A Model of Occupational Choice with Moral Hazard and Human Capital Accumulation

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Abstract

In this paper, I present a model of occupational choice in a labor market with moral hazard and human capital accumulation. The model describes workers' effort decisions as well as their occupational choice decisions and demonstrates that an analysis of the selection pattern in such an economy requires the examination of both decisions simultaneously. I estimate the structural model using maximum likelihood and data from the National Longitudinal Survey of Youth. The results show that the model of occupational choice with moral hazard and human capital accumulation does a very good job of fitting observed data on dismissal rates in white collar and blue collar occupations. Findings indicate that self-selection leads to higher wages and lower dismissal rates in both occupations compared to an economy in which workers are randomly assigned to each occupation. In addition, the analysis results suggest that higher opportunities for human capital accumulation in the white collar occupation would lead to lower dismissal rates amongwhite collar workers and higher dismissal rates among blue collar workers.

1 Introduction

This paper presents a model of occupational choice when the labor market is characterized by moral hazard and workers accumulate occupation-specific human capital over their tenure in an occupation. The model builds on a Shapiro-Stiglitz type shirking model in which firms imperfectly observe output, workers have an incentive to shirk and firms dismiss shirkers that are detected as a result of random monitoring. In such a labor market, workers' effort decisions play an important role in determining the pattern of selection into occupations. Conditional on not shirking, a worker's occupational choice is mostly determined by the relative disutility of effort that the worker received in each occupation. However, workers who shirk consider the relative intensity of monitoring in the two occupations instead of their relative disutility of effort in choosing an occupation. Therefore, an analysis of the consequences of occupational

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selection in a labor market with the moral hazard problem requires a model in which workers' effort decisions are incorporated into their occupational choice decisions. This paper presents such a model, and the structural estimation results of the model suggest that occupational self-selection under moral hazard can successfully explain the dismissal rates observed in white collar and blue collar occupation.

This paper is aimed at providing an alternative framework in which to study sectoral differences in dismissal rates in general and differences in the dismissal pattern between white collar and blue collar occupations in particular. A common finding among studies on involuntary job loss is that blue-collar workers experience substantially higher dismissal rates than white-collar workers. The literature on turnover contains two main approaches to explaining this observed regularity. The first approach is to study within a job matching framework in which dismissals occur as a result of low worker-firm matches (Jovanovic, 1979). One can argue based on this model's implications that occupations that are predominantly occupied by young workers, who experience high rates of turnover, exhibit high rates of dismissals. The job matching model coupled with the human capital model would also imply that occupations with more opportunities for on-the-job training or a higher rate of learning by doing exhibit lower rates of separations since job-specific human capital accumulation increases the value of the worker-firm match relative to the outside alternatives. Although the matching-search framework is successful in explaining several regularities observed in labor turnover behavior, it implies that worker-initiated and firm-initiated separations are behaviorally equivalent. Empirical evidence suggests that there may be underlying differences between the two types of separations. For example, previous research has shown that workers who experience an involuntary separation earn lower wages on their next job following the separation than workers who report a voluntary separation from their previous jobs (Bartel and Borjas, 1981; Gibbons and Katz, 1991).

The other approach to explaining dismissals is to treat them as an outcome of labor demand fluctuations, which are in turn caused by shocks to preferences or technology. To the extent that different sectors of the economy experience different labor demand fluctuations and the prevalence of occupational groups vary across sectors, involuntary separations due to firms' operating decisions will lead to varying firm-initiated separation rates across occupations. Even when all sectors of the economy are equally affected by the shocks and fluctuations in labor demand, different occupations may still experience higher rates of dismissals. If dismissal rates depend on certain socioeconomic characteristics, then the socioeconomic make-up of the workforce in an occupation would determine the rate of dismissals in that occupation. In that case, differences in dismissal rates across occupations can be attributed to the heterogeneity in the population. However, idiosyncratic shifts in labor demand fails to explain certain features of the dismissal data, such as the empirical finding that the conditional probability of being dismissed decreases over one's tenure in the job or in the occupation. Jovanovic and Moffitt present empirical evidence that demand shifts do not explain the majority of the labor turnover in the labor market (1990).

This paper presents a third approach, in which involuntary separations are dependent on workers' effort decision. Firms dismiss workers due to poor performance on the job or malfeasance. In this approach, workers' occupational self-selection leads to differences in average worker productivity across occupations, which contribute to the observed inter-occupational differences in dismissal rates.

The sources of occupational self-selection in this model can be traced back to the dual roles played by the occupation-specific worker abilities which determine both disutility of effort and propensity to shirk in this model. First, conditional on not shirking, the worker type determines the disutility that the worker receives from exerting effort. Workers with high ability in an occupation complete the required tasks with minimal effort, thus they receive relatively low disutility from working in that occupation. On the other hand, low-ability workers have to exert relatively more effort to complete the tasks and thus receive higher disutility from working in that occupation. Second, the occupation-specific worker ability affects the probability that a worker shirks in a given occupation. High-ability workers tend to have a lower propensity to shirk because the disutility that they receive from exerting effort and completing the tasks in an occupation is relatively low. In contrast, workers with low ability are more likely to shirk since they will have more incentive to avoid the large disutility that would result when they exert effort and complete the required tasks.

This paper extends an earlier work on occupational self-selection under moral hazard by adding human capital accumulation and exogenous dismissals (Demiralp, 2006). In the first paper, wages grow over time as a result of the increase in average productivity in a cohort of workers due to the systematic dismissal of shirkers in each period. In the model presented here, workers also experience an increase in their productivity as they gain labor market experience. Therefore, accumulation of occupation-specific human capital provides a second source of wage growth, and the difference in the rate of human capital accumulation across occupations serves as an additional determinant of occupational choice. In particular, I consider two different formulations of human capital growth. In the first formulation, I assume that every worker experiences an increase in his productivity regardless of his effort decision. Workers start accumulating human capital as soon as they enter employment in the firm. In the second formulation, workers' human capital investment is tied directly to their effort decisions. In this case, human capital is accumulated by only those workers who have exerted effort in previous periods. These considerations enable one to study the importance of the possibilities for human capital growth in occupational choice. Furthermore, the original model had difficulty explaining a significant portion of dismissals, especially in the blue collar occupations. The model in this paper incorporates dismissals that are due to reasons exogenous to workers' behavior, such as due to labor demand fluctuations. This addition allows the model to better fit the observed dismissal data.

This paper contributes to the literature on occupational selection by explaining the properties of the self-selection mechanism when the labor market exhibits a moral hazard problem.

While self-selection has been regarded as an important feature of a labor market, its consequences have been analyzed mostly within the labor markets with symmetric information (Roy, 1951; Heckman and Sedlacek, 1985; Willis, 1986). This paper applies the basic Roy framework to a labor market with asymmetric information. The moral hazard problem is characterized by a shirking model by Flinn, which in turn is based on the Shapiro-Stiglitz model (Flinn, 1997; Shapiro and Stiglitz, 1984). Two features of Flinn's model are essential in the analysis undertaken in this paper: i) dismissals are an equilibrium outcome; ii) the dynamic nature of the model allows for the study of wage profiles and dismissal rates over time.

I estimate the structural parameters of the model using data from the National Longitudinal Survey of Youth. The estimation results suggest that white collar jobs provide more opportunities for job-specific human capital accumulation than blue collar jobs. Furthermore, the higher human capital accumulation rate in the white collar sector reinforces the negative selection into the blue collar occupation. Addition of human capital accumulation lowers wages compared to an economy in which no job-specific human capital is required in the production technology, so inefficient workers switch to blue collar jobs in reaction to relatively lower white collar wages. A substantial portion of the wage growth in the white collar sector can be explained by the productivity enhancing effect of human capital investments. On the other hand, the majority of wage growth in the blue collar occupation is generated by the systematic dismissal of shirkers over time. Addition of human capital accumulation to the original model of Chapter 3 enhances the model's fit to the white collar wage data by resulting in a steeper wage profile than the one predicted by the original model. Compared to the other models considered in this thesis, the extension with human capital accumulation and exogenous dismissals best explains the wage and dismissal rates observed in the data.

