The effects of prospective mate quality on investments in healthy body weight among single women

Harris, Matthew and Cronin, Christopher

University of Tennessee, University of Notre Dame

29 October 2014

The Effects of Prospective Mate Quality On Investments in Healthy Body Weight Among Single Women

Matthew C. Harris* and Christopher J. Cronin†‡

October 29, 2014

Abstract

This paper examines how a single female's investment in healthy body weight is affected by the quality of single males in her marriage market. A principle concern in estimation is the presence of market-level unobserved heterogeneity that may be correlated with changes in single male quality. To address this concern, we employ a differencing strategy that normalizes the exercise behaviors of single women to those of their married counterparts. Our main results suggest that when potential mate quality in a marriage market decreases, single black women invest less in healthy body weight. For example, we find that a ten percentage point increase in the proportion of low quality single black males leads to a 5% to 10% decrease in vigorous exercise taken by single black females. No significant response is found for single white women. These results highlight the relationship between male and female human capital acquisition that is driven by participation in the marriage market. Our results suggest that programs designed to improve the economic prospects of single males may yield positive externalities in the form of improved health behaviors, such as more exercise, particularly for single black females.

JEL Codes: I14,I12,J12,J15

*Corresponding Author: University of Tennessee, Department of Economics and Center for Business and Economic Research, 722A Stokely Management Center, 916 Volunteer Boulevard, Knoxville, TN 37996-0570; 865-974-5591;mharris@utk.edu

†University of Notre Dame, Department of Economics

‡We thank Jason Fletcher, Scott Gilpatric, Meghan Skira, Forrest Spence, and others for their comments on this draft. All errors are the authors'.

I Introduction

The obese proportion of the U.S. population grew from 15% in 1980 to 34.3% in 2008. In addition to the obvious health implications, this growth generated significant economic costs (Flegal et al., 2010). Reuters estimates that obesity contributed $190 billion to annual health care costs in the United States in 2012, a figure that exceeds the costs attributable to smoking (Begley, 2012). Obesity is linked to increased hypertension, heart disease, stroke, disability, diabetes, and non-health factors such as decreased productivity in the workplace and stunted human capital formation. The Brookings Institution estimates the aggregate economic costs of obesity to be $215 billion per year, or 1.4% of GDP (Hammond and Levine, 2010).

While the incidence of obesity among all demographic groups in the United States has risen considerably since the 1980s, some groups have been disproportionately affected (see Figure I). The CDC reports that 58.5% of black women over the age of 20 are obese, compared to a population average of 33.9% (Flegal et al., 2010).[1] The demographic discrepancy in severe (grade 2) obesity is even larger. Black women have a severe obesity rate of 27.9% compared to a rate of 14.3% for the total population. While the obesity rate (particularly severe obesity) is highest among black women, the obesity rate among single white women has exhibited the largest growth rate (45% from 1999 to 2011) of any demographic group in recent years. According to the Behavioral Risk Factor Surveillance System (CDC), the obesity rate for single black women under age 45 increased by 27% over the same period.

Biologically, body weight is a function of calories ingested and expended. Economically, the individual's decision to consume net calories is a function of her incentives to invest in healthy eating and exercise. Philipson (2001) posits that an unfavorable marriage market for women may reduce the marginal benefit of pre-marital investment in fitness and therefore contribute to the high rate of obesity. Black women have exhibited greater obesity rates

[1] Obesity is generally defined using the Body Mass Index (BMI), which is calculated as BMI = [weight (lb)/height(in)^2] $*$ 703. The Centers for Disease Control define obesity as a BMI greater than or equal to 30. Severe (grade 2) obesity is defined as a BMI greater than or equal to 35.

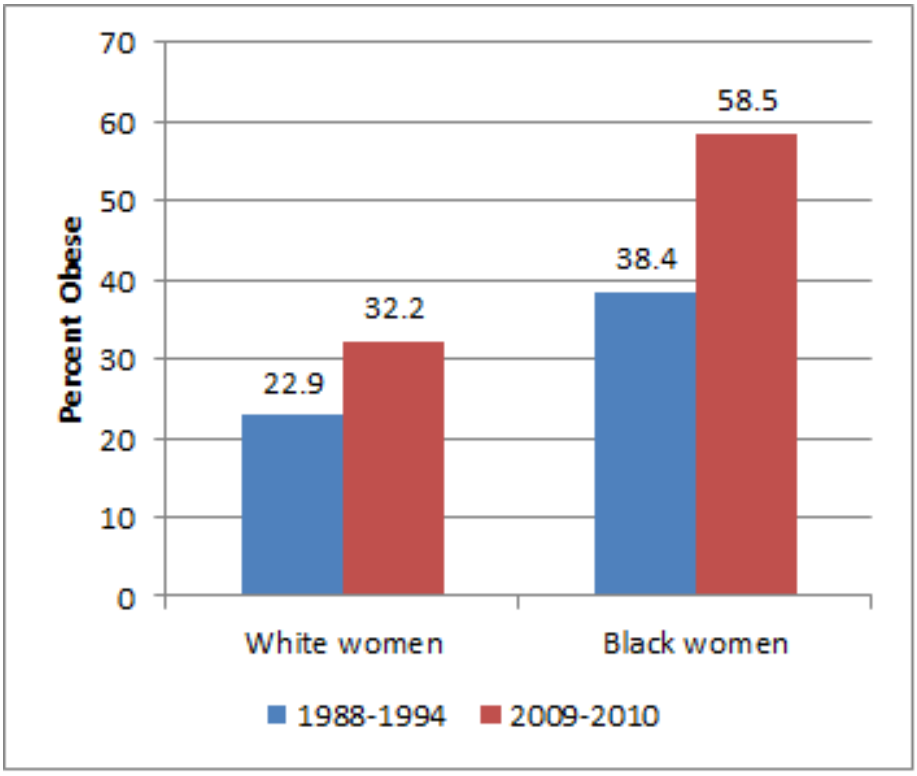

Figure 1: Obesity rates among women by race; 1998-1994 and 2009-2010

and faced less favorable marriage prospects than white women since the 1970s (Wilson and Neckerman, 1986). The U.S Bureau of Justice Statistics (BJS) reports that black males are incarcerated at nearly seven times the rate of white males, and estimates place the proportion of black males with a felony conviction as high as one-third. Black men exhibit 100% greater high school dropout rates and 40% lower college completion rates than white men.[2] The unemployment rate among black men has been approximately twice that of white men since the 1960's and black men are also 45% more likely than white men to not participate in the labor force.[3] Conditional on being employed, median wages are 27% lower for black men than white men.[4] The observed disparities in human capital, employment, wages and incarceration rates are clearly not independent. For example, Western (2002) finds that

[2]Source: National Center for Education Statistics.
[3]Source: Bureau of Labor Statistics, Current Population Survey
[4]Source: American Community Survey.

incarceration decreases earnings by between 10-30%, increases search costs when seeking employment, and limits the set of attainable occupations.

In this paper, we study the effect that single male quality has on a single female's investment in healthy body weight.[5] Our analysis is empirical. Using panel data from the Behavioral Risk Factor Surveillance System - Selected Metropolitan/Micropolitan Area Risk Trends (BRFSS-SMART) we measure pre-marital investment in healthy body weight by minutes of moderate and vigorous exercise per week. As suggested by Becker (1974), we measure a male's quality by his earning potential. Thus, defining marriage markets by MSA, race, and age group, we measure single male quality within a given marriage market using education, employment, income, and arrests rates.[6] Ideally, we would observe the entire distribution of male quality, which would allow us to analyze the behavioral responses of single females to shifts in the entire male quality distribution. However, the data allow us to measure only the proportion of low quality single males within a marriage market (i.e., we observe high school graduation rates, the unemployment rate, percent with low income, and arrest rate). We assume that this measure of the proportion of low quality males reflects a shortage of quality mates (for women) in the marriage market.

We estimate the effect that the proportion of low quality males has on the body weight investment decisions of the average single female in a marriage market. Our regressions include year and marriage-market fixed effects, which control for unobservables that vary by time period (e.g., nationwide economic conditions) and marriage market (e.g., persistent economic, cultural, and geographic factors) that may be correlated with the characteristics of single males. However, there are additional unobservables that vary by both time period and marriage market (e.g., chemical dependency rates, poverty rates, local economic shocks) that

[5]Throughout this paper we will reference the "quality" of males and females participating in the marriage market. In all instances, an individual's quality refers to their value to potential mates. (Burdett and Coles (2001) use the term "pizazz" to describe a similar value.) In theory, single females receive greater utility from matching to a high quality male than a low quality male and vice versa.

[6]The Pew Research Center reports that black-white interracial marriage rates are less than 5% of all black and white marriages. As such, throughout our analysis we treat marriage markets separately for each race.

may be correlated with single male quality. Ignored, this correlation between male quality and unobservables would bias out results. We address the potential omitted variable bias by normalizing the average health investments of single women to those of married women in the same marriage market. We also include differenced control variables and market-level fixed effects in these regressions to account for time varying observable and time-invariant unobservable compositional differences between single and married women respectively at the market level.

