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I, Rebecca A Reeder, hereby submit this original work as part of the requirements for the degree of:

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Change in Composition versus Variable Force as Influences on the Downward Trend in the Sex Ratio at Birth in the U.S., 1971-2006

Student Signature: Rebecca A Reeder

This work and its defense approved by:

Committee Chair: Phillip Neal Ritchey, PhD

Phillip Neal Ritchey, PhD

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Change in Composition versus Variable Force as Influences on the Downward Trend in the Sex Ratio at Birth in the U.S., 1971-2006

Rebecca A. Reeder

Bachelors of Science University of Cincinnati 2008

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Masters of Science University of Cincinnati 2010

McMicken College of Arts & Sciences

Department of Sociology

Committee Chair: Dr. P. Neal Ritchey
Abstract

In the United States, the sex ratio at birth exhibits a downward trend between 1971 and 2006. Prior literature implies, but has not made explicit, the difference between changes in variable force and changes in composition as two important, but very different categories of factors affecting trends. Indeed prior studies examining the trend in the sex ratio at birth have empirically related change in variable force but not change in composition to the trend. An objective of this work was to make this distinction explicit. Also, this work undertook to measure composition change for mother’s education, race, marital status, and age and relate their trends to the recent downward trend in the U.S. sex ratio at birth.

This research used all birth certificates from 1971 to 2006; in total, 125,578,596 birth certificates from 36 separate data files. I used the individual birth certificates for each year to construct a record for that year. Each record contains the sex ratio and measures of variable composition for my four predictors. Thus, my data set has year as the unit of analysis and is comprised of 36 total records. I desired an intuitively meaningful measure of composition. Thus, composition was measured by dichotomizing each of the 4 composition variables and using the percent in the category that had the corresponding lower sex ratio. Nevertheless, a more elaborate procedure was used to arrive at the categories; the procedure strove to exclude as much as possible the confounding of variable force and composition. The sex ratio at birth equals 100 times the male births divided by the female births in a year. Analyses used SAS’s autoregression procedure to derive regression coefficients and their standard errors with correction for autocorrelation.

My analysis of the effects of composition change on the 1971 to 2006 trend in the sex ratio at birth demonstrated the following: 1) the trend in education and, to a small extent, race composition would be expected to exert an upward pressure, while the trend in marital status and age composition exert a downward pressure on the trend in the sex ratio at birth; and 2) the net effect of compositional change in these four variables – these offsetting pressures – was to account for the trend in the sex ratio at birth. The downward trend in the sex ratio from 1971 to 2006 was certainly affected by composition change.
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Introduction

The objective of this study is to demonstrate the necessity and value of parsing the effect of the variable force of a determinant from the change in composition for that determinant over time on a specific trend of interest. Particularly, my purpose is to examine whether the downward trend in the sex ratio at birth (from here on out referred to as the sex ratio) in the United States since 1971 is influenced by a change in the composition of these determinants over time. To my knowledge, prior studies of trends in the literature do not make a distinction between the change in the causal force of a differential relative to the trend of interest and the effects of the changing composition of the differential relative to that same trend. Thus, the literature is unclear where influences in the trend in the sex ratio have been studied both in the U.S. and abroad.

Understanding the sex ratio at birth is vital for understanding multiple aspects of a society. The sex ratio serves as an indicator to the future size, health, and stability of a population. By studying the trend in the sex ratio at birth, one can foreshadow future demographic and social phenomena such as fertility trends and marriage patterns of a society.

As shown in Figure 1, the sex ratio exhibits a downward trend in the U.S. between 1971 and 2006. This is a marked trend where the sex ratio declines about 0.02 per year and year (representing time) explains about 64% of the variation of the sex ratio for the period. I focus on the sex ratio during this time frame because in a study for the United States Center for Disease Control and Prevention, Matthews and Hamilton (2005) explored a jointpoint analysis of the trend in the U.S. sex ratio from 1940 to 2004 and reported that the current downward trend in the United States began in 1971. My data extends 2 years beyond that study.

In this analysis, I will relate the potential effect on the trend in the sex ratio due to compositional change in four variables – all differentials recognized in the literature. The differentials examined are mother’s education, race, marital status, and age.