2 Model

2.1 The Set-Up

The labor market consists of a primary and a secondary sector. Firms in the primary sector cannot observe workers' effort levels, possibly due to a lack of individual worker output measure. Thus, workers have an incentive to shirk. In order to overcome this moral hazard problem, primary sector firms randomly monitor their workers and dismiss those that are caught to be shirking. While primary sector firms cannot observe individual output, they do observe total output produced by a cohort of workers. I assume that there are two types of firms in the primary sector, denoted by j and k. Firms in primary sector j have a monitoring rate, π_j, and output prices, ρ_j, both of which are exogenous parameters of the model. The monitoring rate, π_j, is the probability with which a worker in firm j is monitored in each period of employment. Differences in monitoring rates reflect differences in monitoring technologies and monitoring costs across firms. The punishment for shirking is dismissal from the firm. Workers, who are detected to be shirking and dismissed, find jobs in the secondary sector of the labor market.

Firms in the secondary sector perfectly observe effort via employee-specific output. Secondary sector firms are perfectly competitive, so the secondary sector wage equals the output price. Furthermore, effort needed to produce one unit of output in the secondary sector equals the output price, so each worker receives a utility flow of zero in each period of employment in this sector. The secondary sector consists of two types of firms. Workers that are dismissed from primary sector firm j find employment in the secondary sector firm j and earn wage given by w_j^s. The secondary sector is an absorbing state; workers in this sector cannot be rehired in the primary sector[1]. As I will show below, workers in the primary sector receive a positive utility flow in each period; thus, workers voluntarily start their labor market careers in the primary sector.

Each worker is endowed with a two-dimensional productivity inefficiency index, (ξ_j, ξ_k), whose arguments reveal the minimum amount of effort that the worker needs to exert in order to accomplish the task in firms j and k, respectively. Therefore, worker i's productive inefficiency index is given by $\xi_i = (\xi_{ij}, \xi_{ik})$, where ξ_{ij} denotes his productive inefficiency index in firm j and ξ_{ik} denotes that in firm k. The fact that a worker's type is given by a two-dimensional index bears the assumption that firms j and k require their workers to perform unique tasks that are specific to each firm. Workers are heterogeneous with respect to their productive inefficiency indices. ξ_j and ξ_k are distributed according to a bivariate population distribution, denoted by the cdf, $H(\xi_j, \xi_k)$. The marginal distributions of inefficiencies in the population are given by $H_j(\xi_j)$ and $H_k(\xi_k)$. The marginal distribution of $\log \xi_j$ has mean, μ_j, and standard deviation, α_j, and the covariance of $\log \xi_j$ and $\log \xi_k$ is α_{jk}. The correlation between ξ_j and ξ_k in the population indicate the degree to which workers use similar skills in completing the firm-specific tasks in each firm. Workers know their own endowments of productive inefficiency indices in the beginning of their labor market careers. Finally, workers have infinite horizon, and they discount the future by a factor, β.

Workers in this model make two types of decisions. First, in the beginning of their labor market careers, they decide which type of primary sector firm to work for. Second, they decide whether to shirk or not in each period of employment in the primary sector. Workers' decisions are affected by the rate of human capital accumulation during their tenure in the primary sector. The following two subsections discuss two different ways in which human capital accumulation is incorporated into the model and the equilibrium that results under each case.

2.2 Human Capital Accumulation by All Workers (HC1)

In this formulation, I assume that all workers in the primary sector accumulate human capital in each period of their employment regardless of their effort decisions. I assume that the workers'

[1] This condition has two parts. First, workers who are detected and dismissed in primary sector firm j cannot be rehired by firm j. This condition is an outcome and not an assumption of the model. This result is explained in Flinn (1997). I add the assumption that workers who are dismissed in primary sector firm 1 cannot be hired by primary sector 2. Combined with the above-mentioned result, this assumption yields that secondary sector is an absorbing state.

productivity grows in a deterministic way with labor market experience. The production function for worker i in firm j in period t is given in Equation 1.

$$y_{ijt} = \left\{ \begin{array}{c} e^{-\frac{\gamma_j}{t}} \text{ if } e_{it} \geq \xi_{ij} \\ 0 \text{ otherwise} \end{array} \right\} \tag{1}$$

where t is the period of employment in the firm, e_{it} is the amount of effort, and ξ_{ij} is worker i's productive inefficiency in firm j.

The production function reveals several assumptions of the model. First, a worker's productive inefficiency is the minimum amount of effort that he has to exert in order to produce a non-zero amount of output. Since workers receive disutility from putting forth effort, they either exert the minimum effort possible to produce output (i.e. ξ_j) or they exert no effort at all and shirk. Second, conditional on putting forth effort that is greater than or equal to his productive inefficiency in a given firm, a worker's productivity grows with his number of years at the firm. Therefore, his effort decisions do not affect his productivity growth.

Third, the firm-specific parameter, γ_j, determines both the nonshirkers' productivity in the initial period of employment and the rate of productivity growth over time. According to the production function, a worker, who exerts effort in the initial period of employment, does not produce one unit of output. As he accumulates human capital over his tenure, his productivity rises over time in a deterministic way until it reaches one unit of output in the limit. This assumption may be interpreted in the following way: One can imagine that the production process in the primary sector requires both general and job-specific human capital. Workers enter the firm with the same level of general human capital and with no job-specific skills. While both types of human capital are necessary in the production, the proportions of the two types of human capital necessary to produce one unit of output might differ across firm types. For example, a mechanic might accomplish one third of a task with no job-specific human capital while a janitor might be able to accomplish almost the entire task without any job-specific human capital. Differences in the γ_j parameter across firm types reveal the differences in opportunities to gain job-specific skills that are needed in the production of output.

The human capital accumulation described in this model is of a simple form as it only depends on t. Since the focus of this paper is to compare wage growth generated by dismissals with the wage growth generated by individual productivity growth, the model abstracts from the source of human capital accumulation. In particular, the model is silent on whether skills are obtained with time spent in human capital investment (as in on-the-job training, OJT) or whether skills are acquired through time devoted to work (as in learning-by-doing, LBD). However, the properties of the model are more in line with a human capital investment model as in Becker (1964) or Ben-Porath (1967). In this model, an increase in the rate of productivity growth due to a rise in γ_j occurs simultaneously as a decreases in the productivity level at initial periods of employment. This relationship can be explained by a human capital investment model in which a higher degree of human capital accumulation decreases worker productivity during initial periods when workers are devoting more time to human capital investment.

Workers in this model make two types of decisions: 1) in the beginning of their labor market careers, they decide for which primary sector firm to work, and 2) in each period of employment, they decide whether to work or to shirk. Consider worker i in firm j. The utility flow to worker i in firm j and period t is determined by his wage and the disutility from effort: $U_{ijt} = w_{jt} - e_{ij}$. As explained above, a worker will either choose to exert effort in the amount of his productive inefficiency index, ξ_{ij}, or no effort. Therefore, his work/shirk decision in each period is based on the following maximization problem. The value of employment in firm j in period t by worker i is

$$V_{ijt}(\xi_{ij}) = \max\left\{w_{jt} - \xi_{ij} + \beta V_{ij,t+1}(\xi_{ij}); w_{jt} + \beta(1-\pi_j)V_{ij,t+1}(\xi_{ij})\right\} \tag{2}$$

where the first argument is the value of working, and the second argument is the value of shirking. If wages are monotonically increasing over time, a worker who decides to put for effort in period t also decides to exert effort in all periods following period t. Therefore, it can be shown that under monotonically increasing wage sequences, a worker of type ξ_{ij} will

$$\begin{array}{c}\text{work if } \xi_{ij} \leq \xi_{jt}, \text{ and} \\ \text{shirk otherwise}\end{array} \tag{3}$$

where

$$\xi_{jt} = \frac{\beta\pi_j(1-\beta)}{1-\beta+\beta\pi_j}\left(\sum_{s=t+1}^{\infty}\beta^{s-t+1}w_{js}\right) \tag{4}$$

