Statistical Discrimination with Fertility: Understanding the Gender Wage Gap and Other Labor Market Differences

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Abstract

This paper provides an alternative explanation for gender discrimination. A woman's fertility intentions are treated as the ultimate unobservable characteristic to employers. Women who intend to have children may become less productive in future if they plan to allocate less effort to employment after childbearing. At a minimum, they will lose time due to delivery and breast-feeding. To the extent that small initial comparative advantages in child raising cause women to specialize in these activities within the household, women who plan to have children may also be less productive over the longer term. The model is one of statistical discrimination, with the equilibrium being characterized by population fertility rates that exactly match employer's beliefs about fertility intentions. Since motherhood is believed to decrease women's productivity, women's wages are a decreasing function of expected future fertility rates. The gender wage gap can be addressed in this model, for equally skilled individuals are paid differently according to gender, with the gap being proportional to their expected fertility rates. The fertility threat is predicted to be most important when there are gains to the employment relationship, such as in firm specific occupations or in jobs with high training costs. Finally, the model predicts a negative correlation between skill and fertility choices and a smaller rate of skill investment among women.

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1 Introduction

Gender differences in labor market outcomes such as in wages, labor force participation and job characteristics have been extensively documented in the literature (Altonji and Blank, 1999). The justification for those differences has traditionally pointed to discrimination[1] and there is particular concern in understanding the reasons why employers discriminate on gender, since it can help the formulation of policies that target the reduction of gender gaps.

Discrimination has traditionally been justified by the unobservability of a crucial productivity characteristic, believed to be gender related by employers. In models of statistical discrimination (Phelps, 1972; Arrow, 1973; Coute and Loury, 1993), for example, employers superior beliefs about men's ability might give rise to a self-fulfilling gendered equilibrium in which men end up acquiring more productive skills relative to women. The costliness of verifying worker qualification, however, constitutes a major drawback to this reasoning. Transcripts, resumes and references are easily available and can be verified. Ultimately, workers can also be submitted to tests. This paper proposes an alternative mechanism justifying gender discrimination, which is the unobservability an inherent characteristic of women: their motherhood intentions.

Women who intend to have children might become less productive in future if they allocate less effort to employment after childbearing. At a minimum, they will lose time due to delivery and breast-feeding. To the extent that small initial comparative advantages in child raising cause women to specialize in these activities within the household, women who plan to have children may also be less productive over the

[1]Blau and Kahn (2006) have documented that women earn lower wages than men even after controling for different compositional effects of race, education, experience, industry and occupational choices across the male and female populations. The adjusted pay ratio was 81.6% in 1979, 91% in 1989 and 91.1% in 1998. The "unexplained" gap is commonly taken as an indirect estimate of the gender discrimination, but direct evidence has also been obtained through case studies. Goldin and Rouse (2000), for example, find that the adoption of blind auditions for orchestra musicians increased the proportion of females among new hires.

longer term.

Expected fertility rates are taken into account by employers as a proxy to the fraction of women that will allocate attention towards childbearing activities after motherhood. Its consideration should be most relevant when there are gains to a continued - or demanding - employment relationship, and where current wages anticipate the future surplus generated along a worker's career. Since employers are not able to identify the future mothers, women are paid lower wages because part of them will become less productive once their child is born.

In this paper, motherhood intentions are incorporated into a statistical discrimination framework, in which wages respond to fertility rates, and motherhood choices, in turn, respond to expected labor compensation. In equilibrium, the rate at which women have children exactly matches employers expectations.

The model yields several predictions. First, it is consistent with the evidence the women earn lower wages than men even after controlling for all observable differences that exist between them. The magnitude of the gender wage gap is predicted to be proportional (and increasing) in the equilibrium fertility rate. This suggests, for instance, that the wage gap should be negligible for women beyond childbearing age and high at the peak fertility age group. Childless women should display a steeper wage profile relative to men because they are discriminated against early in their careers, but end up being as productive, and earning the same wages, as their male counterparts in the future. Second, the model predicts that fertility rates should not be important in explaining gender wage gaps when there are small gains to the employment relationship. Fertility is only a threat when employers make investments that accrue throughout a worker's career or in positions that require training or involve learning. Third, motherhood choices should be more frequently observed among unskilled women because both skill and fertility choices depend on expected market wages. As in human capital models, skill investments incentives increases with the time span one expects to be productive over the life-cycle, and are lower for women.

This paper is organized as follows. The next section reviews the theoretical background addressing gender discrimination and contrasts the existing models with the strategy pursued in this paper. The third section outlines the model. Results and comparative statics analysis are developed in section four. A discussion of the model's predictions and the empirical evidence available is contained in section five. Finally, section six concludes.

2 Background

The rationale for gender differences in labor market has been provided by statistical discrimination theories, exploring employers' perceptions of reality and expectations[2]. Firms are taken to have limited information about the skills and turnover propensities of job applicants, and have the incentive to statistically discriminate on observable characteristics, such as gender, if they believe such characteristics are correlated with productivity. Discriminatory equilibria are shown to be possible, in which stereotypes are self-confirming: pre-market characteristics, such as human capital accumulation, respond to the perceptions (or "standards") each group will face by the time they start working. In the case of statistical discrimination on gender, lower productivity expectations for women are followed by less investment in skill and, consequently, lower wages.

Statistical discrimination theories, however, unsatisfactory explains why productivity is noisily perceived by employers, since workers' credentials can be easily verified

[2]Taste based prejudice has been shown difficult to justify in theoretical grounds, since non-discriminatory firms should eliminate discriminatory firms in a long run competitive equilibrium (Arrow, 1973).

through transcripts and resumes, and can be further confirmed through tests or recommendations of previous professors or employers[3].

