. If a Wald Test shows ρ is insignificant then no endogeneity bias present and the two models can be estimated separately as binomial probits. If, however, ρ is significant and the log-likelihood of the bivariate estimate is significantly less than the joint binomial probit log-likelihood, then indeed obesity and marital status are endogeneous processes (Bertaut 1998).[56] Equations (1) and (2) are simultaneously estimated using maximum likelihood, producing unbiased estimates of parameter coefficients and correlation coefficient. The interpretation of ρ is that it captures the correlation between the effects of unobservables in the models of obesity and marital status. If the unobservable effects are purely random across time and individuals, then there will be zero correlation between the disturbance terms in the models. A positive correlation between the error terms

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[56] In recent health literature, bivariate probit has been used to measure the effects of having a regular provider on the use of specific preventive health care services (Ettner (1996)), to show the low-income veterans with relatively greater disabilities were less likely to obtain private insurance and more likely to use VA hospitals (Hisnanick and Surinder (1996)), and to investigate the social determinants of child immunization and prenatal and delivery cares (McQuestions (2001)) and so on.

would be expected if the same unobservables are relevant in the two equations. Equations (1) and (3) can be jointly estimated, of which the results are equivalent to estimating (1) and (2).[57]

But if the same vector of socioeconomic and demographic factors are included in both equations (assuming X_i and Y_i are the same), then the identification comes purely from functional form restrictions. In practice, however, such functional form restrictions are insufficient and hardly defensible, and the bivariate probit model performs relatively poorly. Similarly to instrumental variables, as mentioned above, the bivariate probit model requires valid exclusion restrictions – variables that affect marital status but do not directly affect obesity. Since we failed to have a 'strong' exclusion restriction in this study, the bivariate probit estimation was the poor performance and has very little power to detect reliably true effects.

An alternative identification strategy that does not rely on exclusion restrictions has been raised by Altonji *et al.* (2000). Identification in this case can be achieved by constraining the value of ρ, the correlation coefficient between the disturbance terms in the two equations. Firstly, the analysis can start by constraining ρ to be 0.1 initially and then incrementally increase it to 0.2, 0.3, 0.4, and 0.5. This type of analysis will allow us to

[57] If bivariate probit model is properly used, both estimations should show a consistent estimate of α_1.

examine whether the effect of marital status or marital role on obesity (weight-gain) is robust to such changes, and the threshold at which marital status has no longer statistically significant effect. Next, we constrain ρ such that the amount of selection on unobservable factors is equal to the amount of selection on observable factors. Equal selection would correspond to a situation where the observable determinants of an outcome are truly just a random subset of the complete set of determinants. That is, the data collected on respondents are not necessarily less relevant to obesity than the data which are not observed. Regardless, we can still use this equal selection rule to provide a benchmark against which to compare other estimates. This procedure is discussed in Apendix 1 in greater details.

IX. Results

1. Ordinary Least Squares Analysis

A series of regression analyses are presented in Table 6 for men and Table 7 for women respectively using BMI (Body Mass Index, kg/m^2) as a dependent variable. The first column in each table indicates the Model 1 relationship where body mass index (BMI) is regressed on the dummy variables of marital status; married and previously married. Among men, this relationship without controlling for any other demographic, social and physical variables reveals that both married and previously married men were significantly fatter than their never married counterparts. Among women, we can find a similar pattern existing in that both married and previously married women are significantly fatter than women who had never been married.

Model 2 in the second column of each table includes predetermined demographic variables such as age, race, educational attainment, employment, and family income in the equation along with the two marital status dummy variables to investigate whether the relationships between marital status and obesity or fatness persisted or are spurious one. Only the currently married dummy variable among men continues to be significantly associated with BMI when a set of predetermined demographic variables listed above are controlled. Previously married men are no longer significantly different from the men who had never been married. This appears to be mainly attributable to the significant relationship of the control variable of age. Among women, neither those who are currently married nor those who were previously married were significantly associated with BMI when those demographic variables were controlled. All of those five demographic variables were significantly associated with women's body mass index, with particularly strong relationships for age, race/ethnic backgrounds, and educational attainment.

Model 3 examines the role of social mediating variables in relationships between marital status variables and BMI. The relationship between being currently married and BMI among men persists even when the social variables are included in the regression analysis. In addition to age and income, living alone and number of children are significantly associated with BMI for men. However, they are unable to eliminate the marital status relationship. Among women, the relationship which was revealed insignificant between the marital status variables and BMI is now reduced even further in strength with the introduction of social mediating variables. Having children is significantly associated with women's BMI, and it appears to contribute to mediating between the BMI of married and never married women.