Furthermore, in the beginning of his labor market history, the worker makes a one-time decision on which firm to work for, based on his likelihood of dismissal and the wages offered by different firms. Worker i chooses the firm that maximizes the expected value of employment in the beginning of period 1. Therefore, worker i chooses firm j iff $V_{i,j,t=1} > V_{i,k,t=1}$. Given the equation for V_{ijt} in Equation 2, worker i's sectoral choice decision can be expressed as follows: A worker of type ξ_{ij} chooses firm j if

$$\xi_{ij} < \xi^*(\xi_{ik}; \theta) \tag{5}$$

where ξ^* is a function of ξ_{ik}, worker's productive inefficiency in firm k, as well as the set of model's parameter indicated by θ. The selection rule in Equation 5 leads to a post-selection conditional distribution of ξ_j in firm j that is characterized by the population conditional distribution of ξ_j, truncated from below at $\xi^*(\xi_{ik})$ as stated in Equation 6,

$$f_j(\xi_j|\xi_k) = \frac{h_j(\xi_j)}{H_j(\xi^*(\xi_{ik}))} \cdot I(\xi_j \geq \xi^*(\xi_{ik})) \tag{6}$$

where $j, k = 1, 2$ and $j \neq k$, and the marginal density of ξ_j among people who choose firm j in period 1 is given by

$$f_j(\xi_j) = \int_0^\infty \frac{h_j(\xi_j)}{H_j(\xi^*(\xi_{ik}))} dH_k(\xi_k) \tag{7}$$

The marginal distribution of ξ_j in firm j changes over time in a systematic way. If we consider a cohort of workers who start to work in firm j at the same time, Equation 7 gives the marginal distribution of ξ_j in firm j in the beginning of their first period of employment. As a constant proportion of shirking workers are detected and dismissed from the cohort in each period, the marginal distribution of workers remaining in the cohort changes with the mass point of the distribution moving toward lower levels of inefficiency. While $f_j(\xi_j)$ denotes the distribution of worker types in firm j in the beginning of period 1, $f_{jt}(\xi_j)$ denotes the marginal distribution of workers remaining in the cohort at the end of period t[2]. .

I consider the labor market experiences of a cohort of workers, who enter the firm at the same time, in solving the firm's profit maximization problem. The firm cannot observe the productive inefficiency of each worker in the cohort, so it cannot observe whether each worker is working or shirking. However, the firm observes the marginal distribution of productive inefficiencies within the firm, $f_{jt}(\xi_j)$, and the threshold level of productive inefficiency in each period, ξ_{jt}. Thus, the firm can determine the average productivity in a cohort, given by $F_{jt}(\xi_{jt})$. This assumption is plausible since firms are likely to observe the total output produced by a cohort of workers while they may not perfectly observe each worker's contribution to the total output.

Due to the zero profit condition, the firm pays the members of the cohort the value of the expected productivity in the cohort. As a result, everyone in the cohort earns the same wage although they make different effort decisions based on their productive inefficiency. The wage that firm j offers to the members of a cohort in period t of their employment is given by Equation 8[3]:

$$w_{jt} = \rho_j \cdot e^{-\frac{\gamma}{t}} \cdot F_{ij}(\xi_{jt}) \tag{8}$$

where $F_{jt}(\xi_j)$ is the cumulative distribution function of worker types remaining in firm j in the beginning of period t. Equation 8 shows that the upper bound on the wage sequence as $t \to \infty$ is the output price, ρ_j.

[2] The cdf of worker types remaining in the cohort at the end of period t in firm j can be expressed in terms of the cdf of worker types in firm j in period one. In particular, when the sequence of the ξ_{jt} is increasing, the relationship between $F_{jt}(\xi_{jt})$ and the original population distribution, $F_{j,t=1}(\xi_j)$ is given by the following equation (Flinn, 1997): $F_{jt}(\xi_{jt}) = 1 - \left(1 - F_{j,t=1}(\xi_{jt})\right) A_{jt}\left(\left\{\xi_{js}\right\}_{s=1}^{t-1}\right)$ where $A_{jt}\left(\left\{\xi_{js}\right\}_{s=1}^{t-1}\right) = \left\{1 + \frac{\pi_j}{(1-\pi_j)^{t-1}} F_{j,t=1}(\xi_{j,t=1}) + \cdots + \frac{\pi_j}{1-\pi_j} F_{j,t=1}(\xi_{j,t-1})\right\}^{-1}$

[3] The wage contracts described in this paper are individual wage contracts. Wage contracts that depend on group output are not considered.

The Nash equilibrium wage sequence is defined as the fixed point of the following operator:

$$T(\{w_{jt}\}) = \begin{bmatrix} \rho_j F_{j,t=1}(\xi_{j,t=1}) \\ \rho_j F_{j,t=2}(\xi_{j,t=2}) \\ \vdots \\ \rho_j F_{j,t=\tau}(\xi_{j,t=\tau}) \\ \vdots \end{bmatrix} \tag{9}$$

where ξ_{jt} is given by Equation 4. The fixed points of $T(\{w_{jt}\})$ gives the equilibrium wage sequence in firm j *conditional* on $F_{j,t=1}$, which is the marginal distribution of ξ_j in firm j. Let ν_j and ω_j be the parameters that characterize $F_{j,t=1}$. The parameters of the post-selection marginal distributions in each firm, $F_{j,t=1}$ and $F_{k,t=1}$, are in turn fixed points of the operator given in Equation 10, which completes the characterization of the equilibrium in this model.

$$\begin{bmatrix} F_{j,t=1}(\nu_j, \omega_j) \\ F_{k,t=1}(\nu_k, \omega_k) \end{bmatrix} = \begin{bmatrix} \int\limits_0^\infty \frac{h_j(\xi_j)}{H_j(\xi^*(w_1(F_{j,t=1}(\nu_j,\omega_j)), w_2(F_{k,t=1}(\nu_k,\omega_k))))} dH_k(\xi_k) \\ \int\limits_0^\infty \frac{h_k(\xi_k)}{H_k(\xi^*(w_1(F_{j,t=1}(\nu_j,\omega_j)), w_2(F_{k,t=1}(\nu_k,\omega_k))))} dH_j(\xi_j) \end{bmatrix} \tag{10}$$

Every iteration in solving the fixed point problem in Equation 10 involves the computation of the equilibrium wage sequence; therefore, the algorithm to compute the fixed points of $T(\{w_{jt}\})$ is nested with the fixed point algorithm to compute the parameters of $F_{j,t=1}(\xi_j)$ and $F_{k,t=1}(\xi_k)$.

This equilibrium has several important features. First, the equilibrium wage sequence in firm j depends not only on the parameters of firm j , such as ρ_j, γ_j, and π_j, but also on parameters characterizing firm k. This result can be seen in Equation 9, in which F_{jt} depends on the wages and the monitoring rate in firm k. Intuitively, this result captures the fact that when workers select firm types, they take into account the wages and monitoring rates in both types of firms. Therefore, the marginal distribution of workers in a given firm depends on the wages and monitoring rates observed in the entire primary sector.

The second feature of this equilibrium is that the equilibrium wage sequence is monotonically increasing over time due to the systematic dismissal of relatively inefficient workers. In each period, a proportion of relatively inefficient workers, who choose to shirk, are dismissed. Therefore, the remaining cohort is made up of a lower proportion of relatively inefficient workers. As the average productive inefficiency in the cohort falls, the average productivity and wages, which equal the value of average productivity in the cohort, rise.

Furthermore, a worker's effort decision is not constant over time. With wages monotonically increasing over time, different workers stop shirking at different times depending on their productive inefficiency indices, with high productivity workers (low productive inefficiency workers) deciding to put forth effort earlier than others.

Finally, the system in Equation 9 is not recursive. Although ξ_{jt} depends only on the wage sequence starting in period $t+1$, F_{jt} depends on the entire wage sequence, $\{w_{jt}\}_{t=1}^{\infty}$.

The appendix discusses the computation of the equilibrium wage sequences.