This paper addresses this critique by introducing motherhood intentions in a model of statistical discrimination as the leading source of productivity uncertainty employers face. On the one hand, human capital investment choices - a worker's education or skill - can be inferred by employers, and provide a clear measure of a worker's labor capacity. On the other hand, women's plans on having a child, cannot be observed or verified until delivery itself.

Women who intend to have children might become less productive in future if they allocate less effort to employment after child-bearing. Employers statistically discriminate on gender because it provides some information about a workers' productivity, which is taken to be fertility driven, instead of skill related.

An alternative reason for gender discrimination has been provided by Albanesi and Olivetti (2007a). In their statistical discrimination model, employers uncertainty is related to household division of labor and hours in home production. Allocation of home hours depend on spouses' relative earning, and labor contracts, in turn, depend on expected hours at home production. A self-fulfilling equilibria in which women allocate more time to home production and earn lower wages can arise, and should be magnified in jobs or occupations where effort is more imprecisely inferred. Although their model can explain important features of gender differences in the labor market, such as performance pay structure across gender and the division of tasks within a household, it is silent about the impacts of fertility rates on gender discrimination,

[3] The criticism dates back to Akerloff (1976). In his own words:

'The costliness of testing workers' qualifications suggests that the traits necessary for qualification must be hard to observe. Arrow is specific in this regard: "I'm thinking here not of the conventional type of education and experience, which is easily observable but more subtle types the employer cannot observe directly: the habits of action and thought that favor good performance in skilled jobs, steadiness, punctuality, responsiveness and initiative." [...] But is it also true that these habits of thoughts and action are acquired in response to wage differentials?'

since households always engage in home production, which can be interpreted as the decision to have a child.

Childbearing considerations, and its impacts on labor market outcomes, are not new in the literature [Mincer and Pollachek (1974) and Becker (1985)]. According to the human capital theory, the incentives to accumulate human capital are related to the time one expects to work over the life-cycle. Women invest less in market skills because they expect to interrupt their careers for childbearing. In this paper, I consider a novel mechanism through which motherhood expectations affect women's wages and human capital choices: the employer discrimination channel. Career interruptions (or drops in productivity due to childbearing) also represent losses to employers in the case where there are gains to an employment relationship. Fertility rates can then be taken as a proxy to the probability this surplus will be forgone by the women who chose motherhood and should help to account for gender differences in wage.

3 The Model

3.1 Individuals and Jobs

Individuals belong to either one of two identifiable groups, $G \in \{M, W\}$, where M stands for men and W for women. Male and female individuals differ in that only women attribute value to motherhood and choose whether or not to have a child. I abstract from fatherhood preferences and choices because women are more likely to bear child raising activities within the household. A woman's motherhood decision takes into account the individual benefit she attributes to having a child, which is represented by γ_i, and costs, which will be mainly characterized by foregone labor market wages. Let F denote the binary motherhood status, with $F = 1$ indicating the mothers and $F = 0$ the non-mothers.

Both men and women make a skill choice $S \in \{0,1\}$, where $S = 1$ represents the skilled individuals and $S = 0$ the unskilled ones. Skills are desired because they improve labor productive. However, its acquisition is also costly. Let c_i denote the individual cost incurred by i when $S = 1$.

Each women draws a personal cost and motherhood value (c_i, γ_i) from $q_{c,\gamma}(x_1, x_2)$, which is assumed to be a continuous density function over $(x_1, x_2) \in [0, \infty)X(-\infty, \infty)$,[4] with $Q_{c,\gamma}(c, \gamma)$ being the corresponding cumulative distribution function. They choose (S, F) according to (c_i, γ_i) and the expected wage benefit of skill acquisition. Male workers choose S according to own cost c_i which is drawn for the same marginal distribution of cost for women, $q_c(x_1) = \int_{-\infty}^{+\infty} q_{c,\gamma}(x_1, x_2)dx_2$, and also according to the expected wage benefit of skill acquisition.

Choices are made in the first period, $t = 0$, and individuals work in the two subsequent periods, $t = 1, 2$. There are two jobs in the economy. The first job job can be performed satisfactory by all workers, and its productivity is normalized to be zero in each period. The second job is more demanding and rewarding, and can only be performed by a skilled worker (i.e., unskilled workers have productivity zero if assigned there). At $t = 1$, the net productivity of the skilled worker is ρ. Gains from a continued job relationship accrue at $t = 2$, where the enhanced productivity becomes ρ''. Job learning or training also has outside value ρ' at $t = 2$, with $0 \leq \rho \leq \rho' \leq \rho''$.

Employers perfectly observe a worker's skill choice by the time they start working, $t = 1$, and assign unskilled and skilled workers to the first and second job, respectively[5]. In contrast to standard statistical discrimination models, "credentials" are known and there is no uncertainty whatsoever on how skills affect job productivity. There is, however, uncertainty regarding fertility intentions of women, which are only observed

[4]In principle, fertility values could be either positive or negative, with negative values indicating distaste for motherhood.

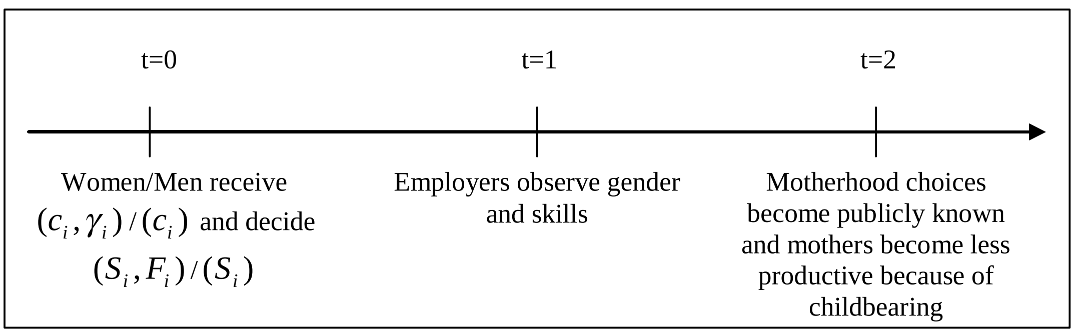
[5]This corresponds to an equal opportunity rule, where assignament does not depend on gender.

at $t = 2$.