Model 4 is the regression analysis in the sequence with the insertion of the demographic variables, marital status, social mediating variables, and health-related physical intervening variables. The relationship between being married and BMI remains significant among men even though there are health-related physical variables in the regression equation. While the relationship between BMI and smoking is significant, its contribution as a mediating variable is not that sufficient to decrease the relationship being married and fatness or obesity among men. Among women, the relationship of marital variables with BMI remains small and also insignificant with the addition of the health-related physical variables. Smoking is also significantly associated with BMI among women.

2. Bivariate Probit Analysis

Table 8 provides the estimates of the effect of marital status on obesity both for men and women using the univariate probit model. Columns 1 and 3 present models with a parsimonious set of commonly observed correlates. Consistent with the results from OLS method in Table 6, the single-equation probit estimates uniformly suggest a significant and positive relationship between marital status and obesity for men. The other independent variables are almost similar except for education level and living status. For women, it bears no significant relationship between marital status and obesity. But women who were previously married got the negative but insignificant relationship with obesity. Probably it is partly because they are willing to keep slim for the reentry into the marriage market for the potential mate but this magnitude depends on the number of children they have to take care of or the occupations and employment status as well. It is also important to note that Black and Hispanic women are more likely to be obese than their counterparts. However, since the single-equation probits do not control for unobservables which potentially correlated with marital status and obesity, they are subject to the endogeneity problem discussed above.

We next turn to the estimates obtained using the identification strategy suggested by Altonji, Elder and Taber (2000). In this model, identification is achieved by assuming that the amount of selection on unobserved variables is equal to the amount of selection on observed variables, or the equal selection rule. Tables 9 and 10 present these estimates among men and women respectively along with several estimates from constrained bivariate probit regressions for which values of the correlation coefficient (ρ) are fixed. Univariate probit estimates, equivalent to ρ equaling zero, are reproduced in column 1 for easy comparison. We want to assess the degree of selection on unobservable characteristics that is necessary to eliminate any positive or negative association between marital status and obesity. Estimates from these models reveal how much selection on unobserved characteristics is necessary to eliminate the positive or negative association between marital status and obesity for men and women in the marriage roles. We assume that lower bound estimates of effects of marital status on obesity are zero since there is little theoretical reason to expect that people in marriage role get a less chance to gain weight.

Estimates among men in Table 9, first of all, indicate that a relatively small amount of selection on unobserved characteristics can eliminate the positive association between marital status and obesity. For example, a correlation coefficient (ρ) of 0.2 or 0.3 eliminates the positive associations between being currently married or number of children or non-smoking behavior, and the probability of being obese in terms of body mass index. Therefore, unless there is very little selection on unobserved factors, it appears unlikely that the positive association between marital status and obesity that are commonly known is causal.

One method for assessing how much selection there is on unobservable variables is to assume that it is equal to the selection on observed variables. This is the suggestion of Altonji, Elder and Taber (2000). The last column of Tables 9 and 10 present estimates from a bivariate probit model for which the equal selection rule (between selection on the included and excluded variables) is used to identify the model. As can be seen, there is a significant amount of selection on observed characteristics, and if this amount of selection also characterizes unobserved variables, the positive associations between marital status and obesity are eliminated. In fact, estimates indicate that selection on unobservable variables would have to be less than half the amount of selection on observed variables for the positive associations between marital status and obesity to remain. We cannot definitely say how much selection remains, but it would have to be significantly less than the amount of selection on observables for there to be a positive association between marital status and obesity.

Table 10 presents estimates among women. Similarly to Table 9, we see that a relatively small amount of selection on unobserved variables will eliminate the positive associations between marital status and obesity. In this case, a correlation coefficient of between 0.1 and 0.3 is sufficient to eliminate the association between the number of children and the probability of being obese for women. Applying the equal selection rule reveals that the amount of selection on observed variables is substantial and if the same amount of selection characterized unobserved factors, the positive associations between marital status and marriage roles and obesity can be eliminated.

X. Discussion

These findings support and even confirm the operation of a marital causation model among men, with the findings that married men are more obese and fatter implying that marital status influences obesity among men. Among women, however, the results do not support a marital causation model.