The current study adds to the literature by illuminating the distinction between variable force and the effect of compositional change of a determinant in an analysis of the sex ratio at birth in the United States from 1971 to 2006.

Background

Variable Force versus Compositional Change

In explaining the downward trend of the sex ratio, I am separating the effects of variable force and composition in the determinants of interest. The variable force of a determinant refers to the difference in sex ratio among categories of the determinant. The statuses reflected in the categories influence the sex ratios. Change in the variable force over time can affect the trend independent of changing composition. Composition refers to distribution of people among categories of the determinant. The distribution of people subject to the differential forces of the statuses reflected in the categories influences the sex ratio. Change in composition over time can
also affect the trend independent of changing composition. Using mother’s marital status as an example, Table 1 portrays a distinction in how the variable force and the compositional change of a determinant affect the trend of the population sex ratio.

In the first tier of the table, I am holding constant the variable force of mother’s marital status. As seen in year 1 the sex ratio for non-married is 102.50 and the sex ratio for married is 105.50. These are held constant in each subsequent year, where year 7 and 10 both show the same 102.50 and 105.50 sex ratios. However, in this tier, I portray a change in composition for the determinant for each year. In year 1, the proportion of non-married mothers is 20% compared to 80% married mothers. In year 7, the proportion of non-married mothers has risen to 38% and the proportion of married mothers has dropped to 62%. In year 10, the proportions in each category have changed even more, showing 47% non-married mothers compared to 53% married mothers. This change in composition contributes to the change in the population trend in the sex ratio. In year 1, the population sex ratio is 104.90. This number is the sum of the proportion non-married times their sex ratio and the proportion of married times their sex ratio (0.2*102.50 + 0.8*105.50 = 104.9). Over the years, the variable force is constant and the downward trend in the population sex ratio is driven by composition change -- the population sex ratio shifts from 104.90 in year 1 to 104.36 in year 7 and 104.09 in year 10.

In the second tier of this table, I have allowed the variable force to change over time while holding constant the composition of the determinant. The proportions of non-married and married mothers remain at 20% and 80%, respectively, each year. By holding constant the proportions, the change in the variable force is the causal factor in the population sex ratio trend. For example in year 1, the variable force is a sex ratio of 102.50 for non-married and 105.50 for married mothers and the resulting population sex ratio is 104.90. By year 7, the variable force of non-married and married mothers has changed to 100.70 and 105.28, respectively. By year 10, it is 99.80 and 105.17. Note the marked decline in the sex ratio among non-married mothers. Also, note that the difference of sex ratios of the married and non-married mothers increases from 3 to 5.37 over the 10 years. The increasing difference means the variable force grows in strength over time. In this case, the change in variable force, the relationship between marital status and the sex ratio, is a downward pressure on the population sex ratio trend. The population sex ratio in year 1, 7, and 10 are (again) 104.90, 104.36, and 104.09.

It is key to understand that change in variable force and change in composition can affect the population sex ratio trend. In this analysis, I parse these effects to better understand their relative contribution to the downward trend in the sex ratio of the United States since 1971.

**Prior Studies of Trends in Sex Ratio**

Although there are prior studies that employ an analysis of trends on the sex ratio, there is a lack of distinction between the effects of variable force and the effects of composition change of the determinants that affect the overall trends. To my knowledge, all prior research focuses on the effects of the variable force of the determinants over time and neglects to separate the possible effects of composition change on the marked trend.

In a study of California births from 1960 to 1996, Smith and Von Behren (2005) sought to determine an explanation for the downward trend of the overall sex ratio. Using mother’s age,
father’s age, race, and birth order as determinants, the authors run a regression analysis for each determinant in order to separate the impact of each determinant on the overall downward trend in the California sex ratio. Although they found that each demographic determinant placed pressure on the overall downward trend of male births in California, they did not address the impact that a possible changing composition of each determinant over time may have had on the overall downward trend. Variation, for example, in the population sex ratio that is attributed to the variable force of mother’s age may have actually been caused by a change in the distribution of mothers over the age categories.

Similar studies have been employed in other countries. In examining a downward trend in the sex ratio for Spain from 1981 to 1997, Gutierrez-Adan, Pintado, and De La Fuente (2000) explored the causal force of mother’s age and marriage age on the downward trend of the population sex ratio using the Pearson correlation test analysis. They also looked at a comparison of the sex ratio by examining the age gap of the mother and father using a chi-square test.

