Fertility Response to Business Cycles: "Gender Asymmetry in Industries"*

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Abstract

Fertility rate in the US declined sharply after the Great Recession (from 2.12 to 1.84 children per women). We argue that fertility response to business cycles is shaped by the gender properties of the labor market as well as cyclical properties of industries. We find that men predominantly work in heavily procyclical industries whereas women work in acyclical industries. Hence, employment and income losses are significant among working men whereas women are not affected as much from recessions. In a joint household fertility choice model with partial specialization, we show that stable (or better) female labor market outcomes contribute to the decline in fertility as well as worse outcomes for males. We argue that procyclical feature of fertility is due to gender asymmetric industry employment and cyclicality of industries. Our quantitative framework predicts that fertility among married couples would have risen by 1.6% if men and women had same income volatility as opposed to 5% decline in the data during the Great Recession.

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1 Introduction

Fertility rate declines during recessions and recovers right after the end of recession (Figure 4) [1][2]. We argue that part of the cyclical feature of fertility can be explained by gender properties of the labor market as well as cyclical properties of industries. Changes in male and female employment affect fertility differently in recessions because the cost of child rearing is mostly born by women (Kleven et al. [2018]). A great majority of women (41%) are employed in acyclical (or countercyclical) industries whereas most men are employed in heavily procyclical industries. Men's income and job losses during recessions have negative impact on fertility. Moreover, stable or better labor market conditions of women during recessions also affect fertility negatively because they become the breadwinner of the family and lose flexibility of leaving the job for child rearing. We find that fertility among married couples would have risen by 1.6% if men and women had same income volatility as opposed to 5% decline in the data during the Great Recession. We believe that amplified procyclicality of fertility in turn might dampen human capital accumulation of women since they have to work in bad times and give birth (thus take a break) in good times[3]. Since low income families are more vulnerable against business cycles and fail in perfect fertility smoothing, they suffer the most from losses in human capital accumulation. Hence the cost of "procyclical fertility" might be thought of as "increased inequality".

In the past century, the US fertility rate experienced large boom and bust periods. These large cycles are shaped by major shifts in both economic and social trends (Figure 2). Great depression (30s), post-war baby boom (40s, 50s), women influx into the labor market (60s) and the pill revolution (70s) are major events which caused the total fertility rate to fluctuate between 2 and 3.6 children per women (Doepke et al. [2015], Jones and Schoonbroodt [2016], Butz and Ward [1979], Goldin and Katz [2000]). Fertility reached a more stable level 1975 onwards, where there are still fluctuations (between 1.74 and 2.12 children per women). This paper studies cyclical properties of fertility during the period of "stable fertility", 1975-2017. We attribute procyclical fertility to; 1- gender asymmetry in industries, 2- cyclical properties of industries, 3- asymmetric child rearing cost of parents.

Industries have different cyclical properties (Abraham and Katz [1984]). Employment in industries such as construction, manufacturing, retail are highly correlated with the national employment changes hence business cycles. On the other hand, education, health services and government are acyclical industries that are not affected from the business cycles. Although education and health services industry has a stable increasing trend, we do not observe a decline in employment or sharp changes in boom times. Gender composition of industries differ as well. A great majority of women

[1] Figure 4 shows that in four of business cycles reported by NBER (1980-81, 1991, 2001, 2007-2009 cycles), fertility rate declined

[2] The decline in fertility rate starts before the reported start date of recession, which might imply that people experience job losses and update their expectations Buckles et al. [2018]

[3] Gallen [2015]argues that mothers incur productivity losses compared to non-mothers which in turn is reflected to their earnings

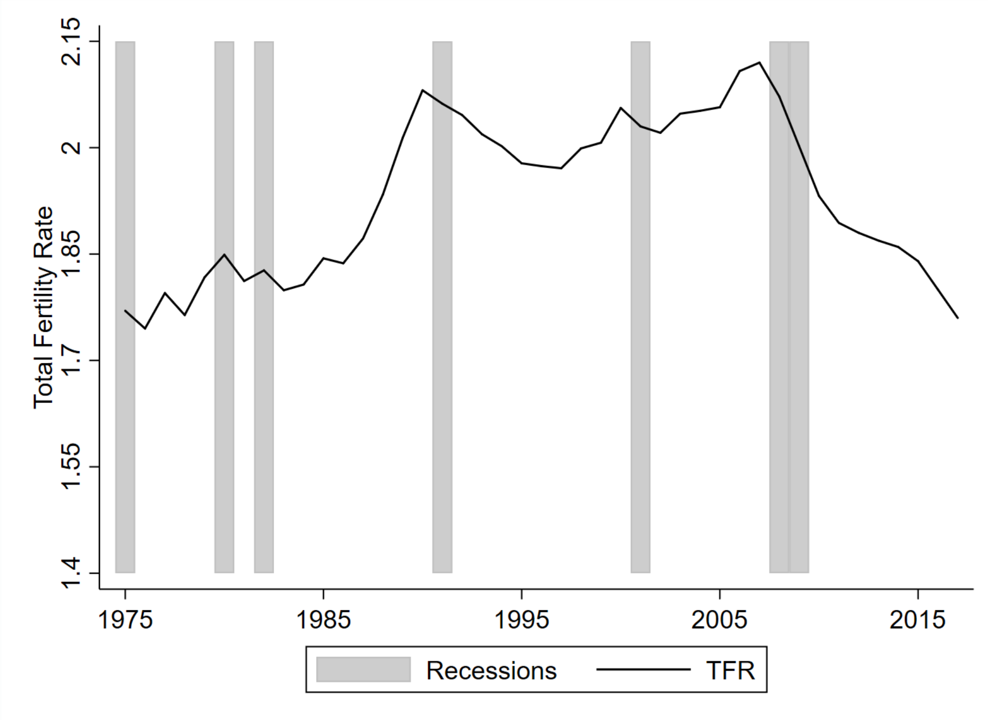

Figure 1: Fertility and Recessions
Note: Shaded areas indicate recession periods

(41%) are employed in industries such as education, health services and government which are acyclical (or even countercyclical) industries. On the other hand, a great majority of men (59%) are employed in the most procyclical industries such as construction, manufacturing, professional services and retail. Albanesi [2018] emphasizes the role of women's employment in making previous recoveries faster, and she argues that jobless recoveries started at the time when female labor force participation rate reached to a plateau.

Despite the changing trends on time use such as more balanced division of labor in child rearing, it is still the women who mostly bear the time cost of a child (Kleven et al. [2018]). Hence the opportunity cost of having a child is foregone earnings of females. Then, increase in male income increases fertility through income effect, while female income increase has ambiguous effect because it produces both income and substitution effects. However, many evidences show that the substitution effect is dominant and higher female income both at cross section and in time series is correlated with lower fertility rates (Heckman and Walker [1990]). In times of economic downturns, since males are employed in heavily procyclical industries, they lose their jobs which decreases household income and it has a negative impact on fertility. On the other hand, female employment is either not affected or affected positively due to acyclical properties of female dominant industries, better economic prospects of women also have a negative impact on fertility. Hence, we argue that fertility decline is amplified in economic downturns because of these two properties of the economy: 1- gender asymmetric industry employment, 2- cyclical properties of industries, 3- asymmetric child

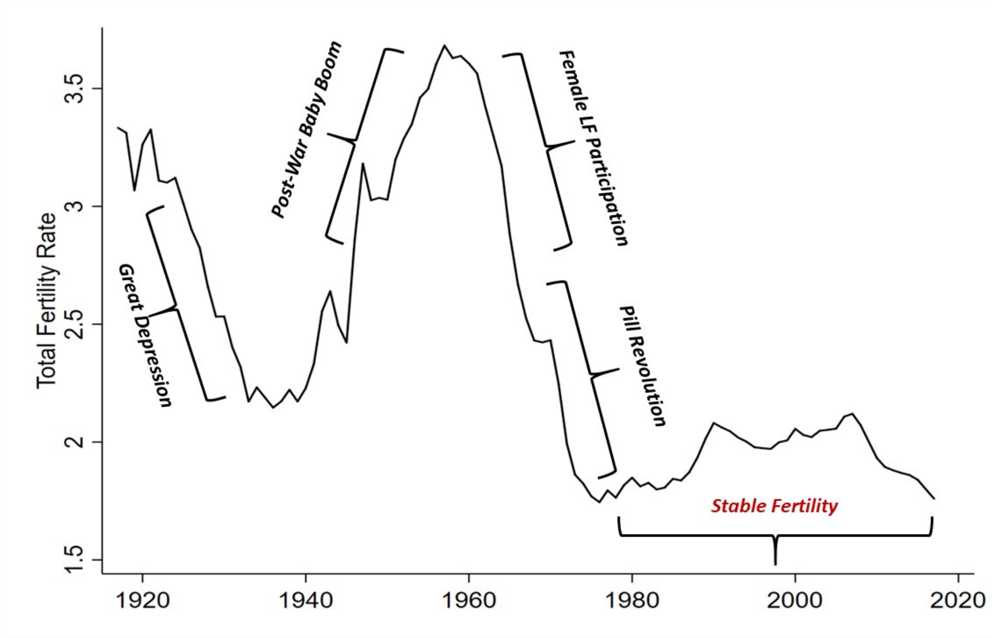

Figure 2: Total Fertility Rate in the last Century (1917-2017)
Data source: National Health Statistics, Office of Population Research (Princeton University)

rearing cost of parents.