There are several possible explanations on the finding that married men are more obese. Men are not typically involved in food preparation in terms of male role in a household. To the extent that men fulfill this aspect of the male role, they may eat more regularly or abundantly when they have a spouse and therefore may be more likely to be obese when they are in marital role through the marriage. And marriage may also involve less physically active lifestyle in addition to the food availability. Higher and more frequent activity may contribute to the tendency for males who are not married to be thinner although this was not supported in this data set. Unmarried men may intentionally manage their weight in an effort to be more attractive to potential mates in marriage market. Thinness among those who were previously married can be possible due to the mental pressure or stress of ending the relationship, which may lead to loss of appetite and consequent weight loss. The analysis of the emotional state variable, however, is not included to support that suggestion.

The lack of relationships between obesity and marital status among women contrasts with the findings among men. And it also reflects a different mix of explanations involving calorie intake, activity level, different value judgement about thinness or slimness, and stresses associated with the different marital status. These stresses associated with marriage in women can involve exercise or calorie intake that may offset exercise influences. It is notable, therefore, that age is a key variable associated with fatness among women, which can be due to aging or cohort effects related to obesity and marriage.

Thinness may be more highly valued among married women than among married men. Appearance is more important for women than for men, and women are more highly motivated by physical appearance in dietary behavior than men. These differences in the importance of thinness may explain gender differences in the relationship between marriage and obesity. Men may remain thin before they get married but have a lower incentive to maintain slimness once they enter the marital role. Among women, by contrast, the motivation to be thin to maintain physical attractiveness exists before marriage and persists even in the marital role. This difference in importance of values of physical appearance in and out of the marital role may explain the gender difference in marital status and obesity in this data.[58]

An array of prior studies has shown that lower mortality and morbidity rates among the people who are married, especially men. Such a healthy relationship is not necessarily the case for obesity, with married men being more obese or fatter than their unmarried counterparts and with no relationship between obesity and marital status among women when several demographic explanatory variables were controlled. This presents an interesting epidemiological paradox among men because it is well known that married men have lower

[58] These patterns of fatness by marital status can partially reflect a relationship between success in weight control and marital status. Prior studies of women show mixed results in assessing whether dieting outcome varies by marital status. Some studies report that married dieters lost more weight than those in any other marital status, while others found no variation in weight loss between married and other women. However, some studies show that married women are better able to maintain weight once losses occurred, although another investigator notes no marital status pattern in maintenance of weight loss.

mortality and morbidity rates for which obesity or weight gain is a risk factor, but married men are more likely to be obese than unmarried men. Several explanations for this paradox are possible. There are more powerful and protective effects from marriage that they overcome any costs of higher obesity while obesity is a risk for related diseases. This interpretation is supported by research that finds that married men are more likely to engage in a variety of healthy behaviors such as getting adequate sleep, avoiding taking risks, and avoiding substance abuse. A parallel physical explanation is that obesity may not be as strong as a risk factor for mortality and morbidity as other conditions influenced by marriage, and therefore even if married men are more obese risk factors like smoking would outweigh the impact of obesity. This epidemiological paradox in the outcomes of marriage and obesity is important to pursue in the further analyses. There are several potential applications for these findings. Screening for obesity may consider marital roles in identifying people at risk for obesity, weight gain, and possible health consequences. Increased obesity among married men suggests that those working with the health consequences of obesity may consider the marital status of men as a factor in weight loss. This is especially important because men are at high risk of diseases associated with obesity, including coronary heart disease, diabetes, and hypertension, which make them a high risk target population group. Clinicians helping their clients to lose or control weight may consider marital status and changes in the marital role in their therapeutic interventions. This could involve anticipatory guidance about the possible weight changes associated with marriage. Some weight loss programs involve social support of spouses to reinforce skills and assist in problem solving, and such couples' weight-loss programs experience some success.

There exist some limitations in this data, including the scope of ages included, sample size confines, and measurement issues. The study examined data for people age 35 to 43, not considering the very early marriages and very late widows and widowers. The overall sample size of 12,686 was adequate for most analyses, but extensive subgroup analysis was not possible because of limited statistical power of among some categories of respondents, such as young widowers and older individuals who never married, and so on. Measurement of fatness and marital status rely on self-report data. Sequential marriages (where married and previously married people may have gone through prior marriages) were not assessed because the NLSY data did not examine repeated marriages, and there was no way to examine the length of time that people previously married had spent in the marriage role. Dietary intake was not available in the data as an explanatory mediating variable. This study extended the existing literature and provided new understanding of the relationship between the marital status and obesity, and the limitations in this data are being used to guide further analysis on this issue.