The authors found that an increase in mother’s age was linked to a decline in the population sex ratio, attributing the change to the variable force of the determinant. And although they provide a figure of the changing composition in mother’s age categories over time, they did not address the force of the differing proportions over time of the changing composition of mothers in those age categories, rather only assessed the correlation between total and age-specific sex ratio over time. While they did note the change in the composition of mother’s age over time, they did not associate the composition change in mother’s age to the population sex ratio. They did correlate mean age at marriage and the population sex ratio. However, the mean age at marriage does not capture much of the change in composition of age at marriage.

Addressing the downward trend in the U.S. sex ratio from 1981 to 2006, Branum, Parker, and Schoendorf (2009) examined the possible causal forces of plurality, gestational age and mother’s race/ethnicity using log binomial regression. Though this study attempted to explain the pressures placed on the downward trend by the variable force of mother’s race, it too failed to separate the variable force and compositional change. Like the trend study in Spain, Branum et. al. present a table of the changing totals and proportions of mothers on determinant characteristics over time. However, they do nothing more than acknowledge the change.

Finding no prior research that separate variable force and compositional change of a determinant in explaining a trend in the sex ratio and go on to relate compositional change to the trend, I intend to take this next logical step. It is necessary to explore whether composition change of the determinant affects the population sex ratio and whether that effect is an upward or downward pressure on the population sex ratio over time.

**Study Variables and Prior Literature**

Figure 2 presents a general model of family formation behavior affecting the sex of the neonate. In this general presentation, notice the inclusion of characteristics of social units as well as characteristics of individuals. Though this is an important distinction that must be examined in future research, I will focus only on the individual characteristics in this analysis. As seen in Figure 2, when addressing the sex of the neonate, there is a separation of characteristics into two main classifications: characteristics operating prior to or at the time of conception and characteristics affecting gestation. Past studies have addressed this idea in regards to the influence on the sex ratio at birth (Winston, 1931; James, 2008; Gibson, Costa,
Koifman, 2009). Some capture a similar distinction using the labels primary and secondary factors affecting the sex ratio (Gibson, Costa, and Koifman, 2009; Chahnazarian, 1988; Seth, 2010).

Prior research also divides the variables affecting the sex ratio into the categories of environmental, biological, and social. Most environmental studies are epidemiological in character (Tragaki and Lasaridi, 2009; Mackenzie, Lockridge, and Keith, 2005; Davis et al., 2007; Astolfie and Zonta, 1999); they study man-made and naturally occurring toxins and other related variables that affect the sex ratio. For example, paternal occupational exposure to toxins is studied as a cause of a declining sex ratio in a community in Canada (Mackenzie, Lockridge, and Keith, 2005) and in Seveso, Italy (Mocarelli et al., 2000). These studies also include the examination of the geographical variation in these factors that affect the sex ratio (Grech, Vassallo-Agius, Savona-Ventura, 2003; Gibson, Costa, Koifman, 2009; Feitosa and Krieger, 1992).

Biological determinants sometimes overlap with demographic and social determinants and include such factors as mother’s age, marital status, and mother’s occupation. Gutierrez-Adan et al. (2000) studied the effects of mother’s age on the downward trend of the sex ratio in Spain. Marital status was addressed in a study linking mother’s partnership status and the sex ratio at birth and reported a significant relationship (Norberg, 2004). In a study addressing mother’s age, mother’s and father’s job type, and father’s income as influences on the sex ratio, Ruckstuhl et al. (2010) found that women in “high stressed” jobs were more likely to give birth to females and women in “low stress” jobs had equal or a small increase in birth to a male child.

This study uses compositional change in mother’s education, race, marital status, and age to account for the trend in the sex ratio. In determining which variables to use, I drew from previously established variables that were found to be important determinants of the sex ratio and were also available on my data sets.