We restrict majority of our empirical analysis to the Great Recession. We show that state level fertility rates are correlated negatively with the changes in female dominant industry employment (and industry compensation) and positively with the changes in male dominant industry employment (and industry compensation) for the sample period of 2002-2016. The correlations are even stronger at post-recession period. We also show that employment (or compensation) changes in gender symmetric industries do not have any effect on fertility rates since the positive effect from men is canceling out by the negative effect from women.

In order to understand the effect of the structural properties of the economy in shaping fertility trends with business cycles and quantify relative importance of these channels, we build a model with the following features: 1-Joint household consumption, saving and fertility decision. 2- Partial specialization. 3-Timing of birth. In our model, male income is positively related to fertility through income effect and female income is negatively related to fertility through substitution effect. We calibrate the model to match pre and post-recession fertility rates for younger and older women by estimating pre and post-recession earnings of men and women. We then ask the question of "what would have happened to fertility if men and women earnings had the same volatility or men and women earnings were equal to each other?'. In all the counterfactual scenarios, we predict the fertility to be countercyclical. Our quantitative exercise predicts that fertility among married couples would have risen by 1.6% if men and women had same income volatility as opposed to 5% decline in the data during the Great Recession.

Fertility decline is becoming an important problem in the developed world. Although, the US did not suffer from this problem as much compared to Europe, the recent data shows that it will in the near future as the current fertility rate is well below the replacement level. We highlight a different aspect of labor market structure and its relation to fertility. Gender asymmetry in labor market affects fertility in an adverse manner. Obviously, it is unfortunate that better labor market outcomes for women worsens fertility. However, one reason why we obtain such a conclusion is that women still incur majority of childbearing and another reason is that women have to sacrifice hours worked when they have children. Since volatile fertility is more pronounced among low income families, we also emphasize how volatile fertility might contribute to the rising inequality through human capital accumulation channel. Hence, other than gender symmetric labor market conditions, policies which may potentially reduce the opportunity cost of child to mothers such as more generous parental leave and access to low-cost childcare may help in rising fertility, and reduce inequality.

2 Related Literature

In his seminal paper, Becker [1960] analyzes fertility as en economic choice where families have utility from both the number of children they have and quality they invest to them. Later, in Becker and Barro [1988], Becker et al. [1990], fertility has been analyzed in the context of economic growth by introducing altruism of parents, hence as an outcome affecting macro economic outcomes. Doepke [2015a] summarizes the quality-quantity trade-off literature by Gary Becker and points the importance of quality perspective in fertility choice as the income elasticity is stronger for quality by also noting that the desired fertility is still positively correlated with income levels which is an evidence for children being normal goods.

The first attempt to analyze the cyclicality of fertility is by Butz and Ward [1979]. In their paper, they argue that fertility in the US fertility became countercyclical in 60s, after the baby boom period. However, there are other studies later on, which argue that the decrease in fertility in the 60s was due to increase in female labor force participation rate as well as the introduction of “the pill”. Macunovich [1995] argues that in recession periods, the negative effect of unemployment surpasses the positive effect of lower opportunity cost. There is also evidence about procyclicality of fertility in a multiple country study by Sobotka et al. [2011]. Finally, Jones and Schoonbroodt [2016] proves that fertility is procyclical in a study by incorporating dynastic altruism and productivity shocks.

Understanding the baby boom in 50s and its consequences on the labor market is a prominent feature of the literature. Greenwood et al. [2000] argue that baby boom in 50s is caused by an atypical burst in technological progress in household sector which lowers the opportunity cost of child. On the other hand, Doepke et al. [2015] argue that after war baby boom was caused by increased female labor market participation by older generations during the war which persisted and competed out younger generation of women from the labor market in after-war period.

The effects of female and male wages on fertility have been studied empirically through the panel data. Heckman and Walker [1990] identify the effect of an increase in female's wage on fertility by analyzing Swedish panel data and find that higher female wage leads to delaying childbirth and lower fertility as a result. In order to identify the effect of male income on fertility, unexpected job displacement has been used as an exogeneous shock. Both Lindo [2010] and Amialchuk [2013] find that an unexpected shock to male income (job displacement) decreases fertility. Schaller [2016] attempts to find both effects by using exogenous labor demand shocks and gender employment indices in industries. Consistent with the literature, she finds positive effect for male wage and negative effect of female wage. Dettling and Kearney [2014] also shows that house prices (hence business cycles) have a positive impact on fertility. Not only wage changes but also the effect of unemployment on fertility has been studied in the literature and the results are similar to those of wage changes. Schmitt [2011] and Özcan et al. [2010] find that male unemployment affects fertility negatively whereas female unemployment affects positively. Following the papers which study the occupation riskiness by looking at the wage and unemployment volatility (Saks and Shore [2005]), Sommer [2016] studies the effect of unexpected earnings risk on fertility and finds that higher earnings risk is associated with delay in fertility and lower fertility. A comprehensive study by Adda et al. [2017] endogenize all life time choices and argue that career choices are made along with fertility choices, hence there is sorting in occupations according to fertility choices during life time.

3 Facts

3.1 Facts on Fertility

The US has relatively high fertility rates but experienced sharpest decline in the Great Recession

Fertility rates have been declining in the 20th century (demographic transition) and there is negative correlation between GDP per capita and fertility rates all over the world (Doepke [2015b], Doepke and Tertilt [2016]). Increase in female labor participation rate, pill revolution certainly have an impact on this long run decreasing trend. There is however, large baby boom and bust periods in the 20th century driven by productivity shocks and changes in labor market conditions (Doepke et al. [2015], Jones and Schoonbroodt [2016]). Since 80s on, fertility rates become more stable, large baby boom and baby bust periods do not exist anymore as it occurred in the middle of the century. However, there are still fertility cycles correlated with business cycles.

In the US, fertility had an increasing trend during late 90's and early 2000s with the housing boom. Then, a sharp declining trend started with the Great Recession. OECD countries have been also affected by global conditions and European countries by the Euro Crisis. However, the decline in the US fertility rate was very sharp and lasted long (Figure 3). Only after 2011, it converged to a plateau.

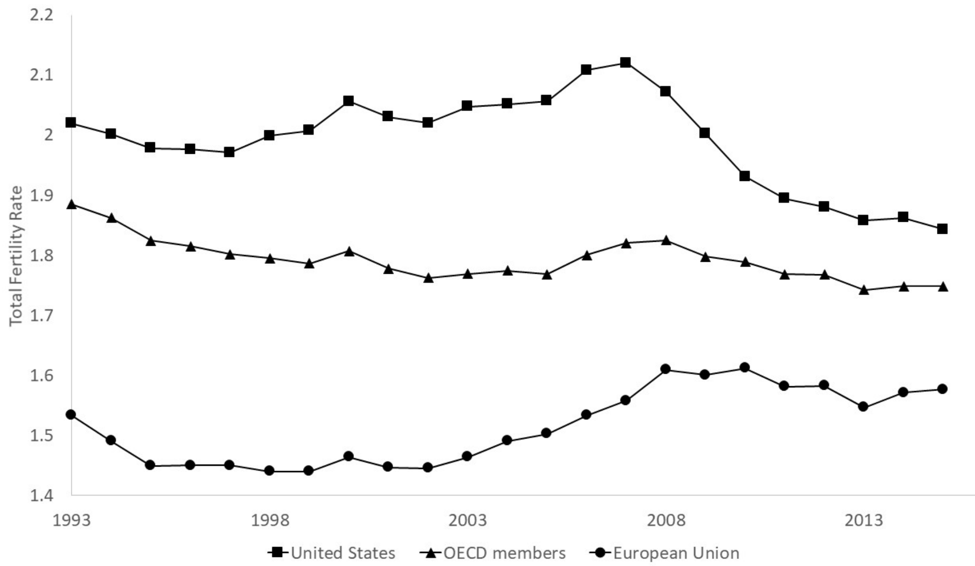

Figure 3: Total Fertility Rate in Developed World
Source: World Bank

Fertility declines in recession times

Figure 4 and 1 shows the fertility trend in the US starting from 1975 and the recession periods. For all the recession periods since 80s, fertility drops with the start of the recession and usually recovers by the end of the recession and follows an increasing trend afterwards. There are two recessions in which fertility continued to drop even after the recession, which are 1990 recession and the Great Recession. One common characteristic of these recessions is that we experience "jobless recoveries" in both (Gordon [1993], Doepke and Tertilt [2016]). Our analysis also shows that fertility is more responsive to employment changes than income changes at aggregate level. Hence, jobless recoveries imply that fertility recovery also takes time.

Fertility change and real GDP per capita change are correlated at state level

Figure 5 shows that the states which experienced the largest GDP decline also experienced the largest fertility decline and vice versa. Hence, not only at time series but also at cross-section, fertility is positively correlated with income changes. For instance, in California and Florida, during the recession, income declined significantly, so as the fertility.