Our results suggest that low quality among single males in a marriage market reduces females' incentives for pre-martial investment in healthy body weight. In our first model (i.e., using single women only), we find that single black women exercise less in response to a decrease in single male quality; a ten percentage point increase in the proportion of low quality single black males (roughly equivalent to elevating the quality of single black men in Orlando, FL to that of the single black men in Indianapolis, IN) leads to a 10% decrease in vigorous exercise taken by single black females.[7] The results for white marriage markets vary in significance and magnitude according to model specification. In our second model, where single women's investment in healthy body weight are normalized to that of the married women, we find that a 10 percentage point increase in the proportion of low quality single black males leads to a 5% decrease in vigorous exercise taken by single black females. Therefore, our econometric correction for time-varying market level unobservables halves the marginal effect of male quality on pre-marital female investment in healthy body weight. Our results are robust to marriage markets defined at the state level. We rule out (empirically) any cross-race effects (i.e., single male quality of one race on single female health investment of another race) and show that single male quality does not affect the

[7]We refer to exercise as "investment in health body weight" throughout this paper. However, it is important to recognize that our results may not generalizable to all health investment decisions. While exercise and healthy eating improve one's health, they improve a female's quality in the marriage market by decreasing/maintaining her body weight, which betters her appearance. We would not necessarily expect a similar relationship to exist between single male quality and single female consumption of the influenza vaccine.

health investments of married women. These results validate our race-specific definitions of marriage markets and normalization strategy, respectively.

As an extension, we consider how the effects of male quality may vary over the distribution of female quality. To that end, we regress individual-level single female investment in health body weight on the proportion of low quality single males in the marriage-market, control variables, and MSA-level fixed effects. We allow estimated coefficients to vary over the distribution of single female quality. We find evidence that the health behavioral responses of single women to changes in single male quality are strongest among females with less education, income, or higher body weight.

This paper merges several related literatures. Previous work has examined the effects of mate quality on racial differences in marriage formation (Brien, 1997; Wood, 1995; Wilson and Neckerman, 1986). A separate, recent literature has examined the spillover effects of marriage market imbalance, particularly for black women (Mechoulan, 2011; Finlay and Neumark, 2010; Lin et al., 2014). While Mechoulan (2011) finds that black females facing an unfavorable imbalance in the marriage market invest in more human capital (e.g., education), it is not clear whether these spillover effects are the result of increased or decreased competition for mates. Women facing a lack of quality mates may invest in more education either to increase their mating capital or in preparation for financial independence. Our analysis indicates that an unfavorable marriage market imbalance leads the average single female to decrease her investment in healthy body weight. This reduction would suggest a decrease in competition, as an increase in body weight cannot be interpreted as increasing mating capital. Additionally, this paper is the first to link marriage market conditions directly to pre-marital investment in healthy body weight. There has been considerable work in the literature on the effects of obesity on marriage market prospects (Oreffice and Quintana-Domeque, 2010; Averett et al., 2008), but very little on how marriage market prospects affect investment in healthy body weight.

The rest of the paper is organized as follows: Section II reviews the existing literature. Section III describes the data and sample construction. Section IV contains empirical results from market-level panel analysis and robustness checks including: analysis at the state level, cross-race effects, and effects of single males on married women's investment in healthy body weight. We then extend the analysis by considering how the effects of low quality males may vary over the support of the female quality distribution. Section V concludes with a discussion of the policy implications of our results, the limitations of our analysis, and directions for future work.

II Related Literature

II.1 Empirical Literature

We are not the first to consider the relationship between marriage market conditions and pre-marital investments. The theoretical models of Burdett and Coles (2001); Iyigun and Walsh (2007); Chiappori et al. (2009). describe the pre-marital investments of forward-looking singles. There is less empirical work on the subject and researchers have focused primarily on educational investments. Boulier and Rosenzweig (1984) estimate a model of female schooling, (spousal) search, and (spousal) selection. Using data from the Philippines, they find evidence that single women facing higher sex ratios (men to women) and higher single male unemployment rates invest less in their educations. Lafortune (2013) studies how sex ratios impact premarital investments in education and the educational characteristics of selected occupations of second generation Americans born between 1885 and 1915. She finds that men and women who face a shortage of potential mates invest in more years of schooling.

Our work also relates to a number of empirical papers suggesting that bodyweight impacts marriage formation differently for men and women. Using the 1997 cohort of NLSY, Mukhopadhyay (2007) finds that obese women are less likely to be accepted into marriage,

but that obesity does not affect the incidence of marriage for men. Oreffice and Quintana-Domeque (2010) find positive assortative mating among spouses in the United States on weight, height, and BMI. Consistent with Mukhopadhyay, they also find significant penalties for obese women. Female BMI is found to be negatively correlated with husband's income, height, and education. Furthermore, Becker (1974) hypothesizes and numerous studies (e.g., Lichter et al. (1991, 1992); Wilson and Neckerman (1986)) show that while males are evaluated in a marriage market by their wages and material possessions, women are typically sought after for non-monetary concerns, such as appearance and education. In a recent study of online dating responses, Chiappori et al. (2012) found that women must compensate for an additional 2 units of BMI with an additional year of education.

This paper also joins a growing literature that seeks to understand how the decreasing number of "marriageable" of black men in the United States, particularly since the 1970s, has altered the marriage trends and behaviors of black women. Researchers have studied how changes in the marriageability of single black men has affected both marriage rates (Wood, 1995) and marriage timing (Brien, 1997) in black populations. Recent work by Mechoulan (2011) and Lin et al. (2014) examines how the increase in incarceration of black men and the sex ratio imbalance it causes affects the behavior of black women. Mechoulan (2011) finds that young black women have responded with greater investment in human capital (e.g., higher educational attainment, increased early employment, and lower teenage fertility rates). Findings by Lin et al. (2014) suggest that as much as 18% of the growth in obesity among black females over the 1990s is due to mate shortages incited by increases in the incarceration of black males.

II.2 Theoretical Literature

Becker (1974) was among the first to study marriage formation as the optimizing behavior of rational economic agents. In Becker's model, which assumed transferable utility, an individual chose to marry if the utility from marriage was greater than the utility from

remaining single. In this frictionless setting, Becker showed that assortative matching would arise if everyone preferred higher (quality) partners. To account for incomplete information, more recent matching models have allowed for search frictions, while assuming both transferable (Becker, 1981) and non-transferable (Burdett and Coles, 1997; Smith, 2006) utility. Much like job seekers in a labor market with frictions, single individuals in these models are assumed to set a reservation (mate) quality and accept the first offer that exceeds the threshold. More recent models have amended this earlier work by allowing for pre-marital investments, which increase an individual's value in the marriage market (Burdett and Coles, 2001; Iyigun and Walsh, 2007; Chiappori et al., 2009; Lafortune, 2013).

While we do not contribute to the theoretical literature on marriage markets or matching models, our empirical work is motivated by Burdett and Coles (2001) equilibrium model of self-improvement. In their model, vertically differentiated singles enter the marriage market endowed with a particular level of quality or "pizazz." An individual's utility from marriage equals their partners pizazz (i.e., non-transferable utility). A single is able to invest, at a cost, in his/her own pizazz, which may increase the expected (utility) value of a match. A female's investment decision is thus influenced by the distribution of both male and female pizazz, as well as the cost of investment.[8] Depending on these factors, the model would predict that some women engage in costly investment, while other women choose to enter the marriage market with their original pizazz endowment. In our empirical work, we will measure how the average female's body weight investment decision is affected by the proportion of males in the left tail of the quality, or "pizazz," distribution. We abstract from the equilibrium effects of the women's behavior, leaving this for future work.

[8]In our paper, a woman's investment in healthy body weight is akin to investing in her "pizazz." Our measure of low male quality within a marriage market provides some measure of the proportion of males to the left of some arbitrarily low threshold in the male "pizazz" distribution.

III Data

The primary data source used in our empirical analysis is the Center for Disease Control's Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS has been conducted annually since the 1980s and is the world's largest telephone health survey. The survey is a repeated cross section, designed to identify trends in health behaviors at the state level to help state health agencies efficiently allocate resources. Beginning in 2002, the BRFSS began tracking local trends from metropolitan and micropolitan areas with 500+ respondents. Our estimation samples are drawn from these data, which are known as BRFSS-SMART (Selected Metropolitan/Micropolitan Area Risk Trends).

While BRFSS is a repeated cross section, we use sample weights to construct a panel at the "marriage market" level. A total of 227 MSA's are included in our four year panel. We define marriage markets using a race (black/white) and age category combinations within each MSA.[9] The age categories are [18-25), [25-35), [35-45), [45-55), [55-65), and $[65, \infty)$. We have tested whether our results were robust to alternative age bands. We found that relaxing the age bands to permit overlapping markets (e.g., 25-35 year old females can now pair with 23-37 year old males) did not affect our results substantially.[10] An alternative strategy would be to define age bands (+/- 5 years) around each single women and characterize her mating pool accordingly. However, this would require a prohibitive number of fixed effects and render any meaningful analysis using panel methods infeasible.

Table I displays the number of MSA's tracked for each year, the total number of marriage markets constructed, and the total number of individual respondents (single and married) for each year of the BRFSS-SMART used to compose these marriage markets. Of the 5,757 marriage markets defined by MSA, age group, race, and time, there are 2,130

[9] We abstract from cohabitation in our analysis as cohabitation is a very small part of the sample. In the 2009 BRFSS, for example, 2.15% of the sample reports being "part of an unmarried couple." If we define cohabitation as broadly as possible, (one man and one woman live together outside of wedlock, regardless of whether or not they have a romantic, familial, or roommate relationship) less than 12% of the *single* population cohabitates.