2.3 Human Capital Accumulation by Non-Shirkers Only (HC2)

In the second specification of the model, I assume that only workers who have exerted effort in previous periods accumulate human capital and experience an increase in their productivity in future periods. This type of human capital accumulation, in which only non-shirkers enhance their future productivity, might be more plausible especially if the human capital accumulation is derived by learning-by-doing. The production function in this case is given by Equation 23.

$$y_{ijt} = \left\{ \begin{array}{c} e^{\frac{-\gamma_j}{\tau}} \text{ if } e_{it} \geq \xi_{ij} \\ 0 \text{ otherwise} \end{array} \right\}$$

where τ is the number of periods in which the worker has exerted effort.

The rules that govern workers' effort decisions and firm choices are the same as those in the HC1 case, and they are states in Equations 3 and 5, respectively. In order to define the wage contract under this specification, we have to examine the effort choices of workers in previous periods. Consider a cohort of workers who have started their employment at the same time. Let F_{jt} define the cdf of worker types for workers still remaining in the cohort in the beginning of period t. Then, $F_{j,t=1}(\xi_{j,t=1})$ gives the proportion of workers who have put forth effort during all t periods of employment since these are the workers who have decided to exert effort in period 1 and therefore in all future periods. $\left(F_{j,t=2}(\xi_{j,t=2}) - F_{j,t=1}(\xi_{j,t=1})\right)$, on the other hand, is the proportion of workers who have decided to shirk in the first period and work in periods 2 and more. These workers have exerted effort in $t-1$ periods of their employment. This kind of reasoning leads to the following wage contract offered by a zero-profit, type j firm.

$$\begin{aligned} w_{jt} = \rho[e^{-\frac{\gamma_j}{t}} \cdot F_{jt}(\xi_{j,t=1}) + e^{-\frac{\gamma_j}{t-1}} \cdot \left(F_{jt}(\xi_{j,t=2}) - F_{jt}(\xi_{j,t=1})\right) + \\ e^{-\frac{\gamma_j}{t-2}} \cdot \left(F_{jt}(\xi_{j,t=3}) - F_{jt}(\xi_{j,t=2})\right) + ... + e^{-\frac{\gamma_j}{1}} \cdot \left(F_{jt}(\xi_{j,t}) - F_{jt}(\xi_{j,t-1})\right)] \quad (11) \end{aligned}$$

The wage sequence is bounded above by the output price, ρ_j, and the equilibrium wage sequence can be found by using the fixed point algorithm given in the Appendix.

3 Representative Simulations

In this section, I present results of representative simulations that are aimed at demonstrating some of the properties of the model. In practice, I have found the equilibrium results of HC1 and HC2 to be very similar under various parameter values, so I apply the HC1 model in this section to demonstrate the workings of the model. The model of self-selection under asymmetric information, which is described in this paper, exhibits properties that are similar to a standard self-selection model of symmetric information, in which workers with two-dimensional types sort between two sectors. First, in the model presented here, the covariance between the random variables defining a worker's type in each sector plays an important role in determining the selection pattern as it does in a standard sectoral choice model. In Figures 1a-2b, I compare the post-selection marginal distribution of worker's productive inefficiency index in each firm to the population marginal distributions. The parameters used in these simulation exercises are given in Table 1. Figures 1a-2b show that when the correlation coefficient between ξ_1 and ξ_2 is highly negative, selection into both firms tend to be positive. In other words, workers with low productive inefficiency in a given firm are likely to choose that firm while workers with high inefficiency in a given firm tend to choose the other firm. This result is expected since a negative correlation between ξ_1 and ξ_2 means that workers who have high ability in a given firm tend to have low ability in the other firm, leading workers to choose the firm in which they have an absolute advantage. When the two random variables are strongly positively correlated, selection pattern changes considerably. Selection into Firm 1 is still positive but it is not as strong as the case with negative correlation. On the other hand, selection pattern into Firm 2 is mixed. Workers with low productive inefficiency in Firm 2 tend to choose Firm 1 as well as workers with very high productive inefficiency in Firm 2. The net effect of this mixed selection on the average worker productivity in Firm 2 depends on which one of the opposing effects dominate.

The equilibrium wage and dismissal sequences that result under the two correlation coefficients are consistent with these results as shown in Table 2. Wages are higher and dismissal rates are lower in the case of negative correlation compared to the positive correlation case because the likelihood that workers with low productive inefficiency indices in a given firm choose that firm is higher when the correlation coefficient is negative. When ξ_1 and ξ_2 have a strong positive correlation in the population, the diminished degree of positive selection into Firm 1 and the negative selection into Firm 2 result in higher prevalence of shirking and consequently lower wages and higher dismissal rates in both firms.

Another property of the equilibrium is that due to occupational self-selection, parameters characterizing one firm influence the outcomes observed in both firms. I demonstrate this property by presenting the changes in equilibrium wages and dismissal rates when the Firm 2 monitoring rate increases from 0.1 to 0.2. As shown in Tables 3a and 3b, a higher monitoring rate in Firm 2 leads to lower wages in Firm 1 and higher wages in Firm 2. This result indicates that the proportion of shirkers in Firm 1 increases and that in Firm 2 decreases as a result of a higher Firm 2 monitoring rate. An increase in the Firm 2 monitoring rate discourages potential shirkers in that firm (workers with high ξ_2) from choosing that firm, leading to higher average productivity in Firm 2. Due to the positive correlation between ξ_1 and ξ_2, workers with high ξ_2, who are now more likely to choose Firm 1, tend to come from the higher end of the ξ_1 distribution in the population. As a result, average productivity in Firm 1 falls, leading to a decrease in wages. The adverse selection into Firm 1 due to the higher monitoring rate in Firm 2 also explains the higher dismissal rates that result in that firm under a higher π_2. On the other hand, a higher monitoring rate in Firm 2, initially increases the dismissal rate in that firm as shirkers are detected and dismissed more frequently. However, Firm 2 dismissal rates fall rapidly over time due to the fact that shirkers are eliminated much faster when π_2 is high.

4 Estimation

I estimate the structural parameters of the model using maximum likelihood. The data used in the estimation procedure consist of workers' occupational choices, wages, and information on whether they were dismissed in each period. Before specifying the likelihood function, I will discuss several empirical issues that are addressed in mapping the theoretical model to the data.

First, I translate workers' selection of firm types in the model to selection of occupations through the assumption that firm j employs only white-collar workers and firm k employs only blue-collar workers. This characterization applies to a labor market in which the white-collar and blue-collar workers employed in a firm produce separate goods and have no interaction in the production process. Furthermore, the monitoring technologies involved in monitoring white-collar workers are different from the monitoring technology for blue-collar workers.

Second, the model predicts that workers with the same tenure in a given occupation earn the same wage. In order to account for the variation in wages observed among workers of same tenure in an occupation, I add measurement error to wages. The measurement error takes on the following form:

$$\begin{aligned} \ln w_{ijt} &= \ln w^*_{jt} + \varepsilon_t \\ \ln w_{ijt} &= \ln ws_j + \varepsilon_t \end{aligned} \tag{12}$$

where w_{ijt} is the reported wage, w^*_{ijt} the primary sector wage predicted by the model, and ws_j is the secondary sector wage of a worker dismissed from primary sector firm j. ε_t is independently and identically distributed over time according to a normal distribution with mean zero and standard deviation, σ_ε.

Another issue that should be addressed in the estimation is the number of dismissals per worker. According to the model, a worker experiences only one dismissal due to malfeasance in his labor market career. Yet, roughly 26 percent of the sample report having more than one dismissal. In cases of multiple dismissals over a labor market career, I assume that the first dismissal that the worker experiences during the sample period is due to shirking. In addition, I allow for the possibility of exogenous dismissals, which do not depend on workers' behavior. Dismissals that are due to a negative demand shock fall into this category. I assume that in each period, *conditional* on not having been dismissed for cause, primary sector workers face a constant probability of dismissal for reasons exogenous to their behavior, such as demand fluctuations. I further assume that primary sector firms are able to differentiate between workers who are dismissed due to exogenous reasons and those who have been dismissed for cause. The workers who have experienced exogenous dismissals are able to immediately find a new job in the primary sector, and they are admitted to the cohort from which they have been dismissed. As as result, exogenous dismissals do not affect either the worker's welfare or the firm's profit function. These exogenous dismissals may be interpreted as temporary layoffs which result in immediate new work for workers who experience them.