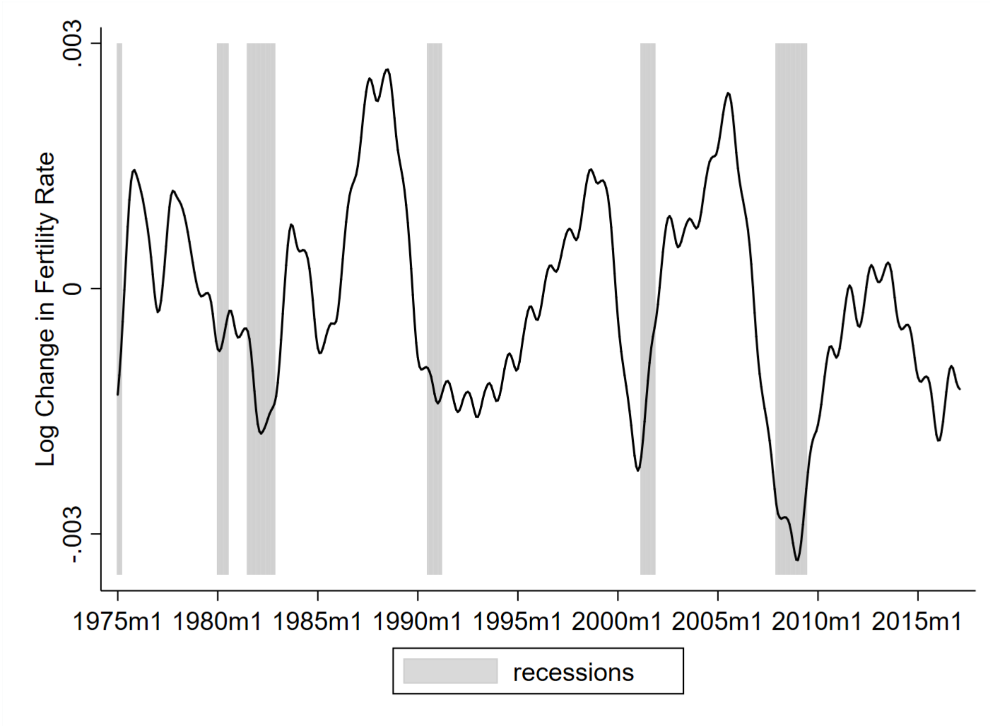

Figure 4: Fertility and Recessions

Note: Data source is National Health Statistics birth records. Monthly fertility rate (number of births to women aged 15-44/ population of women aged 15-44) has been adjusted by 10 months to reflect conception date of realized births. To remove seasonality and irregular components, HP filter with smoothing parameter $\lambda = 1500$ is used. Recession dates are taken from NBER business cycles (from peak to through).

Tempo vs. Quantum Effects

Sobotka [2004] discusses tempo and quantum effects in fertility for Europe. In the developed world, there is a trend towards postponing childbirth to later years of adulthood, which is called "tempo effect". On the other hand, the overall decrease in fertility is called "quantum effect". Figure 6 shows these effects for the US. In 2007, both tempo and quantum effects are positive relative to 2003. In 2011, there is a significant quantum effect, however we do not observe a tempo effect as there is no right shift in age profile of fertility. In 2015 though, there is a tempo effect as the whole distribution shifts to the right relative to 2011. It means that younger females have lower fertility rates but older females have higher fertility rates. Hence, between 2007-2011, we do observe the pure effect of the recession as there is an overall decline which is mostly pronounced among young females. In 2015, we start observing the recovery of fertility rate among older women who postponed fertility during the recession.

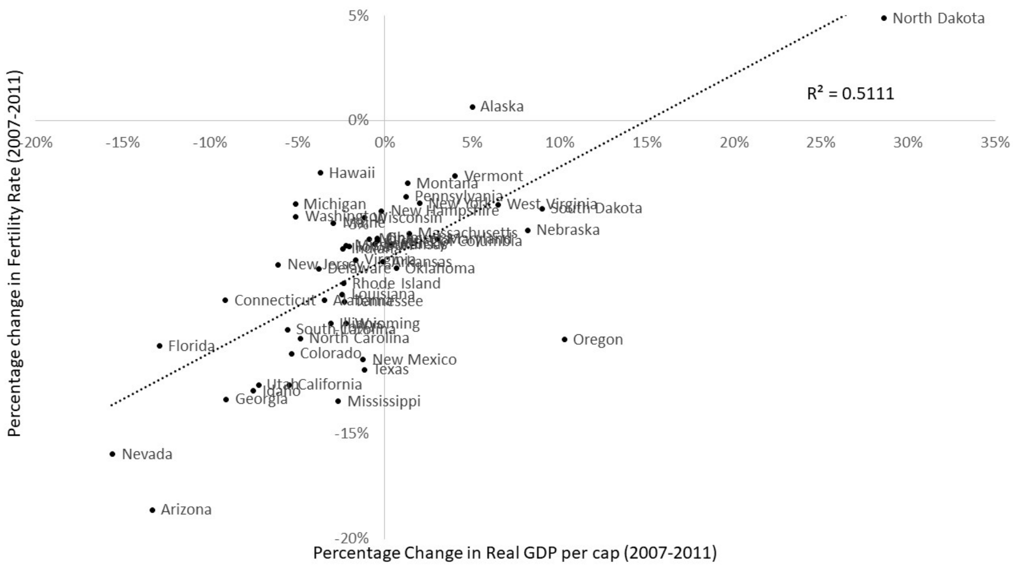

Figure 5: Fertility vs. Real GDP per capita Change

Note: Fertility data has been taken from National Health Statistics. State level real GDP per capita data has been taken from Bureau of Economic Analysis

Fertility decline was the sharpest among young, low income, low-educated groups:

Figure 7 shows that women of age 25-29 and 20-24 had the highest birth rates. However, they experienced the largest decline after the recession possibly due to delaying motive, hence fertility decline in 20-30 age group has been partially translated into increase in birth rates of women of age 30-39. As reported by Kleven et al. [2018], even in Denmark where family policies are more generous with maternity leaves, and cash transfers, there is a child penalty in hours worked and earned wages among women. Hence, among younger age groups there is a career cost of children (Adda et al. [2017]), which makes fertility among young more responsive. In our model section, we are going to incorporate different trends across age groups.

First and second panel in Figure 7 shows that all income and education groups responded to the recession but women whose family income is at the bottom 20% of the income distribution as well as people who have less than HS degree decreased their fertility the most[4]. It is reasonable to observe such an outcome as poor families tend to be financially more constrained. We incorporate this in our model and argue that if there are no financial constraints, there will be perfect smoothing in fertility timing which is inconsistent with the data. Moreover, We believe that higher fertility volatility among poor families, dampen their labor market outcomes and cause losses in human capital accumulation.

[4]The fact that the 1st income quintile has the highest fertility in the firts panel and people who have less than HS degree has the lowest fertility might seem inconsistent as we expect these two groups to be highly correlated. However, it is due to the nature of the statistic we are using as well as variation in age groups according to the education level. Since women who have more than college degree tend to be older than other groups, once they have the degree they have higher probability of given rate at a given year where for low educated groups, fertility is expanded to a larger span.

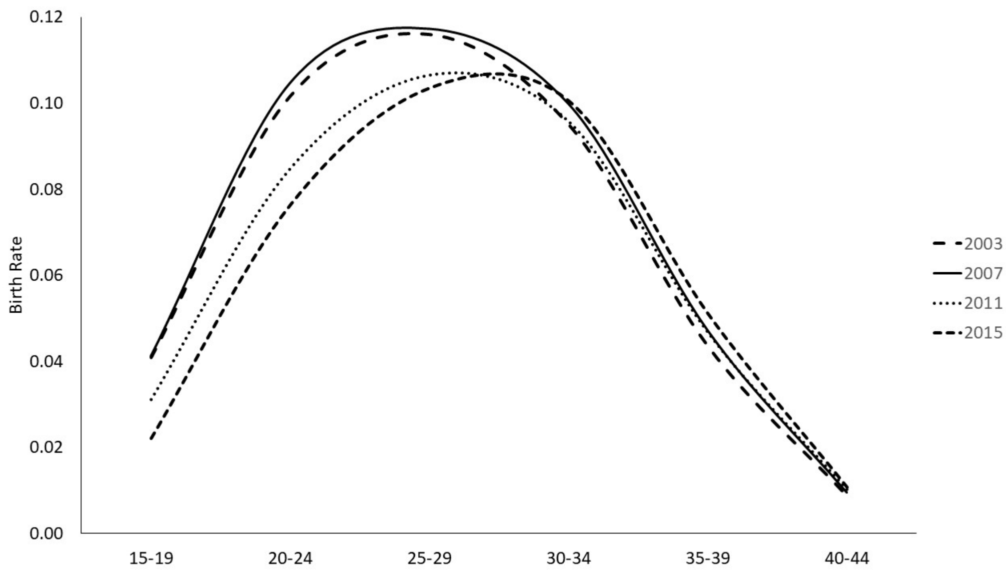

Figure 6: Tempo vs. Quantum Effects
Source: National Health Statistics

The last panel in Figure 7 shows that fertility rates of married and unmarried women increased until the recession and decreased afterwards. While fertility of married women decovered by the end of the recession, fertility of unmarried women did not.

3.2 Facts on Labor Market

Figure 8 shows that female versus male employment within each industry vary significantly. Some industries such as education and health services, financial activities and government are female dominant where construction, manufacturing and mining industries are heavily male dominant. Especially education and health services industry is the most female dominant industry where 77% percent of industry employment is female. On the other hand, construction and mining industries are most male dominant industries where 87% of employment is male. Furthermore, these changes do not change over time.

