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ABSTRACT

Home Production, Market Production and the Gender Wage Gap: Incentives and Expectations*

This paper explores the hypothesis that gender wage differentials arise from the interaction between the intra-household allocation of labour and the contractual relation between firms and workers in the presence of private information on workers' labour market attachment. In our model, if firms believe women to be less attached to market work than men, they will offer them labour contracts with lower earnings and lower hours even in the absence of gender differences in productivity. This implies that it is efficient for wives to allocate more time to home production. Hence, women will be less attached to market work and firms' expectations are confirmed. If firms instead believe that labour market attachment is the same across genders, they will offer the same labour contracts to male and female workers. Then, the efficient intra-household allocation of labour will not be related to gender. It is statistical discrimination that determines gender differentials in the first type of equilibrium. Given that firms may use gender as a screening device, discrimination actually reduces the incentive problem for firms, eliminating adverse selection. Additionally, our model predicts that, in equilibria with female discrimination, gender earning gaps should be higher in industries/occupations in which the incentive problem is more severe. We use Census data for the year 2000 to show that this is the case.

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1 Introduction

The purpose of this paper is to study the emergence and persistence of gender differences in wages and in the division of labor within the household. We explore the hypothesis that gender wage differentials arise from the interaction between the intra-household allocation of labor and the contractual relation between firms and workers in the presence of private information on workers' labor market attachment.[1]

Our model bridges three literatures: the literature on the sexual division of labor in the Beckerian tradition; the one on statistical discrimination, as in Coate and Loury (1993) and Lundberg and Starz (1983); and finally the literature on labor contracts, as in Gibbons and Waldman (1999). As argued by Becker (1985), what distinguishes gender and racial discrimination is that the feedback on the optimal intra-household division of labor generates a larger impact on earnings. The centerpiece of our model is to identify the source of statistical discrimination with the incentive problem in the interaction between firms and workers, given that labor market attachment, which is inversely related to hours devoted to home production, is private information. Our empirical analysis is motivated by our theoretical findings. We use data on earnings to test the prediction that gender differences in pay across sectors and occupations reflects the severity of incentive problems.

Our theoretical analysis is based on a model in which the intra-household allocation is efficient.[2] In particular, households are assumed to optimally choose the contribution of each spouse to home production. Workers with high home hours are less attached to market work. Individual home hours and effort applied to market work are private information. Firms face both adverse selection and moral hazard in contracting with workers. They offer incentive compatible labor contracts that are constrained-efficient, and imply earnings that are positively related to labor force attachment. If firms believe women to be less attached to market work than men, they will offer women labor contracts with lower earnings and lower hours even in the absence of gender differences in productivity. This implies that it is efficient for wives to allocate more time to home production. Hence, women will be less attached to market work and firms' expectations will be confirmed. If firms believe that labor market attachment is the same across genders, they will offer the same labor contracts to male and female workers. As a consequence, spouses will face the same earning opportunities, and the efficient intra-household allocation of labor will not be related to gender. Hence, our model predicts a negative correlation between relative home hours of husbands and wives and their relative earnings, as would be the case for other efficient models of intra-household allocation. We use the PSID to show that indeed this is true in the data.

Absent ex-ante differences in productivity for male and female workers, there are two types

[1] There is a vast empirical literature that studies the gender wage gap and its evolution over time. Altonji and Blank (1999) provide an extensive review of this literature for the post-war period. Goldin (1990) presents an extensive historical analysis for the United States.

[2] We model the households according to Chiappori's (1988, 1997) "collective labor supply" model. This paradigm does not focus on a particular model of spousal interaction, rather it merely restricts household decisions to be Pareto efficient. This framework is consistent with a variety of "household bargaining" models, as in McElroy and Horney (1981) and Manser and Brown (1980).

of equilibria. One in which there is a systematic gender differential in earnings, accompanied by a gendered intra-household division of labor; and one in which earnings and home hours are not systematically related to gender. It is statistical discrimination that determines gender differentials in the first type of equilibria. Given that firms use gender as a screening device in this type of equilibrium, discrimination actually reduces the incentive problem for firms, eliminating adverse selection.[3] This property of the model implies that equilibria with gender discrimination will be hard to break, which is consistent with the persistence of the gender earnings gap and the intra-household division of labor observed in the data.[4]

Our model highlights the importance of incentives and differences in the pay structure in determining gender differences in earnings. This prediction resonates with current debates on gender discrimination in personnel policy. For example, in June 2004 a federal judge ruled in favor of class-action status for the Dukes vs Wal-Mart gender discrimination lawsuit. The ruling was based on extensive evidence presented by the plaintiffs, Drogin (2003), showing that women working at Wal-Mart stores face pay disparities in most job categories, and take longer to enter management positions.[5] Finally, it is also interesting to note how expectations of a gender wage gap characterize both male and female workers. As documented by Babcock and Laschever (2003): "Women report salary expectations between 3 and 32 percent lower than those of men for the same jobs; men expect to earn 13 percent more than women during their first year of full-time work and 32 percent more at their career peaks."

Our model predicts that, in an equilibrium with female discrimination, gender earning gaps should be higher in industries/occupations in which the incentive problem is more severe. This is consistent with the historical developments documented by Goldin (1986, 1990) and with present day Census evidence. Goldin discusses how with the expansion of the clerical sector "even though many women would eventually be in the labor force for an extensive duration, firms often used sex as a signal of shorter expected job tenure. ... By segregating workers by sex into job ladders (and some dead-end positions), firms may have been better able to use the effort-inducing and ability-revealing mechanisms of the wage structure." We use Census data for year 2000 to show that gender differentials in earnings are greatest in high management and sales occupations. We argue that incentive problems are most stringent in these occupations. High level managers have a wide range of responsibilities, hence the uncertainty associated with their performance, given their effort should be greater. Similarly, sales volumes depend to a large degree on variables that are not directly related to sales personnel's effort. These considerations are less important for production workers and low level managers.

[3] If we allow for higher relative productivity of women in home production, female workers will necessarily be less attached to market work. The interaction between optimal intra-household allocations and the incentive problem in the contracting relationship between firms and workers exacerbates the gender differential in earnings that stems from differences in productivities.

[4] O'Neill (2003) shows that there is still a 10% differential in female and male wages in the U.S. in 2000 that remains unexplained by gender differences in schooling, actual experience and job characteristics. Moreover, PSID data for the period 1976-1993 show that husbands' home hours are roughly one third of wives' and that this difference is very stable over time.

[5] Discrimination lawsuits based on analogous complaints where filed by a team of women brokers at Merrill Lynch and by women researchers working at Rand corporation during the summer of 2004. See The New York Times, August 22, 2004 and The New York Times, September 5, 2004, respectively.

Our paper is organized as follows. Section 2 presents the model and discusses the results of numerical simulations. Section 3 reports evidence supporting the model's predictions. Finally, Section 4 concludes.

2 The Model

The economy is populated by a continuum of agents, ex ante identical except for gender. The population is equally divided by gender, all agents are married and belong to a household. Households are made up of two agents of different gender. Individual utility is defined over market consumption, leisure and consumption of a public home good, which is household specific. The public home good is produced using time of each spouse and the market good. The economy is also populated by a continuum of identical firms. Firms hire workers to produce consumption goods. In this section, we describe the household problem, the firms' problem and present our definition of equilibrium for this economy.

2.1 Households

Each individual has a utility function:

$$U\left(c_i, h_i, n_i, e_i\right) + \theta \log\left(G\right), \tag{1}$$

where c_i is individual consumption of the market good, h_i denotes home hours and n_i denotes market hours, and e_i denotes effort applied to market work for $i = f, m$, with f denoting females and m males. We adopt the following CARA specification:

$$U\left(c, h, n, e\right) = -\exp\left(-\sigma\left[c - v\left(h, n, e\right)\right]\right),$$

where the coefficient of relative risk aversion σ is strictly greater than 0 and $v\left(\cdot\right)$ denotes the cost of market and home work. We assume assume that v is increasing in all its arguments, twice continuously differentiable and that:

$$v_{hn} > 0, v_{he} > 0. \tag{2}$$

Hence, the marginal cost of market hours and effort is increasing in home hours[6], and the marginal cost of effort is decreasing in market hours.