In particular, I assume that conditional on not being dismissed for cause, a worker in firm j faces a constant probability, λ_j of being dismissed for reasons unrelated to his behavior. In other words, the relationship between for-cause type dismissals and exogenous dismissals are given by

$$\Pr(d^e_{ijt} = 1 | d^*_{ijt} = 0) = \lambda_j$$

and

$$(d^e_{ijt} = 1 | d^*_{ijt} = 1) = 0$$

where d^e denotes an exogenous dismissal and d^* indicates a for-cause dismissal. Since I assume that workers find immediate work in the primary sector after an exogenous dismissal, this formulation does not affect the welfare of the worker or the profits of the firm, and the characterization of the equilibrium in this model is the same as the one in Equations 9 and 10. However, the addition of exogenous dismissals affects the likelihood function, which is discussed below. After a for-cause dismissal, workers enter the secondary sector. Dismissals in the secondary sector are assumed to have no effect on workers' welfare. When a dismissal is reported in the primary sector, it may be due to shirking or due to exogenous reasons. However, when no dismissal is reported, neither for-cause dismissal nor exogenous dismissal is experienced by the worker.

Furthermore, workers can experience in the secondary sector, but they are assumed to find a new job immediately after a secondary sector dismissal. Therefore, dismissals in the secondary sector do not have any effect on workers' welfare and the specification of the likelihood function.

Finally, I assume that workers types in the population are distributed according to a bivariate lognormal distribution, characterized by the following parameters: $\mu_j, \mu_k, \alpha_j, \alpha_k$, and α_{jk}. The existence of a unique equilibrium wage sequence among the class of increasing wage sequences requires the distribution function of productive inefficiency to be concave. The lognormal distribution satisfies the concavity condition.

The likelihood function requires the numerical computation of equilibrium wages based on the model's parameters, according to the algorithm included in the appendix. The equilibrium wage sequence, together with the parameters of the model, can then be used to calculate the likelihood function as described below.

Let θ be the set of the model's parameters. Then, the likelihood contribution of sample member i working in sector j is given by

$$L_i = \Pr(V_j > V_k, \{\ln w_{ijt}\}, \{d_{ijt}\}; \theta) = \Pr(V_j > V_k, \{\ln w_{ijt}\} | \{d_{ijt}\}; \theta) \cdot \Pr(\{d_{ijt}\}; \theta) \quad (13)$$

where V_j is the value of working in occupation j, $\{w_{ijt}\}$ is the worker's reported wage sequence and $\{d_{ijt}\}$ is his reported dismissal history, indicating whether he has been dismissed or not in each period of employment. The difference between the two model specifications (HC1 and HC2) is in the computation of the equilibrium wage contract in each case.

The addition of exogenous dismissals directly affects the likelihood function requires consideration of the probability of a reported dismissal conditional on the worker's history of dismissal for-cause. Then, the likelihood contribution of worker i is given by

$$L_i = \sum_{\{d^*_{ijt}\} \in D^*} \Pr(V_j > V_k, \{\ln w_{ijt}\}, \{d_{ijt}\} | \{d^*_{ijt}\}) \cdot \Pr(\{d^*_{ijt}\})$$

where $\{d_{ijt}\}$ is the reported dismissal sequence, $\{d^*_{ijt}\}$ is the for-cause dismissal sequence, and D^* is the set $\left\{ d^*_{ijt} = 1, \sum d^*_{ijt} = 0 \right\}$. Conditional on $\{d^*_{ijt}\}$, the stochastic process governing occupational choice, the measurement error in wages (ε_t) and the exogenous dismissals are independent. Therefore, worker i's likelihood contribution can be stated as

$$L_i = \sum_{\{d^*_{ijt}\} \in D^*} \Pr(V_j > V_k | \{d^*_{ijt}\}) \cdot \Pr(\{\ln w_{ijt}\} | \{d^*_{ijt}\}) \cdot \Pr(\{d_{ijt}\} | \{d^*_{ijt}\}) \cdot \Pr(\{d^*_{ijt}\}) \quad (14)$$

The first component in the likelihood contribution is given in Equations 15 and 17. The probability that a worker has chosen occupation j conditional on having no dismissals over T periods is

$$\Pr(V_j > V_k | \sum_{t=1}^{T} d_{ijt} = 0) = (1 - \pi_j)^T \iint I(\xi^*_j(\xi_k) \geq \xi_j > \xi_{j,t=T} | \xi_k) \cdot dH(\xi_j, \xi_k) \quad (15)$$

$$+ (1 - \pi_j)^{T-1} \iint I(\xi^*_j(\xi_k) \geq \xi_j | \xi_k) I(\xi_{j,t=T} < \xi_j \leq \xi_{j,t=T-1}) \cdot dH(\xi_j, \xi_k)$$

$$+ \cdots + \iint I(\xi^*_j(\xi_k) \geq \xi_j | \xi_k) * I(\xi_j < \xi_{j,t=1}) dH(\xi_j, \xi_k) \quad (16)$$

The probability that a worker has chosen occupation j conditional on his being dismissed in period T is

$$\Pr(V_j > V_k | d_{ij,t=T} = 1) = (1 - \pi_j)^{T-1} \pi_j \iint I(\xi^*_j(\xi_k) \geq \xi_j > \xi_{j,t=T} | \xi_k) dH(\xi_j, \xi_k) \quad (17)$$

The bivariate integral in the above equation is numerically evaluated for each individual.

The probability of the wage sequence conditional on having no dismissals over T periods is

$$\Pr(\{\ln w_{ijt}\} | \sum_{t=1}^{T} d^*_{ijt} = 0) = \sigma_\varepsilon^{-T} \prod_{t=1}^{T} \phi\left(\frac{\ln w_{ijt} - \ln w^*_{ijt}}{\sigma_\varepsilon}\right) \tag{18}$$

The probability of the wage sequence for a worker who has been dismissed at the end of period T and has spent T^s periods in the secondary sector is given by

$$\begin{aligned}\Pr(\{\ln w_{ijt}\} | d^*_{ij,t=T} &= 1) = \sigma_\varepsilon^{-T} \prod_{t=1}^{T} \phi\left(\frac{\ln w_{ijt} - \ln w^*_{ijt}}{\sigma_\varepsilon}\right) \\ &\cdot \prod_{t=T+1}^{T^s} \phi\left(\frac{\ln w_{ijt} - \ln ws_{ij}}{\sigma_\varepsilon}\right)\end{aligned} \tag{19}$$

where ϕ is the pdf of a standard normal variable.

The process governing exogenous dismissals conditional on $\{d^*_{ijt}\}$ can be stated by the following equations.

$$\Pr(\sum_{t=1}^{T} d_{ijt} = 0 | \sum_{t=1}^{T} d^*_{ijt} = 0) = (1 - \lambda_j)^T \tag{20}$$

$$\Pr(d_{ijT} = 1 | \sum_{t=1}^{T} d^*_{ijt} = 0) = \lambda_j (1 - \lambda_j)^T$$

$$\Pr(d_{ijt} = 1 | d^*_{ijt} = 1) = 1$$

Note that $\Pr(\sum_{t=1}^{T} d_{ijt} = 0 | d^*_{ijt} = 1)$ is equal to zero, and therefore that case is not considered.

Finally, the probability of the for-cause dismissal sequence $\{d^*_{ijt}\}$ is

$$\begin{aligned}\Pr(\sum_{t=1}^{T} d^*_{ijt} = 0) &= F_j(\xi_{j,t=1}) + (1 - \pi_j)\left[F_j(\xi_{j,t=2}) - F_j(\xi_{j,t=1})\right] + \cdots \\ &+ (1 - \pi_j)^{T-1}\left[F_j(\xi_{j,t=T}) - F_j(\xi_{j,t=T}) + (1 - \pi_j)^T \left[1 - F_j(\xi_{j,t=T})\right]\right]\end{aligned} \tag{21}$$

$$\Pr(d^*_{ijt} = 1) = \pi_j (1 - \pi_j)^{t-1}\left[1 - F_j(\xi_{jt}),\right] j = 1, ...T - 1$$

5 Data

5.1 The Sample

The sample used in the estimation is constructed from the National Longitudinal Survey of Youth (NLSY), which is a survey of individuals who were between the ages of 14-22 when they were first interviewed in 1979. Since then, the respondents have been interviewed annually until 1994 and once every two years after 1994. At the time of the analysis, 19 waves of the NLSY were available from 1979 to 2000.