[10] Except for women within one year of the upper boundary, these overlapping markets capture 85% of observed marriage-age-pairs according to the CPS.

black marriage markets and 3,627 white markets. The BRFSS-SMART only reports results for MSA's with at least 500 respondents. Some MSA's are either insufficiently diverse to form marriage market estimates for blacks or had insufficient numbers of black respondents to form reliable estimates. Our MSA-level markets form an unbalanced panel. Table II displays the number of markets with 1, 2, 3, or 4 observations.

Table I: MSAs, Markets, and Respondents by Wave

Year	**No. of MSA's**	**No. of Markets**	**No. of Respondents**
2003	102	1,019	129,779
2005	148	1,400	201,539
2007	177	1,700	253,071
2009	173	1,638	250,584
N		5,757	700,583

Our estimation sample includes marriage markets with at least five single men and five single women satisfying the MSA-race-age criteria. Given our precise definition of a marriage market, increasing this threshold rapidly decreases the numbers of markets we can include in the sample. Admittedly, the presence of these small markets calls to question the representativeness of our results; to which we have two comments. First, including markets with small numbers of observations is likely to increase the noise in our data. If these individuals are randomly sampled from the population, these small numbers of individuals should create classical measurement error, resulting in attenuation bias on our parameters of interest and therefore understate the true effect. To test for such bias, we repeat our analysis restricting the sample to markets with a minimum of 10, 15, and 20 individuals of each sex. These restrictions have little effect on our point estimates, but the smaller sample sizes do increase the standard errors. Second, we also repeat our analysis with state-level marriage markets (where BRFSS is representative) to alleviate concerns about non-randomness in MSA's with small numbers of respondents. We find that our key results strengthen when we aggregate to the state level, consistent with alleviating classical measurement error in the MSA-defined markets.

Table II: Observations Per Market

Observations Per Market	No. of Markets
1	693
2	360
3	264
4	888

The dependent variables in our empirical analysis are minutes of moderate and vigorous exercise per week by single females. After the 2002 initiation of the BRFSS-SMART, questionnaires in odd years (2003, 2005, 2007, 2009) elicited information on behaviors related to changes in body weight, including minutes of moderate/vigorous exercise taken.[11] Our dependent variables of average minutes of moderate (or vigorous) exercise per week are formed by averaging over individual reports in each market. We use post stratification weights in constructing these measures. Summary statistics for our dependent variables are found in the top 2 rows of Table III.

In each market, we also form measures of male quality, our explanatory variable of interest. In addition to health information, the BRFSS asks respondents about their highest degree attained in school, a very coarse categorical income measure, and employment status. From these reports, we use post-stratification weights to construct three measures of male quality in each market: the proportion of single males who are high school dropouts, the proportion of single males who earn less than $20,000 per year,[12] and the proportion of single males who are unemployed for greater than six months or not in the labor force. We supplement this information with average arrest rates by marriage market, which are compiled from the Bureau of Justice Statistics, Uniform Crime Reports (UCR) Annual Summary.[13] While

[11] BRFSS also contains information about food intake, but only about healthy food intake, such as 'servings of fruits and vegetables per day.' In considering investment in healthy body weight, we are equally (if not more) concerned with 'unhealthy food abstinence' as we are 'healthy food intake.' These are two entirely separate variables, one does not imply the other. In previous versions of the paper, we have considered fruit and vegetable intake. The results were mixed. We are happy to share them as asked.

[12] The $20,000 threshold was selected because it is the closest to the U.S. Census Bureau's poverty line for a family of four. Under the assumption that males are valued in the marriage market as providers for the family, the federal poverty line for a family of four provides an objective threshold for insufficient earnings.

[13] The Bureau of Justice Statistics does not report the marital status of arrestees. We are therefore unable to separately identify arrest rates for single versus married men.

related works have measured the impact of the penal system on males using incarceration rates, we suspect that arrest rates provide a better contemporaneous measure of the corrections aspect of mate quality.[14] The UCR reports offenses at the Original Reporting agency Identifier (ORI; e.g., Knoxville Police Department), both by race and by age-sex, but not by race-age-sex. Thus, we assume that for a given ORI, the race proportion is constant for each age-by-sex cell. In other words, we assume that if 40% of the arrestees in a given MSA were black, then 40% of the 27-year old arrested men are black. We count arrests only for felony offenses, which are most likely to have long term economic consequences, decreasing a male's value as a mates. Summing the offenses for each age-sex cell and distributing racial proportions, we are able to calculate the proportion of arrested men in a given marriage market. Summary statistics for our measures of low male quality are in the bottom panel of Table III.

In each market, we also construct control variables to characterize the population of single females. We construct market averages that parallel our measures of low quality males: high school dropout rates, low income rates, and joblessness rates. We do not use arrest rates among females, which are less than 1% in the median marriage market, and we add the average number of children per single woman in each market. Summary statistics for these market average rates are also in Table III.

Our econometric technique requires market-level variation in male quality over time. Table IV shows the variance of each measure of male quality and the share of that variance within and between each MSA. The table shows that roughly 45% of the total variation for our economic measures of male quality comes from within each MSA-level market. We did the same exercise for marriage markets defined at the state level where BRFSS is designed to

[14]Incarceration rates alone are likely to understate to impact of the penal system on marriage markets. While incarceration removes an individual from participating in the market, arrests increase the likelihood of conviction, which lowers an individual's economic prospects. As such, arrests probabilistically diminish an individual's value in the marriage market. Given that roughly 52% of American males will be arrested at some point in their life (Tillman, 1987), while only 9.0% will ever be incarcerated (Bonczar and Beck, 1997), identifying externalities of high arrest rates is important. Note also that incarcerated males are not included in the non-institutionalized population we consider.

Table III: Market-Level Descriptive Statistics

Variable	**Mean**	**S.D.**	**Min**	**Max**
Health Markers - Single Females				
Minutes of Moderate Exercise Per Week	43.47	26.18	0	180.10
Minutes of Vigorous Exercise Per Week	21.91	18.57	0	108.96
Low Income Rate	0.28	0.19	0	0.75
Joblessness Rate	0.17	0.16	0	0.64
H.S. Dropout Rate	0.11	0.14	0	0.55
Averge Number of Children	0.69	0.63	0	2.51
Mate Quality Rate Variables - Single Males				
Arrests Per Capita	0.05	0.07	0	0.32
Low Income Rate	0.22	0.21	0	0.73
Joblessness Rate	0.17	0.19	0	0.64
H.S. Dropout Rate	0.12	0.15	0	0.49

Table IV: Variance of Male Quality Measures Within and Between Markets

Variable	**Total Variance**	**Proportion Between**	**Proportion Within**
Markets Defined at MSA Geographic Level			
H.S. Dropout Rate	0.0238	0.547	0.453
Low Income Rate	0.0433	0.557	0.443
Joblessness Rate	0.0345	0.543	0.457
Arrests Per Capita	0.0042	0.857	0.143
Markets Defined at State Geographic Level			
H.S. Dropout Rate	0.0247	0.557	0.443
Low Income Rate	0.0381	0.523	0.477
Joblessness Rate	0.0311	0.496	0.504
Arrests Per Capita	0.0060	0.890	0.110

be representative. Again, roughly 45% of the total variation in male quality at the state level comes from within-market variation. A much lower proportion of the variance in Arrests Per Capita comes from variation within markets. While this may be attributable to properties of this specific variable, the UCR is true population data whereas the BRFSS is (albeit very large) sample data. Overall, while the within-market variation at the MSA level may be larger than expected, the state level BRFSS is designed to be representative. Therefore, the consistency of within and between shares of variance at the MSA-level and State-level BRFSS measures provides evidence that our market-level data has adequate variation to study the relationship between single male quality and female health investment decisions.

IV Empirical Analysis

We empirically evaluate how a single female's investment in healthy body weight (i.e., exercise) responds to a change in the proportion of low quality single males within her marriage market. In subsection IV.1, we outline our empirical strategy, discuss the primary sources of bias with which we are concerned, and make explicit the conditions under which our estimates are unbiased. In subsection IV.1.1, we present our primary findings. In subsection IV.1.2 we conduct two sets of falsification tests. We also attempt to mitigate concerns over other potential sources of bias. In subsection IV.2.1 we extend our empirical analysis to control for sex ratios, demonstrating that our main result can be interpreted as a quality-based mate shortage. In section IV.2.2 we replicate our preferred specification at the state level to alleviate concerns about non-representativeness in MSA-markets. Finally, in section IV.2.3, we use individual-level, cross sectional data to consider how the effect of male quality on female pre-marital investment in healthy body weight varies over the distribution of female quality.

IV.1 Market-Level Empirical Strategy

Let us assume that the average weekly minutes of exercise among single women in marriage market j and time t can be written as

$$E_{jt} = \beta_1 Q_{jt} + \beta_2 X_{jt} + \alpha_t + \gamma_j + \epsilon_{jt} \tag{1}$$

where Q_{jt} measures the proportion of low quality single males and X_{jt} measures average single female characteristics in the same marriage market and time period. Our parameter of interest is β_1. To produce an unbiased estimate, we must control for three types of unobservables which are likely correlated with Q_{jt}. Unobservables that vary by time period, α_t, and unobservables that vary by marriage market, γ_j, are easily controlled for using separate time and marriage-market fixed effects. However, we are not able to control for unobservables that vary by both time period and marriage market, ϵ_{jt}, using fixed effects, as time-and-market fixed effects are not identified without an individual-level panel of observations. We include control variables, X_{jt}, which vary by market and time to reduce some of the potential bias caused by these unobservables, but additional work is needed to reduce this bias further.