Women who decide to have children become less productive in the future because they allocate less effort to employment for child-bearing. We let motherhood choice ($F = 1$) be accompanied by a zero period productivity in $t = 2$, regardless the job position. Note that the severity of the drop in productivity is assumed to be greater for skilled women, where productivity would have been ρ'', in comparison to unskilled women, where productivity would have remained zero[6].

The model's timeline is given as below:

Figure 1: Timeline



Workers are paid according to their expected productivity. Therefore, at $t = 1$, wages can be set differently according to skill choices and gender, S and G, the publicly known productivity-related characteristics. Gender provides a proxy for motherhood only at $t = 1$ and once the actual choices are observed in $t = 2$, wages are set differently according to S and F.

Since all workers, whether male or female, mothers or not, have zero productivity in the unskilled job, their wages are set to zero in both periods. Wages for skilled male workers reflect their labor returns ρ and ρ''. While it would be possible to pay workers

[6]This assumption is consistent with the evidence that the depreciation rate of the earning power of women are higher for larger levels of human capital stock. [Mincer and Polachek, 1974].

according to their period productivity, firms are not believed to credibly commit to that strategy. The best outside option for a skilled worker in the second period pays ρ' and employers can always retain the trained worker at a wage smaller than ρ'', but greater than ρ', and make positive profit. Therefore, skilled workers expect their wages to be ρ' at $t = 2$.

Competition and free entry of firms drive profits to zero, and the second period surplus $(\rho'' - \rho')$ is transferred to wages in the first period. At $t = 1$, a skilled male worker earns $\rho + (\rho'' - \rho')$, the net of training first period productivity plus the second period surplus.

The rationale for women is similar, with the only difference being that wages depend on motherhood status, and not gender, at $t = 2$. Skilled non-mothers are as productive as skilled male and earn ρ'. Mother, on the other hand, are not able to perform on the skilled job. Their wages reflect their productivity at $t = 2$, and are set to zero.

Let π denote employers' belief about the fraction of mothers among skilled female workers, i.e., $\pi = \Pr(F = 1|S = 1, G = W)$. The first period wage of skilled women takes into account that surplus will be generated only through the $(1 - \pi)$ fraction of women that do not choose motherhood. They are set to $\omega = \rho + (\rho'' - \rho')(1 - \pi)$, and the fertility threat imposes a penalty on women's wages.

3.2 Equilibrium

The utility of an individual is linear in wages, skill cost and motherhood values, and is given by:

$$U_i = w_{SG1} + w_{SF2} - (c_i)I_{[S=1]} + (\gamma_i)I_{[F=1]}I_{[G=W]} \tag{1}$$

where $S \in \{0,1\}$ indexes skills, $G \in \{M,W\}$, gender and $F \in \{0,1\}$, motherhood choices of women; $I_{[.]}$ is the logical indicative function and w_{SG1} and w_{SF2} correspond to wages at periods 1 and 2, respectively. Skill acquisition is costly, while motherhood can either increase or decrease utility, being a taste parameters only for women.

Equilibrium characterization in the male population corresponds to the benchmark case, since their skills (and productivity) are completely known to employers and no fertility threat is present. A man will invest in skills so long as his cost c_i is less than his lifetime benefit in the skilled job, which is given by the first and second period wages $\rho + (\rho'' - \rho')$ and ρ'. The proportion of skilled male workers in the male population is $Q_c(\rho + \rho'')$.

Women jointly decide (S,F) based on (c_i, γ_i) and the lifetime benefit in the skilled job. For a given first period skilled female wage $\omega = \rho + (\rho'' - \rho')(1-\pi)$, payoff comparison delivers optimality rules that depend only on individual costs and motherhood values. The pairs of (c_i, γ_i) that determine each optimal solution are represented in the picture below:

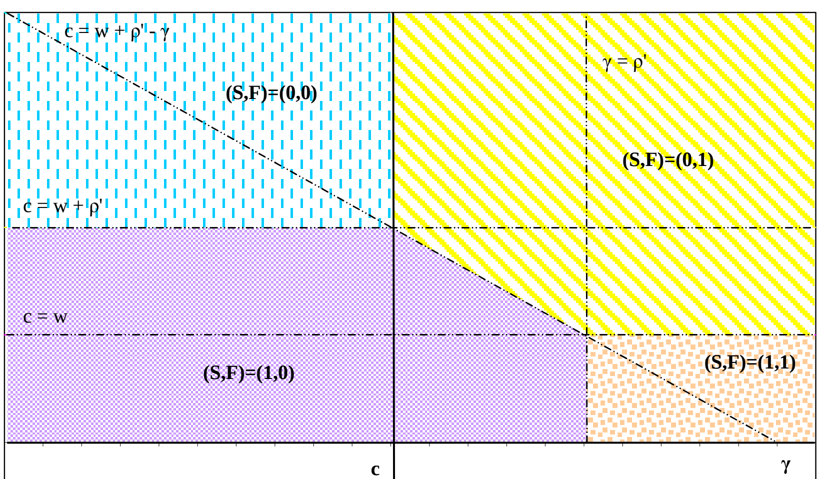


Figure 2: Women's Choices

For example, women who choose $(S, F) = (1, 1)$ have low skill costs and and high motherhood preferences. Using the joint distribution of (c, γ), the proportion mothers among skilled women, as a function of ω, is given by[7]:

$$p(\omega) = \Pr(F = 1|S = 1, G = W) = \frac{\Pr(F = 1, S = 1, G = W)}{\Pr(S = 1, G = W)} \tag{2}$$

$$\begin{aligned}
\text{where } \Pr(F &= 1, S = 1, G = W) = \int_{\rho'}^{\infty} \int_{0}^{\omega} q_{c,\gamma}(x_1, x_2) dx_1 dx_2 \\
\text{and } \Pr(S &= 1, G = W) = \int_{-\infty}^{\infty} \int_{0}^{\omega} q_{c,\gamma}(x_1, x_2) dx_1 dx_2 \\
&+ \int_{-\infty}^{0} \int_{\omega}^{\omega+\rho'} q_{c,\gamma}(x_1, x_2) dt_1 dt_2 + \int_{0}^{\rho} \int_{\omega}^{\omega+\rho'-x_2} q_{c,\gamma}(x_1, x_2) dx_1 dx_2.
\end{aligned}$$