My Study

In my study I use national data—all of the birth certificates in the United States and its territories from 1971 to 2006 to study the trend in the sex ratio at birth. My goal is to determine if this trend is driven by specific compositional changes—the trends in composition for mother’s education, race, marital status, and age. Measures of composition are developed that are intuitively meaningful. The analysis will begin with an examination of the trends in the composition of my four determinants. The trend in some of these variables’ change in composition would be expected to exert an upward pressure, while others exert a downward pressure on the trend in the sex ratio at birth. At that point I developed my expectations of the individual variables’ influence on the trend. However, I expect the net effect of compositional change in these four variables to attenuate the trend in the sex ratio at birth.
Methods

Data

I obtained all birth certificates from 1971 to 2006 from the United States Center for Disease Control and Prevention website (www.cdc.gov). The birth certificates are in yearly files from 1968 to 2006. As noted earlier, I chose to use 1971 to 2006 because 1971 was established as the beginning of the current downward trend in the sex ratio by Matthews and Hamilton (2005) in their jointpoint analysis. In total, I obtained 125,578,596 birth certificates from 36 separate data files. I used the individual birth certificates for each year to construct a record for that year. Each record contains the sex ratio and measures of variable composition for my four predictors. Thus, my data set has year as the unit of analysis and is comprised of 36 total records.

My items were limited because more questions are asked in later years on birth certificates and there is an issue of comparability of questions and response sets. In a few cases, I had to use 1 item for most years and another item for a few other years. Also, in earlier years not all states obtained the same information; therefore for some items on some years the measures are based on a subsample of states.

Variables

Dependent Variable

The sex ratio at birth was computed each year by dividing the total number of male births for that year by the total number of female births for that year and multiplying by 100. The average sex ratio at birth for my time period, 1971 to 2006, was 105.01.

Independent Variables

My study will use a simple form, a dichotomy, of my four predictors -- mother’s education, race, marital status, and age -- in order to have intuitively meaningful measures of change in composition. I dichotomized each predictor which required aggregating categories in most instances. In aggregating variables, the guiding principle has been to maximize the between-category difference and minimize within-category differences.

For each variable, I took the most extensive classification (series of categories) that I could create from the available data that were comparable for all years. I then computed the sex ratio for each category by year. Next I calculated an average sex ratio for each category over the years. Because I am interested in the composition separate from variable force, I computed the simple average for each category across years, which are averages un-weighted by the counts in the categories across years, i.e., un-weighted by composition on the variable.

For each variable, I then worked to find a dichotomy that would maximize between-category variation in corresponding sex ratios while minimizing my within-category variation in sex ratios. Again, I excluded consideration of composition, i.e., I considered the sex ratios independent of size of the numbers giving rise to those sex ratios. Table 2 shows the results. Next I will explain how I measured change in composition.
Composition is measured on a yearly basis by using the proportion of the mothers in the determinant’s category with the lower sex ratio. These annual percents and their trends will be discussed later in this manuscript. At present, I cover some of the detail of my study variables that appeared in the data sets.

**Mother’s Education.** Mother’s education was mainly documented into 11 education categories with the lowest being 0-8 years of elementary school education followed by a category for each individual year of high school education and college education with the highest category being 5 or more years of college. Based on my attempts to maximize between category differences, I dichotomized the variable mother’s education into 13 or less years of total education completed and 14 or more years of education completed. As seen, the category representing less education shows an average sex ratio of 104.68 which is a 0.77 difference from the average sex ratio of the higher education category which is 105.45. This represents the average variable force of mother’s education. Composition of mother’s education was measured by taking the proportion of mothers in the 13 or less years of education category because, as stated above, I will measure composition based on the count of mothers in the categories with the lower sex ratio.

**Mother’s Race.** Race of mother was separated into the categories of white and black. Originally the data files used had over 30 racial and ethnic categories that differed on count and category across years. Since there was such a great change in the categories and some categories offered such a low count of mothers, I found it necessary to narrow the variable into black and white. The average sex ratio of the category labeled black was 103.05 which showed a 2.31 difference from the 105.36 average sex ratio of the white category. This variable has the greatest average variable force. The composition of the racial category was measured as the proportion in the black category in relation to whites because the black category has the lower sex ratio and only blacks and whites are included in the sample.