The production function for the home public good is $G = g\left(h_f, h_m, k\right)$, where k is the amount of market good used in home production. We assume that g is increasing in each argument and concave, and restrict attention to specifications in which h_f and h_m are substitutes in the production of the public home good.

Each household is endowed with initial wealth. As in Chiappori (1988, 1997), households decide on consumption of the home public good, on the optimal production of the home good, and on how to share household wealth. Each spouse chooses market hours, effort and private consumption. All decisions occur simultaneously.[7]

[6] For a discussion of this, see Becker (1985).

[7] This way of modelling the household is consistent with a broad class of efficient bargaining models. See Bergstrom (1997) for a review.

Households and individuals take as given the price of the market good and the labor contracts offered by firms, $\mathcal{C}$. Here, $\mathcal{C}$ is a mapping that specifies earnings w, hours n, and effort e, as a function of gender and home hours: $\mathcal{C} = \{w_i, n_i, e_i\}(h)$ for $i = f, m$ where w_i denotes total earnings. We will describe the derivation of this mapping in sections 2.2 and 2.3. We represent the solution of the spouses' individual choice problem as a value function $V_i(s_i, h_i; \mathcal{C})$.[8] Then, the households' problem is to choose G, k h_i and s_i to maximize:

$$\sum_i \lambda_i V_i(s_i, h_i; \mathcal{C}) + \theta \log(G), \tag{H}$$

subject to (3) and $\sum_i s_i + k = a + \Pi$. Here, a is household wealth, s_i is the share of household wealth distributed to each spouse, Π denotes dividend income, and λ_i, for $i = f, m$, represents the weight of each spouse in household decisions.

2.1.1 Solution to the Household Problem

The household choice of G, k and h_f, h_m can further be simplified by first analyzing the intra-household allocation of home hours for a given k and G. This amounts to a cost minimization problem and is independent of the weights λ_i. The opportunity cost of home hours for a spouse is her labor earning potential, which depends on labor contracts. The substitutability of spousal hours in the production of the public home good implies that marginal differences in market earnings will give rise to an asymmetric intra-household allocation of home hours, with the spouse with lower earning potential in market work devoting more time to home production. It is important to note that we interpret the intra-household allocation of home hours as a long term arrangement of the spouses, that may be costly to reverse in the short run. This is consistent with an interpretation of our model as a description of a long-run spousal role allocation within the household.

We adopt the following functional form for g:

$$\begin{aligned} g(h_f, h_m, k) &= (h_f + h_m)^{\delta} k^{1-\delta} \text{ for } h_f, h_m > 0 \text{ and } \max\{h_f, h_m\} / \min\{h_f, h_m\} \leq \xi, \\ &\quad 0 \text{ otherwise,} \end{aligned} \tag{3}$$

with $\delta \in [0, 1]$ and $\xi > 1$. This specification captures the externality associated with each spouse's home hours, given the public nature of the home good. At the same time, it imposes that production of the home good be joint, in the sense that both spouses need to provide a minimum contribution[9].

The technology for home production implies that the optimal allocation of home hours

[8] The household model does not contemplate a participation decision by workers. This is consistent with the fact that a participation constraint is imposed on the firm problem. The household model can be easily extended to allow for a participation decision.

[9] This specification for g is a special case of a CES. We adopt it for analytical simplicity. However, any functional form for g that allows for some degree of substitutability in spousal home hours would deliver similar predictions.

does not depend on the weights λ_i and is given by:

$$\begin{cases} h_f = \xi h_m \text{ if } w_f(h) < w_m(h), \\ h_m = \xi h_f \text{ if } w_f(h) > w_m(h) \\ prob\,(h_f = \xi h_m) = 0.5 \text{ if } w_f(h) = w_m(h). \end{cases} \tag{4}$$

When $w_f(h) = w_m(h)$, households are indifferent over the allocation of home hours across spouses. We assume that they randomize. By substituting (3) and (4) into the objective function, the household optimization problem amounts to the choice of h_f, k , and s_i subject to the household budget constraint. The solution to this problem gives rise to the policy functions: $s_i(a, \mathcal{C})$, $h_i(a, \mathcal{C})$, $k(a, \mathcal{C})$ and $G(a, \mathcal{C})$.

We assume that θ is the same for all households. Then, in any equilibrium, there will be two values of home hours in the population, $\{h_L, h_H\}$ with $h_H = \xi h_L$. Workers with high home hours face a higher marginal cost of market work than workers with low home hours. Given this, we interpret workers with high home hours as having *low labor market attachment*.

2.2 Firms and Labor Contracts

Each firm hires one worker. Output is related to hours and effort exerted by the worker, according to:

$$y = f(n, e) + \omega,$$

Here, the function $f(n, e)$ denotes expected output, where f is strictly increasing in both hours, n, and effort, e, twice continuously differentiable and weakly concave. We assume $f_{ne} \geq 0$, so that hours and effort are substitutes in production, and we restrict $e \in \{0, 1\}$. The random variable ω is distributed normally with zero mean and variance $\Sigma > 0$.

Labor contracts, $\{w, n, e\}(h)$, are constrained-efficient. Hours, effort and earnings are chosen to maximize the surplus from the employment relationship subject to feasibility and participation constraint and incentive compatibility constraints. We impose free entry in the firm sector, which requires firm profits to be equal to zero and pins down the level of labor earnings. The properties of labor contracts depend on the informational assumptions. *We assume that workers' effort and home hours are not observed by firms, while output and market hours are observable.* Hence, firms face both moral hazard and adverse selection when contracting with workers[10]. To elucidate the role of these incentive problems in the determination of earnings, we first derive the properties of constrained-efficient labor contracts when there is no private information and when only home hours are observable.

If home hours and effort are observable, firms choose n and e for an individual with home hours equal to h to solve:

$$\max_{n \in N(h), e \in \{0,1\}} f(n, e) - v(h, n, e). \qquad \text{(Problem 1)}$$

[10] The CARA preference specification implies that home hours is the only intrinsically relevant worker characteristics for firms.

Here, $N(h)$ is the set of feasible values of n, which may depend on h. The first order conditions for n is:

$$f_n(n,e) - v_n(h,n,e) = 0,$$

which implies that n is decreasing in h for given e, by (2). Optimality also implies that $e = 1$ only if:

$$\frac{f_e(n,1)}{f_n(n,1)} \geq \frac{v_e(h,n,1)}{v_n(h,n,1)}. \tag{5}$$

Condition (5) states that the marginal rate of substitution between hours and effort in production is greater then their marginal rate of substitution in the workers' utility. We assume that it is satisfied for all values of n and h at $\bar{e}$, so that the highest effort level will be implemented for all agents absent private information.

If firms observe home hours but effort is not observable, firms face a moral hazard problem. The constrained-efficient labor contract will be of the form $\{w(y), n, e\}(h)$, where the dependence of earnings on output, y, may allow to implement a positive level of effort[11]. The need to provide incentives by making earnings depend on output, y, implies that earnings are stochastic. This introduces an inefficiency and reduces the surplus from the employment relationship, given that workers are risk averse. Under CARA utility, without loss of generality, we restrict attention to earnings functions of the form: $w(y) = \bar{w} + \tilde{w}y$. We refer to $\bar{w}$ and $\tilde{w}y$ as the salary and the incentive component of earnings, respectively.

The constrained-efficient labor contract for an individual with home hours h solves the problem:

$$\max_{\bar{w},\tilde{w},n\in N(h),e\in\{0,1\}} f(n,e) - v(h,n,e) - \sigma\Sigma(\tilde{w})^2/2 \tag{Problem 2}$$

subject to

$$E\left[\frac{u(n,1)}{u(n,0)}\right] \geq 1. \tag{6}$$

Here, $f(n,e) - v(h+n,e) - \sigma\Sigma(\tilde{w})^2/2$ is the surplus from the employment relationship, (6) is the incentive compatibility constraint and all expectations are taken with respect to the random variable ω.