In summary, it appears that there is a relationship between obesity and marital status for men, with married men more obese or fatter. The cross-sectional data from this study support and confirm a marital causation model for the relationship between marital status and obesity for men, who were more obese than their unmarried counterparts. The lack of a relationship for women when other factors were controlled does not support a marital causation model. The direction of causality may operate such that marital status influences fatness, fatness influences entry into or termination of marriage, or both. Additional cross-sectional as well as longitudinal analysis is needed to assess that issue. Also, there is a need to examine the mechanism for the relationship, whether it would be through caloric intake, energy expenditure, social values about obesity, or a combination of these and other factors. Several social factors influence the prevalence of obesity, and marital status must be considered among the social roles which are associated with obesity.

Appendix I

Equal Selection Constraint

The intuition behind the Altonji, Elder, and Taber (2000) strategy can be illustrated as follows. Rewriting the equations (1) and (2) in matrix form:

(4) $\mathbf{O} = \boldsymbol{\alpha}\mathbf{M} + \mathbf{W}'\boldsymbol{\Gamma}$

(5) $\mathbf{M} = \mathbf{X}'\boldsymbol{\Pi} + \boldsymbol{\upsilon}$

Note that equation (4) represents the fully specified model as such, includes no disturbance term. The non-marriage related determinants of obesity or weight-gain ($\mathbf{W}'\boldsymbol{\Gamma}$) can be decomposed into two parts: the observed and unobserved determinants, or

(6) $\mathbf{O} = \boldsymbol{\alpha}\mathbf{M} + \mathbf{X}'\boldsymbol{\gamma} + \boldsymbol{\varepsilon}$

,where $\mathbf{X}'\boldsymbol{\gamma}$ is the observed component of obesity and $\boldsymbol{\varepsilon}$ is the unobserved component. The identification problem is that marital status $\mathbf{M}$ is likely correlated with the unmeasured component $\boldsymbol{\varepsilon}$, but marital status is also likely correlated with the measured component. These correlations can be expressed in terms of the linear projection of marital status on the observable and unobservable determinants of the obesity.

(7) $\mathbf{Proj}(\mathbf{M} \mid \mathbf{X}'\boldsymbol{\gamma},\ \boldsymbol{\varepsilon}) = \mathbf{Proj}(\mathbf{M} \mid \mathbf{W}'\boldsymbol{\Gamma}) = \boldsymbol{\varphi}_c\mathbf{X}'\boldsymbol{\gamma} + \boldsymbol{\varphi}_c\boldsymbol{\varepsilon}$

Equation (7) assumes that the correlation between marital status and the measured component of obesity is equal to the correlation between marital status and the unmeasured component of obesity. This is the equal selection rule. And it is justified for example, if the measured variables were chosen at random from a large set of possible determinants, which is a reasonable assumption given that most secondary data sets used for economic analyses were not derived for the specific research question under investigation (Altonji *et al.*, 2000). Altonji *et al.* show that under certain condition, the correlations in equation (7) are equal to the following:[59]

(8) $\varphi_c = \dfrac{\mathrm{Cov}(M, X'\gamma)}{\mathrm{Var}(X'\gamma)} = \dfrac{\mathrm{Cov}(X'\Pi + \upsilon, X'\gamma)}{\mathrm{Var}(X'\gamma)} = \dfrac{\mathrm{Cov}(X'\Pi, X'\gamma)}{\mathrm{Var}(X'\gamma)}$ and

(9) $\varphi_c = \dfrac{\mathrm{Cov}(M, \varepsilon)}{\mathrm{Var}(\varepsilon)} = \dfrac{\mathrm{Cov}(X'\Pi + \upsilon, \varepsilon)}{\mathrm{Var}(\varepsilon)} = \dfrac{\mathrm{Cov}(\upsilon, \varepsilon)}{\mathrm{Var}(\varepsilon)}$,

so we get, $\dfrac{\mathrm{Cov}(X'\Pi, X'\gamma)}{\mathrm{Var}(X'\gamma)} = \dfrac{\mathrm{Cov}(\upsilon, \varepsilon)}{\mathrm{Var}(\varepsilon)}$.