For expository purposes, we rewrite ϵ_{jt} as

$$\epsilon_{jt} = \lambda_{jt} + \eta_{jt} \tag{2}$$

where $corr(\lambda_{jt}, Q_{jt}) \neq 0$ and $corr(\eta_{jt}, Q_{jt}) = 0$; our endogeneity problem stems from the first of these two conditions. The standard procedure for addressing this unwanted correlation is to employ an instrumental variables method; however, we think it unlikely that any variable that is correlated with Q_{jt} has no other effect on E_{jt}. Investments in healthy body weight are made by individuals maximizing their utility, subject to a constraint, while interacting with the built environment in which they live. Any local variation which affects the economic characteristics of single males is likely to affect the outcome of the single woman's maximization problem by altering either her constraint or the built environment.

Therefore, we opt for a different strategy, which reduces the correlation between Q_{jt} and ϵ_{jt} by normalizing the outcomes of single women to those of married women in the same time period and marriage market.

To describe this strategy, we first rewrite Equation 1 for *married* women as

$$\tilde{E_{jt}} = \tilde{\beta_1} Q_{jt} + \tilde{\beta_2} \tilde{X_{jt}} + \tilde{\alpha_t} + \tilde{\gamma_j} + \tilde{\epsilon_{jt}} \tag{3}$$

where all variables and parameters are redefined for married women, except Q_{jt}, which still defines the quality of single males in market j and time period t. Subtracting (3) from (1) yields

$$E_{jt} - \tilde{E_{jt}} = (\beta_1 - \tilde{\beta_1}) Q_{jt} + \beta_2 (X_{jt} - \tilde{X_{jt}}) + \hat{\beta_2} \tilde{X_{jt}} + (\alpha_t - \tilde{\alpha_t}) + (\gamma_j - \tilde{\gamma_j}) + (\epsilon_{jt} - \tilde{\epsilon_{jt}}) \tag{4}$$

where $\hat{\beta_2} = \tilde{\beta_2} - \beta_2$. We then make the following two assumptions

1. $\tilde{\beta_1} = 0$
2. $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda_{jt}})) = 0$.

Under these assumptions, Equation 4 reduces to

$$E_{jt} - \tilde{E_{jt}} = \beta_1 Q_{jt} + \beta_2 (X_{jt} - \tilde{X_{jt}}) + \hat{\beta_2} \tilde{X_{jt}} + \hat{\alpha_t} + \hat{\gamma_j} + \hat{\epsilon_{jt}} \tag{5}$$

where $\hat{\alpha_t} = (\alpha_t - \tilde{\alpha_t})$, a time fixed effect; $\hat{\gamma_j} = (\gamma_j - \tilde{\gamma_j})$, a market fixed-effect, and $\hat{\epsilon_{jt}} = \epsilon_{jt} - \tilde{\epsilon_{jt}}$ is an *i.i.d.* random shock. We estimate Equation 5.[15]

Our identification technique relies on assumptions (1) and (2) above. The first assumption implies that the proportion of low quality single males has no effect on the health investments of married females; this is tested in Section IV.1.2. The second assumption

[15] Including married females' characteristics, $\tilde{X_{jt}}$, has virtually no effect on the parameters of interest, yet it reduces the adjusted R^2 and, therefore, the efficiency of our estimates. As a result, $\hat{\beta_2} \tilde{X_{jt}}$ is not included in the differencing results presented in Table VII. Supplementary results are available from the authors upon request.

implies that Q_{jt} is exogenous to $(E_{jt} - \tilde{E}_{jt})$, or that unobserved factors that are correlated with single male quality have an equal effect on the health behaviors of single and married females, on average over marriage markets, j, and time periods, t.[16] While no statistical test can validate this assumption, single and married females should be equally affected by the time-and-market varying unobservables that we consider most likely to be correlated with Q_{jt} (i.e., local economic conditions, chemical dependency rates, and quality food access). Even if the condition $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda_{jt}})) = 0$ is not met, the endogeneity of Q_{jt} (and, therefore, the bias in β_1) decreases with greater correlation between λ_{jt} and $\tilde{\lambda_{jt}}$. Therefore, any correlation between λ_{jt} and $\tilde{\lambda_{jt}}$ should reduce bias in β_1.

The above should also clarify why analysis is conducted using market-level, rather than individual-level, data. First, since our data are a repeated cross section, we cannot observed the same individual in more than one period. Therefore, we cannot evaluate how that individual will change her investment in healthy body weight as male quality changes, but we can evaluate how the market average investment changes as male quality changes. Second, our differencing strategy cannot be conducted using individual level data. The inability to empirically address λ_{jt} at the individual level motivates our use of a market panel.

IV.1.1 Market-Level Results

Before discussing the results of our differencing regressions, which can be found in Table VII, we present market-level results for single females (i.e., Equation 1) for comparison purposes. Tables V and VI contain these base results. The dependent variables are average minutes of vigorous exercise per week and average minutes of moderate exercise per week respectively. For both black and white women, we regress these dependent variables on the

[16] If $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda_{jt}})) = 0$ is satisfied, then Q_{jt} is exogenous by definition. The assumption $\lambda_{jt} = \tilde{\lambda_{jt}} \; \forall \; j, t$ (i.e., that unobserved factors that are correlated with single male quality have an equal effect on the health behaviors of single and married females *for every* marriage market and time period), is a stronger assumption, which is not necessary for the exogeneity of Q_{jt}.

proportion of low quality single male in the market, while controlling for market-average single female characteristics.

We estimate each model twice, utilizing different strategies to measure single male quality. Our first strategy allows the four market-level measures of single male quality discussed above to enter as separate independent regressors. The advantage of this strategy is that it enables us to examine which specific characteristics of quality are most important. However, the joint effect of the multiple measures can be difficult to interpret and sometimes yields mixed results (see Tables XV - XVI). One solution to this problem is to simulate the marginal effect of a proportional increase in all four measures of low male quality, which yields a single marginal effect that is easy to interpret. Our second strategy uses a single-index measure of male quality from the first principal component of the four market-level measures. In contrast with the multivariate approach, this strategy yields marginal effect that is easily interpreted. However, nearly half the information available in the four measures of single male quality is discarded when we use only the first principal component (Kaiser-Meyer-Olkin (KMO) statistic of 0.531).[17] Given the strengths and weaknesses of each method, we conduct analysis using both. We believe each method provides insight on whether the quality of single males affects single females' health investment, but find neither method to be strictly preferable.

Table V (vigorous exercise) and VI (moderate exercise) contains the results of our panel data regressions for the full sample (Column 1), for white women (Column 2), and black women (Column 3). Panel A results are found using multiple measures of low male quality, while Panel B results use the single-index measure of low male quality. For ease of interpretation, we report simulated marginal effects for our multivariate (Panel A) results throughout. Individual parameter estimates for each quality measure are shown in the appendix. To generate this marginal effect, we first take 10,000 draws from the covariance matrix of our estimates. Using these draws, we simulate single female behavior once using

[17]The Kaiser-Meyer-Olkin statistic is a measure of sampling adequacy. The principle component analysis literature suggests that a KMO statistic below 0.5 is "unacceptable" (i.e., one should not factor).

observed single male quality, a second time with a 10% increase in all four (low) single male quality measures, and a third time with a 10 percentage point increase in the same four measure of (low) single male quality. We calculate the average minutes of weekly exercise within each marriage market for each simulation, and report in the table the average percentage change in exercise behavior across markets in response to the changes in male quality. Also in Panel A, we report the F-statistic and p-value for the joint significance of the multivariate measure of mate quality, which are derived from analytical tests of the joint significance of the parameters, not the simulated marginal effects.[18] All regressions control for marriage-market fixed effects and year fixed effects. In all specifications, standard errors have been clustered at the MSA level.

Table V: Market Level Results: Average Minutes of Vigorous Exercise, Single Women

Panel A: Multivariate Measure of Male Quality
Simulated Marginal Effects

	All Races	**White Only**	**Black Only**
(10 pct point increase in low quality)	-11.2%	-29.5%	-9.8%
(10 % increase in low quality)	-1.4%	-1.2%	-1.6%
F-statistic	2.58	3.55	1.98
P-value	0.036	0.006	0.096
Joint Significance	1%	1%	10%

Panel B: Principle Component Measure of Male Quality

	All Races	**White Only**	**Black Only**
First Component	-0.97	-0.53	-1.25
	**(0.38)	(0.51)	**(0.54)
Fixed Effects	Yes	Yes	Yes
N	4525	3004	1521

All regressions include controls for market characteristics of single females and clustered standard errors. Simulated Marginal Effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality. See Table XV for point estimates.

[18] Whether the simulated marginal effect is significantly different from zero can be artificially determined by the number of draws from the covariance matrix used in simulation. We use a large number of draws, so all marginal effects are highly significant. With the previous caveat, the analytical test of joint significance (and resulting F-statistics and p-values) provide a more rigorous rejection of the null hypothesis of joint insignificance than simulated marginal effects.