Given the CARA assumption on preferences, we can write:

$$E\left[\frac{u(n,1)}{u(n,0)}\right] = -\exp\left\{-\sigma\left[\tilde{w}\left[f(n,1) - f(n,0)\right] - v(h,n,1) + v(h+n,0)\right]\right\}.$$

Then, the incentive compatibility constraint simplifies to:

$$\tilde{w}\left[f(n,e) - f(n,0)\right] - v(h,n,e) + v(h,n,0) \geq 0. \tag{7}$$

We first consider the case in which $e = 1$ is implemented. The first order necessary conditions are:

[11] This can be interpreted as a multi-task moral hazard problem, as in Holmstrom and Milgrom (1991). The fact that hours are observable corresponds to there being a perfectly informative signal on hours.

$$0 = f_n(n,1) - v_n(h,n,1) + \mu\{\tilde{w}[f_n(n,1) - f_n(n,0)] - v_n(h,n,1) + v_n(h,n,0)\}, \quad (8)$$

$$\mu[f(n,1) - f(n,0)] - \sigma\Sigma\tilde{w} \leq 0, \quad (9)$$

with equality at $\tilde{w} > 0$,

$$[\tilde{w}[f(n,1) - f(n,0)] - v(h,n,1) + v(h,n,0)]\mu = 0, \ \mu \geq 0,$$

μ is the multiplier on (7).

Condition (8) implies that the optimal value of n is decreasing in h for given e, from (2). Implementing $e = 1$ requires $\tilde{w} > 0$[12]. Since $\Sigma\sigma > 0$, the incentive compatibility constraint will be binding from (9), and:

$$\tilde{w} = \frac{v(h,n,1) - v(h,n,0)}{f(n,1) - f(n,0)} > 0. \quad (10)$$

The zero profit condition implies that:

$$\bar{w} = f(n,e) - \tilde{w}f(n,e). \quad (11)$$

Then, the fraction of earnings accounted for by incentive pay is equal to $\tilde{w}$.

Total earnings are decreasing in home hours, since the surplus from the employment relation is also decreasing in home hours. The remaining properties of the earnings function in the optimal contract when high effort is implemented depend on the production function and on the utility cost of working. We summarize them in the following proposition[13].

Proposition 1 *If the optimal contract implements $e = 1$, then:*
i) if $f_{ne} \geq 0$ and $v_{ne} \leq 0$, $\tilde{w}$ is increasing in h.
ii) if $f_{ne} < 0$ and $v_{ne} > 0$, $\tilde{w}$ could be increasing or decreasing in h.
iii) for $h_L < h_H$, $\tilde{w}_L f(n_L,1) > \tilde{w}_H f(n_H,1)$ if $h_H - h_L$ is sufficiently large.

If low effort is implemented, the incentive compatibility constraint will not be binding and the resulting value of n will be same as with full information for the case in which $e = 0$.

The gains from implementing high effort depend on the production technology. The choice of the effort to be implemented in Problem 2 depends on the utility cost of implementing high effort for given h. The multiplier on the incentive compatibility constraint, μ, can be interpreted as a measure of the cost of implementing high effort and as an indicator for the severity of the incentive problem:

$$\mu = \frac{\sigma\Sigma\tilde{w}}{f(n,1) - f(n,0)}. \quad (12)$$

[12] If n and e are perfect substitutes for the worker, the firm cannot influence and agent's choice of e. We exclude this case.

[13] These predictions would arise from a large class of models with hidden effort, and they are not specific to this example.

If incentive pay, $\tilde{w}$, is increasing in h, the multiplier μ will be higher for workers with high home hours, which corresponds to a more severe incentive problem for these workers. As shown in Proposition 1, the relation between $\tilde{w}$ and h depends on the degree of substitutability between n and e both in the production function and in the cost of working.

The multiplier also rises with Σ, the variance of output given effort and market hours, and with the coefficient of risk aversion, σ. A higher value of Σ implies that output is a less informative signal of workers' effort. This increases the severity of the incentive problem, especially when $\tilde{w}$ is high. Similarly, the cost of implementing high effort is increasing in the workers' risk aversion.

If both home hours and effort are unobserved, firms face both adverse selection and moral hazard[14]. This introduces additional constraints on optimal contracts, stemming from the incentive compatibility condition on home hours. We refer to these as the adverse selection incentive compatibility constraints. As in the case where home hours are observed, firms will post two contracts, designed respectively for workers with low and high home hours. The adverse selection incentive compatibility constraint implies that workers will self-select the contract appropriate to their level of home hours. However, a binding adverse selection incentive compatibility constraint for one type of worker exacerbates the incentive problem associated with hidden effort. This reduces the surplus generated from the employment relation and influences the level of effort that can be implemented for both types of workers, as well as the level of hours and earnings specified by the optimal contract.

The pattern of binding adverse selection incentive compatibility constraints depends on the properties of the functions f and v. If $f_{ne} \geq 0$ and $v_{ne} \leq 0$, $\tilde{w}$ is increasing in h for h observable. We also assume that $f(n,1) - \sigma\Sigma > 0$ for all $n \in N(h_j)$, $j = L, H$, which ensures that a worker's utility is increasing in $\tilde{w}$. Under these conditions, the adverse selection incentive compatibility constraint for workers with high home hours will not be binding. We focus on this case here.

If π_j is the fraction of workers with home hours equal to h_j for $j = L, H$, constrained-efficient contracts solve the problem[15]:

$$\max_{\{T_j, n_j \in N(h_j), e_j \in \{0,1\}\}_{j=L,H}} \sum_{j=L,H} \pi_j \left[f(n_j, e_j) - \sigma\Sigma \frac{(\tilde{w}_j)^2}{2} - T_j - v(h_j, n_j, e_j) \right] \quad \text{(Problem 3)}$$

s.t.

$$\tilde{w}_j \left[f(n_j, 1) - f(n_j, 0) \right] - v(h_j, n_j, 1) + v(h_j, n_j, 0) \geq 0, \text{ for } j = L, H, \tag{13}$$

$$T_L + \tilde{w}_L f(n_L, e_L) - \sigma\Sigma \frac{(\tilde{w}_L)^2}{2} - v(h_L, n_L, e_L) \geq -\sigma\Sigma \frac{(\tilde{w}_H)^2}{2} + \max_{e=0,1} \left\{ \tilde{w}_H f(n_H, e) - v(h_L, n_H, e) \right\}. \tag{14}$$

The variable T_j denotes the informational rent for a type j worker, which stems from adverse selection and also reduces the surplus from the employment relationship. For this problem,

[14] MacLeod and Malcomson (1988) study a dynamic model of labor contracts with moral hazard and adverse selection.

[15] A version of the Revelation Principle holds for this problem, as shown in Laffont and Martimort (2002).

$T_L = \bar{w}_L - \bar{w}_H$ and $T_H = 0$ by construction. The variable $\bar{w}_H$ will be pinned down by the zero profit condition.

The moral hazard incentive compatibility constraints (13) are the same as in Problem 2. The adverse selection incentive compatibility constraint, (14), is simplified from:

$$E\left[\frac{u_L\left(n_L, e_L\right)}{\max_{e=\{0,1\}} u_L\left(n_H, e\right)}\right] \geq 1,$$

where $u_j\left(n_k, e_k\right) = -\exp\left\{-\sigma\left[\tilde{w}_k f\left(n_k, e_k\right) - v\left(h_j, n_k, e_k\right)\right]\right\}$ for $j, k = H, L$ using the CARA preference specification. The formulation of this constraint reflects the fact that a worker with low home hours may not find it optimal to choose the same level of effort as a worker with high home hours when offered the same contract.