Half of women are employed in education, health and government industries

Not only education and health services industry is female dominant but also a large fraction (22%) of females are working in that industry. Figure 9 shows that almost half of employed women are working in two major industries; education and health services and government. Also, industry trends in female employment is stable over time.

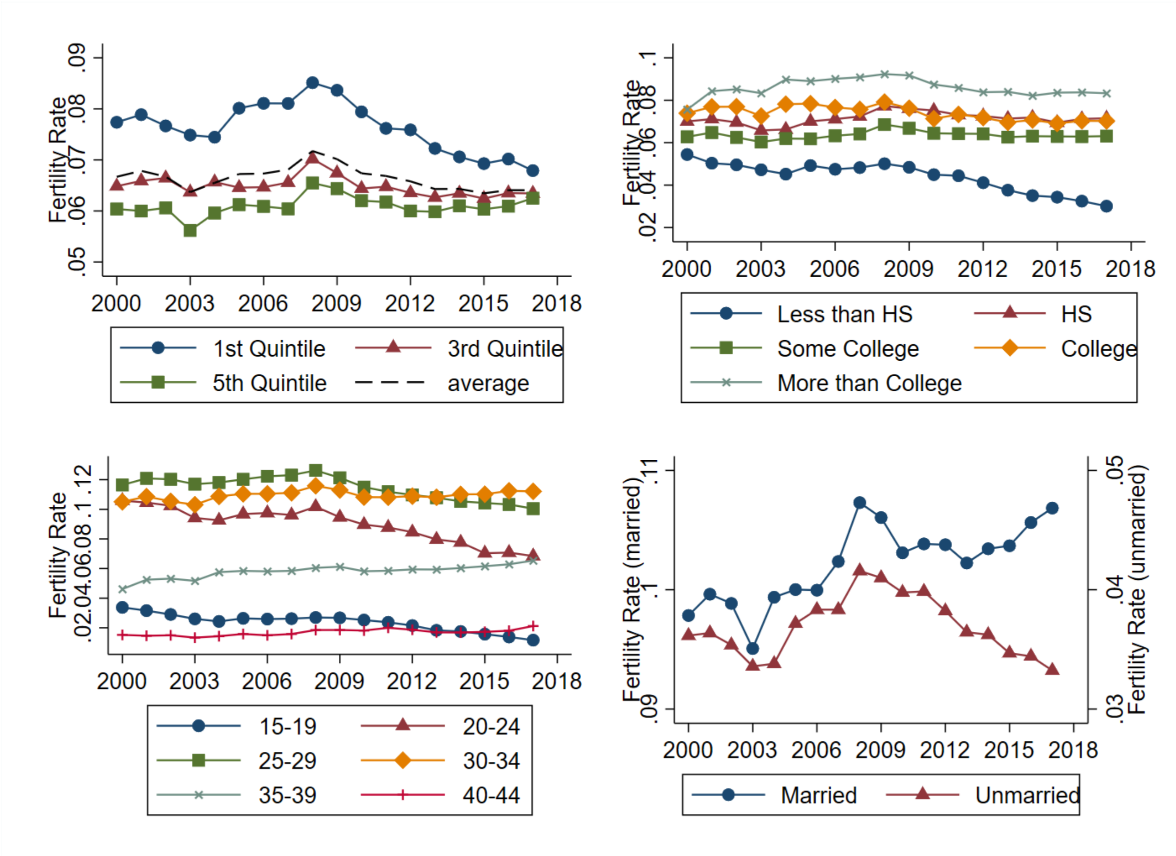

Figure 7: Fertility across Income, Education, Age, Marital Status Groups

Note: Data source is American Community Survey. Fertility rates are calculated based on the sample of women, ages 15-44 using fertility variable that is "whether given birth in the past 12 months". Income variable is "total family income", but results are robust with "personal income" as well. Details of the sample selection is discussed in Data section.

Male dominant industries are procyclical and female dominant industries are countercyclical

In terms of number of people each industry employs, male dominant industries experience a large employment decline during recessions where female dominant industries do not deviate from the long term trend. Hence, Figure 10 shows that construction and manufacturing industries are procyclical whereas education, health services and government industries are acyclical.

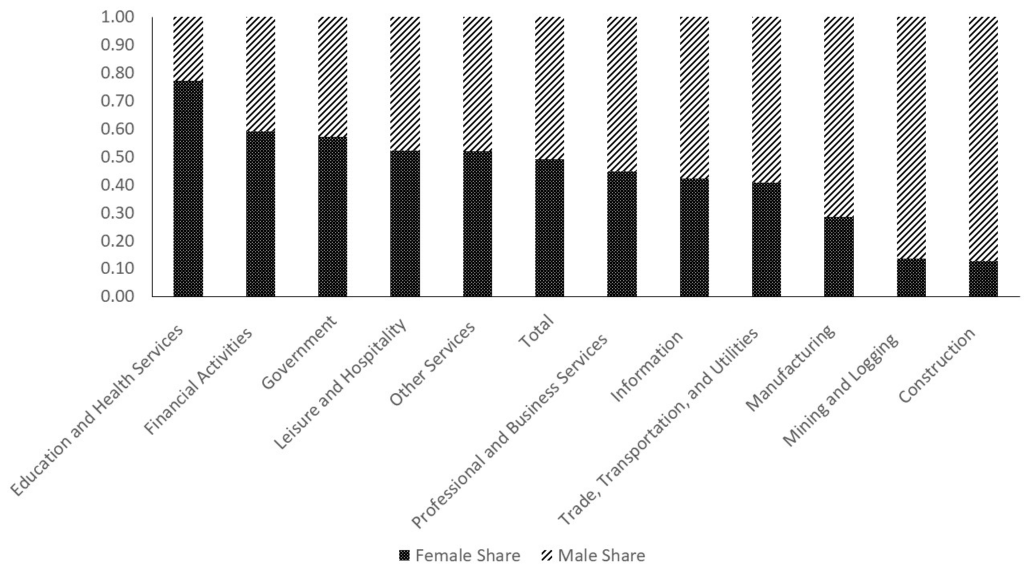

Figure 8: Gender Bias in Industries

Note: The data is taken from Bureau of Labor Statistics. Women shares are averages across years 2002-2015.

Employment among low educated people is more cyclical

4 Data

4.1 National Health Statistics

Fertility data; ratio of number of births to total population and to female population of 15-44 age for every state between years 2003-2016 is taken from National Health Statistics. Age and race specific fertility rates, as well as monthly fertility rates are also obtained from National Health Statistics database and digitized from monthly vital statistics reports.

4.2 Bureau of Labor Statistics

We take industry employment numbers at state level between years 2002-2015 as well as female and male employment at industry level from Bureau of Labor Statistics database. Monthly data has been used to calculate the correlation between total employment changes and industry level employment changes. To calculate female employment share in each industry and industry share in total female employment, the annual data has been used. To form the fertility rate-employment matched data set between years 2002-2016, state level annual industry employment levels have been used.

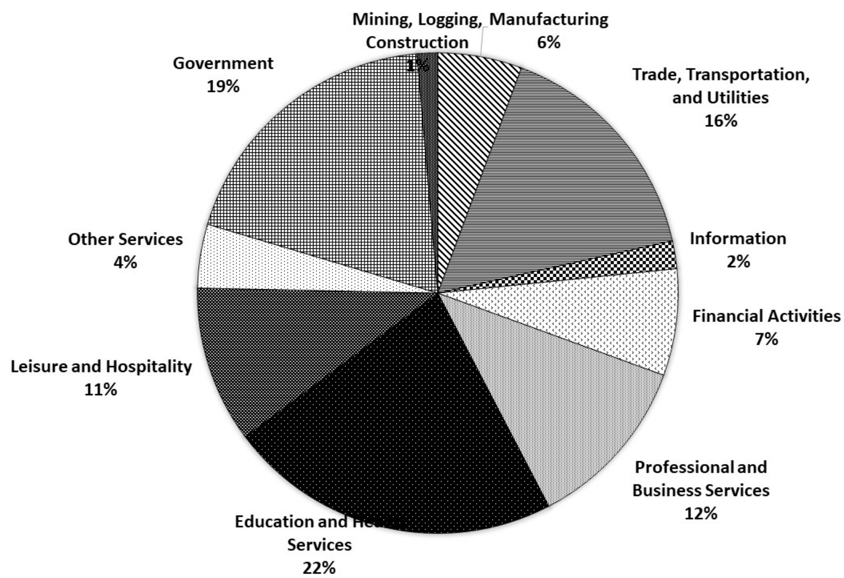

Figure 9: Female Employment

Note: The data is taken from Bureau of Labor Statistics. Industry shares are averages across years 2002-2015.

4.3 Bureau of Economic Analysis

Regional Statistics from Bureau of Economic Analysis has been used to get the total employee compensation at industry and state level. CPI index has been used to get real employee compensation to be consistent in yearly changes. The data is matched to state level birth rate data.

4.4 Current Population Survey

IPUMS-CPS has been used to estimate earnings gap between female and male, as well as between young and old workers. These estimates have been used as model inputs when constructing compensation of four different agents. Moreover, industry employment composition for different race and education groups have been also estimated as robustness check.

4.5 American Community Survey

IPUMS-USA has been used to report fertility rates of income and education groups. Fertility variable is being asked to report whether the respondent has given birth in the past 12 months. Hence, income and marital status may not be the same as we report at the time of the birth.