**Mother’s Marital Status.** Mother’s marital status is categorized as married and non-married with the non-married category showing a lower average sex ratio than the married category. Though the total number of categories in the variable rarely deviated across the years, from 1971 to 1978 the categories are labeled legitimate and illegitimate rather than married and non-married respectively. Though there may be some issue in the translation of the category labels I did not believe that there were any major issues of concern. As seen in Table 1, the average sex ratio for the non-married category was 104.32 which is 0.90 less than the average of 105.22 for the married category. This difference captures the variable force of mother’s marital status. The composition of mother’s marital status is calculated as the proportion of mothers in the non-married category because that category showed the lowest sex ratio for the marital status variable.

**Mother’s Age.** Age of mother was originally categorized by individual year of age. These categories are then narrowed into 5 year age categories and I finally separated age of mother into under 35 years of age and 35 years or older. The higher age category had an average sex ratio of 104.29 which was 0.85 lower than the sex ratio of 105.14 for the under 35 years of major category. Composition for mother’s age was measured as the proportion of mothers in the 35 years or older age category because that was the category of the age variable that yielded a lower sex ratio.
Procedure of Analysis

I begin this analysis with a description of the trend in composition for each of my variables. This effort includes a surmise as to what their pressure would be on the sex ratio trend. To test the effects of composition on the trend of the sex ratio -- the relationship of the sex ratio and year, I examine the contrast of the effect of year both when my composition variables are not controlled and when they are controlled. The effect of controlling for my composition variables on the relationship of year and the sex ratio (trend) is the focus of my test. My expectation is that some of the changes in composition are upward pressures and some are downward pressures on the sex ratio trend. However, I expect the downward pressures to more than offset the upward pressures, which would cause an attenuation of the trend, perhaps markedly, with control of my composition variables. Thus, the absolute value of the coefficient for year will be attenuated by the control for change in composition.

All regressions in this analysis are run in SAS 9.2 using the procedure AUTOREG, which yields regression analyses of trends with corrections for autocorrelation, that is, the correlations of the error terms over time. Thus, statistical tests are based on the corrected error variances.

Analysis

Trends in Composition Change, 1971-2006

In this section, I began examining the individual trends of my variables and discern their logical effect on the trend in the sex ratio at birth. Table 3 displays the coefficients from regressions that adjust for autocorrelation.

Table 3 here

Figure 3 shows the trends for composition change in mother’s education, race, marital status, and age for the study period. The relationship between composition change in education and year is negative, marked, and statistically significant. Mothers with 13 or less years of education declines sharply as a share of all yearly mothers over the study period and would be expected to markedly influence the trend in the population sex ratio at birth. Notably, the direction of this change in composition is an upward pressure on the sex ratio.

Figure 3 here

The trend in the composition of mother’s race is also negative and statistically significant; as year moves towards 2006, the share black mothers comprise of the sum of white and black mothers declines modestly. Thus, the change in the composition of mother’s race could be expected to be a modest upward pressure on the population sex ratio at birth.

However, the trends for mother’s marital status and age can be expected to offset the effects of change in education and race composition. The trend in composition of mother’s marital status is markedly positive and statistically significant; as year moves towards 2006, the share of non-married mothers increases substantially. This change in composition of mother’s marital status is a marked downward pressure on the population sex ratio at birth.

The relationship between the composition of mother’s age and year is also positive and statistically significant; the share of mothers that are 35 or older increases moderately over the
study period. Thus, the effect of change in age composition also would be expected to be a moderate downward pressure on the trend in the population sex ratio at birth.

**Compositional Change Effects on the Trend in the Sex Ratio at Birth**

Table 4 shows the results of the two regressions that are used to test the basic idea of this study – change in composition of mother’s education, race, marital status, and age drove changes in the downward trend of the sex ratio from 1971-2006. Equation I presents the coefficient for year’s effect on the sex ratio at birth. As noted early in this work, the relationship is statistically significant. With each passing year, the sex ratio at birth declined by 0.0172. Year and the sex ratio at birth share substantial variation, 64% – the equation R² is .643.

Table 4 here

Equation II is the regression of sex ratio at birth on year and composition change in education, race, marital status, and age. Note that the coefficient for year is no longer statistically significant. Control for the four composition variables attenuated year’s effect from statistically significant to statistically non-significant. The change in composition among these four determinants completely accounts for the downward trend in the sex ratio. Note that no composition trend is found as statistically significant in this equation. I deduced their logical effect on the trend in sex ratio in the previous section and retained the color coding of the previous section to remind me of the direction of pressure that each variable logically has on the trend in the sex ratio. The last column on the table presents R²’s from the regression of each composition variable on the other three. Note they share extremely high amounts of variation. It is not possible to discern their independent effects in Equation II.