One of the strengths of the NLSY compared to other longitudinal datasets is the detailed employment information that it collects. It includes the beginning and end dates of up to five jobs that the respondent has had in a year. Therefore, a relatively more accurate date of transition into the labor market can be established and job tenure can be fully captured. In addition, it includes data on usual hours worked, number of weeks worked, the hourly rate of pay, the three-digit industry and occupation codes, and the reason for separation from the job.

The model makes certain predictions about wages and dismissal rates among workers who have worked the same number of years in their first occupation. Therefore, the beginning of one's labor market career needs to be determined for the empirical analysis. Following Farber (1994), I assume that a worker's labor market career starts when he makes a permanent transition into the labor force. According to this definition, a permanent labor market transition occurs in the beginning of the first 3-year spell of "primarily working," following at least one year in which the worker was "not primarily working"[4]. A worker is defined to be primarily working if he has worked at least half of the weeks since the last interview and averaged at least 30 hours per week during the weeks in which he worked. The sample includes only workers who have made a permanent transition into the labor force during the sample period. Consequently, people who have never worked primarily for three consecutive years during the sample period and those who were primarily working in the first year in which they were observed in the dataset are excluded from the sample. Restricting the sample to those who have made a long-term transition into the labor market during the sample period not only mitigates the initial condition problem, but also allows one to focus on workers' permanent labor market careers. Furthermore, I exclude workers who have started their labor market careers before the age of 16.

Only jobs that start after the worker's permanent labor market transition are included in the sample. In addition, jobs without valid data on wage, occupation and reason for separation are excluded. The occupation data are collected for jobs that last for at least 9 weeks; as a result, jobs with shorter tenure are excluded from the sample.

The discrete period of analysis is an interview year, which spans the time between two consecutive interviews and is approximately equal to one calendar year. The sample includes the first 8 years of a worker's labor market history beginning with his permanent transition into

[4] Farber (1994) and Farber and Gibbons (1991) show that the definition of permanent labor force entry is able to define a sharp transition from non-work to work.

the labor force. Since the dataset has information on up to 5 jobs per year and the job tenure is in weeks, I use the following rules to construct the variables used in the analysis.

Occupation: I categorize occupations into blue-collar or white-collar based on one-digit census codes[5]. The worker's occupation in a given year is the one in which he has worked the most number of hours. For multiple job holders, the jobs that are not in the worker's assigned occupation are excluded from the analysis. For example, if a multiple job holder has worked the most number of hours in the white-collar occupation in a given year, any blue-collar job that he may have had during that year is excluded. Formulating the two types of primary sectors as white-collar and blue-collar occupations in the estimation carries the underlying assumption that workers use different types of skill sets in different occupations and that jobs within each occupation are homogeneous with respect to their output prices and monitoring rates. Increasing the number of occupational categories would probably capture skill heterogeneity and firm heterogeneity more accurately; however, the computational burden would also increase.

Wages: I use hourly wages in 2000 dollars. For multiple job holders, I calculate the weighted average of wages in the worker's occupation by multiplying each wage by the number of hours worked in each job and dividing the total earnings by the total number of hours worked in occupation.

Dismissals: If the worker has reported a firing or lay-off during an interview year, he is considered to have experienced a dismissal at the end of that year. I consider layoffs as dismissals in this analysis because there might be arbitrariness involved in a worker's self-reporting. He may choose to report a firing as lay-off due to the stigma that might be associated with a firing. Furthermore, a portion of the workers who were dismissed during a lay-off might be those that are the least productive and that would be fired in any event. Although it is quite difficult to accurately measure dismissals, this is probably the best definition given the available data. If the worker reports a quit and takes on another job in the same occupation following the quit, I treat the tenure in that sector as uninterrupted. If the worker becomes unemployed during the sample period, I only consider his experience until he enters unemployment.

Furthermore, about 20 percent of the individuals in the sample report switching to jobs in a different occupation before their first dismissal. The theoretical model does not inter-occupational moves while in the primary sector; therefore, I include only his labor market experience until he switches occupations in the analysis sample.

5.2 Descriptive Statistics

After I impose the criteria described in the previous subsection, the resulting sample includes 5391 individuals. 2059 (38%) of these individuals are employed in the white-collar occupation in

[5] White collar occupations are 1) professional, technical, and kindred; 2) managers, officials, and proprietors; 3) sales workers; 4) farmers and farm managers; and 5) clerical and kindred. Blue collar occupations are 1) craftsmen, foremen, and kindred; 2) operatives and kindred; 3) laborers, except farm; 4) farm laborers and foremen; and 5) service workers.

the first year of their labor market careers; and they remain in the white-collar sector until their first dismissal or occupation switch. The remaining 3332 (62%) are employed in the blue-collar sector.

Table 2 shows the observable sample heterogeneity in terms of age and education at the start of the labor market career. These statistics suggest that blue-collar workers start their long-term labor market careers earlier than white-collar workers. 45 percent of blue-collar workers make a permanent transition into the labor market between the ages of 16-18 while only 32 percent of white-collar workers start their labor market careers before they turn 19. A possible reason for this difference is reflected in the educational composition of the labor force in the two occupations. Approximately 83 percent of the blue-collar workers have at most a high school degree at the beginning of their permanent labor market careers. On the other hand, white-collar employees are relatively more educated when they start their careers, with 41 percent having more than a high school degree.

Dismissal rates and average log wages in each occupation conditional on the sample period are given in Table 3. Dismissal rates are calculated by dividing the total number of people with dismissals in a given period over the total number of people remaining in the sample in that period. Dismissal rates in both occupations follow a general downward trend over time, except for the second period of employment among blue collar workers. This pattern is consistent with the model's prediction that dismissal rates fall in the primary sector because over time a smaller proportion of the people remaining in the cohort choose to shirk. The blue-collar sector has higher dismissal rates over the first eight years in the occupation. The average white collar dismissal rate during this period is about 5 percent while the average blue collar dismissal rate is roughly 10 percent.

6 Results

6.1 Parameter Estimates

Table 6 presents the parameters estimates of the two model specifications considered in this paper as well as the associated asymptotic standard errors. Parameter estimates of the model according to the HC2 specification are very close to those of the HC1 specification; therefore, here I discuss the findings according to the HC1 model. Similar conclusions hold when the HC2 model estimates are considered. According to the estimates of the HC1 model, which assumes that workers experience human capital growth over tenure regardless of their effort decisions, white collar output price is 15.34 while the blue collar output price is 13.61. These parameters can be interpreted as the upper bounds on the wage sequences in the two occupations. γ_1, which determines the rate of human capital accumulation in the white collar occupation is higher than that in the blue collar occupation, suggesting that white collar workers experience higher productivity growth over their tenure than blue collar workers. Furthermore, the white collar monitoring rate is estimated to be 0.32, and the blue collar monitoring rate estimate is

0.25. According to these estimates, white collar workers face a higher probability of being monitored by their supervisors than blue collar workers.

The model estimates for the mean and variance of log ξ_1 in the population are 2.10 and 1.21, where ξ_1 indicates the white collar inefficiency index. The population marginal distribution of log ξ_2 is characterized by a mean of 2.46 and a variance of 0.90. The covariance between log ξ_1 and log ξ_2 in the population is estimated to be 0.87, yielding a correlation coefficient of 0.92. After workers select into occupations, the marginal distribution of log ξ_1 among white collar workers have a mean and variance of 2.05 and 1.25, respectively. On the other hand, the mean and variance of log ξ_2 among blue collar workers are 2.11 and 0.49. The pattern of selection is shown in Figures 7 and 8. Figure 7 reveals that there is evidence of a slight positive selection into the white collar occupation as workers with low values of log ξ_1 have a slightly higher likelihood of choosing the white collar occupation while workers with high values of log ξ_1 are slightly less likely to choose the white collar occupation. The pattern of selection into the blue collar occupation, on the other hand, is mixed. Figure 8 shows that both workers with values of log ξ_2 greater than the population mean and those with very low log ξ_2 have a lower likelihood of choosing the blue collar occupation. As workers at both ends of the population log ξ_2 distribution avoid the blue collar occupation, the net effect of this selection on blue collar wages and dismissal rates would be determined by which one of these two opposing effects dominates.