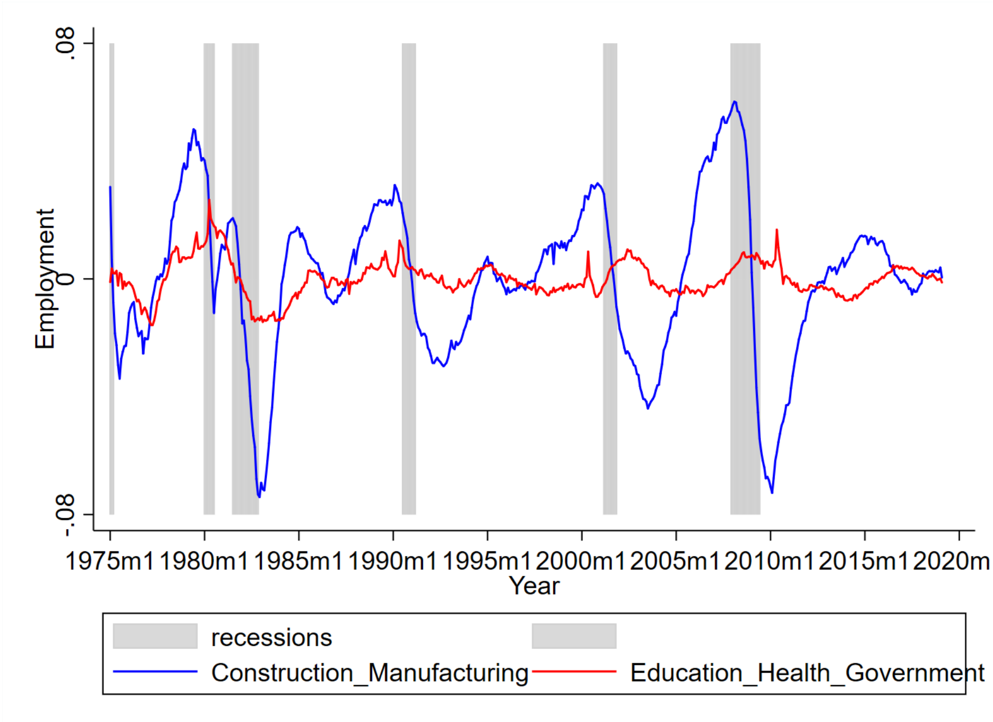

Figure 10: Male vs. Female Dominant Industries

Note: Bureau of Labor Statistics.

5 Empirical Analysis

5.1 Cyclical Properties

The first step of the empirical analysis is to identify the cyclical properties of industries. To do that, we use monthly employment data from BLS for years 1990-2018. We document cyclical properties in two ways. First we document volatility of employment by documenting standard deviation of cyclical component of industry employment. Second, we document the correlation between industry level employment cyclicality and total employment cyclicality to assess the degree of pro-cyclicality. Table 1 shows that the correlation between industry employment changes to the total employment changes ranges from -0.18 to 0.98. Countercyclical industries are education , health services and government at which an important fraction (40%) of women are working[5]. On the other hand, the most procyclical industries trade, transportation, utilities, construction and manufacturing at which 46% of men are working. Moreover, not only male dominant industries are more pro-cyclical but also their employment volatility is very high.

[5] [Charles et al.] find that college attendance decreased during boom times and increased in recession times. This finding can be also thought as a reason why education, health services are acyclical, and even countercyclical sometimes.

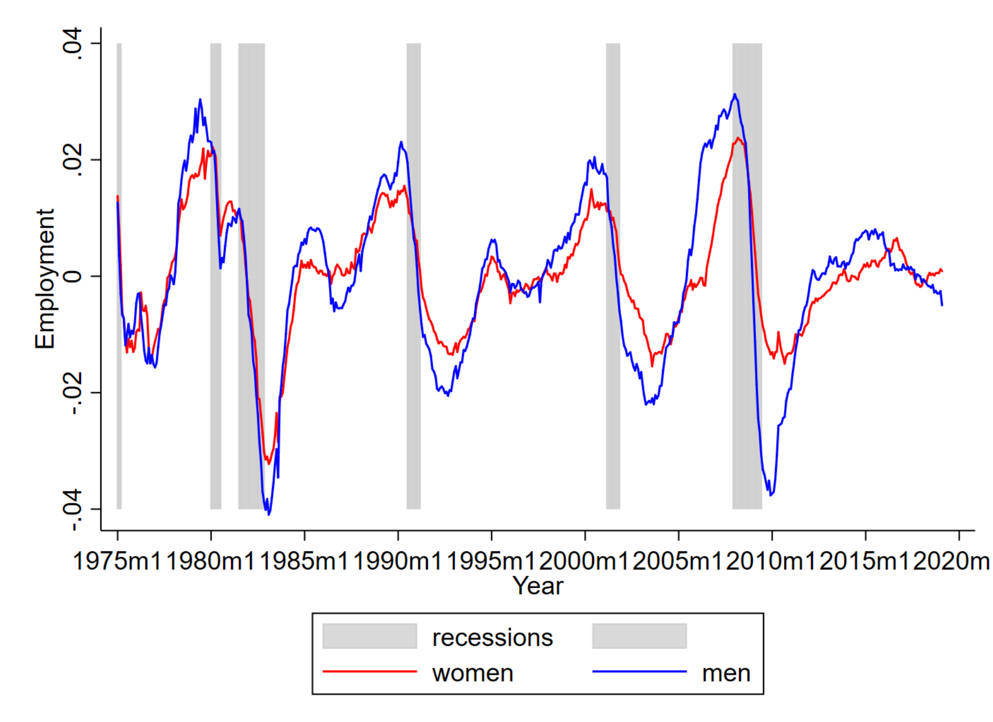

Figure 11: Male vs. Female Dominant Industries

Note: Bureau of Labor Statistics.

5.2 State Level Analysis

We construct a dataset which includes fertility rates and industry employment at state level. For male income effects, we use employment of male dominant industries (construction, manufacturing) as a proxy and for female income, we use employment of female dominant industries (education, health services and government). Table 2 shows that employment changes in female dominant industries have negative impact on fertility changes, whereas employment changes of male dominant industries have positive impact as we argued. In other words, 1% employment increase in male dominant industries leads to 0.19 ppt increase in fertility and 1% employment increase in female dominant industries leads to 0.50 ppt decrease in fertility at state level.

We can consider that employment changes may not be a good proxy for income changes, we have also used total industry compensation changes as it captures both the changes in employment and changes in earnings. Table 8 shows the results for different specifications. Coefficients for male and female income effects remains qualitatively same and significant. Moreover, regression results for post-recession period give larger effects.

Finally, in order to rule out potential problem which may arise from excluding industries other than the ones we defined as female and male dominant industries, we have included all the industry compensation changes in our analysis. Consistent with our hypothesis, compensation changes of gender equal industries do not have significant effect on fertility as positive male effect and negative

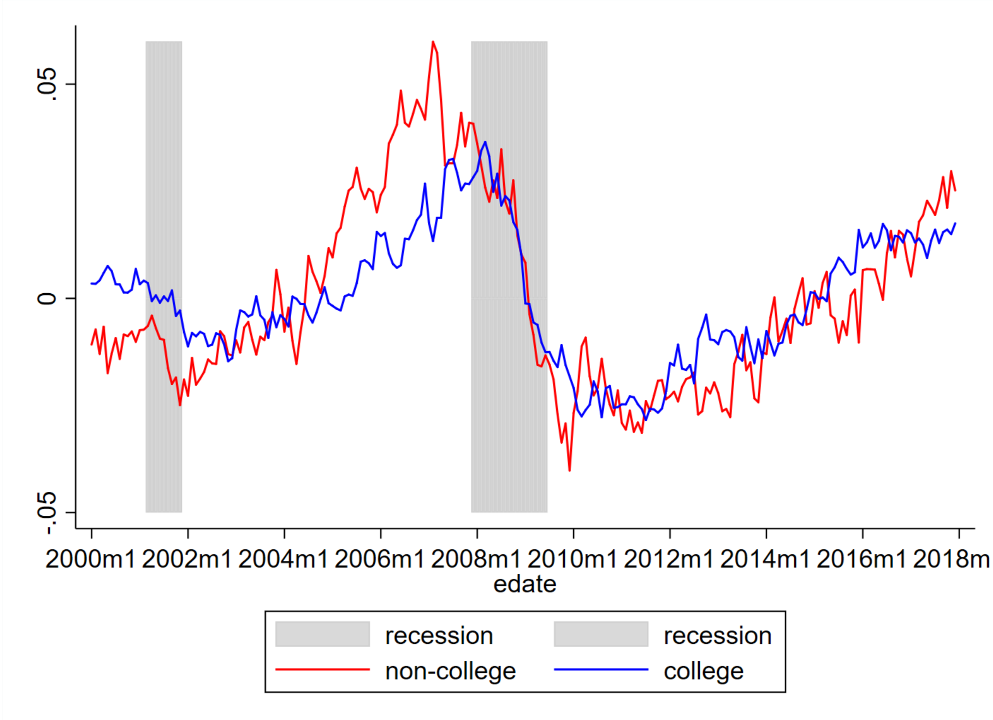

Figure 12: Male vs. Female Dominant Industries
Note: Bureau of Labor Statistics.

female effect cancel out each other. Nevertheless, male dominant and female dominant industry compensation changes still have significant effect on fertility outcomes, where the signs are the same as in the baseline specification (Table 8).