The important point here is that the term on the *l.h.s.* of the last equality of the equation (9) can be estimated using observed data, and it is equal to the correlation in the bivariate (stan-dard) normal distribution. This equality can be used to identify the model, since it provides an estimate of ρ – the correlation between the errors in the bivariate probit model. Actual estimation proceeds in steps. Initially, we can assume that ρ is zero and obtain estimates of $\dfrac{\mathrm{Cov}(X'\Pi, X'\gamma)}{\mathrm{Var}(X'\gamma)}$ to use as an estimate of ρ. We then re-estimate the model to obtain a new estimate of $\dfrac{\mathrm{Cov}(X'\Pi, X'\gamma)}{\mathrm{Var}(X'\gamma)}$ and ρ. We continue this process until the estimate of ρ converges.

[59] The necessary conditions are: random selection of observed variables, large number of determinants of obesity or weight-gain, and independence of observed and unobserved variables.

Appendix II: Tables

Table 1

Standards for Body Weight

Height †	Male		Female	
(inches)	Standard	Acceptable Range	Standard	Acceptable Range
55			96	86-112
56			98	88-114
57			100	90-116
58			102	92-119
59			104	94-122
60	115	104-133	107	96-125
61	119	108-137	110	99-128
62	123	112-141	113	102-131
63	127	115-144	116	105-134
64	130	118-148	120	108-138
65	133	121-152	123	111-142
66	136	124-156	128	114-146
67	140	128-161	132	118-150
68	145	132-166	136	122-154
69	149	136-170	140	126-158
70	153	140-174	144	130-163
71	158	144-179	148	134-168
72	162	148-184	152	138-173
73	166	152-189		
74	171	156-194		
75	176	160-199		
76	181	164-204		
77	186	169-209		

Source: Metropolitan Life Insurance Company of New York. "1983 Metropolitan Height and Weight Tables." *Statistical Bulletin* 64, 1 (1983): 1-9.

† Heights are measured without shoes, and weights without clothes.

Table 2

Body Mass Index Values, Classifications of Obesity and Risk of Comorbidity from World Health Organization (WHO)

BMI range	Obesity Classification	Risk of Comorbidity
18.5 – 24.9	Normal	Average
25.0 – 29.9	Overweight	Increased
30.0 – 34.9	Obese Class I	Moderate
35.0 – 39.9	Obese Class II	Severe
≥ 40	Obese Class III	Very Severe

Source: World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation presented at: the World Health Organization; June 3-5, 1997; Geneva, Switzerland. Publication WHO/NUT/NCD/98.1.

Table 3
Body Mass Index (BMI) by Age among Men

Age	Average BMI	Standard Deviation	Percent Under-weight	Percent Healthy Weight	Percent Over-Weight	Percent Obese	Number of Observations
16	21.9	3.0	28.1	57.7	12.1	2.1	516
17	22.2	3.1	22.4	61.7	14.0	1.9	1279
18	22.9	2.9	15.8	65.5	16.7	2.0	1489
19	23.4	3.1	13.6	64.7	17.9	3.8	1477
20	24.0	3.3	11.3	62.3	22.0	4.4	2015
21	23.9	3.1	10.1	60.9	24.2	4.8	2728
22	24.2	3.6	9.7	62.7	22.0	5.6	2989
23	24.4	3.3	8.1	61.5	23.5	6.9	3127
24	24.6	3.5	6.8	58.9	26.9	7.4	3128
25	25.3	3.7	5.6	57.0	29.4	8.0	2986
26	25.8	3.6	5.2	54.3	31.6	8.9	3203
27	26.0	3.9	4.3	49.3	36.8	9.6	3253
28	25.9	3.8	4.1	45.0	39.6	11.3	3289
29	26.0	4.5	3.8	43.2	40.6	12.4	3221
30	26.0	4.1	3.4	41.4	42.1	13.1	3457
31	26.3	4.8	3.0	40.8	41.6	14.6	3306
32	26.2	5.2	2.7	38.9	42.8	15.6	3083
33	26.4	5.0	2.5	37.9	43.9	15.7	2464
34	26.5	4.6	2.5	37.3	42.8	17.4	1969
35	26.8	4.7	2.2	34.0	46.2	17.6	1641
36	26.7	4.5	2.3	34.5	43.6	19.6	1176
37	26.9	4.4	2.0	33.8	44.9	19.3	1053
38	27.0	4.3	2.3	32.7	45.2	19.8	987
39	27.3	4.9	1.9	30.8	46.8	20.5	889
41	27.1	4.6	2.1	29.5	46.8	21.6	690
42	27.2	4.2	1.7	29.9	45.5	22.9	435
43	27.4	4.3	1.5	28.9	46.5	23.1	204