In equilibrium, the fraction of high skilled female workers that decide to have children precisely match the rate postulated by the employer's belief. More formally, an equilibrium is a belief π^* satisfying $\pi^* = p[\omega(\pi^*)]$, with $\pi^* \in [0, 1]$.

Let w_{GAP} denote the resulting first period gender wage gap in the skilled occupation, with

$$w_{GAP} = \frac{(\rho'' - \rho')\pi^*}{\rho + (\rho'' - \rho')} \tag{3}$$

In this model, an equilibrium with a positive fertility rate generates a gender wage gap for equally skilled individuals. The prediction of a justified wage gap fits the well-known empirical evidence that wages are lower for women even after taking into account all the

[7] If c and γ are independent, $p(\omega)$ simplifies to:

$$p(\omega) = \frac{Q_c(\omega)(1 - Q_\gamma(\rho'))}{Q_c(\omega)(1 - Q_\gamma(\rho')) + Q_c(\omega + \rho')Q_\gamma(0) + \int_0^{\rho'} q_\gamma(t_2) Q_c(2w_{11} - t_2) dt_2}$$

observable dimensions at which men and women differ. In contrast to the human capital theory, the gap is not the result of an unexplained gender difference. On the contrary, it results from a discriminatory behavior of employers, that set wages according to gender because it provides a proxy for fertility, which is the main unobservable characteristic affecting productivity. In comparison to statistical discrimination theories, uncertainty regarding productivity remains the leading force driving the wage wedge, but the focus shifts from unobserved skills to unobserved fertility intentions.

The gender wage gap w_{GAP} is increasing in the equilibrium fertility rate π^*. A higher proportion of skilled mothers increases the rate at which the second period surplus is foregone, amplifying the penalty that is imposed on women's wages. Moreover, non-mothers catch up to male wages once fertility choices are observed, and the model predicts a steeper wage profile (relative to men) for them.

Fertility rates should be most important addressing wage gaps in jobs that have some learning or training involved. To that extent, we can interpret ρ'' as a firm specific productivity gain and ρ' as the general human capital accumulated in that job. If we believe employers will not have the incentive to pay workers their enhanced productivity ρ'' at future, some surplus sharing should be engaged at present, for which the fertility rate of skilled women is the relevant discount factor. When $\rho'' = \rho'$, workers can be paid according to their period productivity, with no credibility risk. The inability to signal motherhood intentions only play a role when there are gains to a continued employment relationship, that cannot be contracted beforehand[8].

[8]Should the ρ'' payment commitment be possible, a first period gender wage gap might still emerge if firms are able to offer differents wage contracts that induce motherhood revelation. The idea is that non-mother would choose a steeper wage profile (lower initial wages with high second period reward) relative to mothers, though further investigation is still granted.

4 Uniformity and Independence of Costs and Motherhood Values

The model outlined in the previous section shows that when motherhood intentions of women are introduced as the leading source of productivity uncertainty employers face, a gender wage gap exists and is positively related to equilibrium fertility rate. The resulting fraction of women choosing to become skilled and the correlation between motherhood and skill choice should, likewise, depend on π^*. This section characterizes the conditions under which an equilibrium fertility rate is attained and analyses the dependence of other outcomes to this parameter.

In what follows, it is assumed that costs to skill acquisition and motherhood values are independent and uniformly distributed. Independence guarantees that no ex ante correlation between c and γ exits, which would naturally lead to an interdependence between skill and motherhood choices of women. Moreover, both men and women are equally treated in terms of costs: for any given motherhood value $\gamma = x_2$, the conditional cost distribution of women, $q_{c|\gamma}(x_1|\gamma = x_2)$, is exactly the same as the one for men, $q_c(x_1)$. The uniform distribution delivers closed form solutions for equilibrium fertility rates and other outcomes, and is used for illustrative purposes.

Let costs to skill acquisition and motherhood values be independent and uniformly distributed with[9]:

$$\begin{aligned} \gamma &\sim Unif[\overline{\gamma} - a, \overline{\gamma} + a], \text{ where } a > |\overline{\gamma}| \\ c &\sim Unif[0, k], \text{ where } k > 0 \end{aligned} \tag{4}$$

In this setup, an equilibrium π^* is shown to exist and to be unique. Preposition 1

[9]That is, $E(\gamma) = \overline{\gamma}$, $Var(\gamma) = a^2/3$, $E(c) = k/2$ and $Var(c) = k^2/12$. Positive and negative motherhood values are guaranteed with the assumption that $a > |\overline{\gamma}|$.

below states this result. A proof is provided in the appendix.

Proposition 1 *If cost and motherhood values are independent, with distributions given by (4), where* $k > \rho + \rho''$ *and* $\overline{\gamma} + a > \rho'$[10]*, there exists an unique* $\pi^* \in (0,1)$ *that satisfies* $\pi^* = p[\omega(\pi^*)]$*, which is given by:*

$$\pi^* = \frac{y - \sqrt{y^2 - 8a(\rho'' - \rho')(\rho + \rho'' - \rho')(\overline{\gamma} + a - \rho')}}{4(\rho'' - \rho')} \quad (5)$$

$$\textit{where } y = 2a\rho + \rho'(3\rho'/2 - 2\overline{\gamma} - 2a) + \rho''(\overline{\gamma} + 3a - \rho')$$

In comparison to statistical discrimination models, employers initial beliefs play no role in inducing a perverse gendered equilibrium, since equilibrium was shown to be unique. The model fits within that literature insofar employers perceptions of reality are taken into account, generating a feedback mechanism between wages and fertility rates. The gender wage gap is computed by substituting π^* into equation (3), and since π^* is strictly positive, skilled wages are set differently according to gender.