The first order necessary conditions for this problem are:

$$\begin{aligned} 0 &= \pi_L\left(f_{n,L} - v_n\left(h_L, n_L, e_L\right)\right) \\ &\quad +\mu_L\left\{\tilde{w}_L\left(f_n\left(n_L, 1\right) - f_n\left(n_L, 0\right)\right) + v_n\left(h_L, n_L, 0\right) - v_n\left(h_L, n_L, 1\right)\right\} \\ &\quad +\phi_L\left\{\left[\tilde{w}_L f_{n,L} - v_n\left(h_L, n_L, e_L\right)\right]\right\}, \end{aligned} \tag{15}$$

$$\begin{aligned} 0 &\leq \pi_L\left(f_{e,L} - v_e\left(h_L, n_L, e_L\right)\right) + \mu_L\left\{\left[\tilde{w}_L f_e\left(n_L, 1\right) - v_e\left(h_L, n_L, 1\right)\right]\right\} \\ &\quad +\phi_L\left\{\left[\tilde{w}_L f_e\left(n_L, e_L\right) - v_e\left(h_L, n_L, e_L\right)\right]\right\}, \end{aligned} \tag{16}$$

at $e_L = 1$,

$$\begin{aligned} 0 &= \pi_H\left(f_{n,H} - v_n\left(h_H, n_H, e_H\right)\right) \\ &\quad +\mu_H\left\{\tilde{w}_H\left(f_n\left(n_H, 1\right) - f_n\left(n_H, 0\right)\right) + v_n\left(h_H, n_H, 0\right) - v_n\left(h_H, n_H, 1\right)\right\} \\ &\quad -\phi_L\left\{\left[\tilde{w}_H f_{n,H} - v_n\left(h_L, n_H, e_H\right)\right]\right\}, \end{aligned} \tag{17}$$

$$\begin{aligned} 0 &\leq \pi_H\left(f_{e,H} - v_e\left(h_H, n_H, e_H\right)\right) + \mu_H\left\{\left[\tilde{w}_H f_e\left(n_H, 1\right) - v_e\left(h_H, n_H, 1\right)\right]\right\} \\ &\quad -\phi_L\left\{\left[\tilde{w}_H f_e\left(n_H, e_H\right) - v_e\left(h_L, n_H, e_H\right)\right]\right\}, \end{aligned} \tag{18}$$

at $e_H = 1$,

$$-\pi_L + \phi_L \leq 0, \tag{19}$$

with equality at $\bar{w}_L > 0$,

$$0 \geq \mu_L\left[f\left(n_L, 1\right) - f\left(n_L, 0\right)\right] - \pi_L \sigma \Sigma \tilde{w}_L - \phi_L\left(-f\left(n_L, e_L\right) + \sigma \Sigma \tilde{w}_L\right), \tag{20}$$

with equality at $\tilde{w}_L > 0$,

$$0 \geq \mu_H\left[f\left(n_H, 1\right) - f\left(n_H, 0\right)\right] - \pi_H \sigma \Sigma \tilde{w}_H + \phi_L\left(-f\left(n_H, e_H\right) + \sigma \Sigma \tilde{w}_H\right), \tag{21}$$

with equality at $\tilde{w}_H > 0$, where μ_j and ϕ_j are the multipliers on the effort and screening incentive compatibility constraints.

Note that (20) and (21), $f(n_j, 1) > \sigma\Sigma\tilde{w}_j$, a binding adverse selection incentive compatibility constraint for j workers increase the value of μ_j, thus exacerbating moral hazard for those workers. For parameter values such that high effort is implemented irrespective of home hours when home hours are known, if the solution to Problem 3 also features $e_L = e_H = 1$, then n_H will be lower than in the solution to Problem 2. This property stems from the additional inefficiency introduced by adverse selection. However, depending on parameter values, it is also possible that high effort cannot be implemented for both types of workers in Problem 3.

2.3 Equilibrium

Based on the previous analysis, we allow firms to offer contracts of the form: $\{w_i(y), n_i, e_i\}(h)$ for $i = f, m$, with $w_i(y) = \bar{w}_i + \tilde{w}_i y$. Since gender is observable, contracts are allowed to depend on gender. However, given that the contract space is unrestricted, firms will find it optimal to offer different contracts to female and male workers *only if* they believe the distribution of home hours to be different across genders.

The assumptions on the home production technology and on household preference over θ imply that the population is equally split across agents with home hours equal to h_L and $h_H = \xi h_L$. However, given that individuals of different genders are ex ante identical, the distribution of home hours across genders is not pinned down by technology. Instead, it depends on firms' self-fulfilling beliefs about this distribution. We denote with $\pi(h_j|i)$ for $j = H, L$ and $i = f, m$, firms' belief about the distribution of home hours in the population. Hence, we can describe the set of available labor contracts as a mapping $\mathcal{C}(\pi(h|f), \pi(h|m))$ from firms' beliefs to a function $\{w_i(y), n_i, e_i\}(h)$ for $i = f, m$.

We say that there is *gender discrimination* when firms believe that the distribution of home hours is different in the population of female and male workers. We now formally define the equilibrium and then illustrate the properties of equilibria with and without gender discrimination.

Definition 1 *An equilibrium is given by a set of firm beliefs on the distribution on labor market attachment, $\pi(h_j|i)$ for $i = f, m$ and $j = H, L$, labor contracts $\mathcal{C}(\pi(h|f), \pi(h|m)) = \{w_i, n_i, e_i\}(h)$ for $i = f, m$, and policy functions for the household problem $\{G, k, h_f, h_m, s_f, s_m\}$, so that:*

i) Labor contracts solve the firms' problem given beliefs $\pi(h_j|i)$;

ii) Household policy functions solve the household problem given labor contracts $\{w_i, n_i, e_i\}(h)$ for $i = f, m$;

iii) The resulting distribution of labor market attachment in the population is consistent with firms' beliefs.

In an *equilibrium with gender discrimination*, beliefs about the distribution of home hours are degenerate. In particular, in an equilibrium with discrimination of female workers, $\pi(h_H|f) = 1$ and $\pi(h_L|m) = 1$. In such an equilibrium, gender acts as a screening device, and the only incentive problem is moral hazard with respect to the worker's hidden effort. Firms determine labor contracts by solving Problem 2, with $h_f = h_H$ and $h_m = h_L$. They will offer male workers the contract corresponding to h_L and the one corresponding to h_H to female workers. Given that earning potential from market work is lower for women, households will find it optimal to set $h_f = \xi h_m$, confirming firms' expectations.

In an *equilibrium without gender discrimination*, firms believe that the distribution of home hours is the same for male and female workers, which implies: $\pi(h_H|f) = 0.5$ and $\pi(h_L|m) = 0.5$. Thus, gender does not reveal information about a worker's home hours. Labor contracts will solve Problem 3. The same selection of labor contracts will be offered to female and male workers. Households will be indifferent over which spouse should be assigned high home hours and they will randomize over this choice according to (4). This results in a symmetric distribution of home hours for male and female workers, thus confirming firms' expectations[16].

2.4 Numerical Experiments

We illustrate the properties of efficient labor contracts and the resulting implications for the gender earnings differentials numerically. We focus on equilibria with gender discrimination in which women have high home hours, so that the only incentive problem is moral hazard due to hidden effort. A firm may decide to implement low or high effort for a worker, this decision will mostly depend on the cost of implementing high effort. Such a cost, which is larger for workers with high home hours, depends on the degree of substitutability of n and e in utility and in production, as discussed in section 2.2. We first explore this, and then run two experiments. We increase the parameter Σ, which corresponds to the variance of output for given hours and effort. An increase in this parameter makes it harder to infer effort from observed output. In our second experiment, we increase the workers' relative cost of effort in utility. As discussed in section 2.2, each of these changes tend to make the incentive problem more severe and to increase the cost of implementing high effort.

We restrict attention to the following functional forms. The disutility from labor is:

$$v(h,n,e) = -\gamma \log (T - h - \eta(n,e)), \tag{22}$$

where η represents the time cost of market work. We assume:

$$\eta(n,e) = [\nu (n+1)^\rho + (1-\nu)(e+1)^\rho]^{1/\rho} - 1, \tag{23}$$

with $\rho, \nu \in (0,1)$, which implies $\eta_{ne} > 0$ and $v_{ne} > 0$. The production function is:

$$f(n,e) = [(1-\phi)(1+\varepsilon e)^z + \phi(1+n)^z]^{1/z} - 1, \tag{24}$$

[16] Francois (1998) presents a model in which equilibria with gender wage differentials are self-fulfilling. His result relies on exogenously given job heterogeneity. One class of jobs operate under an efficiency wage setting while a second class of jobs operate under piece rate wage setting. Earnings are higher in the efficiency wage jobs. In an equilibrium with female wage discrimination, the first class of jobs is assigned to men, the second to women. The female wage differential stems from job segregation. If all workers were to operate under the same job, the gender wage gap would be reversed. Hence, this model cannot account for gender differentials within the same occupational categories.

with $\varepsilon > 0$ and $\phi, z \in (0,1)$. The functional forms for η and f are extremely flexible and allow us to explore the properties of optimal contracts as a function of the degree of substitutability between effort and hours in each function.