Table 4
Body Mass Index (BMI) by Age among Women

Age	Average BMI	Standard Deviation	Percent Under-weight	Percent Healthy Weight	Percent Over-Weight	Percent Obese	Number of Observations
16	20.6	3.0	42.1	48.7	7.9	1.3	447
17	21.3	3.1	40.4	50.5	7.6	1.5	1103
18	21.6	3.9	38.8	48.5	10.6	2.1	1373
19	21.4	3.4	35.6	52.2	9.1	3.1	1351
20	21.8	3.3	31.3	53.9	11.4	3.4	1789
21	21.7	3.7	29.1	53.4	13.4	4.1	2465
22	22.2	3.6	28.5	54.5	12.4	4.6	2732
23	22.5	4.3	28.3	54.2	11.7	5.8	2872
24	22.9	4.2	27.6	52.6	13.4	6.4	2876
25	23.1	4.1	24.4	55.4	14.0	6.2	2655
26	23.4	4.6	23.6	53.8	15.2	7.4	2888
27	23.5	4.8	21.5	54.3	16.2	8.0	3078
28	23.7	4.9	20.9	53.2	17.0	8.9	3121
29	24.1	5.0	19.3	54.1	17.3	9.3	3015
30	24.2	5.1	18.7	52.8	17.9	10.6	3262
31	24.7	5.6	15.7	54.7	18.3	11.3	3265
32	24.9	5.4	15.3	53.6	20.1	11.0	2962
33	25.1	5.7	14.3	52.5	20.7	12.5	2427
34	25.6	5.9	14.0	51.3	21.3	13.4	1939
35	25.8	5.5	13.6	49.3	22.1	15.0	1665
36	25.6	6.1	13.4	47.8	23.7	15.1	1180
37	26.1	6.4	13.0	46.9	24.1	16.0	1071
38	26.3	6.2	12.1	48.5	23.6	15.8	987
39	26.1	5.9	11.6	48.1	23.0	17.3	790
41	26.4	6.6	10.2	47.7	25.0	17.1	677
42	26.5	6.2	11.3	47.7	24.8	16.2	481
43	26.3	6.3	10.9	48.1	24.0	17.0	214

Table 5
Summary Statistics of Selected Variables

Variables	Definition	Mean	Standard Deviation	Minimum	Maximum
Body Mass Index	Weight in kilograms divided by height in meters squared	25.831	5.910	7.834	63.610
Indicator: Obese	1 if Body Mass Index is equal to or greater than 30	0.182	0.393	0	1
Indicator: Black	1 if respondent is Black but not Hispanic	0.299	0.451	0	1
Indicator: Hispanic	1 if respondent is Hispanic	0.191	0.392	0	1
Indicator: Male	1 if respondent is Male	0.489	0.500	0	1
Age	Age of respondent	38.860	3.984	35	43
Education	Highest grade completed	12.600	2.133	0	20
Employment	Years of actual work experience	14.320	4.953	0	24.34
Indicator: Married	1 if respondent is currently married	0.562	0.500	0	1
Indicator: Previously Married	1 if respondent is previously married	0.287	0.431	0	1
Children	Number of children in household	1.596	1.221	0	9
Family Income	Household income in thousands	24.078	53.366	0	1214.437
Non-Smoker	1 if respondent is currently not smoking	0.621	0.239	0	1
Living Status	1 if respondent currently lives as partner with opposite sex adults	0.293	0.307	0	1
Physically Active	1 if respondent is physically active without any supplements	0.733	0.131	0	1

Table 6
Sequenced Multiple Regression Models of Marital Status and BMI among Men

	Model 1			Model 2			Model 3			Model 4		
	Std.	Unstd.	S.E.	Std.	Unstd.	S.E.	Std.	Unstd.	S.E.	Std.	Unstd.	S.E.
Constant		23.544	0.221***		22.761	0.731***		22.782	0.633***		23.011	0.761***
Age				0.141	0.04	0.010**	0.150	0.044	0.011**	0.150	0.041	0.012**
Age Squared				- 0.014	- 0.008	0.000***	- 0.013	- 0.008	0.000***	- 0.013	- 0.008	0.000***
Black				0.050	0.501	0.382	0.041	0.492	0.380	0.041	0.442	0.401
Hispanic				0.061	0.610	0.335	0.061	0.591	0.444	0.062	0.566	0.310
Education				- 0.061	- 0.151	0.082	- 0.061	- 0.151	0.080	- 0.070	- 0.181	0.081*
Employment				0.051	0.492	0.263	0.051	0.452	0.273	0.051	0.481	0.273
Family Income				0.051	0.131	0.061	0.051	0.151	0.061*	0.051	0.151	0.072*
Married	0.243	1.720	0.201***	0.141	1.021	0.294**	0.142	0.990	0.293**	0.150	1.081	0.281**
Previously Married	0.071	0.772	0.361*	0.021	0.202	0.416	0.011	0.081	0.430	0.023	0.232	0.391
Having Children							0.070	0.471	0.195*	0.071	0.481	0.190*
Living Alone							0.061	0.744	0.322*	0.065	0.815	0.334*
Physically Active										- 0.032	- 0.421	0.381
Non-smoker										0.073	0.502	0.212*
	$R^2 = 0.053$			$R^2 = 0.072$			$R^2 = 0.081$			$R^2 = 0.081$		