Finally, the blue collar occupation has a higher exogenous dismissal rate than the white collar occupation, suggesting that blue collar workers face a higher probability of being dismissed due to reasons other than lack of effort compared to white collar workers.

6.2 Equilibrium Wages and Dismissal Rates

Figures 3 and 4 present the dismissal rates that would arise in equilibrium in the HC1 and HC2 models according to the parameter estimates given in Table 6. Dismissal rates under both specifications follow a downward trend as dictated by the model's implication that the proportion of the workforce that is shirking decreases over time due to systematic dismissal of shirking workers. The dismissal rates predicted by the HC1 specification seem to be slightly higher than those given by the HC2 model. The wage sequences predicted by the two models are quite close as shown in Figures 5 and 6. Predicted wages are monotonically increasing over tenure in the occupation as implied by the model. The wage profiles are also concave as a result of the lower dismissal rates in later years. Since the dismissal rate is an important source of wage growth in this model, lower dismissal rates lead to lower wage growth as the tenure in occupation increases.

In this section, I also consider the model's fit to the wage and dismissal rate data in the blue collar and white collar occupations. Figures 3 and 4 present the dismissal rates that would arise in equilibrium defined by the parameter estimates given in Table 6 and compare them to the observed dismissal rates in each occupation. As presented in these Figures, the dismissal rates predicted by the HC1 and HC2 models are quite similar; however, the HC1 dismissal rates seem to be closer to the observed dismissal rates in both occupations. Similarly, the wage sequences predicted by the two models are also very close, but the white collar wages predicted by the HC1 specification seem to fit the data better, as shown in Figures 5 and 6.

6.3 The Effect of Self-Selection on Equilibrium Wages and Dismissal Rates

I use the HC1 model's parameter estimates to evaluate the impact of self-selection on the wages and dismissal rates in the two occupations. In particular, I compare the wages and dismissal rates that are predicted by the self-selection model with those that would result if workers were randomly assigned to different occupations. In the latter case, the workforce in each sector would be a random draw from the population. The equilibrium wages and dismissal rates in the random assignment case are calculated by setting the parameters of the marginal distributions in each occupation to the population parameters. Table 8 compares the equilibrium wages in the self-selection model to those that would result if workers in each occupation are randomly drawn from the population. Results indicate that the random assignment of workers leads to lower wages in both white collar and blue collar occupations when compared to the equilibrium wages with self-selection. Higher wages under self-selection compared to the random assignment case signal that workers' selection into occupations decreases the prevalence of shirking and thus increases the expected productivity in both occupations. These results provide further evidence for the above finding that there is positive selection into the white collar occupation in the sense that the expected worker productivity in the white collar occupation rises as a result of self-selection. The previous section also documents the evidence of negative selection into the blue collar occupation at low levels of ξ_2 and positive selection at high levels of ξ_2. The net effect of these two types of selection on blue collar wages seems to be positive as blue collar wages under self-selection are higher than those under the random assignment of workers. Therefore, workers' sorting into occupations leads to higher average productivity in both blue collar and white collar occupations.

The existence of self-selection also affects the dismissal rates observed in the labor market. As shown in Table 9, dismissal rates are lower in both occupations when compared to the case in which workers are randomly assigned to occupations. Lower dismissal rates as a result of self-selection provide further support for the finding that workers' selection into occupations leads to lower incidence of shirking and thus higher expected productivity in both occupations.

6.4 The Effect of Human Capital Accumulation on Dismissals Rates

In this subsection, I conduct a comparative static exercise in order to better understand the effect of human capital accumulation on equilibrium wages and dismissal rates that are estimated by the HC1 model. I compute the dismissal rates that would arise in equilibrium when the human capital accumulation parameter in the white collar occupation (γ_1) increases to 1.2. An increase in γ_1 could occur if the white collar jobs increased their on-the-job training opportunities or if a shock to the production technology in this sector required relatively more firm-specific human capital. According to the results shown in Table 10, an increase in γ_1 leads to lower dismissal rates in the white collar occupation and higher dismissal rates in the blue collar occupation. These results suggest that a higher human capital accumulation rate changes the selection pattern in such a way that it decreases the proportion of shirkers in the white collar occupation and increases the prevalence of shirking in the blue collar occupation.

In order to demonstrate the effect of an increase in γ_1 on the pattern of selection into occupations, I compare the marginal distribution of worker types in each occupation after selection to the marginal distributions in the population. According to the results presented in Figures 7-10, an increase in γ_1 significantly increases the degree of positive selection into the white collar occupation. When the rate of human capital accumulation in the white collar occupation rises, workers at the lower end of the ξ_1 distribution become much more likely to choose the white collar occupation. Since these workers are those who are likely to exert effort, their decision to go into the white collar occupation decreases the prevalence of shirking in that sector. In contrast, a higher γ_1 increases the degree of negative selection into the blue collar occupation as workers with high ξ_2 become more likely to choose the blue collar occupation. Since these workers are potential shirkers as blue collar workers, their decision to go into the blue collar occupation increases the incidence of shirking and thus the dismissal rates in that sector.

The change in the selection pattern as a result of a higher γ_1 can be explained by the following argument. An increase in the opportunities for human capital accumulation in the white collar occupation means that workers get lower wages in the earlier periods as they obtain training or other forms of human capital investment. This decrease in wages in the early periods discourages workers who are likely to shirk in the white collar occupation because shirkers discount the value of future employment more heavily than non-shirkers due to their probability of dismissal. Since ξ_1 and ξ_2 are positively correlated in the population, workers who are likely to shirk in the white collar occupation are also likely to shirk in the blue collar occupation. As these workers move to blue collar jobs, the proportion of workers who shirk decreases among white collar workers while it increases among blue collar workers.

The implications of this sorting pattern on dismissal rates are clear. As average productivity in the white collar occupation rises due to a higher rate of human capital accumulation in the white collar occupation, white collar dismissal rates fall. On the other hand, the increase in the proportion of shirkers in the blue collar occupation leads to higher dismissal rates in that occupation.

The implications of a higher rate of human capital accumulation in the white collar occupation on the dismissal rates in that occupation are consistent with the outcomes that are predicted by the standard human capital model within a job matching framework. When dismissals are modeled as resulting from low worker-firm match value, an increase in the opportunities for human capital growth in the white collar sector would lead to lower dismissals among white collar workers. The reason for this result is that a higher rate of human capital investment increases the value of the current match relative to the outside options, thus decreasing the likelihood of the match ending in separation. The comparative static exercise in this section reveals that a model of occupational choice with moral hazard and human capital growth provides an alternative explanation for the same result.

7 Conclusion

In this paper, I present a model of occupational choice in a labor market with moral hazard and human capital accumulation. The moral hazard problem is characterized by a shirking model in which dismissals are used by firms as a form of punishment for shirking. The human capital accumulation is described by an exogenous parameter that determines a worker's productivity growth over time in a deterministic way. In such a labor market, workers make two types of decisions: i) occupational choice decision between two occupations, and ii) work/shirk decision in each period of employment. The model demonstrates that workers' occupational choices depend on their effort decisions, and therefore, an analysis of the consequences of self-selection in this labor market requires the examination of both decisions simultaneously. The main difference between occupational self-selection under symmetric information and occupational choice under asymmetric information is that in the latter case occupation-specific worker abilities, which determine both disutility of effort and propensity to shirk, affect occupational selection not only through their effect on workers' comparative advantage but also through their effect on workers' effort decisions.