Childbearing decreases the time span at which women pay off their skill acquisition costs, and a lower rate of investment is expected even in the absence of discrimination. Motherhood and future productive work are rival in the sense that second period wages are only earned for women that choose not to have children. Since equilibrium fertility rate are strictly positive, the investment rate is further reduced because wages are lower for women. Indeed, for any given cost value $\widehat{c} \in (\omega, \rho + \rho'']$, where men find it profitable to become skilled, women's investment are not amortized by first period wages alone. For sufficiently high $\widehat{\gamma}$ (for example, $\widehat{\gamma} > \rho'$), motherhood is chosen, making it unprofitable for women within that cost range to acquire skills. The skill gap is defined as the difference between the skill rates of men and women,

[10]These two inequalities guarantee a nice behavior of the areas shown in Figure 2.

$$S_{GAP} = \frac{2a(\rho'' - \rho')\pi^* + \rho'(\overline{\gamma} + a - \rho'/2)}{2ak}, \tag{6}$$

and is increasing in π^*: the higher the fertility rate among skilled women, the lower their first period wage, which in turns decreases the benefits of skill acquisition among women, amplifying the gender skill gap.

In the same line of argument, mothers will tend to be unskilled, whereas childless women will be frequently observed in the skilled pool. This conjecture holds true and is stated in the following preposition, whose prove is contained in the appendix.

Proposition 2 *Skill and motherhood choices of women are negatively correlated.*

The interdependence between S and F is due to the joint nature of women's choice problem, since childbearing prevents women from earning the market returns of their skills. It is important to highlight that we have not assumed women are a disadvantaged group in terms of skill costs. In fact, the cost distribution looks alike for both men and women. Differences arise because women are biologically responsible for initial childrearing - and might specialize in those activities within the household in future - bearing alone its costs, in terms of future wages, and benefits.

4.1 Sensitivity Analysis

When fertility rate considerations are incorporated into employers belief about women's future productivity, there is a feedback mechanism between wages and fertility rates. On the one hand, wages respond to fertility rates because they reflect at present the benefits (surplus) from a continued firm-worker relationship, which is obtained only by the fraction of childless women. Fertility rates, on the other hand, respond to wages because lower lifetime returns to skill increases the incentives to motherhood. In equilibrium, there is a gender wage gap, which is increasing in the fertility rate of skilled women. Pre-market human capital investments (skill acquisition) also respond to the equilibrium rate and motherhood choices are expected to be higher among unskilled women.

The interdependence strength between wages and fertility rates, and the resulting skill and motherhood choices of women, depend both on the magnitudes of productivities ρ, ρ' and ρ'' and on the (c, γ) distribution. In this section, I analyze how sensitive equilibrium fertility rates are to those parametrizations and on what direction it responds to them. For example, while an increase in mean motherhood values $\overline{\gamma}$ is expected to increase the fraction of mothers, it is in principle unclear how the fraction of mothers in the skilled pool will behave, since skill investment incentives are also lower. Similarly, an increase in skill productivity ρ increases the incentives to skill acquisition, but might drag both moms-to-be and non-moms into the skilled job. The comparative statics analysis that follows will focus on these two parameters.

An increase in $\overline{\gamma}$ corresponds to a right shift in the distribution of motherhood values: it keeps the variance of the distribution constant, introducing higher-valuation women and dropping the lower-valuation ones. It can be shown (details in the appendix) that stronger motherhood preferences increase the fraction of mothers in the skilled pool. The intuition is that the fraction of non-mothers exiting the skilled pool (the lower valuation women) is larger than the fraction of mother entering the skilled pool, since mothers only become skilled at lower cost values ($c < \omega$) than non-mothers ($c < \omega + \rho'$). In net, the fraction of skilled women decreases, with a higher rate of skilled women in the female population. The conditional rate at which skilled women choose motherhood consequently increases, widening the gender wage gap.

The parameter ρ corresponds to the difference in the productivity of skilled and unskilled workers, and is referred to as the skill premium. Assuming that changes in the skill premium at present are also carried over to future periods, an increase in ρ shifts the entire stream of skilled labor returns ρ' and ρ''[11]. It increases the overall incentive to acquire skills, since costs can now be paid off at higher levels. But the fraction of women who choose to become skilled and have children changes for two reasons. First, a greater fraction of women now have motherhood valuation smaller than increased second period wage ρ'. Those women will still acquire skills but will no longer choose to have children. Second, higher first period wages brings moms-to-be into the skill pool, since these wages do not compete with the benefits accrued to motherhood in the second period. The net effect is shown to decrease equilibrium fertility rates π^*, and the gender wage gap is reduced. The formal details of this analysis are demonstrated in the appendix.

4.2 Examples

According to equation (5), equilibrium fertility rate π^* is uniquely determined as a function of the parameters ρ, ρ',ρ'',$\overline{\gamma}$ and a. The upper bound cost value k is important to determine the unskilled fraction of women, since it adds/subtracts high cost women not willing to acquire skills (from picture (2), only areas $(S, F) = (0, 0)$ and $(S, F) = (0, 1)$ are affected). This section computes equilibrium fertility rate, and the corresponding wage outcomes and pre-market fertility and skill choices of individuals, under different calibrations of these parameters.