As noted above the trend in education and, to a small extent, race composition would be expected to exert an upward pressure, while the trend in marital status and age composition exert a downward pressure on the trend in the sex ratio at birth. However, the net effect of compositional change in these four variables – these offsetting pressures -- was to account for the trend in the sex ratio at birth. The downward trend in the sex ratio from 1971 to 2006 was certainly affected by composition change.

**Discussion and Conclusion**

Understanding the sex ratio at birth is necessary in order to understand important social and structural characteristics in a society. The sex ratio is a demographic factor that affects the organization and future health of a population (Winston, 1931; Matthews and Hamilton, 2005; Nicolich, Huebner, and Schnatter, 2000). It has been directly connected to later changes in such demographic phenomena as the time it would take for a population to double in size based on its growth rate (doubling time) and the rates of fertility. (Matthews and Hamilton, 2005; Fossett and Kiecolt, 1991). Marriage patterns and availability of desirable marriageable companions have been directly associated to the sex ratio (Hesketh and Xing, 2006). Included among these patterns of family formation (and dissolution) are age at first marriage, sexual behaviors, fertility, divorce, and prostitution (Winston, 1931; Fossett and Kiecolt, 1991). The sex ratio also has been related to affecting future suicide rates, labor force participation, gender roles, levels of antisocial behavior, and violence (Winston, 1931; Fossett and Kiecolt, 1991; Hesketh and Xing, 2006; Matthews and Hamilton, 2005).
Prior literature implies, but has not made explicit, the difference between changes in variable force and changes in composition as two important, but very different categories of factors affecting trends (Matthews and Hamilton, 2005; Branum, Parker, and Schoendorf, 2009; Gutierrez-Adan, Pintado, and De La Fuente, 2000; Smith and Von Behren, 2005; Davis et al, 2007). Indeed prior studies examining the trend in the sex ratio at birth have empirically related change in variable force but not change in composition to the trend. An objective of this work was to make this distinction explicit. Also, this work undertook to measure composition change for mother’s education, race, marital status, and age and relate their trends to the recent downward trend in the U.S. sex ratio at birth.

My analysis of the effects of composition change on the 1971 to 2006 trend in the sex ratio at birth demonstrated the following: 1) the trend in education and, to a small extent, race composition would be expected to exert an upward pressure, while the trend in marital status and age composition exert a downward pressure on the trend in the sex ratio at birth; and 2) the net effect of compositional change in these four variables – these offsetting pressures – was to account for the trend in the sex ratio at birth. The downward trend in the sex ratio from 1971 to 2006 was certainly affected by composition change.

Though I have established that the compositional variables used in my analysis exert pressures on the sex ratio trend, it would be advantageous to find a measure that would allow one to simultaneously but distinctly study the measures of variable force and of composition change for the determinants in relation to the trend in the sex ratio. Many prior studies, though neglecting composition, were able to measure the variable force of a determinant on the trend (Matthews and Hamilton, 2005; Smith and Von Behren, 2005; Grech, Vassallo-Agius, and Savona-Ventura, 2003; Feitosa and Krieger, 1992; Gibson, Costa, and Koifman, 2009; Branum, Parker, and Schoendorf, 2009). My analysis takes this a step further by measuring an effect of composition change on the trend, but serves as a stepping stone to a more complex investigation. In fact, I experimented with a measure of variable force but found it to be unsatisfactory.

As seen in Table 2, race of mother exhibited the highest variable force reflected in the difference between the average sex ratios corresponding to the white and black categories. Though it yielded the strongest variable force of the four variables, it exhibited only minimal compositional change over the trend. Its potential for high impact on the trend due to compositional change was great, but its compositional change was not. This type of knowledge needs to be systematically accrued in the future.

Limited by data availability, I opted for intuitively meaningful measures of composition. Although I used what I believe was a thoughtful decision making process in arriving at the measures, this research, as demographic research in general, would benefit from definitive powerful measures of composition. These more powerful measures would capture compositional change without having to resort to aggregating as I have done. Still, there is no reason to believe that the findings presented here are not correct. It is more a matter of being able to measure compositional change more precisely.