Our benchmark parameterization is based on empirical evidence where possible and is reported in Table 2. The value of δ is set following Benhabib, Rogerson and Wright (1991). The parameter ξ is chosen to be consistent with the ratio of home hours for married women and men, which ranges from 4.3 in 1976 to 2.8 in 1993 based on PSID data. We set ξ equal to 3, which is the average value of this statistic for the 1990's. The values of γ and T are set so that the ratio of market to home hours matches data from the PSID. The average of this ratio for the 1990's is equal to 1.25 for married female workers and to 6.04 for married male workers. The parameters ρ, ν, z, ϕ, ε and Σ, which pertain to the utility cost of working and the firm's production technology, cannot be calibrated based on aggregate data. We restrict attention to the range $\phi, \nu > 0.5$ and $z, \rho > 0.5$. We set ε so that it is optimal to implement high effort for both types of workers, given the other parameters. The value assigned to the parameter Σ implies that the standard deviation of output conditional on effort and hours is approximately equal to 9% for males and 10% for females.

Table 2: Benchmark Parameters

σ	γ	T	ν	ρ	ϕ	ε	Σ	z	δ	ξ	θ
1.1	0.3	1	0.68	0.8	0.68	2.5	1	0.75	0.68	3	1

Tables 3A and 3B reports summary information for the benchmark parameterization:

Table 3A: Model Properties

	w	$\widetilde{w}$	$\overline{w}$	n	e	Σ/y	h	y	n/h
Male	3.32	0.89	0.33	0.66	1	0.09	0.1	3.3216	6.6
Female	2.88	0.91	0.24	0.37	1	0.10	0.3	2.8808	1.23

Table 3B: Model Properties

Earnings Ratio	Unexplained (Hours)	Unexplained (Output)
0.89	13%	11%

The female/male earnings ratio is equal to 0.89. We use a simple Oaxaca-Blinder decomposition of female earnings, at the male parameters, to evaluate the component of the earnings gap not explained by differences in observable characteristics, that is hours and/or output. The decomposition is based on the earnings schedule, hours and output generated by the model. We find that 13% of the earnings gap is not explained by differences in hours worked on the market across genders. The unexplained component drops to 11% if we use output as the observed characteristic.

We now investigate the role of the complementarity between effort and hours in production and utility. For all experiments, we vary each relevant parameter in isolation, maintaining the

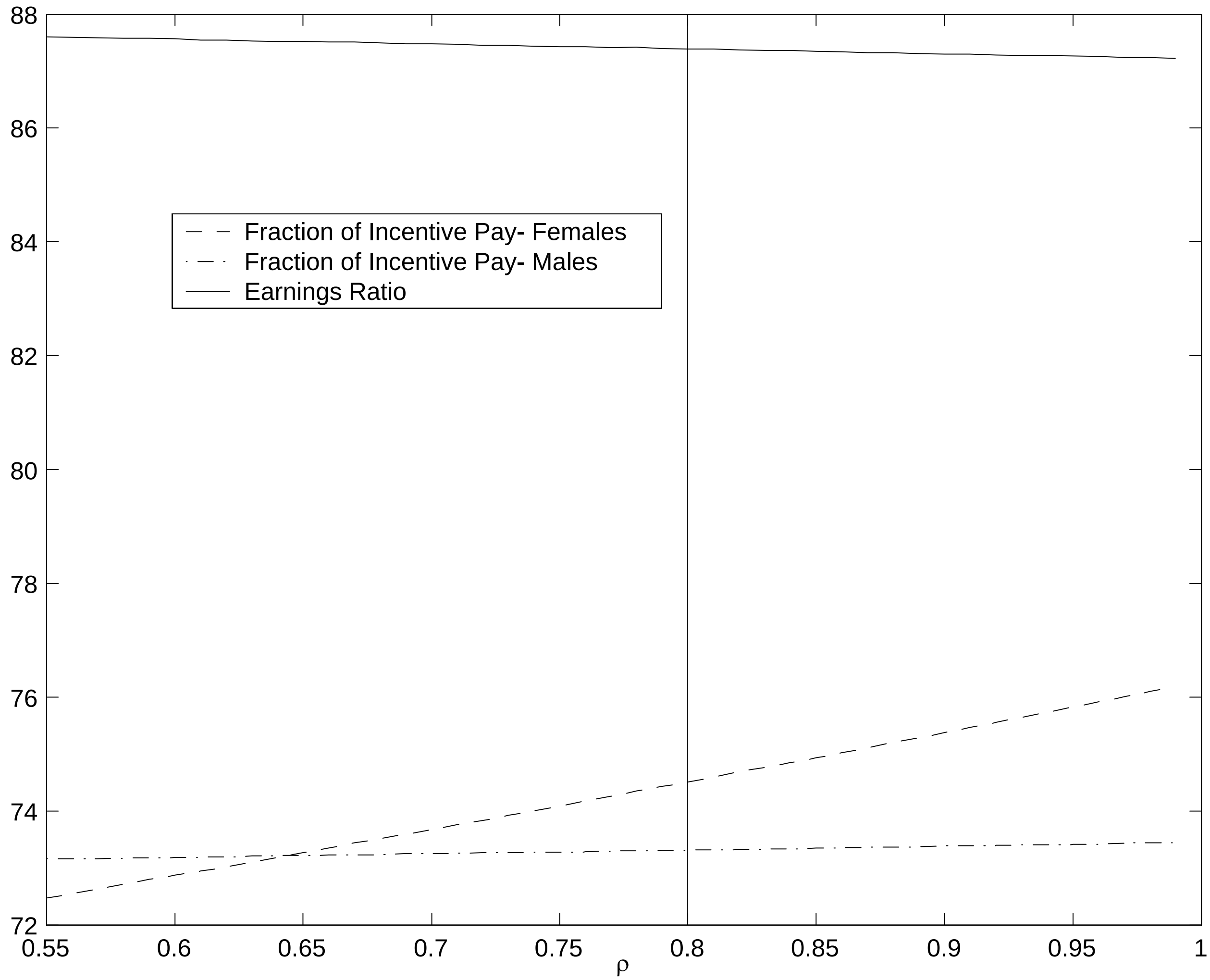


Figure 1:

remaining parameters at their benchmark values. Figure 1 displays how the fraction of incentive pay in earnings for females and males and the earnings ratio vary with ρ, which determines the degree of complementarity between output and hours in the utility cost of working. The dashed and dash-dotted lines represent the fraction of incentive pay in earnings, which is equal to $\tilde{w}$, for females and males, respectively. The solid line represents the earnings ratio. All numbers are expressed in percentages. The vertical line corresponds to our benchmark parameterization. As ρ increases, the fraction of incentive pay increases for both male and female workers, but more so for females. Higher values of ρ correspond to higher substitutability between effort and hours in utility. This exacerbates the incentive problem, more so for women who have a higher marginal cost of effort. For high enough values of ρ, the fraction of incentive pay is higher for women than men.