The results of our vigorous exercise regressions can be observed in Table V. Focusing first on Panel A, we find that the joint effect of the multiple measures of low male quality on single females' vigorous exercise is significant at the 1% level for white women and 10% level for black women. The simulations suggest that the marginal effect of a 10% increase in the proportion of low quality males leads single black (white) women to decrease their vigorous exercise by 1.6% (1.2%), while a 10 percentage point increase in the proportion of low quality males leads single black (white) women to decrease their vigorous exercise by 9.8% (29.5%). Note that while it is reasonable to assume that policy or other economic shocks could cause a 10% change in either black or white male quality in most marriage markets, a 10 percentage point change in the proportion of low quality while males is superfluous. The observed proportion of low quality males is considerably higher in black marriage markets than in white ones; the difference is most notable with arrest rates. On average, for black men there are 0.12 arrests per capita per year, a figure four times that of white men (0.03). Thus, the predicted decrease in vigorous exercise for single white women in response to the 10 percentage point change in male quality is driven almost entirely by the quadrupling of the arrest rate. For this reason, little attention should be paid to the result. The PCA results in Panel B confirm the multivariate results. While the effect of low male quality on market-average vigorous exercise by single females is still significant for the full sample and for single black women (a 10 percentage point increase in our (low) quality measure decreases average vigorous exercise for single women and single black women by 3.0% and 8.4%, respectively), it is no longer significant for white women. This result is intuitive; lack of variation in arrest rates causes the the PCA index to places lower weight on arrest rates than the other economic measures. The result suggests that arrest rates are the primary driver of joint significance for white women in the multivariate model.

Our results for moderate exercise can be found in Table VI. Unlike the results for vigorous exercise, none of the multivariate regressions yield estimates in which the four coefficients on low male quality are jointly significant. For white women, we find that an

increase in the proportion of low quality single males leads to a decrease in moderate exercise (with 5% significance) when using the index from the first principal component. This result suggests that a ten percent increase in the proportion of low quality single white males leads to a 3% decrease in moderate exercise by single white women. For black women, we find no effect on moderate exercise.

Briefly summarizing the results from our market-level regressions so far, an increase in the proportion of low quality males leads to a decrease in market-average vigorous exercise by single black women. The evidence that a greater proportion of low quality males decreases exercise among single white women is mixed for both exercise type and male quality specifications.

Table VI: Market Level Results: Average Minutes of Moderate Exercise, Single Women

Panel A: Multivariate Measure of Male Quality Simulated Marginal Effects			
	All Races	**White Only**	**Black Only**
(10 pct point increase in low quality)	-2.8%	-5.4%	-1.5%
(10 % increase in low quality)	-0.3%	-0.4%	-0.3%
F-statistic	0.97	1.20	0.86
P-value	0.422	0.309	0.488
Joint Significance	None	None	None
Panel B: Principle Component Measure of Male Quality			
	All Races	**White Only**	**Black Only**
First Component	-0.82	-1.15	-0.58
	*(0.50)	**(0.58)	(0.73)
Fixed Effects	Yes	Yes	Yes
N	4525	3004	1521

All regressions include controls for market characteristics of single females and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for multivariate measure of male quality. See Table XV for point estimates.

The results from our differencing regressions (i.e., Equation 5) are presented in Table VII. Recall, the dependent variables measure the difference in average investment in healthy body weight between single and married women in a given marriage market and time period. We regress these differenced variables on our previously defined market-level measures of low

male quality and differenced market-level female characteristics. Using both multivariate and single-index measures of male quality, we find no statistically significant effect of low quality single white males on single white female health investments. For black women, we find that the joint effect of the multivariate measure of low quality males is statistically significant at the 10% level for vigorous, but not moderate exercise. However, the marginal effects are negative for both types of exercise. A 10 percentage point increase in the proportion of low quality males leads to a 5% decrease in vigorous exercise taken by single black women. We find similar results when estimation is conducted with the single-index measure of male quality. An increase in the proportion of low quality males decreases average vigorous exercise among single black women in the population (at a 5% level of significance) and has a negative, though insignificant, effect on average moderate exercise. This marginal effect can be interpreted as follows: If the quality of males in a given marriage market deteriorates from median quality to 25^{th} percentile quality, single black women will decrease their vigorous exercise by 10%.

For both races, the simulated marginal effect of a 10% increase in low male quality on vigorous exercise under our differencing specification is roughly 20% lower than our results in Table V. Furthermore, the marginal effect of a 10 percentage point increase on vigorous exercise is approximately halved for black women when we difference the single women from the married women. These results are fairly consistent with the findings from the single-index model. For black women, the marginal effect of an increase in low male quality on vigorous exercise is negative and 35% lower in the differencing model than in the base model. These results suggest that an increase in the proportion of low quality single black males decreases the vigorous exercise taken by single black women within a marriage market. Furthermore, differencing married women from single women is effective at reducing bias from time-and-market varying unobserved heterogeneity. Recall that the differencing regression results can be interpreted as unbiased estimates of the effect of low male quality on single female investment in health body weight only if the effect of low single male quality on *married*

female investment in healthy body weight is zero. We test that assumption in the next section.

Table VII: Market Level Differencing Regression: Single- Married Women

	White Women		Black Women	
	Mod. Ex.	**Vig. Ex.**	**Mod. Ex.**	**Vig. Ex.**
Panel A: Multivariate Measure of Male Quality Simulated Marginal Effects				
(10 pct point increase in low quality)	4.6%	-26.3 %	-1.8%	-5.0%
(10 % increase in low quality)	0.3%	-1.0%	-0.4%	-1.3%
F-statistic	0.59	1.16	0.81	2.10
P-value	0.671	0.327	0.52	0.079
Joint Significance	None	None	None	10%
Panel B: Principle Component Measure of Male Quality				
First Component	0.52	-0.04	-0.94	-1.68
	(0.92)	(0.64)	(1.36)	**(0.85)
N	3561	3561	1611	1611

All regressions include controls for differenced market characteristics of females, time fixed effects, marriage-market fixed effects, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for multivariate measure of male quality. See Table XVI for point estimates. Percentage change calculated with average exercise among *single females* as the base, rather than the difference. Ultimately, the exercise of single females, not the spread, is the outcome of interest.

IV.1.2 Market-Level Falsification Checks

We subject the MSA-level results to two falsification tests. First, we regress the average vigorous exercise taken by single females on the proportion of low quality single males from the other race in the same MSA-age marriage market. Data from Pew Research Center show that individuals in the United States primarily marry within their own race (Taylor, 2010). As such, the characteristics of *white* 25-34 year old males in St. Louis should have a much smaller effect on the incentives of *black* females to invest in healthy body weights. Throughout this paper, we have assumed that marriage markets are separated by race. We show below that the quality of the males of one race does not affect investment in healthy body weight by females of the other race, which validates our within-race definition of a

marriage market. Second, we regress marriage-market level average investment in healthy body weight by married women on the proportion of low quality single males and the usual set of control variables (high school dropout rate, kids per capita, low income rates and joblessness rates). With this regression, we test the validity of the assumptions underlying our differencing regressions, namely that single male quality does not affect post-marital investment in healthy body weight. Given the consistency of PCA and multivariate regressions in the previous section, we conduct this analysis using the single-index measure of male quality only for ease of interpretation.

Results from these two falsification tests can be observed in Table VIII. Columns 1 and 2 contain the results of the cross-racial falsification test. We find that for both races and both behaviors related to investment in healthy body weight, the results are statistically insignificant from zero. We interpret this as a validation of our MSA-level results and race-specific definitions of marriage markets. The results for the regressions of married women's exercise on single male quality are found in columns 3-4. We find that the effect of the proportion of low quality single males on all black married female investment and white married female vigorous exercise is insignificantly different from zero. In general, these results support our differencing strategy as an effective means to control for market-and-time varying unobserved heterogeneity. We do find that married white women's moderate exercise behavior is significantly increasing in single white male quality (i.e., an increase in the proportion of low quality single males leads married white women to exercise less). While this violates our assumption of no relationship, the impact of this result on the differenced marginal effect is straightforward. Returning to Equation 4, we estimate $(\beta_1 - \tilde{\beta}_1)$, but are interested in β_1. Finding that $\tilde{\beta}_1$ is negative suggests that our differencing regression results are biased up. This explains why low male quality decreased moderate exercise for single white women in our level specification but not when differenced against the married women.

Several other potential sources of bias have been considered. First, location choice is endogenous. Individuals' location choices may be affected by marriage market conditions

Table VIII: Falsification Tests: Cross-Race Estimation & Married Women

	Cross-Race Effects		Married Women	
	White Women	Black Women	White Women	Black Women
	Principle Component Measure of Male Quality			
Vigorous Exercise	-0.03	0.02	-0.37	0.58
	(0.26)	(0.78)	0.37	(0.72)
Moderate Exercise	-0.10	0.69	-1.52	0.19
	(0.33)	(1.30)	**(0.76)	(1.15)
N	3004	1521	3004	1521

All regressions include controls for market characteristics of single females, time fixed effects, marriage-market fixed effects, and clustered standard errors.

as well as economic conditions. If individuals who are competitive in the marriage market (and presumably investing in healthy body weight) move to areas with concentrations of high mate quality, our results would be biased away from zero. Data from the American Community Survey (ACS) mitigate, but do not eliminate this concern. Approximately 3.3% of single individuals move between different states per year according to ACS 5-year estimates. Contrary to the idea of high potential individuals moving to locations with more favorable mating pools, geographic mobility is highest among those with less education and less income. Intrastate annual migration is 4.5% for those making less than $15,000 per year compared to 2% for those earning more than $65,000 per year. The interstate annual migration rate is 3.0% for those earning less than $15,000 per year compared to 2.1% for those earning more than $65,000 per year. Two other factors mitigate our concerns: much migration among single people is from rural areas to cities - our analysis is already restricted to cities. Additionally, we control for changing characteristics of the single female population of an MSA by including variables for single females' high school dropout rates, joblessness rates, low income status rates, and number of children per single female.