Future research could also increase the number of variables related to the trend in the sex ratio at birth. Though I chose the variables that were accessible and logical for my research, they are few in number and limited in scope. As indicated in Figure 2, the sex ratio at birth can be affected by variables in two distinct time-related categories: characteristics that affect prior to and at the time of conception and characteristics that affect gestation. Though, originally we included additional variables that only relate to the latter category, e.g., duration of gestation, they did not add to the explanatory power of the model presented here. Nor were we able to
parse direct and indirect effects. Of course, this issue was compounded by multi-colinearity. It is a serious limitation to the type of study undertaken here. Of course, future research needs to explore other methods of addressing the trend in sex ratio while not handicapped by colinearity issues.

Despite limitations, this research underscores a critical distinction affecting trends – variable force as opposed to composition change. It also demonstrates that the impact of composition change on the recent trend in the sex ratio is substantial.


Table 1. Hypothetical Depiction of the Difference between Variable Force and Composition Change in a Determinant

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<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Married</td>
<td>80</td>
<td>77</td>
<td>74</td>
<td>71</td>
<td>68</td>
<td>65</td>
<td>62</td>
<td>59</td>
<td>56</td>
<td>53</td>
</tr>
<tr>
<td>Non-Married</td>
<td>20</td>
<td>23</td>
<td>26</td>
<td>29</td>
<td>32</td>
<td>35</td>
<td>38</td>
<td>41</td>
<td>44</td>
<td>47</td>
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</tbody>
</table>

**Trend in Population Sex Ratio at Birth**

| Year | 104.90 | 104.81 | 104.72 | 104.63 | 104.54 | 104.45 | 104.36 | 104.27 | 104.18 | 104.09 |

**Tier 2**

<table>
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<td><strong>Change in Variable Force</strong></td>
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<tr>
<td>Married</td>
<td>105.50</td>
<td>105.46</td>
<td>105.43</td>
<td>105.39</td>
<td>105.35</td>
<td>105.32</td>
<td>105.28</td>
<td>105.24</td>
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<td>105.17</td>
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<td>Non-Married</td>
<td>102.50</td>
<td>102.20</td>
<td>101.90</td>
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<td>101.30</td>
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<td>100.70</td>
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<td>Difference between Married and Non-Married</td>
<td>3.00</td>
<td>3.26</td>
<td>3.53</td>
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<td>4.05</td>
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<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
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<th>Percent</th>
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<td>Married</td>
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<td>80</td>
<td>80</td>
<td>80</td>
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<td>80</td>
<td>80</td>
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<tr>
<td>Non-Married</td>
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<td>20</td>
<td>20</td>
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<td>20</td>
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<td>20</td>
</tr>
</tbody>
</table>

**Trend in Population Sex Ratio at Birth**

| Year | 104.90 | 104.81 | 104.72 | 104.63 | 104.54 | 104.45 | 104.36 | 104.27 | 104.18 | 104.09 |

13
Table 2. Aggregated Categories of Un-Weighted Average Sex Ratios for 1971-2006, for Mother's Education, Race, Marital Status, and Age

<table>
<thead>
<tr>
<th>Education - Years of School Completed</th>
<th>Average Sex Ratio</th>
<th>Difference in SR (Hi - Lo)</th>
<th>Marital Status of Mother</th>
<th>Average Sex Ratio</th>
<th>Difference in SR (Hi - Lo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 or Less Years</td>
<td>104.68</td>
<td>0.77</td>
<td>Married</td>
<td>105.22</td>
<td></td>
</tr>
<tr>
<td>14 +</td>
<td>105.45</td>
<td></td>
<td>Non-Married</td>
<td>104.32</td>
<td>0.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race of Mother</th>
<th>Average Sex Ratio</th>
<th>Difference in SR (Hi - Lo)</th>
<th>Age of Mother</th>
<th>Average Sex Ratio</th>
<th>Difference in SR (Hi - Lo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>105.36</td>
<td></td>
<td>Under 35 years</td>
<td>105.14</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>103.05</td>
<td>2.31</td>
<td>35 Years or Older</td>
<td>104.29</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Table 3. Coefficients for Trends of each Composition Variable, 1971-2006