6 Model

We formalize the idea of asymmetric impact of female and male earnings in fertility and we conduct counterfactual scenarios such as "What would have happened if men and women earnings had the same volatility" or "What would have happened if earnings were gender balanced?". To address these issues, we build a household fertility choice model with partial specialization (Jones et al. [2010]). Partial specialization feature allows both genders to work in the market, however only female incur the time cost of childbearing.

6.1 Descriptive Model

A representative household solve the maximization problem in (1) by choosing how much to consume (c) and how many kids to have (n). σ_c is curvature of the utility function with respect to consumption, σ_n is curvature of the utility function with respect to fertility. α_n represents preference towards children with respect to consumption. Household has income from male (w_m) and

Industry	Std. Dev	Corr	Women Share	Men Share	College Share
Education and Health Services	64	-0.18	21%	6%	50%
Government	128	-0.03	19%	14%	45%
Mining, Logging	36	0.47	0%	1%	17%
Other Services	41	0.63	4%	4%	23%
Information	67	0.71	2%	2%	46%
Financial Activities	84	0.77	7%	5%	46%
Leisure	139	0.92	10%	9%	18%
Manufacturing	309	0.95	7%	16%	26%
Construction	236	0.96	1%	8%	12%
Professional Services	338	0.96	12%	13%	47%
Trade, Transportation, Utilities	345	0.98	16%	22%	21%

Table 1: Correlation of Industry Employment Changes and Total Employment Changes
Note: Monthly employment data (1990-2018) is taken from Bureau of Labor Statistics. The cyclical component of industry level employment has been calculated by using HP filter with smoothing parameter $\lambda = 129600$. The first column represents the standard deviation of cyclical component, the second column represents the correlation of cyclical component of each industry with the aggregate employment changes. Third and fourth column represents the share of total women and men employment working in corresponding industry.

Baseline Specification		
Dependent Variable: $\Delta Fertility\ Rate_{t,t-1,s}$		
$\%\Delta Employment\ Female\ Dominant\ Industries_{t-1,t-2,s}$	-0.31***	-0.50***
	(0.108)	(0.098)
$\%\Delta Employment\ Male\ Dominant\ Industries_{t-1,t-2,s}$	0.22***	0.19***
	(0.015)	(0.021)
Year Fixed Effects	No	Yes
R^2	0.35	0.73
n	576	576

Table 2: Fertility Rate and Gender Biased Industry Employment
Note: The data includes state level industry employment and birth rates for years 2002-2016. Female dominant industries are education, health services and government, male dominant industries are construction and manufacturing. Birth data is from NHS and industry employment data is from BLS. The regression is weighted by state employment level.

from female (w_f). However, female has to sacrifice her time from working when they have a kid by a factor γ. There is no labor force participation decision. Both genders work full time, female works less when they have a kid.

$$\max_{c,n} \frac{c^{1-\sigma_c}}{1-\sigma_c} + \alpha_n \frac{n^{1-\sigma_n}}{1-\sigma_n} \quad s.t.\ c \leq w_m + (1-\gamma n)w_f$$

Optimality Condition:

$$\left(\frac{[w_m + (1-\gamma n*)w_f]}{n*^{\sigma_n/\sigma_c}}\right) = \left(\frac{\gamma w_f}{\alpha_n}\right)^{1/\sigma_c}$$

Special Case $\sigma_c = \sigma_n = 1$:

$$n* = \frac{w_m + w_f}{\left(\gamma w_f + \left(\frac{\gamma w_f}{\alpha_n}\right)\right)} \tag{1}$$

$$\partial n^* / \partial w_m = \frac{\alpha_n}{\gamma w_f(\alpha_n + 1)} > 0 \tag{2}$$

$$\partial n^* / \partial w_f = \frac{-w_m \alpha_n}{\gamma(\alpha_n + 1) w_f^2} < 0 \tag{3}$$

$$\partial n^* / \partial w_m \partial w_f = \frac{-\alpha_n}{\gamma w_f^2 (\alpha_n + 1)} < 0 \tag{4}$$

$$\partial n^* / \partial^2 w_f = \frac{2 w_m \alpha_n}{\gamma(\alpha_n + 1) w_f^3} > 0 \tag{5}$$

Fertility is an increasing function of male income and decreasing function of female income. Moreover, female income has a negative impact on the response of fertility to the male income changes. It means that fertility changes less to a shock to the male income if female income is high. On the other hand, fertility responds more to a shock to the female income if male income is high and less if female income is high.

6.2 Dynamic Model

Households live for 3 periods in the model, we denote these stages as young, old and retired. Young represents age 20-30, old represents 30-45[6]. Lifetime utility is represented by:

$$V = U_y + \beta E[U_o] + \beta^2 E[U_r]$$

Agents derive utility from consumption and having kids. Parents also invest in the quality of their children. The utility function is in the form,

$$U = \frac{c^{1-\gamma}}{1-\gamma} + \frac{(qn)^{1-\sigma}}{1-\sigma}$$

where c is the total private household consumption, n is total fertility when young, q is the quality investment for children born.

Similar to De la Croix and Doepke [2003], parents can make expenditure, e per child to achieve quality,

[6] More details are provided in quantitative analysis

$$q = (\theta + e)^{\eta}$$

Retirement utility is as follows:

$$U_r(a_r, q_o n_o, q_y n_y) = \frac{(a_r(1+r)+b)^{1-\gamma}}{1-\gamma} + \frac{\left(q_o n_o + q_y n_y\right)^{1-\sigma}}{1-\sigma}$$

where a_r is the retirement assets and b is the retirement benefit. Retired people derive utility from the kids they made when young and old.

Old problem is as follows:

$$V_o(w_m, w_f, n_y, a_o) = \max_{c_0, a_r, n_o, e_o} \frac{c_o^{1-\gamma}}{1-\gamma} + \xi \frac{\left(q_0 n_o + q_y n_y\right)^{1-\sigma}}{1-\sigma} + \beta U_r(a_r, q_o n_o, q_y n_y)$$
$$\text{s.t.} c_o + a_r + e_o n_o = w_m + w_f f(n_y)(1 - \tau_1 n_o - \tau_2 n_y) + (1+r)a_o$$

We assume only women incur the time cost of children, hence their earnings are penalized when they have kids, in the spirit of Kleven et al. [2018]. τ_1 represents the time cost involved for younger children and τ_2 represents the time cost involved for older children. Moreover, we assume that female earnings evolve endogeneously with the number of children through human capital function $f(n_y)$. A woman who stops working to care for her children when she is young will lose out opportunity to accumulate experience in the work place. Hence, women's potential earnings in the second period depends on how many kids were born in the first period and how much earnings growth is penalized due to fertility. Not only the current earnings but also earnings growth is dampened by the number of children as shown by Kleven et al. [2018]. Human capital function takes the following form:

$$f(n_y) = 1 + \phi(1 - \tau_1 n_y)^h$$

Young problem is as follows:

$$V(a_y, w_m, w_f) = \max_{c_y, a_o, n_y} \frac{c_y^{1-\gamma}}{1-\gamma} + \xi \frac{\left(q_0 n_y + \lambda\right)^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}\left[V_o(w_m', w_f', n_y, a_o)\right]$$

$$\text{s.t } c_y + a_o + e_y n_y = w_m + w_f(1 - \tau_1 n_y) + a_y$$

where λ is the preference parameter which can be thought as the utility from being childless and which allows them to postpone fertility if necessary. Baudin et al. [2015] finds that 2.5% of women remain childless due to poverty and 8.1% due to high opportunity cost. Hence, this parameter can serve to both purposes faced by young women.

With probability p, old agent is facing a recession and with probability $1-p$, the agent faces a boom. When households are making the decision in period 1, they consider two different states of the world (recession and boom) and their potential earnings in those states.

6.3 Parameterization

Parameter	Definition	
β	Time discount	0.95
R	Interest rate	$1/\beta$
γ	Risk aversion	1.5
p	Probability of a recession	12%
τ_1	Time cost of young children	0.2
τ_2	Time cost of old children	0.01
ϕ	Human capital growth	0.3
h	Human capital function curvature	2
Calibrated Parameters		
σ	Child utility curvature	2.89
ξ	Utility weight of children	$1.8e4$
λ	Childless utility	16.81
θ	Minimum investment per children	-4.24

Table 3: Parameters

6.4 Results

The main feature of the model is to show how expectation of a downturn affects life-time fertility and how fertility decision in turn affects human capital accumulation. We have documented several facts on heterogeneity of earnings volatility i.e., men earnings are more volatile than women earnings. Here, we report how higher volatility of earnings affect lifetime fertility.

Assume earnings of old take the following form:

$$w_g = \bar{w}_g + \sigma_g$$

where g denotes gender, $\bar{w}$ represents the average earnings of the respective type and σ represents the volatility.

One stark observation is that volatility of fertility when old goes up as men's earning become more volatile (σ_m) (Figure 13). In the boom, the family has more money, which increases fertility due to income effect. Conversely, in the bust, the family does not have enough income to support more kids. In order to compensate, the family makes more kids when they are young. This makes women incur child penalty early on in her career. Due to less average income, the family invests less in quality. Overall, in families with more volatile male earning, we see more kids and low quality.