Figure 2 plots the fraction of incentive pay in earnings for females and males and the

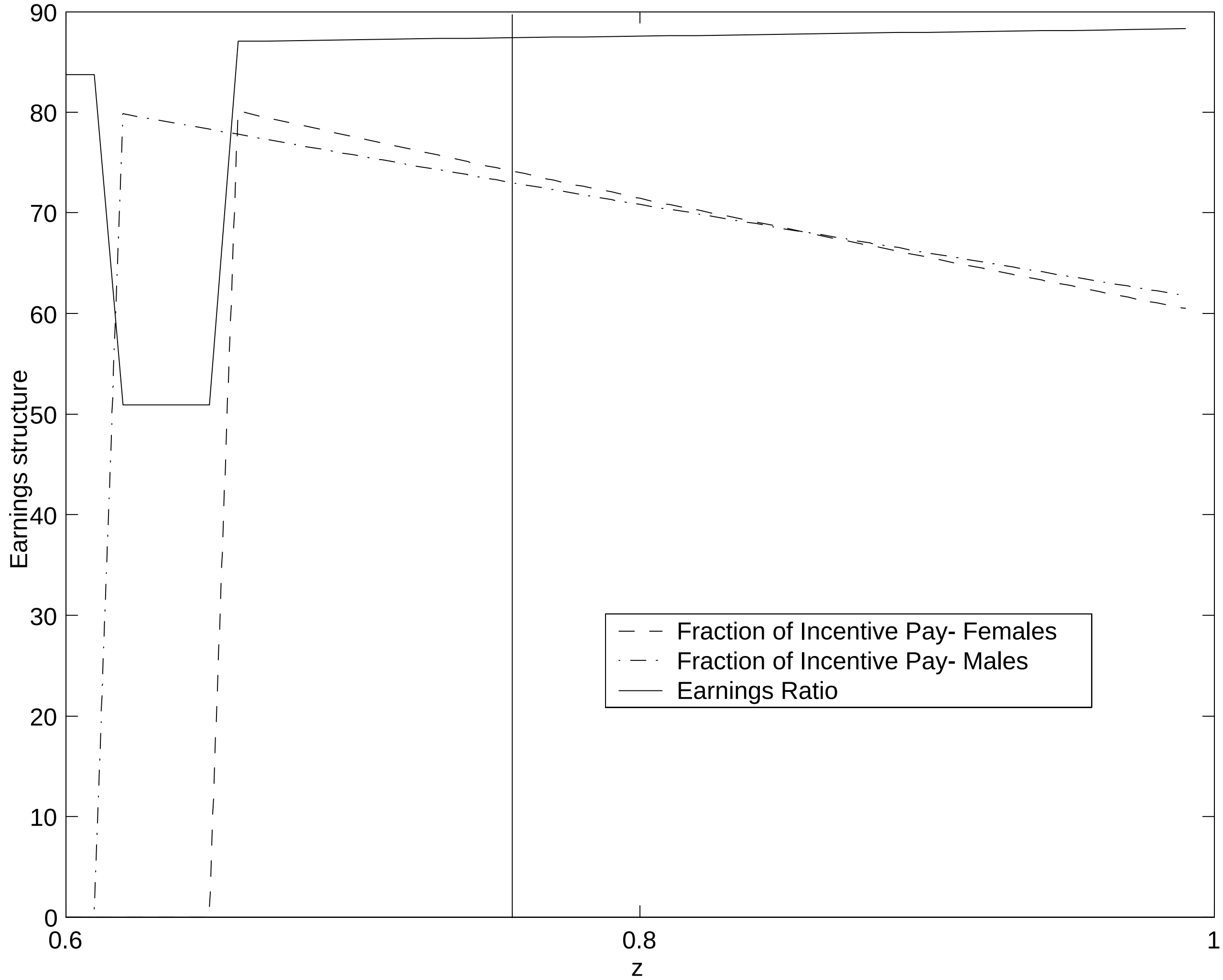


Figure 2:

earnings ratio as a function of z. Lower values of z correspond to lower substitutability between effort and hours in production. This reduces the marginal product of effort for firms at lower values of hours. It follows that lower values of z increase the cost of implementing high effort more for female workers, since they work fewer hours. As long as high effort is being implemented for male and female workers, the fraction of incentive pay in earnings is very similar for both genders, though higher for women. For sufficiently low values of z, however, firms will find it optimal to implement low effort for female workers, while high effort is still implemented for males. This determines a large drop in the earnings ratio.

We also explore the dependence of labor contracts on the standard deviation of output for given hours and effort, Σ, and the relative cost of effort, ν. Figure 3 displays the fraction of incentive pay in earnings for females and males and the earnings ratio for different values of Σ.

We vary Σ from values approximately equal to 10% of output to values approximately equal to 60% of output for males. As Σ increases, the surplus from the employment relationship declines, given that workers are risk averse. This can be seen from the multiplier on the incentive compatibility constraint, derived in section 2.2, which is proportional to Σ. It follows that the returns from implementing high effort for firms decline. This effect is greater for women, who have a higher marginal cost of effort. Then, there will be a critical value of Σ, for which it becomes too costly for firms to implement high effort for females, but not for males. As discussed for Figure 2, as long as high effort is being implemented for both, the fraction of incentive pay in earnings is similar across genders, though higher for women and the earnings ratio roughly constant. The earnings ratio drops significantly, when low effort is implemented for females. Lastly, we focus on the parameter ν, which determines the relative cost of effort for workers. Results are displayed in Figure 4. As ν declines, the relative cost of effort increases, and this exacerbates the incentive problem. The interpretation is similar to the one for Figures 2 and 3. We connect the role of ν to historical evidence below.

Our findings are consistent with historical evidence on the gender wage gap and on the structure of earnings for female and male workers in manufacturing and in the clerical sector in Goldin (1986, 1990). She documents that in manufacturing, piece-rate compensation was more prevalent for women. Specifically, 47% of female operatives and 13% of males in the same positions are paid by the piece in manufacturing in 1890. This accords with equilibria in our model in which male and female workers both exert high effort, as long as the substitutability of effort and hours in utility is sufficiently high, as discussed above.

Goldin argues that with the growth of the clerical sector, "career tracks" emerged as a standard motivational device, replacing the piece-rate compensation schemes prevalent in manufacturing. She maintains that in the clerical sector: "Firms often used sex as a signal of shorter expected job tenure. ... By segregating workers by sex into job ladders (and some dead-end positions), firms may have been better able to use the effort-inducing and ability-revealing mechanisms of the wage structure."[17] She also argues that clerical sector work was perceived as less onerous for production workers, involving less physical fatigue and discomfort than in manufacturing. In the context of our model, this corresponds to an increase in the relative cost of effort, ν. If we adopt a job ladder interpretation, labor contracts implementing low effort can be thought of as "dead end jobs", while labor contracts that implement high effort can be thought of as positions that allow for career growth. Then, our results on the effect of a higher relative cost of effort on the earnings structure are consistent with the transition to the clerical sector in the period 1930/1940, when, as discussed in Goldin (1990), there was also a significant rise in the gender wage gap.

[17] Even for more recent cohorts, firms' expectation of a shorter job tenure for women might be incorrect. For instance, Light and Ureta (1992) show that the quit behavior of men and women born in 1952-54 is indistinguishable once observable characteristics are accounted for.