<table>
<thead>
<tr>
<th>Education - Years of School Completed (% 13 Years or Less) Coefficients</th>
<th>Marital Status of Mother (% Non-Married) Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1650.0000 *</td>
</tr>
<tr>
<td>Year</td>
<td>-0.7952 *</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9943 *</td>
</tr>
<tr>
<td>Intercept</td>
<td>-1516.0000 *</td>
</tr>
<tr>
<td>Year</td>
<td>0.7749 *</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9766 *</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race of Mother (% Black) Coefficients</th>
<th>Age of Mother (% 35 or older) Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>54.2666 *</td>
</tr>
<tr>
<td>Year</td>
<td>-0.0194 *</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.1618 *</td>
</tr>
<tr>
<td>Intercept</td>
<td>-670.0818 *</td>
</tr>
<tr>
<td>Year</td>
<td>0.3414 *</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9211 *</td>
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</tbody>
</table>

* p < .05

* Downward Pressure

* Upward Pressure
Table 4. Regressions of Sex Ratio at Birth on Year and on Year and Composition Changes, 1971-2006

<table>
<thead>
<tr>
<th></th>
<th>Equation I</th>
<th></th>
<th>Equation II</th>
<th>Composition Measure Multi-Colinearity*</th>
<th>R²</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Pr &gt;</td>
<td>t</td>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>139.1178</td>
<td>0.0000</td>
<td>-45.9579</td>
<td>0.6292</td>
<td></td>
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<tr>
<td>Year</td>
<td>-0.0172</td>
<td>0.0000</td>
<td>0.0745</td>
<td>0.1162</td>
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<tr>
<td>Education - Years of School Completed (% 13 Years or Less)</td>
<td>0.0730</td>
<td>0.2083</td>
<td>0.9909</td>
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<td></td>
</tr>
<tr>
<td>Race of Mother (% Black)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital Status of Mother (% Non-Married)</td>
<td>-0.0726</td>
<td>0.5389</td>
<td>0.8468</td>
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<tr>
<td>Age of Mother (% 35 or older)</td>
<td>-0.0194</td>
<td>0.5890</td>
<td>0.9940</td>
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<td></td>
<td>-0.0585</td>
<td>0.1427</td>
<td>0.9644</td>
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<tr>
<td>R²</td>
<td>0.6428</td>
<td></td>
<td>0.7141</td>
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</table>

- **Downward pressure on sex ratio trend per findings in previous section**
- **Upward pressure on sex ratio trend per findings in previous section**

* R² for equations regressing current composition measure on other composition measures
Figure 1. U.S. Sex Ratio at Birth by Year, 1971-2006

Intercept 139.1178
Year - 0.0172

R² 0.6428
Figure 2. Model of Family Formation Behavior Affecting Sex Ratio at Birth

Prior to or at Time of Conception

- Properties or Typologies of Social Units
  - Regional Neighborhood
  - Complex Organizations
  - Groups, including Family

- Statuses & Attributes of Individuals at Conception
  - Mother:
    - Age
    - Race
    - Education
    - Employment Status
    - Income
    - Occupational Prestige
    - Parity
    - Substance-use
    - Nutrition
    - Depression
  - Father:
    - Age
    - Race
    - Education
    - Employment Status
    - Income
    - Occupational Prestige

Sample Selection Bias

Gestation

- Mother’s Behaviors Related to Fetal Health
  - Prenatal Care
    - ATOD Use

- Congenital Conditions affecting likelihood of Live Birth
  - At Risk Conditions

Birth

Prob (Male) [Sex Ratio]

- Some Variables Social (SES)
- Some Demographic (Sex of Neonate)
- Some Interpretable as Both
Figure 3. Yearly Estimated Percent & Linear Trend of Estimated Percent in Variable Category with Lower Sex Ratio at Birth -- Reflecting the Variable’s Composition -- for Study Determinants, 1971-2006

- **Mother’s Education**
- **Mother’s Race**
- **Mother’s Marital Status**
- **Mother’s Age**

**Linear (Mother’s Education)**
**Linear (Mother’s Race)**
**Linear (Mother’s Marital Status)**
**Linear (Mother’s Age)**