* P < 0.05; ** P < 0.01; and *** P < 0.001

Table 7

Sequenced Multiple Regression Models of Marital Status and BMI among Women

	Model 1			Model 2			Model 3			Model 4		
	Std.	Unstd	S.E.	Std.	Unstd.	S.E.	Std.	Unstd.	S.E.	Std.	Unstd.	S.E.
Constant		21.831	0.242***		24.732	0.731***		24.282	0.981***		24.130	1.425***
Age				0.241	0.080	0.013***	0.273	0.091	0.012***	0.271	0.093	0.011***
Age Squared				- 0.010	- 0.004	0.000***	- 0.011	- 0.005	0.000***	- 0.013	- 0.007	0.000***
Black				0.141	1.823	0.290***	0.131	1.723	0.281***	0.133	1.662	0.311***
Hispanic				0.164	1.610	0.235***	0.161	1.591	0.233***	0.162	1.566	0.240***
Education				- 0.161	- 0.625	0.091***	- 0.150	- 0.594	0.103***	- 0.151	- 0.591	0.082***
Employment				- 0.072	- 0.603	0.252*	- 0.062	- 0.542	0.251*	- 0.062	- 0.491	0.263
Family Income				- 0.081	- 0.270	0.123*	- 0.091	- 0.300	0.110*	- 0.081	- 0.274	0.111*
Married	0.175	1.631	0.392**	0.061	0.583	0.341	0.042	0.352	0.382	0.081	0.362	0.395
Previously Married	0.193	2.264	0.303***	0.012	0.141	0.313	- 0.013	- 0.141	0.292	- 0.001	- 0.031	0.301
Having Children							0.072	0.663	0.283*	0.083	0.735	0.273*
Living Alone							0.015	0.144	0.404	0.012	0.192	0.402
Physically Active										- 0.030	- 0.537	0.771
Non-smoker										0.091	0.757	0.191**
	$R^2 = 0.021$			$R^2 = 0.153$			$R^2 = 0.165$			$R^2 = 0.172$		

* P < 0.05; ** P < 0.01; and *** P < 0.001

Table 8
Univariate Probit Estimates of Marital Status and Obesity among Men and Women

	Men				Women			
	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E.	Coeff.	S.E.
Constant	- 2.9021	0.3921***	- 1.6772	0.2795***	- 2.5460	0.3510***	- 2.0474	0.3821***
Age	0.2310	0.0821**	0.1023	0.0512*	0.3207	0.0532***	0.3772	0.1677*
Age Squared	- 0.0005	0.0003	- 0.0002	0.0002	- 0.0004	0.0003	- 0.0013	0.0020
Black	0.0089	0.0147	0.0142	0.0077	0.0179	0.0090*	0.0331	0.0133*
Hispanic	0.0068	0.0178	0.0099	0.0120	0.0188	0.0094*	0.0480	0.0199*
Education	- 0.0148	0.0067*	- 0.0143	0.0071*	0.0244	0.0109*	0.0533	0.0258*
Employment	0.0250	0.0187	0.0323	0.0209	- 0.0031	0.0051	- 0.0114	0.0100
Family Income	0.0239	0.0139	0.0328	0.0248	- 0.0181	0.0088*	- 0.0230	0.0097*
Married	0.1167	0.0358***	0.1398	0.0426***	0.0137	0.0073	0.0332	0.0291
Previously Married	0.0077	0.0510	0.0102	0.0711	- 0.0083	0.0170	- 0.0153	0.0334
Having Children	0.0203	0.0101*	0.0576	0.0254*	0.0165	0.0081*	0.0229	0.0093*
Living Alone	0.0109	0.0054*	0.0232	0.0207	0.0069	0.0178	- 0.0011	0.0024
Physically Active	- 0.0099	0.0162	- 0.0100	0.0399	- 0.0078	0.0098	- 0.0074	0.0121
Non-smoker	0.0183	0.0077*	0.0232	0.0093*	0.0177	0.0066**	0.0332	0.0142*
Pseudo R-Squared	0.233		0.371		0.287		0.402	
Additional Covariates †	No		Yes		No		Yes	