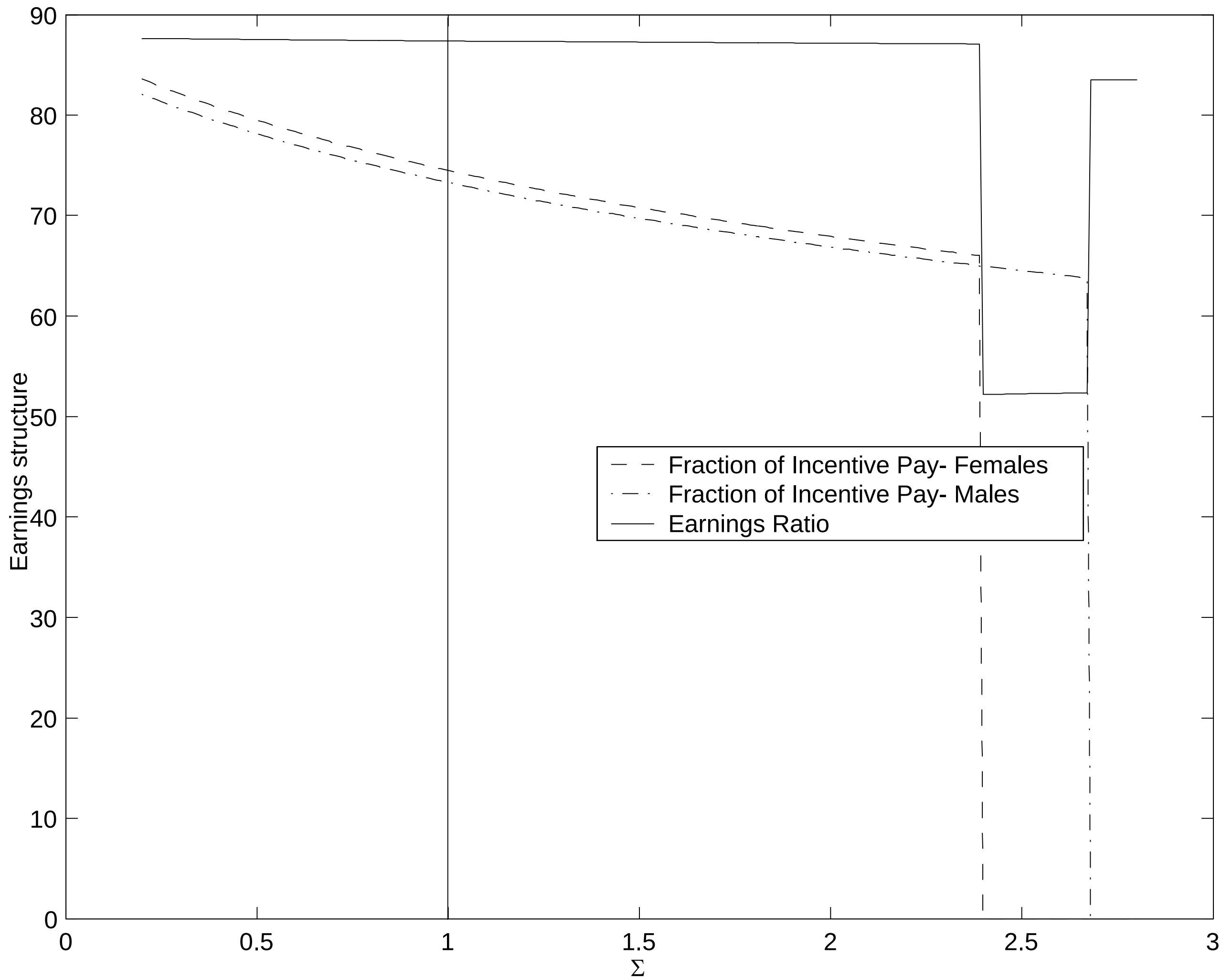
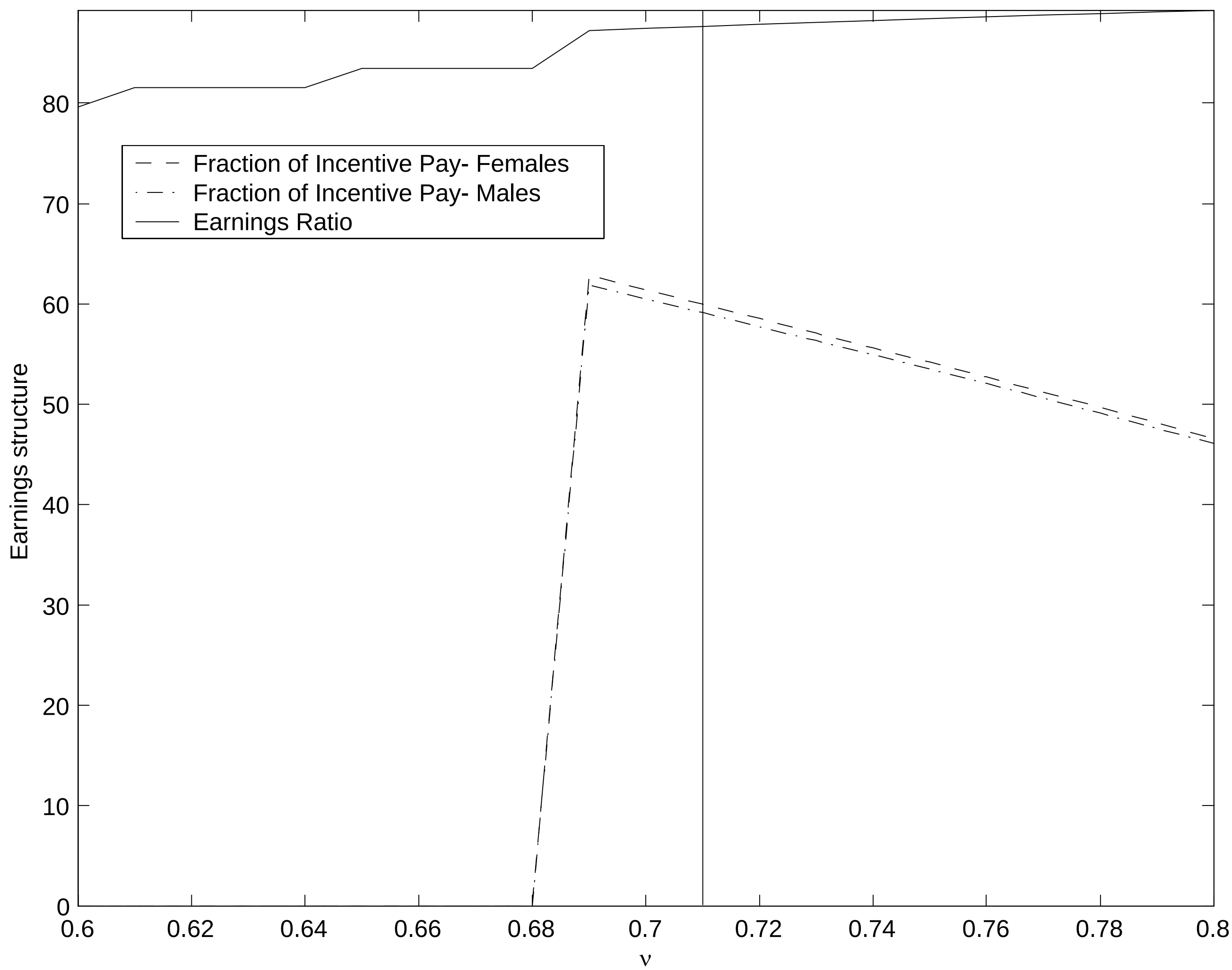

Earnings structure
Σ
Fraction of Incentive Pay- Females
Fraction of Incentive Pay- Males
Earnings Ratio
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3

Figure 3:



Fraction of Incentive Pay- Females
Fraction of Incentive Pay- Males
Earnings Ratio
Earnings structure
ν
0
10
20
30
40
50
60
70
80
0.6
0.62
0.64
0.66
0.68
0.7
0.72
0.74
0.76
0.78
0.8

Figure 4:

3 Connecting the Model with the Evidence

There are two distinct predictions of our framework that we need to document. First, in our model, there is a negative correlation between relative home hours of husbands and wives and their relative earnings, as would be the case for other efficient models of intra-household allocation. We use the PSID to show that there is indeed a negative and significant correlation between the husband/wife ratio of home hours and the husband/wife ratio of total labor income in the data. Second, the gender earnings gaps should be higher in industries/occupations in which the incentive problem is more severe. We study gender earnings differentials across industries for broad occupational categories. We find that gender differentials are greatest in high management and sales occupations across all industries. We argue that these occupations are likely to be the ones in which incentive problems are most stringent.

3.1 Relative wages and home hours for married couples

Our model predicts that husband-wife ratio of earnings should be negatively correlated with their home hours ratio, that is, the spouse with higher earnings will contribute fewer hours to the production of the home public good. We use PSID data, which includes information on hours of housework and earnings for each spouse, to study this correlation.[18] We find that there is a negative and significant (at the 1 per cent level) correlation between the husband/wife ratio of home hours and the husband/wife ratio of total labor income. The correlation coefficient ranges from 0.12 for the whole sample to approximately 0.25 for the sub-sample of couples where the husband's labor income is in the upper half of the male earnings distribution. This is also true when we concentrate on couples where both the husband and the wife work full time.

Table 4 reports on the fraction of married couples that display a negative relationship between earnings and home hours of the spouses. We find that 86.3% of married couples in the PSID sample display a correlation which is consistent with our model's prediction.[19] We also investigate how this fraction varies by the husband's position in the male earnings distribution. The fraction of married couples for which we observe a negative correlation between these two ratios ranges from 73% in the bottom quartile to approximately 95% in the top quartile.[20]

Table 4: Composition of the PSID sample

[18] We follow the procedure in Katz and Murphy (1992) and impute annual earnings at 1.45 times the annual topcode amount for individuals with top coded labor earnings. We also exclude workers with real weekly earnings below $67 in 1982 dollars.

[19] In 3.7% of the remaining households the husband is both the main earner and the main provider of home hours. This leaves a 10% of households where wives have both higher earnings and higher home hours than their husbands.