Selection into marriage creates another potential concern. If changes in male quality alters whether some women get married, the observed change in pre-marital investment in healthy body weight may simply reflect changes in the composition of the population of single women. We rely on our female quality control variables to mitigate potential bias. We

also note that there are well documented differences in exercise trends between married and single women. To address these differences, our differencing regressions include a constant to capture global differences in exercise between the sexes and contain marriage market level fixed effects to capture local variation in exercise behavior (unrelated to single male quality) between married and single women.

IV.2 Empirical Extension

IV.2.1 Controlling for Differences in Sex-Ratio

While our analysis is focused on the effects of low quality single males, a related literature has examined the effect of market-level sex ratios on investment in human capital (Mechoulan, 2011; Lafortune, 2013; Lin et al., 2014). For example, Lin et al. find that unfavorable sex ratios induced by the expansion of the criminal justice system contributes to obesity among single black females. In this section, we repeat our MSA-level (non-differencing) analysis using our single-index measure of the proportion of low quality males, while controlling for sex-ratio at the marriage market level to see if the response to quality varies by sex ratio.

Table IX contains our results. Denoting the female-to-male ratio FMR, in Columns 1 and 2 we split the sample on whether there is a shortage of males ($FMR > 1$) or a surplus of males ($FMR < 1$). We find that the effect of an increased proportion of low quality males on single female investment in healthy body weight increases when there is already a shortage of males. For single black women facing a mate shortage, the additional effect of a high proportion of low quality mates on vigorous exercise is negative and significant at the 1% level. For white women, the larger effect is on moderate exercise for women facing a mate shortage (10% significance). This result is intuitive. In a market already characterized by a shortage of males, an increase in the proportion of low quality males will increase the number of women who cannot find a suitable mate, potentially leading these women to quit

the marriage market. In contrast, a market with a surplus of males provides some buffer for women facing a downward shift in male quality.

Table IX: Market Level Regressions - by Race and Sex Ratio

	Principal Component Measure of Male Quality	
Variable	**FMR<1**	**FMR>1**
	Black Women	
Vigorous Exercise	-0.35	***-1.66
Moderate Exercise	-0.15	-0.82
N	450	1071
	White Women	
Vigorous Exercise	-1.07	0.04
Moderate Exercise	-1.11	*-1.23
N	1364	1640

All regressions include controls for market characteristics of single females, time fixed effects, marriage-market fixed effects, and clustered standard errors. FMR is the ratio of Females/Males in a given market.

IV.2.2 State-Level Analysis

Brien (1997) finds evidence that even using large data sets (i.e., Decennial Census, Sample A) that MSA-level measures of economic indicators are troubled by measurement error. If classical measurement error is present in our MSA-level estimates, then the true effect low quality single males on female health behaviors should be stronger than our estimates due to attenuation bias. Therefore, to verify that our results are not driven entirely by some endogenous measurement error, we repeat our preferred differencing specification using state-level data from BRFSS. While BRFSS-SMART is weighted to increase representativeness at the MSA level, it is not fundamentally designed to be representative at the MSA level. BRFSS, however, is designed to be representative at the state level. While we view the MSA as the correct geographic definition of a marriage market, we do view these state-level

results as validation of our findings at the MSA level.[19] Furthermore, these results may be seen as a robustness check against any problems related to small numbers of observations is MSA-market cells.

The results of the differencing regressions (married from single women) of health investment on the market-level measures of single men are found in Table X. In using the multivariate approach, none of the estimated coefficients are jointly significant for white women. Single black women are shown to decrease moderate and vigorous exercise by 2.2% and 3.6% in response to a 10% increase in the proportion of low quality males; coefficients are jointly significant at the 5% level. This compares to respective a 0.4% and 1.3% decreases at the MSA-level, suggesting our MSA-level results may suffer from classical measurement error due to attenuation bias. Similar to our previous specifications, we also conduct regressions with a PCA-created single-index measure of male quality.[20] With this measure of mate quality, our results for the effect of mate quality on vigorous exercise for black women are negative and significant at the 5% level, though the point estimate is very close to that found with an MSA-level definition of marriage markets (Table VII, Column 6). Again supporting the notion that our MSA-level results may suffer from attenuation bias, we find that an increase in the proportion of low quality males has a negative effect (1% level of significance) on black single female moderate exercise at the state level, but no significant effect at the MSA level.

IV.2.3 Heterogeneous Investment: Variation over the Female Quality Distribution

Thus far, we have conducted our analysis using market averages over single women. However, it is probable that the response of single females' investment in health body weight

[19] Brien (1997) finds that state-level "marriage-market" variables outperform indicators of "marriageability" defined at the local level due to considerable measurement error at the local level.

[20] (KMO=0.515)

Table X: Differencing Regression - Single vs. Married Women, Health Behaviors, State Level

	White Women		Black Women	
	Mod. Ex.	**Vig. Ex.**	**Mod. Ex.**	**Vig. Ex.**
Panel A: Multivariate Measure of Male Quality				
Simulated Marginal Effects				
(10 pct point increase in low quality)	32.2%	-17.6%	-9.6%	-22.3%
(10 % increase in low quality)	1.6%	-0.8%	-2.2%	-3.6%
F-statistc	1.71	0.91	2.98	2.94
P-value	0.147	0.457	0.020	0.022
Joint Significance	None	None	5%	5%
Panel B: Principle Component Measure of Male Quality				
First Component	-0.59	-1.47	-2.93	-1.50
	(1.58)	(1.29)	***(1.13)	**(0.70)
N	1256	1255	877	879

All regressions include controls for differenced market characteristics of females, time fixed effects, marriage-market fixed effects, and clustered standard errors. Simulated Marginal Effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

to changes in male quality varies over the distribution of female quality.[21] To evaluate whether the response in female pre-marital investment in healthy body weight varies by female quality, we must move to individual level data.[22]

To assess the effects of prospective mate quality on individual single female health behaviors, we use individual-level data from females in the BRFSS-SMART and the calculated market-level characteristics for single men. To split the sample on the basis of female quality, we use Multiple Correspondence Analysis (MCA) to rotate the individual female categorical reports of income, education, and body weight into a single, continuous index of female quality.[23] We then split the sample into quintiles of female quality. As in our

[21]This is especially true with our empirical analysis, as our measures of male quality are in fact capturing the proportion of low quality males.

[22]In nearly all MSA's, we do not have enough observations to split the market into quality-quintiles by market. The cross sectional nature of the data also prevents us from utilizing any differencing methodology. Whereas in the market analysis, we utilize a type of triple difference (between married and single; over time; as male quality changes) the static diff-in-diff framework requires observation in the treatment/control group (married/single) be exogenous. We do not find that assumption credible in this context.

[23]MCA and Principal Components Analysis (PCA) both are data reduction tools, used for transforming multi-variate measures into a single measure. Whereas PCA is used to transform continuous variables into a single-index variable, MCA is used to transform discrete categorical variables into a single-index variable.

market-level regressions, we consider two specific health investment behaviors: minutes of moderate exercise per week and minutes of vigorous exercise per week. We use an ordered probit specification for each behavior.[24] In all regressions, we control for a female education, income, employment, number of children, age-category fixed effects, and MSA-level fixed effects. Unlike our market-level regressions, we can now include a time-trend variable for each MSA. Mirroring our market-level analysis, we employ a multivariate specification with simulated marginal effects and analytical tests for joint significance, and a single-index measure of male quality constructed from the first principal component. For each quintile of female quality we regress single female investment in healthy body weight on the multivariate (or PCA) measure of male quality with aforementioned controls and fixed effects.

Table XI contains the results of our regressions using hours of vigorous exercise as the dependent variable. Panel A contains the results from our multivariate specification of low male quality. We find jointly significant effects (at the 1% level) of male quality on hours of vigorous exercise for only single black women in the lowest quintile of female quality. To calculate the marginal effect of a change in the proportion of low quality males we increase each measure of low male quality by both 10 percentage points (top row) and 10% (second row). Among single black females in the lowest quality quintile, the only subset for which the estimated coefficients are jointly significant, a 10 percentage point increase in the proportion of low quality single males decreases vigorous exercise by 15.8%. A 10% increase in the proportion of low quality single males decreases vigorous exercise by 3.4%. Parameter estimates are available in Table XIII. Panel B contains our findings from the PCA-derived single index specification. For black women in the bottom quintile of the quality distribution, an increase in low male quality decreases the amount of vigorous exercise undertaken. A ten

The variables for males are market-level averages and, as such, are continuous. The female variables are at the individual level and are categorical, hence the need to use different techniques for male and female quality.