The exercise in panel A holds ρ, ρ', ρ'', a and k fixed, and varies mean motherhood values $\overline{\gamma}$. The skill premium ρ is set to one, and all other parameters can be interpreted in relation to it. The general learning of a skilled worker is assumed to be 30% higher than ρ, whereas the firm specific learning enhances productivity by 50%. Mean skill costs are 1,5. The lifetime benefit of acquiring skills lies within the cost range, and some individual will choose to become skilled. The variance of motherhood values is

[11]More formally, in this analysis it is assumed that $\rho' = a\rho$ and $\rho'' = b\rho$, with $1 < a < b$.

fixed at 5,33. The first column shows that even when $\overline{\gamma} = 0$ - i.e., the average utility of motherhood is similar to men's benefits - wages are still lower for women. The simple existence of high valuation women guarantees that, among them, the ones with low cost will be able to pay for their skills with first period wages only. These are the women responsible for a positive equilibrium fertility rate among skilled women. In that case, women earn 3,41% lower wages then men, even being as productive (at present) as their male counterparts. In accordance with the results of the beginning of this section, women's skill investments are lower and skill and fertility choices are negatively correlated. The unconditional rate at which women have children, $\Pr(F = 1)$, can be seen as the fraction of women that choose motherhood over their lifetime (in contrast to the rate at which the population of women has child at present[12]). As mean motherhood valuation increases, π^* increases, and so does the wage gap. At $\overline{\gamma} = 3$, the gap in pay between men and women is 9,52%[13].

Panel B displays the results under different calibrations of the skill premium ρ. General and firm specific gains are held fixed as before, at 30 and 50 percent; mean motherhood value is 3 and its variance is again set to 5,33. The upper support of the cost distribution is at a higher value, $k = 7$, but is held constant throughout all examples of panel B. The first column of panel A mirrors the last column of panel B, except for k. Higher mean costs (and dispersion) do not affect the equilibrium fertility rate π^* (and the wage gap), but do affect skill and fertility decisions. In line with the comparative statics results of the previous section, and increase in the skill premium, which is carried over to future productivity, decreases π^* and the wage gap. In the

[12] The rate at which women have children at present can be roughly estimated at 2.81%, using the 2006 number of births from the U.S. Vital Statistics Records and the 2006 population estimate of women from the U.S. Census. However, the fraction of childless women between 15 to 44 years old is estimated to be 44.6% in 2004 according to the Census, which is a number closer in magnitude to the fertility rates displayed in the tables.

[13] As guideline, the adjusted gender pay gap was estimated to be 8.9% in 1998 [Blau and Kanh (2006)].

example of panel B, the wage gap of 9,52% is reduced to 5,67% as ρ increases from 1 to 2,5.

Table 1: Calibration Results

Panel A: An increase in mean motherhood values E(γ)

	0	1	2	3
Pr(F=1|S=1)	0.2043	0.3041	0.4238	0.5714
wage gap	0.0341	0.0507	0.0706	0.0952
% skilled men	0.8333	0.8333	0.8333	0.8333
% skilled women	0.6383	0.5774	0.5153	0.4513
Pr(F=1)	0.4020	0.5281	0.6544	0.7810
Corr(S,F)	-0.5356	-0.5244	-0.4998	-0.4596

Note: ρ=1; ρ'=1.3ρ; ρ''=1.5ρ; k=3; a=4

Panel B: An increase in the skill premium ρ, with ρ'=1.3; ρ''=1.5ρ

	ρ=1	ρ=1.5	ρ=2	ρ=2.5
Pr(F=1|S=1)	0.5714	0.4889	0.4122	0.3405
wage gap	0.0952	0.0815	0.0687	0.0567
% skilled men	0.3571	0.5357	0.7143	0.8929
% skilled women	0.1934	0.3050	0.4261	0.5566
Pr(F=1)	0.8347	0.7835	0.7109	0.6165
Corr(S,F)	-0.3471	-0.4738	-0.5677	-0.6360

Note: k=7; E(γ)=3, a=4

5 Discussion

5.1 Fertility Rates and the Gender Wage Gap

Birth rates have experienced substantial reductions worldwide. According to the United Nations[14], the number of children per women dropped from 4.49 in the early 70's to 2.65 in the 2000-2005 period. In the United States, the picture is very similar: the percentage of childless women increased from 35.1 in 1976 to 44.6 in 2004[15]. Existing

[14] "World Population Prospects: The 2004 Revision"

[15] Fertility of American Women, U.S. Census Bureaus, Historical Time Series Tables H1 and H2.

studies also document substantial variation in fertility rates across women of different characteristics. Rindfuss, Morgan and Offutt (1996) find that the age pattern of fertility has shifted toward older ages between 1973 and 1988: fertility rates have decreased for the 15-24 age group and increased for the 25-39 age group. Moreover, they show that although fertility has declined for all educational groups, it has dropped most sharply for women with college degree. In a similar fashion, Sullivan (2005) documents the emergence of a bimodal age pattern for first birth rates during the 1990's.

Fertility variation across time and through different identifiable groups of women (by age and education, for example) provide a valuable test to the model. If employers statistically discriminate on gender - and also on all other available characteristics of women - because childbearing decreases their productivity, wage gaps should be higher among the groups with highest fertility rates. This suggests, for instance, that the wage gap should be negligible for women beyond childbearing age and high at the peak fertility age group. Blau and Kahn (2006) documented that adjusted wage gaps[16] have experienced a markedly decrease after the 1980's, with relative stability in 1990's, following the similar time trend of fertility.

It is important to highlight, however, that the best one can hope for is a negative correlation between wage gaps and fertility rates, with no causal interpretation. As models of statistical discrimination make clear, there is a feedback mechanism between those two variables: motherhood choices increase when wages are low, and lower wages increase the fraction of women having children.