[20] Findings are similar if we consider the sample of white married couples, which starts with the 1985 wave.

	All	Quartile of Male Earnings Distribution			
		<25	25-50	50-75	>75
couples with negative $\text{corr}\left(\frac{w_m}{w_f}, \frac{h_m}{h_f}\right)$	86.3%	73%	85.3%	92%	95.3%
# of couples	45,049	10,386	13,181	12,014	9,468

3.2 Evidence from the Census

In this section, we use Census data to document differences in gender earnings differentials across all industries for four broad occupational categories: higher level management, lower level management, sales and production.[21] We consider this occupational classification based on the notion that incentive problems are more stringent in sales and high management relative to production and low management. We link the severity of the incentive problem to the degree of uncertainty over the workers' effort for given observable measures of performance, which correspond, respectively, to the parameter Σ and output in our model[22]. For management occupations, the uncertainty associated with managers' effort given observable performance measures should be related to the range of responsibilities held. Hence, we expect it to be greater for high level managers. For sales occupations, sales volumes are typically used as a benchmark measure of performance. Yet, these depend to a large degree on variables that are not directly related to a sales personnel's effort and hours of work and may be uncertain[23]. These considerations are less important for production workers.

Table 5 reports the results of this analysis. Following the Census classification we consider 19 industries: Agriculture; Forestry Fishing and Hunting, Mining, Utilities, Construction, Manufacturing, Wholesale Trade, Retail Trade, Transportation and Warehousing, Information, Finance and Insurance, Real Estate and Rental/Leasing, Professional, Scientific and Technical Services, Administrative and Support and Waste Management and Remediation Services, Educational Services, Health Care and Social Assistance, Arts, Entertainment and Recreation,

[21] We use Census 2000. The industry variable, INDNAICS, reports the type of establishment in which a person worked in terms of the good or service produced. Industries are coded according to the North American Industrial Classification System developed in 1997. We use the variable OCCSOC for occupation. OCCSOC classifies occupations according to the 1998 Standard Occupational Classification (SOC) system. The Census also provide an aggregation of all the occupations in 23 broader categories that includes the four broad categories used in this analysis. The definition of production occupations also includes construction and extraction workers. Our sample includes all individuals between 15 and 64 years of age, who are not in school, do not reside on a farm or live in group quarters. We also exclude the armed forces and restrict attention to those individuals who work at least 50 weeks in the previous year and who usually work at least 30 hours per week.

[22] See sections 2.2 and 2.4.

[23] For example, sales workers are typically assigned to specific territories or products. Hence, sales volumes will fluctuate with shocks to local demand. See Catalyst (1995) for a description of the sales occupation, especially in relation to gender.

Accomodation and Food Services, Other Services (except Public Administration), and Public Administration.

Table 5: Gender differences in earnings across industries
for four broad occupational categories. (Full time, year round workers.)

	female/male wage ratio	% times lowest ratio	% times highest ratio
higher level management	.69	21	0
lower level management	.74	5	0
sales	.64	74	0
production	.96	0	1

The first column in the table reports the female/male ratio of median earnings for full-time year-round workers for the four broad occupational categories. The second and third column report, respectively, the frequency with which the gender wage ratio is lowest (second column) and highest (third column) across the four categories.

Table 6: Variation in female/male median earnings ratios by industries and occupation

	Lowest	Highest	All
Accomodation and Food	0.57 (sales)	0.97 (production)	0.73
Administrative and Support	0.69 (sales)	0.93 (production)	0.87
Agriculture, forestry	0.59 (sales)	0.96 (production)	0.84
Arts, Entertainment & Recreation	0.71 (sales)	0.86 (production)	0.80
Construction	0.62 (high mgt.)	0.97 (production)	0.83
Educational Services	0.57 (sales)	1 (production)	0.76
Finance and Insurance	0.53 (high mgt.)	1 (production)	0.55
Health Care and Social Assistance	0.53 (sales)	0.86 (production)	0.66
Information	0.68 (high mgt.)	1 (production)	0.72
Manufacturing	0.64 (sales)	1 (production)	0.66
Mining	0.60 (sales)	0.90 (production)	0.75
Other Services (except Public. Adm.)	0.59 (sales)	0.92 (production)	0.70
Professional, Scientific and Technical Services	0.63 (low mgt.)	0.93 (production)	0.60
Public Administration	0.61 (sales)	1.02 (production)	0.74
Real Estate and Rental/Leasing	0.65 (high mgt.)	1.03 (production)	0.80
Retail Trade	0.59 (sales)	0.96 (production)	0.66
Transportation and Warehousing	0.67 (sales)	0.89 (production)	0.78
Utilities	0.60 (sales)	1 (production)	0.72
Wholesale Trade	0.65 (high mgt.)	1 (production)	0.74

We find that the female/male median earnings ratio is lowest for sales occupations in 14 industries - 74% of the cases. In 4 of the remaining 5 industries (21% of the cases) the occupation that display the lowest ratio of female to male median earnings is high management.[24] Workers in production occupations display the largest ratio in *all* industries. The average female/male ratio of median earnings in all industries varies from a minimum of 0.64 in sales to a maximum of 0.96 in production.

We also report the female/male median earnings ratio by industry in Table 6. For each industry, we include the value for the occupation with the lowest and highest ratio, as well as for all occupations in the Census. The variation of the median earnings ratio across industries is striking, ranging from 0.53 for high management in Finance and Insurance to 1.03 for production in Real Estate. This variation could be exploited to calibrate industry specific values of the production technology parameters in our model to the gender earnings ratio in different industries and analyze the resulting structure of earnings by occupation. We plan to pursue this in further research, as well extend the analysis to a more disaggregate level.

4 Conclusion

We plan to extend our analysis along several dimensions. We have shown that in equilibria with gender discrimination, given that firms use gender as a screening device, discrimination actually reduces the incentive problem for firms, eliminating adverse selection. We conjecture that this property of the model implies that equilibria without discrimination are unstable. We plan to formally analyze this conjecture in future drafts of the paper. Moreover, in our current framework, there are no costs associated with gender discrimination. We plan to extend the analysis to environments where discrimination is potentially associated with efficiency losses stemming from the misallocation of workers.

Our model also predicts that gender earnings gaps should be higher in industries/occupations in which the incentive problem is more severe. Using Census data, we have shown that gender earnings differentials are greatest in high management and sales occupations across all industries. We argue that these occupations are likely to be the ones in which incentive problems are most stringent. We plan to extend this analysis to a more disaggregate level.

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5 Appendix

Proof of Proposition 1

Conditions (10) and (11) imply that Γ, the fraction of earnings given by incentive pay satisfies:

$$\Gamma := \frac{\tilde{w} f(n,1)}{\bar{w} + \tilde{w} f(n,1)} = \tilde{w}.$$

We are interested in:

$$\frac{d\tilde{w}}{dh} = \frac{\partial \tilde{w}}{\partial h} + \frac{\partial \tilde{w}}{\partial n}\frac{dn}{dh}.$$

Condition (10) implies:

$$\frac{\partial \tilde{w}}{\partial h} = \tilde{w}\frac{v_h(h,n,1) - v_h(h,n,0)}{v(h,n,1) - v(h,n,0)} < 0,$$

by (2). In addition:

$$\frac{\partial \tilde{w}}{\partial n} = \tilde{w}\left[\frac{v_n(h,n,1) - v_n(h,n,0)}{v(h,n,1) - v(h,n,0)} - \frac{f_n(n,1) - f_n(n,0)}{f(n,1) - f(n,0)}\right].$$

Hence, if $v_{ne} \leq 0$ and $f_{ne} \geq 0$, $\frac{\partial \tilde{w}}{\partial n} \leq 0$; if $v_{ne} > 0$ and $f_{ne} < 0$, $\frac{\partial \tilde{w}}{\partial n} > 0$. Then, if $dn/dh \leq 0$, $v_{ne} \leq 0$ and $f_{ne} \geq 0$ guarantees $\frac{d\tilde{w}}{dh} \geq 0$. Incentive pay depends on h as follows:

$$\frac{d\left[\tilde{w} f(n,1)\right]}{dh} = \frac{d\tilde{w}}{dh} f(n,1) + \tilde{w} f_n(n,1)\, dn/dh.$$

The result follows.■