[24]While both exercise variables are continuous, the distribution of responses is multi-modal with considerable mass at each hour mark. We therefore discretize the individual reports of exercise using a floor function with hours as units.

percent increase in the proportion of low quality single males decreases vigorous exercise by 3.6%. This result is significant at the 5% level.

Table XI: Individual Level Results, Ordered Probit: Hours of Vigorous Exercise Per Week

Panel A: Multivariate Measure of Male Quality - Marginal Effects

			Black Women		
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
(10 pct point increase in low quality)	-15.8%	2.8%	10.2%	-8.8%	1.2%
(10 % increase in low quality)	-3.4%	-0.2%	2.9%	-1.6%	0.1%
χ^2 value (Joint Sig. of Parameters)	15.73	3.84	7.74	3.79	2.48
P-value	.003	0.428	0.101	0.436	0.648
Joint Significance	1%	None	None	None	None
			White Women		
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
(10 pct point increase in low quality)	-17.2%	5.1%	-5.9%	-3.9%	0.3%
(10 % increase in low quality)	-0.1%	-0.1%	-0.4%	-0.0%	0.2%
χ^2 value (Joint Sig. of Parameters)	6.63	2.87	5.94	1.83	2.80
P-value	0.156	0.579	0.203	0.766	0.591
Joint Significance	None	None	None	None	None

Panel B: Univariate measure (First Principal Component) by female quality quintile

			Black Women		
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
PCA Index	-0.02	-0.01	0.02	-0.02	0.01
	**(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
			White Women		
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
PCA Index	0.001	-0.00	-0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

Table XII contains the results for our regressions using hours of moderate exercise as the dependent variable. Similar to the Panel A results for vigorous exercise, we find jointly significant effects (at the 10% level) of low male quality on hours of moderate exercise for only single black women in the lowest quintile of quality. Increasing each of the four measures of

low male quality by 10% and 10 percentage points leads to a decrease in moderate exercise by low quality black women; 2% and 10.6%, respectively. An important finding from this table is that the decrease in vigorous exercise for single black women in the lowest quality quintile is being compounded by, rather than offset by, responses in moderate exercise. Parameter estimates are available in Table XIV. In Panel B, we find that the effect of the single-index measure of male quality on single black females' moderate exercise is negative and significant at the 5% level for women in the lowest quintile of quality. For these women, a 10% increase in the proportion of low quality males leads to a 1.6% decrease in moderate exercise. Counter to our primary results for black females, Panel B shows that an increased proportion of low quality single males leads to decreased exercise by high quality (4th quintile) white females.

In summary, our individual-level cross-sectional analysis produces two primary results. First, we consistently find that single black women at the low end of the quality distribution exercise less when there is a greater proportion of low quality males. This result holds for vigorous and moderate exercise, under multivariate and single index measures of male quality. Second, we find mixed evidence on whether single white women change their investment in healthy body weight in response to a change in the proportion of low quality males in the market. Note that these results are only suggestive of a causal relationship between single male quality and single female health investment that varies over the female quality distribution. While we have controlled for MSA-level fixed effects and MSA-specific time trends, it is possible that time specific MSA-shocks can cause both a deterioration in single male quality and a decrease in single female investment in health body weight. Furthermore, we recognize that BMI is endogenous to exercise decisions in the PCA/MCA analysis. As higher body weight lowers mate quality, the women in the lowest quintile typically do not exercise very much. As such, if there is any bias from subdividing the sample partially on the basis of BMI, it is towards zero. Additionally, since exercise is discrete and bounded below by zero, the variation in exercise behavior for those women in the bottom quintile is primarily on the extensive margin.

Table XII: Individual Level Results, Ordered Probit: Hours of Moderate Exercise Per Week

Panel A: Multivariate Measure of Male Quality - Marginal Effects

	Black Women				
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
(10 pct point increase in low quality)	-10.6%	2.8%	1.7%	1.0%	1.8%
(10 % increase in low quality)	-2.0%	-0.0%	0.1%	0.1%	0.6%
χ^2 value (Joint Sig. of Parameters)	7.91	3.76	0.76	0.81	1.29
P-value	.090	0.439	0.943	0.937	0.8626
Joint Significance	10%	None	None	None	None
	White Women				
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
(10 pct point increase in low quality)	7.8%	-4.7%	-2.0%	1.0%	-2.6%
(10 % increase in low quality)	0.8%	-0.4%	-0.6%	-0.1%	-0.2%
χ^2 value (Joint Sig. of Parameters)	3.72	3.77	1.51	6.83	2.95
P-value	0.445	0.437	0.825	0.145	0.567
Joint Significance	None	None	None	None	None

Panel B: Univariate measure (First Principal Component) by female quality quintile

	Black Women				
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
PCA Index	-0.02	-0.01	0.01	0.00	-0.01
	**(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	White Women				
	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
PCA Index	0.00	-0.01	-0.01	-0.03	0.00
	(0.01)	(0.01)	(0.01)	***(0.01)	(0.01)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

V Discussion

This paper examines how a single female's investment in healthy body weight is affected by the quality of single males in her marriage market. We find that a greater proportion of low quality mates in a marriage market leads to decreased investment in healthy body weight by single females, particularly for black females. This result holds when marriage markets are defined at both the MSA and state level. Additional empirical analysis suggests that the impact of low male quality is strongest in marriage markets with a shortage of males and on single black women who are less educated, low income, and heavy.

None of our results suggest increased competition for mates in response to a reduction in mate quality. Previous work on the effects of mate shortage on human capital investment (Mechoulan, 2011; Lafortune, 2013) have found that a shortage of mates yields increased investment. By contrast, our results are consistent with Lin et al. (2014), who find that mate shortage is associated with increased obesity rates among single females. In fact, when we control for sex ratios, we find that the negative effects of low quality males are strongest for black women in the presence of a mate shortage. These inconsistencies in pre-marital investment behavior can be explained by either of the following two conditions: (1) investing in education/labor market human capital is more cost effective than investing in healthy body weight, or (2) that the increased investment in education under shortage conditions reflects preparation for financial independence.

On the source of racial differences in mate quality, previous studies have examined the relationship between incarceration rates and female investment in human capital and obesity. Our results show that conditional on an observed mate shortage (induced by incarceration or not), low quality among the remaining candidates matters. We believe that abstracting from mate quality and focusing purely on mate shortage understates the impact of incarceration on pre-marital investment in body weight and family formation. While sentences are often short (BJS estimates expected time served for a drug trafficking conviction at 28 months), felony convictions carry severe consequences for earning potential for the balance of the

individual's life. Insofar as women value marriage as a means of financial support, while the expansion of the corrections system in the United States increased in the proportion of males of all races with low economic value, black males have been disproportionately affected. Charles and Luoh (2010) find that a one 1% increase in incarceration rates decreases the proportion of women who marry by 2.4%.

While we show that the economic characteristics of the mating pool affect investment in healthy body weight by single women more than arrest rates, the corrections system is still an appropriate point for a policy intervention. Specifically, the removal of the 'have you been convicted of a felony' box from job applications, at least for non-violent drug offenses, may improve the economic prospects for many once-incarcerated black men. Our analysis suggests that the economic result of this policy change will likely create positive health externalities for single black women. Although black women comprise 6.5% of the U.S. Population, they make up 17.7% of the morbidly obese U.S. population. Given the scale of societal costs of obesity and the high rates of obesity (60%) and morbid obesity (28%) among black women, any policy that yields positive health externalities for black women is worthy of further study.

References

Averett, S. L., A. Sikora, and L. M. Argys (2008). For better or worse: Relationship status and body mass index. *Economics and Human Biology 6*, 330–349.

Becker, G. S. (1974). A theory of marriage. In T. W. Schultz (Ed.), *Economics of the Family: Marriage, Children, and Human Capital*, pp. 299–344. Chicago: The University of Chicago Press.

Becker, G. S. (1981). *A Treatise on the Family*. Harvard University Press.

Begley, S. (2012, April). As america's waistline expands, costs soar. http://www.reuters.com/article/2012/04/30/us-obesity-idUSBRE83T0C820120430. Thomson Reuters.

Bonczar, T. P. and A. J. Beck (1997, March). Lifetime likelihood of going to state or federal prison. *Bureau of Justice Statistics (NCJ 160092)*, 1–13.

Boulier, B. L. and M. R. Rosenzweig (1984). Schooling, search, and spouse selection: Testing economic theories of marriage and household behavior. *Journal of Political Economy 92(4)*, 712–732.

Brien, M. J. (1997). Racial differences in marriage and the role of marriage markets. *Journal of Human Resources 32*, 741–789.

Burdett, K. and M. G. Coles (1997). Marriage and class. *The Quarterly Journal of Economics 112*(1), 141–168.

Burdett, K. and M. G. Coles (2001). Transplants and implants: The economics of self-improvement. *International Economic Review 42(3)*, 597–616.

Cawley, J. (2004). The impact of obesity on wages. *The Journal of Human Resources 39(2)*, 451–474.

Charles, K. K. and M. C. Luoh (2010). Male incarceration, the marriage market, and female outcomes. *Review of Economics and Statistics 92*, 614–627.

Chiappori, P.-A., M. Iyigun, and Y. Weiss (2009). Investment in schooling and the marriage market. *American Economic Review 99(5)*, 1689–1713.

Chiappori, P.-A., S. Oreffice, and C. Quintana-Domeque (2012). Fatter attraction: Anthorpmetric and socioeconomic matching on the marriage market. *Journal of Political Economy 120(4)*, 659–695.