<Notes>
1. * P < 0.05; ** P < 0.01; and *** P < 0.001
2. Additional covariates include work experience, work experience squared, union status, unemployment rate in local labor market, whether is in an urban area, geographical region of residence, and occupations.

Table 9
Effect of Marital Status on Obesity from National Longitudinal Survey of Youth 79 (NLSY 79)
Constrained Bivariate Probit Estimates among Men

Obesity (BMI≥30)	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Married	0.1398*** (0.0426)	0.0938* (0.0426)	0.0688 (0.0423)	0.0433 (0.0423)	- 0.0179 (0.0420)	- 0.0479 (0.0421)	- 0.1136** (0.0425) [$\rho = 0.66$]
Previously Married	0.0102 (0.0711)	0.0100 (0.0712)	- 0.0003 (0.0693)	- 0.0027 (0.0683)	- 0.0107 (0.0663)	- 0.0346 (0.0663)	N. A. [$\rho > 1$]
Number of Children	0.0576* (0.0254)	0.0439* (0.0201)	0.0410* (0.0200)	0.0303 (0.0200)	0.0138 (0.0198)	- 0.0046 (0.0197)	- 0.0488* (0.0201) [$\rho = 0.69$]
Non-Smoker	0.0232* (0.0093)	0.0213* (0.0088)	0.0189* (0.0087)	0.0166 (0.0086)	0.0054 (0.0084)	- 0.0104 (0.0083)	-0.0334*** (0.0091) [$\rho = 0.59$]
Additional Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes

<Notes>

1. Robust standard errors are in parentheses.
2. * P < 0.05; ** P < 0.01; and *** P < 0.001
3. Additional covariates include work experience, work experience squared, union status, unemployment rate in local labor market, whether is in an urban area, geographical region of residence, and occupations.
4. $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$ is calculated by two-step procedure. An initial value for ρ was chosen and then the bivariate probit model was estimated. Rho was then re-calculated using estimates of $X'\Pi$ and $X'\gamma$ from the bivariate probit. This procedure was reported until estimates of rho converged.

Table 10
Effect of Marital Status on Obesity from National Longitudinal Survey of Youth 79 (NLSY 79)
Constrained Bivariate Probit Estimates among Women

Obesity (BMI≥30)	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Married	0.0322 (0.0291)	0.0177 (0.0187)	0.0096 (0.0176)	0.0047 (0.0173)	- 0.0108 (0.0172)	- 0.0283 (0.0179)	- 0.0432* (0.0181) [$\rho = 0.63$]
Previously Married	- 0.0153 (0.0334)	- 0.0388 (0.0320)	- 0.0532 (0.0313)	- 0.0760* (0.0312)	- 0.1023*** (0.0313)	- 0.1331*** (0.0320)	- 0.1202*** (0.0333) [$\rho = 0.42$]
Number of Children	0.0229* (0.0093)	0.0157 (0.0092)	- 0.0048 (0.0091)	- 0.0238** (0.0092)	- 0.0210* (0.0089)	- 0.0301*** (0.0093)	- 0.0365*** (0.0096) [$\rho = 0.51$]
Non-Smoker	0.0332* (0.0142)	0.0298* (0.0138)	0.0167 (0.0127)	0.0043 (0.0122)	- 0.0153 (0.0119)	- 0.0258* (0.0123)	- 0.0401*** (0.0134) [$\rho = 0.57$]
Additional Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1. Robust standard errors are in parentheses.
2. * $P < 0.05$; ** $P < 0.01$; and *** $P < 0.001$
3. Additional covariates include work experience, work experience squared, union status, unemployment rate in local labor market, whether is in an urban area, geographical region of residence, and occupations.
4. $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$ is calculated by two-step procedure. An initial value for ρ was chosen and then the bivariate probit model was estimated. Rho was then re-calculated using estimates of $X'\Pi$ and $X'\gamma$ from the bivariate probit. This procedure was reported until estimates of rho converged.

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