Figure 14 depicts the same exercise with women. When the volatility of women's income (σ_f) increases, the family has more kids when they are old. During the boom, they have more money to afford a kid, so the family has more kids with higher quality investment. During the bust, the cost of children is low (women's opportunity cost of leaving the work), the family has more children but they invest less in them. Overall, the family postpones fertility to old age, which enables women to get more experience at work and enjoy higher salaries later in her career.

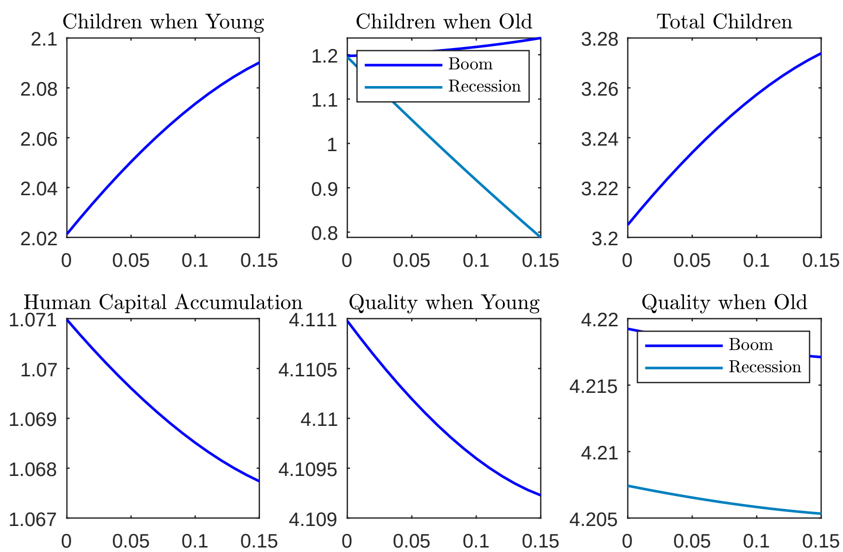

Figure 13: Volatility of Male Income

Hence, these results show us that since low-educated low income families face a higher risk of men's income loss, knowing that they cannot have children in recession state as much as they would want to, they give birth earlier. However, having more children at an early age, decreases women's potential earnings and their ability of benefiting from returns to experience. In other words, one other dimension we are investigating here is that earnings growth is smaller among low-educated people also due to the fact that they have higher fertility rates at young ages which is driven by labor market uncertainty that they face.

7 Quantitative Analysis

The purpose of the quantitative analysis is to answer the following questions:

How much of the fertility decline is due to gender-asymmetric income cyclicality?

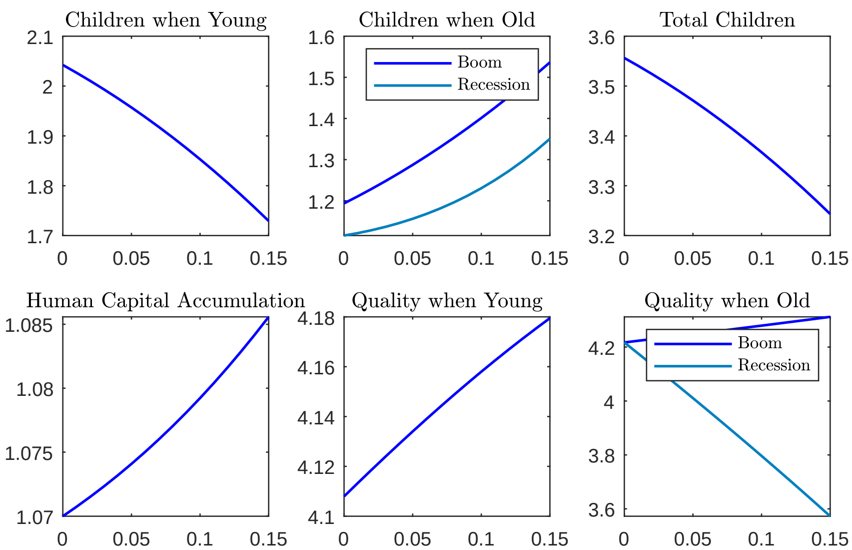

Figure 14: Volatility of Female Income

What would be the fertility and the human capital if earnings were gender symmetric and exhibit same volatility?

One important part of the quantitative analysis is estimating male and female earnings as model inputs. There are two main concerns while performing the estimation. First, since we are interested in analysing the fertility changes around the business cycle, earnings should account for possible unemployment spells and the state of not being in the labor force. Hence, the appropriate measure is not the wage as done in the literature but earnings averaging all population. Our method involves a direct estimation from American Community Survey which allows us focusing on married population and also capturing possible heterogeneity across low and high educated people.

7.1 Estimating Earnings from ACS

Our mechanism is to explore how earnings risk affect household fertility decision, hence our main population of interest is married population. We assume that assortative mating applies in terms of educational attainment and age. The average age gap between couples is estimated to be 2. Hence, we focus on married population, age 20-50, where young female and male corresponds to age 20-29 and 20-34 respectively, old female and male corresponds to age 30-44 and 35-49 respectively. High educated group is defined as the ones who have at least college degree and low educated group is defined as the ones who have less than college degree. Then, we estimate average annual earnings for each group across years to be used as model inputs. To account for the changes in real terms, we deflate earnings by using CPI, hence the reported earnings are in 2015$. We normalize earnings of young female to 1 and report relative earnings of each group. As an approximation to boom and recession earnings, we report earnings in 2007 and 2009. Table 4 shows the results of our estimation. For every age and education group, male earnings decline more than female earnings. For every age and gender group, low educated earnings decline more than high educated earnings.

	w_{fy}	w_{my}	w_{fo}	w_{mo}	w_{fyh}	w_{myh}	w_{fyl}	w_{myl}	w_{foh}	w_{moh}	w_{fol}	w_{mol}
2007	1	2.27	1.43	3.28	1.61	3.27	0.7	1.78	2.08	5.1	0.99	2.28
2009	0.95	2.05	1.4	3.03	1.56	3.05	0.64	1.56	2.08	4.82	0.91	2.01
% Change	-4.6%	-9.6%	-1.7%	-7.6%	-2.9%	-6.8%	-8.6%	-12.3%	0.2%	-5.4%	-8.1%	11.7%

Table 4: Earnings using ACS

Note: Subscript f and m denotes female and male, y and o denotes young and old, h and l denotes high and low educated respectively.

7.2 Fertility of Young and Old

Table 5 documents the average number of children for the age group of 20-29 and 30-44 among married women to be used as the targets in the model. We also document fertility patterns across high and low educated women. Comparing younger and older women's fertility show us that younger women respond more to the economic shocks, i.e. the average number of children decreases from 2.07 to 1.93 for the age group 20-29, whereas it does not decrease for age group 30-44. Moreover, lower educated women decreases their fertility more than highly educated women because they are exposed to larger earnings decline. We show in results section that one reason why low educated women have kids earlier is to compensate potential fertility decline in recession time.

	n_y	n_o	n_{yl}	n_{ol}	n_{yh}	n_{oh}
2007	2.07	1.17	2.16	0.87	1.87	1.63
2010	1.94	1.15	2.05	0.85	1.73	1.56
Change	-6.1%	-2.2%	-5.4%	-2.1%	-7.5%	-4.4%

Table 5: Average number of kids per age group

Note: The data is from American Community Survey. The population of interest is married women age 20-44 where young is 20-29 and old is 30-44. Yearly fertility rates are multiplied by 10 and 15 respectively to calculate average number of children born per women. l refers to low-educated and h refers to high-educated.

7.3 Model Fit and Counterfactual

Target	Data	Model
Young boom fertility	2.06	2.04
Young recession fertility	1.94	1.96
Old boom fertility	1.17	1.20
Old recession fertility	1.14	1.12

Table 6: Model Fit

Here we do two similar counterfactual exercises. We start with the calibrated model and ask what if men and women had the same earning volatility? In this exercise, we leave average men and women earnings unchanged and distribute the gains in the boom and the losses in the recession evenly. We observe that women postpone child bearing in the boom and accumulate more human capital. In the next exercise, we assume that men and women have the same earnings both in boom and recession. We simply divide total family earnings by two. Here, families have less kids on average and particularly when they are young, which allows women to postpone child penalty and accumulate work experience. When men and women have the same volatility of earnings, the model predicts fertility to be countercyclical. In a recession, less men will lose jobs, which will increase fertility due to income effect. At the same time, there will be more women losing jobs, who will seize upon the opportunity to have more children.

	Baseline	Same Volatility	Same earning
Young boom fertility	2.04	1.99	1.76
Young recession fertility	1.96	2.1	1.82
Old boom fertility	1.20	1.21	1.06
Old recession fertility	1.12	1.15	1.01
Human capital accumulation	1.07	1.072	1.084

Table 7: Counterfactual Exercise

In all counterfactual scenarios, we show that human capital accumulation would be higher because women delay childbearing and hence have a faster income growth. In Figure 15, we show that same men and women earnings volatility make the fertility countercyclical by keeping the level more or less the same. However, distributing earnings evenly, i.e. removing gender gap in earnings, not only would make fertility countercyclical but also decrease the level.