Finlay, K. and D. Neumark (2010). Is marriage always good for children: Evidence from families affected by incarceration. *Journal of Human Resources 45(4)*, 1046–1088.

Fitzgerald, J. (1991). Welfare durations and the marriage market. *Journal of Human Resources 26(3)*, 545–561.

Flegal, K. M., M. D. Carroll, C. L. Ogden, and L. R. Curtin (2010). Prevalence and trends in obesity among us adults, 1999-2008. *The Journal of the American Medical Association 303(3)*, 235–241.

Hammond, R. A. and R. Levine (2010). The economic impact of obesity in the united states. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy 3*, 285–295.

Iyigun, M. and R. P. Walsh (2007). Endogenous gender power, household labor supply and the demographic transition. *Journal of Development Economics 82(1)*, 138–155.

Lafortune, J. (2013). Making yourself attractive: Pre-marital investments and the returns to education. *American Economic Journal: Applied Economics 5(2)*, 151–178.

Lichter, D. T., F. B. LeClere, and D. K. McLaughlin (1991). Local marriage markets and the marital behavior of black and white women. *American Journal of Sociology 96(4)*, 843–867.

Lichter, D. T., D. K. McLaughlin, G. Kephart, and D. J. Landry (1992). Race and the retreat from marriage: A shortage of marriageable men? *American Sociological Review 57(6)*, 781–799.

Lin, W., K. McEvilly, and J. Pantano (2014). Anthropometric matching inthe marriage market, sex-ratio and pre-marital fitness investments. Working Paper.

Mechoulan, S. (2011). The external effects of black male incarceration on black females. *Journal of Labor Economics 29(1)*, 1–35.

Mukhopadhyay, S. (2007). Do women value marriage more? the effect of obesity on cohabitation and marriage in the usa. *Review of Economics in the Household 6*, 111–126.

Oreffice, S. and C. Quintana-Domeque (2010). Anthropometry and socioeconomics among couples: Evidence in the united states. *Economics and Human Biology 8*, 373–384.

Philipson, T. (2001). The world-wide growth in obesity: an economic research agenda. *Health Economics 10*(1), 1–7.

Schneider, D. (2011). Wealth and the marital divide. *American Journal of Sociology 117*, 627–667.

Smith, L. (2006). The marriage model with search frictions. *Journal of Political Economy 114*(6), 1124–1144.

Taylor, P. (2010). *Marrying Out: One-in-Seven Marriages is Interracial or Interethnic*, pp. 5. Washington D.C.: Pew Research Center.

Tillman, R. (1987, August). The size of the 'criminal population': The prevalence and incidence of adult arrest. *Criminology 25(3)*, 561–580.

Western, B. (2002). The impact of incarceration on wage mobility and inequality. *American Sociological Review 67(4)*, 526–546.

Wilson, W. J. and K. M. Neckerman (1986). Poverty and family structure: The widenig gap between evidence and public policy issues. In S. H. Danziger (Ed.), *Fighting Poverty: What Works and What Doesn't*, pp. 232–259. Cambridge: Harvard University Press.

Wood, R. G. (1995). Marriage rates and marriageable men: A test of the wilson hypothesis. *Journal of Human Resources 30*, 163–193.

Table XIII: Parameter Estimates from Multivariate Approach: Table XI

Individual Vigorous Exercise on Multivariate Measure of Mate Quality

Black Women

	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
H.S. Dropout Rate - Single Males	-0.21	-0.17	0.23	-0.13	0.29
	(0.27)	(0.24)	(0.18)	(0.18)	(0.19)
Low Income Rate - Single Males	0.06	-0.22	0.23	-0.17	0.22
	(0.16)	(0.16)	(0.14)	(0.16)	(0.20)
Arrest Rate - Single Males	-0.58	0.54	1.00	-0.47	-0.19
	(0.92)	(0.80)	(0.65)	(0.74)	(0.62)
Jobless Rate - Single Males	-0.54	-0.10	0.09	-0.11	-0.21
	***(0.18)	(0.19)	(0.16)	(0.14)	(0.19)

White Women

	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
H.S. Dropout Rate - Single Males	0.07	0.06	-0.11	-0.03	0.09
	(0.13)	(0.14)	(0.12)	(0.12)	(0.14)
Low Income Rate - Single Males	0.13	0.09	0.14	-0.12	-0.05
	(0.13)	(0.13)	(0.11)	(0.11)	(0.12)
Arrest Rate - Single Males	-1.62	0.54	-0.42	-0.36	-0.18
	**(0.80)	(0.87)	(0.85)	(0.61)	(0.80)
Jobless Rate - Single Males	-0.03	-0.20	-0.11	0.06	0.18
	(0.12)	(0.13)	(0.12)	(0.11)	(0.13)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors.

Table XIV: Parameter Estimates from Multivariate Approach: Table XII

Individual Moderate Exercise on Multivariate Measure of Mate Quality

Black Women

	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
H.S. Dropout Rate - Single Males	0.16	-0.15	0.04	0.09	0.05
	(0.22)	(0.19)	(0.17)	(0.19)	(0.15)
Low Income Rate - Single Males	-0.08	-0.12	-0.08	-0.05	-0.02
	(0.14)	(0.14)	(0.13)	(0.14)	(0.13)
Arrest Rate - Single Males	-0.94	0.72	0.25	0.17	0.06
	(0.69)	(0.58)	(0.68)	(0.68)	(0.57)
Jobless Rate - Single Males	-0.29	-0.13	-0.00	-0.08	0.14
	**(0.14)	(0.14)	(0.14)	(0.15)	(0.15)

White Women

	Lowest	**Second**	**Middle**	**Fourth**	**Highest**
H.S. Dropout Rate - Single Males	-0.03	-0.08	-0.08	-0.26	0.19
	(0.13)	(0.13)	(0.13)	**(0.13)	(0.14)
Low Income Rate - Single Males	0.03	0.02	-0.04	-0.16	0.01
	(0.12)	(0.12)	(0.11)	(0.14)	(0.13)
Arrest Rate - Single Males	0.78	-0.37	-0.06	0.53	-0.47
	(0.74)	(0.75)	(0.76)	(0.67)	(0.79)
Jobless Rate - Single Males	0.18	-0.22	-0.09	0.08	-0.14
	(0.12)	*(0.13)	(0.10)	(0.10)	(0.13)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors.

Table XV: Parameter Estimates: Multivariate Approach for Tables V & VI

	All Races	White Only	Black Only
Panel A: Multivariate Measure of Male Quality - Vigorous Exercise			
H.S. Dropout Rate - Single Males	-2.40	-6.31	-0.11
	(2.85)	*(3.47)	(4.27)
Low Income Rate - Single Males	-5.01	-1.57	-6.62
	**(2.12)	(3.10)	**(2.80)
Arrest Rate - Single Males	-20.86	-72.47	-8.03
	*(11.66)	***(24.81)	(12.91)
Jobless Rate - Single Males	-1.59	0.73	-3.30
	(2.17)	(3.10)	(2.98)
Panel B: Multivariate Measure of Male Quality - Moderate Exercise			
H.S. Dropout Rate - Single Males	0.47	-6.21	4.52
	(3.16)	(4.36)	(6.18)
Low Income Rate - Single Males	-5.23	-1.44	-7.91
	*(3.23)	(3.72)	*(4.68)
Arrest Rate - Single Males	-6.37	-13.54	-4.19
	(17.67)	(31.38)	(20.82)
Jobless Rate - Single Males	-1.09	-4.39	1.48
	(3.04)	(3.39)	(4.70)

All regressions include controls for market characteristics of single females and clustered standard errors.

Table XVI: Market Level Differencing Regression Multivariate Parameter Estimates, Table VII

	White Women		Black Women	
	Mod. Ex.	**Vig. Ex.**	**Mod. Ex.**	**Vig. Ex.**
Panel A: Multivariate Estimates - Differencing Regressions (MSA Level)				
H.S. Dropout Rate - Single Males	0.63	-2.31	-4.88	-3.33
	(6.71)	(4.43)	(8.07)	(6.24)
Low Income Rate - Single Males	6.43	-1.12	-11.97	-13.32
	(0.08)	(4.50)	*(7.54)	***(4.93)
Arrest Rate - Single Males	16.58	-70.18	-3.03	5.24
	(54.71)	*(39.91)	(36.39)	(23.87)
Jobless Rate - Single Males	-2.87	2.73	2.06	5.99
	(4.71)	(3.72)	(7.79)	(5.43)
N	3561	3561	1611	1611
Panel B: Multivariate Estimates - Differencing Regressions (State Level)				
H.S. Dropout Rate - Single Males	-7.65	-8.25	13.04	-1.30
	(10.02)	(7.73)	(9.59)	(5.35)
Low Income Rate - Single Males	17.23	2.44	-12.44	-5.26
	*(8.84)	(6.05)	(8.87)	(5.14)
Arrest Rate - Single Males	141.52	-36.86	-21.56	-30.25
	(94.49)	(62.30)	(29.22)	*(16.87)
Jobless Rate - Single Males	3.95	-4.15	-19.10	-7.08
	(7.69)	(4.79)	**(9.33)	*(4.57)
N	1256	1255	877	879

All regressions include controls for differenced market characteristics of females, time fixed effects, marriage-market fixed effects, and clustered standard errors.