The model also predicts that fertility rates should display weaker (or even inexistent) correlation with wage gaps when there are smaller gains from an employment relationship, such as in low skill service jobs (cashiers, clerks, waiters, etc.) and occupations (office and administrative support). In jobs that involve firm specific learning,

[16] Adjusted wage gaps control for race education, experience, occupation, industry and collective bargain coverage.

such as managerial positions, or that require training, as in some sales and production occupations, wage gaps and fertility rates are predicted to be strongly negative correlated.

5.2 Childcare Technologies and the Household Division of Labor

Fertility intentions of women provide a proxy for the rate at which women become less productive in future, should they reduce the attention devoted to work after childbearing. As was argued before, there is a minimum female commitment necessary to reproduction, but ongoing childcare can be shared by both mothers and fathers.

Technological progress from the 1920's to 1950's, as documented by Albanesi and Olivetti (2007b), have enabled women to reconcile work and motherhood. Among them are the advances in medical procedures, reducing the time cost associated to women's reproductive role, and the introduction of baby formulas, reducing women's comparative advantage in childcare. Female labor force participation, in turn, has substantially risen, with remarkable changes since the 1950 cohort [Albanesi and Olivetti, 2007; Fernandez, 2007 and Bailey, 2006], and has shift towards continuous employments [Light and Ureta, 1990].

Insofar these technological developments have reduced women's time cost associated to childbearing, also allowing them to delegate childcare to other parties, expected fertility rates should have become a weaker proxy to the productivity threat. In relation to the model, we would expect a smaller productivity drop once women have become mothers, decreasing the surplus that is forgone after childbearing.

5.3 The Skill Gap

Goldin, Katz and Kuziemko (2006) provide an excellent survey of the evolution of the college gap - differences in enrollment and graduation rates between men and women - since 1870. The authors document that women's relative numbers in college have increased continuously since 1950, narrowing the gender skill gap, until 1980, when there was a reversal in the gap, with women overcoming the fraction of male college graduates.

While women's expectations of future work have played an important role into shaping women's attitudes towards educational attainment [Goldin and Katz, 2002; Bailey, 2006; Goldin, Katz and Kuziemko, 2006], employers' reduced discrimination, brought about changes in the fertility behavior of women, might also have provided additional incentives for skill investments. The model presented here, however, cannot account for the reversal of the college gender gap, and as Goldin, Katz and Kuziemko (2006) argue, some other source of gender difference should be called for.

Two explanations are considered in their paper: a relatively greater economic benefit of college for females and a relatively higher effort costs of college going and preparation for males. Both of these suggestion can be accommodated in the model by either having labor productivities ρ, ρ' and ρ'' or cost to skill acquisition c differ by gender. Gender differences in costs can readily account for the skill gap reversal phenomena, while still maintaining the gender wage gap prediction, whereas gender differences in productivities might also reverse the gender wage gap prediction.

5.4 Trends in the Skill Premium

According to the skill-biased technological change (SBTC) hypothesis, the introduction of micro-computers in the early 1980's has increased the demand for highly skilled workers, which are more likely to use computers on the job than unskilled workers, increasing their relative earning [Card and DiNardo, 2002]. If computer usage is skill related, and skilled men and women equally benefit from the introduction of these new technologies, we can interpret the SBTC hypothesis as an increase in the skill premium ρ (with possible spill over effects to future productivities ρ' and ρ''). Exogenous shifts to the skill premium were shown to reduce the equilibrium fertility rates π^* and diminish the gender wage gap, since it amplifies the benefits to skill investment and work relative to motherhood. Therefore, the SBTC hypothesis would also go in line with the empirical evidence on gender wage gaps, where higher skill premiums would be followed by lower wage gaps. Although we are not able to pin-down the relative importance of the skill premium and fertility rates on the wage gap, this paper suggest that both factors might be important in understanding its evolution in time.

6 Conclusion

Over the last century, women have attained higher levels of education, increased labor force participation and are now present in jobs that where traditionally occupied by men. The wage gap, in turn, has been falling over time, but women still earn lower wages than men. Changes in women's attitudes alone cannot explain the persistence of gender differences in labor market earnings.

This paper provides an explanation for gender discrimination in the labor market, which can address the gender wage gap evidence. In contrast to previous statistical discrimination justifications, skills provide a clear measure of a workers productivity and can be verified by employers. Fertility intentions, however, cannot be observed and affect women's productivity in future since mothers allocate attention toward childbearing activities. Women are responsible for initial childcare, such as visits to doctors while pregnant and the baby delivery itself, which cannot be delegated. They might end up carrying other activities (nurture and day care, for example) should they develop comparative advantages in childcare within the household. To that extend, aggregate fertility rate expectations provide a proxy to employers about the fraction of women that will become less productive in future because of childbearing.

In the case where there are gains to a continued employment relationship, and the surplus is shared and anticipated to current wages, women earn lower wages than men because their future expected productivity is lower. Fertility rates provide the relevant discount factor, and women's wages are decreasing in expected future fertility rate.

The model predicts that wage gaps and fertility rates across different groups of women should be negatively correlated, which still grants empirical investigation, but is an encouraging direction given the sharp decline in fertility rates across time and its variance across women of different characteristics, such as by age and education. Technological progress in childcare technologies, which allow women to reconcile motherhood and work, should mitigate the penalty fertility rates impose on women's wages., and the correlation between wage gaps and fertility rates is predicted to be stronger before these technologies were introduced. A further test to this model should examine the relation between wage gaps and fertility across jobs and occupations. Fertility rates are not expected to address gender wage gaps when there are no productivity gains from a continued (and productive) employment relationship.

Reductions in fertility rates can also account for the narrowing of gender skill gaps, which were observed since the 1950's. Lower fertility intentions increase the incentives for human capital accumulation, since women expect to remain productively working for longer periods, but also reduces the penalty that is imposed on their wages, through the employer discrimination channel, amplifying furthermore the incentives to acquire skills. As within the bulk of the literature, the model cannot account for the recent reversal of the gender skill gap, in which women have become the majority of college graduates, unless ex ante gender differences are assumed, such as differences in educational effort or in returns to education.