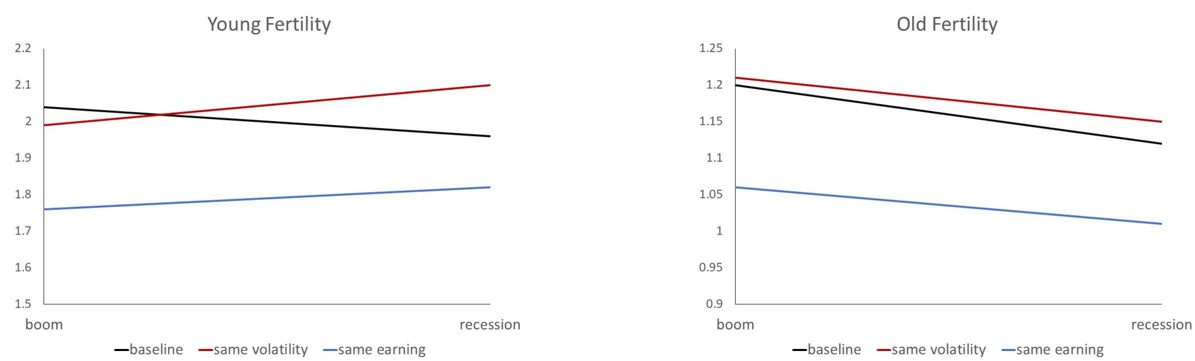

Figure 15: Baseline vs. Counterfactuals

8 Conclusion

This paper attempts to give a complementary explanation for procyclical feature of fertility. We argue that part of the reason why fertility is procyclical is due to gender asymmetry in industries as well as different cyclical properties of industries. Men are employed in heavily procyclical industries whereas women are employed in acyclical industries. In recession times, worse labor market outcomes of men negatively affect fertility. On the other hand, better or stable labor market outcomes of women also negatively affect fertility due to substitution effect of female wage. Hence, gender asymmetry feature of the labor market amplifies the fertility response to business cycles.

We show that increases in employment (and total compensation) in male dominant industries have positive impact on fertility at state level whereas increases in female dominant industries have negative impact on fertility. Our empirical analysis is robust to the measure used (either employment or compensation) and also robust when all industry changes are incorporated. The outcome changes in gender-equal industries do not seem to have a significant effect on fertility.

We build a model of household fertility choice with partial specialization. We show qualitatively that under reasonable parameters, female wage affects fertility negatively and male wage affects fertility positively. With a dynamic model, we are able to present quantitative results by also incorporating fertility differences among age groups. Our quantitative model predicts that fertility would behave countercyclicaly if men and women had the same volatility of earnings.

In order to quantify the importance of gender asymmetry in industries, we perform a counterfactual analysis by asking the question " what would be the fertility after the recession if industries were gender-equal and/or genders experience same cyclical shocks?". In all scenarios, we find that fertility decline would have been milder. Our accounting predicts that fertility among married couples would have risen by 1.6% if men and women had same income volatility as opposed to 5% decline in the data during the Great Recession.

We argue that mostly low income families are affected from the cyclical properties of industries. Since women in lower income families become the breadwinners of the family during a recession, they tend to shift childbirth to boom times, for which they leave work when the job opportunities are more abundant. This might hamper human capital accumulation in lower income women and increase inequality.

We believe that our findings are important in order to understand why fertility is procyclical, what feature of the labor market causes this phenomenon and finally why better labor market outcomes of women means lower fertility. One reason why we obtain such a conclusion is that women still incur majority of childbearing and that women have to sacrifice hours worked when they have children. Hence, other than gender symmetric labor market conditions, policies which may potentially reduce the opportunity cost of child to mothers, with easy access to low cost child care may help in rising fertility.

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A Appendix

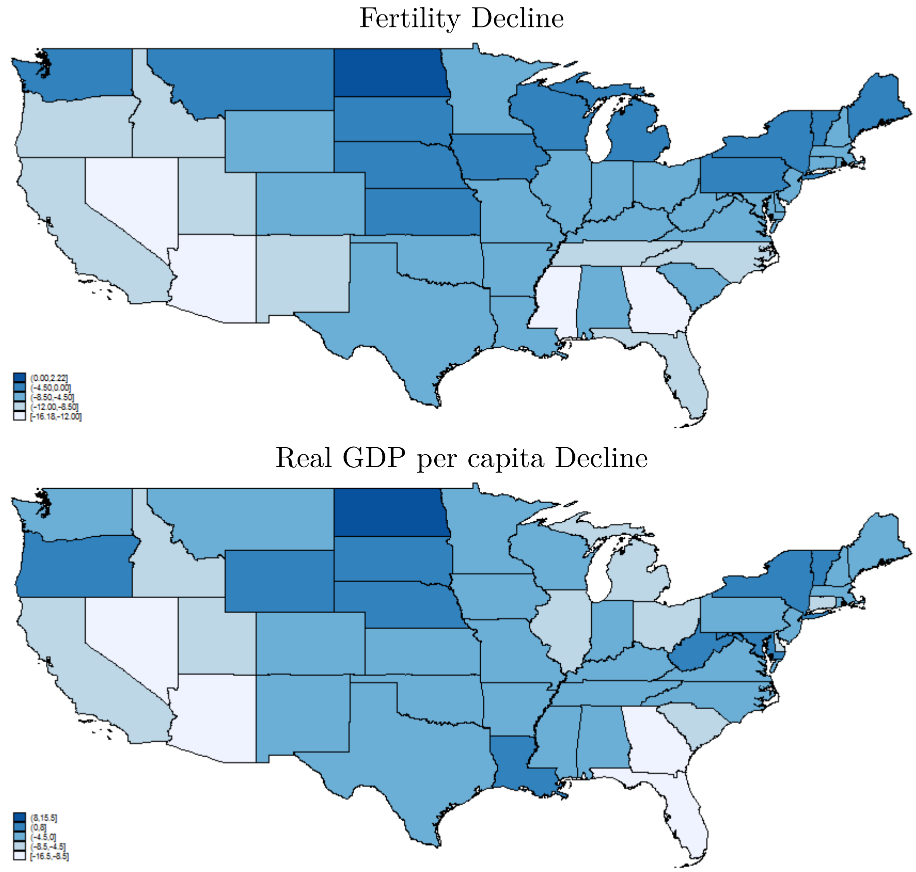

Figure 16: Fertility and Real GDP per capita

Note: Upper figure shows the fertility decrease from 2007 to 2010. Below figure shows the real GDP per cap decrease for the same period. The data is taken from National Health Statistics for fertility and Bureau of Economic Analysis for real GDP per capita.

	(2002-2016)				(2007-2011)		
Dependent Variable: $\Delta Birth\ Rate_{t,t-1,s}$	1	2	3	4	5	6	7
$\%\Delta Employment\ Female\ Dominant\ Industries_{t-1,t-2,s}$	-0.31***	-0.22*			-0.64***		
	(0.11)	(0.13)			(0.09)		
$\%\Delta Employment\ Male\ Dominant\ Industries_{t-1,t-2,s}$	0.22***	0.30***			0.17***		
	(0.01)	(0.06)			(0.01)		
$\%\Delta Total\ Employment_{t-1,t-2,s}$		-0.21					
		(0.18)					
$\%\Delta Total\ Compensation\ Female\ Dominant\ Industries_{t-1,t-2,s}$			-0.22***			-0.35***	
			(0.06)			(0.04)	
$\%\Delta Total\ Compensation\ Male\ Dominant\ Industries_{t-1,t-2,s}$			0.11***			0.16***	
			(0.04)			(0.02)	
$\%\Delta Total\ Compensation\ in\ Mining_{t-1,t-2,s}$				-0.01			-0.01
				(0.01)			(0.01)
$\%\Delta Total\ Compensation\ in\ Construction_{t-1,t-2,s}$				0.18***			0.1***
				(0.02)			(0.01)
$\%\Delta Total\ Compensation\ in\ Manufacturing_{t-1,t-2,s}$				0.03			0.02
				(0.03)			(0.03)
$\%\Delta Total\ Compensation\ in\ Trade_{t-1,t-2,s}$				0.1			0.11
				(0.07)			(0.07)
$\%\Delta Total\ Compensation\ in\ Information_{t-1,t-2,s}$				-0.03**			0.01
				(0.01)			(0.01)
$\%\Delta Total\ Compensation\ in\ Finance_{t-1,t-2,s}$				0.11***			0.01
				(0.03)			(0.03)
$\%\Delta Total\ Compensation\ in\ Business_{t-1,t-2,s}$				-0.05**			-0.06**
				(0.03)			(0.03)
$\%\Delta Total\ Compensation\ in\ Education, Health_{t-1,t-2,s}$				-0.17***			-0.29***
				(0.06)			(0.05)
$\%\Delta Total\ Compensation\ in\ Leisure_{t-1,t-2,s}$				-0.13***			-0.04
				(0.05)			(0.06)
$\%\Delta Total\ Compensation\ in\ OtherServices_{t-1,t-2,s}$				-0.3***			-0.06
				(0.04)			(0.05)
$\%\Delta Total\ Compensation\ in\ Government_{t-1,t-2,s}$				0.0414			-0.11**
				(0.05)			(0.04)
Constant	0.00*	0.00**	-0.01***	0.01***	-0.00**	-0.01***	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
n	576	576	611	579	384	408	383
R^2	0.352	0.355	0.201	0.512	0.566	0.514	0.567

Table 8: Robustness Checks

Note: The dataset is a merged dataset using state level compensation levels from BEA, state level fertility rates from National Health Statistics and state-industry level employment from BLS. All the regressions are weighted by state total employment.