7 Appendix

Proof of Preposition 1: The uniform and independence assumptions allow simple calculation of the $(S, F) = (1, 0)$ and $(S, F) = (1, 1)$ areas as in Figure 2. A close form solution for $p(\omega)$ is given by

$$p(\omega) = \frac{\omega(\overline{\gamma} + a - \rho')}{2a\omega + \rho'(\rho'/2 - \overline{\gamma} + a)}.$$

Substituting $\omega = \rho + (\rho'' - \rho')(1 - \pi)$ into the previous equation, we obtain

$$p(\omega(\pi)) = \frac{(\rho + \rho'' - \rho')(\overline{\gamma} + a - \rho') - (\rho'' - \rho')(\overline{\gamma} + a - \rho')\pi}{2a(\rho + \rho'' - \rho') + \rho'(\rho'/2 - \overline{\gamma} + a) - 2a(\rho'' - \rho')\pi},$$

which is a continuously differentiable function of π, $\forall \pi \in \Re$ but $\widetilde{\pi} > 1$, where

$$\widetilde{\pi} = \frac{2a(\rho + \rho'' - \rho') + \rho'(\rho'/2 - \overline{\gamma} + a)}{2a(\rho'' - \rho')}.$$

Moreover, $p(\omega(\pi))$ is strictly decreasing over $[0, 1]$ with $p(\omega(0))$ and $p(\omega(1)) \in (0, 1)$, since:

$$p(\omega(0)) = \frac{(\rho + \rho'' - \rho')(\overline{\gamma} + a - \rho')}{2a(\rho + \rho'' - \rho') + \rho'(\rho'/2 - \overline{\gamma} + a)} \quad (7)$$

$$p(\omega(1)) = \frac{\rho(\overline{\gamma} + a - \rho')}{2a\rho + \rho'(\rho'/2 - \overline{\gamma} + a)} \quad (8)$$

$$sign\left\{\frac{\partial p(\omega(\pi))}{\partial \pi}\right\} = sign\left\{-(\rho'' - \rho')(\overline{\gamma} + a - \rho')\rho'(\rho'/2 - \overline{\gamma} + a)\right\} < 0$$

By the intermediate value theorem, there exists $\pi^* \in (0, 1)$ such that $\pi^* = p(\omega(\pi^*))$. It is unique because $p(\omega(\pi))$ is monotonic over $(0, 1)$. The function $p(\omega(\pi))$ intersects the 45^o line at two points, the roots of the quadratic equation $\pi = p(\omega(\pi))$. The smallest root corresponds to $\pi^* \in (0,1)$.

Proof of Proposition 2:

$$\begin{aligned} Corr(S,F) &= \frac{\Pr(S=1,F=1)-\Pr(S=1)\Pr(F=1)}{\sqrt{Var(S)}\sqrt{Var(F)}} \\ &= \frac{\Pr(S=1)[\Pr(F=1|S=1)-\Pr(F=1)]}{\sqrt{Var(S)}\sqrt{Var(F)}} \end{aligned}$$

Since $\Pr(S=1)$, $Var(S)$ and $Var(F)$ are strictly positive, it's sufficient to show $[\Pr(F=1|S=1)-\Pr(F=1)]<0$. Define δ as

$$\delta = \frac{\overline{\gamma}+a-\rho'}{2a}.$$

It is possible to compare $\Pr(F=1|S=1)$ and $\Pr(F=1)$relative to δ as:

$$\begin{aligned} \Pr(F &= 1|S=1) = \frac{\omega(\overline{\gamma}+a-\rho')}{\omega(2a)+\rho'(\rho'/2--\overline{\gamma}+a)} < \frac{\omega(\overline{\gamma}+a-\rho')}{\omega(2a)} = \delta \\ \Pr(F &= 1) = \frac{k(\overline{\gamma}+a-\rho')+\rho'(k-\omega)-(\rho')^2/2}{k(2a)} > \frac{k(\overline{\gamma}+a-\rho')}{k(2a)} = \delta \end{aligned}$$

which guarantees that $[\Pr(F=1|S=1)-\Pr(F=1)]<0$.

The increase in mean motherhood values $\overline{\gamma}$: By equation (7) and (8), a higher $\overline{\gamma}$ increases the values of $p(\omega(0))$ and $p(\omega(1))$, shifting the $p(\omega(\pi))$ curve outward. The intersection with the 45^o degree line happens further away and the new equilibrium fertility rate π^* is higher.

The increase in the skill premium ρ: Assuming $\rho' = \alpha\rho$ and $\rho'' = \beta\rho$, with $1<\alpha<\beta$, we can re-write $p(\omega(0))$ and $p(\omega(1))$ as:

$$\begin{aligned}
p(\omega(0)) &= \frac{(1+\beta-\alpha)(\overline{\gamma}+a-\alpha\rho)}{2a(1+\beta-\alpha)+\alpha(\alpha\rho/2-\overline{\gamma}+a)} \\
p(\omega(1)) &= \frac{(\overline{\gamma}+a-\alpha\rho)}{2a+\alpha(\alpha\rho/2-\overline{\gamma}+a)}
\end{aligned}$$

Taking derivatives with respect to ρ:

$$\begin{aligned}
sign\left\{\frac{\partial p(\omega(0))}{\partial \rho}\right\} &= sign\left\{-\alpha(1+\beta-\alpha)[2a(1+\beta-\alpha)+\frac{\alpha}{2}(3a-\overline{\gamma})]\right\} < 0 \\
sign\left\{\frac{\partial p(\omega(1))}{\partial \rho}\right\} &= sign\left\{-\alpha[2a+\frac{\alpha}{2}(3a-\overline{\gamma})]\right\} < 0
\end{aligned}$$

The $p(\omega(\pi))$ curve shift inward and new equilibrium fertility rate π^* is lower.

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