I estimate the structural model using maximum likelihood and data from the National Longitudinal Survey of Youth. The results show that the model of occupational choice with moral hazard and human capital accumulation does a very good job of fitting observed data on dismissal rates in white collar and blue collar occupations. The parameter estimates suggest that the higher monitoring rate in the white collar sector and the probability of dismissals that are due to labor demand shocks is higher among blue collar workers. Furthermore, the model estimates a higher rate of human capital accumulation in the white collar occupation, providing evidence for the existence of more opportunities for specific human capital growth in white collar jobs.

Furthermore, I analyze the impact of a higher human capital accumulation rate in the white collar sector. Such an increase would occur if the white collar jobs increased their on-the-job training opportunities or if a shock to the production technology in this sector required relatively more firm-specific human capital. The analysis results suggest that increased opportunities for human capital growth in the white collar occupation increases positive selection into the white collar occupation and negative selection into the blue collar occupation. As a result, this change would lead to lower dismissal rates among white collar workers and higher dismissal rates among blue collar workers. Finally, when the labor market has a moral hazard problem and productivity growth due to human capital accumulation, occupational self-selection brings about higher wages and lower dismissal rates in both occupations compared to an economy with identical parameters but one in which workers are randomly assigned to each occupation.

The model presented in this paper is aimed at providing an alternative explanation for the difference in dismissal rates across occupations. The estimation results show that the model does a good job of explaining the observed data on dismissal rates and wages, and the empirical analysis shows the implications of occupational self-selection and occupation-specific rates of human capital accumulation on dismissal rates. This work can be extended by explicitly modeling the determination of the monitoring rate or the human capital accumulation parameter, and by adding uncertainty to the environment.

8 Appendix

The computation of the equilibrium wage contract consists of two sets of fixed point iterations, one nested in the other. Let (ν_j, ω_j) be the set of parameters that characterize the post-selection marginal distribution of ξ_j in occupation j. Then, (ν_j, ω_j) and (ν_k, ω_k) are the fixed points of the following operator:

$$\begin{bmatrix} (\nu_j, \omega_j) \\ (\nu_k, \omega_k) \end{bmatrix} = \begin{bmatrix} \int_0^\infty \frac{h_1(\xi_1)}{H_1(\xi^*(w_1(\theta_1,\theta_2),w_2(\theta_1,\theta_2)))} dH_2(\xi_2) \\ \int_0^\infty \frac{h_2(\xi_2)}{H_1(\xi^*(w_1(\theta_1,\theta_2),w_2(\theta_1,\theta_2)))} dH_1(\xi_1) \end{bmatrix}$$

Embedded in this fixed point algorithm is a second fixed point algorithm because the wage sequence in each occupation is itself the fixed point of the following operator:

$$T(\{w_{jt}\}) = \begin{bmatrix} \rho_j F_{j,t=1}(\xi_{j,t=1}) \\ \rho_j F_{j,t=2}(\xi_{j,t=2}) \\ \vdots \\ \rho_j F_{j,t=\tau}(\xi_{j,t=\tau}) \\ \vdots \end{bmatrix}$$

The finite approximation of this infinite horizon problem is given by the following mapping:

$$T_S(\{w_{jt}\}) = \begin{bmatrix} \rho_j F_{j,t=1}(\xi_{j,t=1}) \\ \vdots \\ \rho_j F_{j,t=S}(\xi_{j,t=S}) \\ \rho_j \\ \rho_j \\ \vdots \end{bmatrix} \tag{22}$$

Every iteration in solving the fixed point problem in Equation 22 involves the computation of the conditional equilibrium wage sequence; therefore, the algorithm to compute the fixed points of $T_S(\{w_{jt}\})$ is nested in the algorithm to compute the parameters of $f_j(\xi_j)$.

The fixed points of $T_S(\{w_{jt}\})$ gives the equilibrium wage sequence in firm j *conditional* on the marginal distribution of ξ_j in firm j. Every iteration in solving the fixed point problem in Equation 14 involves the computation of the conditional equilibrium wage sequence; therefore, the algorithm to compute the fixed points of $T_S(\{w_{jt}\})$ is nested in the algorithm to compute the parameters of $f_j(\xi_j)$.

The procedure to calculate the equilibrium wages and marginal distribution parameters in each firm are explained below. The execution of the following procedure relies on parametric assumption regarding both the marginal distribution of worker types in the population and the marginal distribution of types in each occupation. $H(\xi_j, \xi_k)$ indicate the bivariate distribution of productive inefficiencies in the population is assumed to be a bivariate lognormal distribution. $F_{jt=1}(\xi_j)$ is the marginal distribution of ξ_j in firm j in the beginning of period 1, and it is also assumed to be a lognormal distribution. The algorithm to compute the equilibrium wage sequence in each firm is as follows:

Step 1: Choose positive constants κ and ψ, and set S to a large positive integer.

Step 2: Randomly draw N observations from the bivariate population distribution, $H(\xi_j, \xi_k)$.

Step 3: Choose initial values for the wage sequence and denote it $\{w_{jt}\}^0$ and $\{w_{kt}\}^0$.

Step 4: Using the operator $T(\{w_{jt}\})$, iterate until Equation 23 is satisfied.

$$d_\infty\left(\{w_{jt}\}^{K+1}, \{w_{jt}\}^{K}\right) \leq \kappa \tag{23}$$

The value of the wage sequence at the final iteration is $\{w_{jt}\}^*$. Do the same for firm k and compute $\{w_{kt}\}^*$.

Step 5: Using $\{w_{jt}\}^*$, $\{w_{kt}\}^*$ and the parameters of the model, calculate $V_{i,j,t=1}$ and $V_{i,k,t=1}$ according to Equation 2, and determine which of the N (ξ_j, ξ_k) pairs choose firm j and which ones choose firm k. Recall that a worker chooses firm j if $V_{i,j,t=1} > V_{i,k,t=1}$.

Step 6: Compute ν_j, ω_j, ν_k, and ω_k by fitting the post-selection marginal distributions that are generated in Step 5 to lognormal distributions using maximum likelihood.

Step 7: Denote parameters estimated in Step 6, $(\upsilon_j, \omega_j)^0$ and $(\upsilon_k, \omega_k)^0$.

Step 8: Repeat steps 4-6. Denote the parameter estimates $(\upsilon_j, \omega_j)^*$. Compute $D_j =$

$d_\infty\left((\upsilon_j,\omega_j)^*, (\upsilon_j,\omega_j)^0\right)$ for firm j and k. Iterate (repeat steps 4-6) by setting $(\upsilon_j,\omega_j)^0 = (\upsilon_j,\omega_j)^*$ and $(\upsilon_k,\omega_k)^0 = (\upsilon_k,\omega_k)^*$ until $D_j \leq \psi$ and $D_k \leq \psi$. If $D_j \leq \psi$ and $D_k \leq \psi$, the approximate equilibrium wage sequence in firm j is $\{w_{jt}\}^*$ and the parameter estimates of the distribution of ξ_j in firm j is $(\upsilon_j,\omega_j)^*$.

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Table 1: Parameters Used in Figures 2-5

Parameter	*Description*	*Value*
ρ_1	Output price in firm 1	30
π_1	Monitoring rate in firm 1	0.15
μ_1	mean of log(ξ_1)	3.5
α_1^2	var of log(ξ_1)	2.5
γ_1	Rate of human capital growth in firm 1	0.01
ρ_2	Output price in firm 2	25
π_2	Monitoring rate in firm 2	0.1
μ_2	mean of log(ξ_2)	2.5
α_2^2	var of log(ξ_2)	2
γ_2	Rate of human capital growth in firm 2	0.01
α_{12}	cov(ξ_1,ξ_2)	2

Table 2a: Hourly Wages Under Different Correlation Coefficients

	Corr(ξ1,ξ2) = -0.89		Corr(ξ1,ξ2) = 0.89	
Period	*Firm 1*	*Firm 2*	*Firm 1*	*Firm 2*
1	25.06	19.96	14.32	10.88
2	25.83	20.50	15.74	11.74
3	26.43	20.93	17.09	12.56
4	26.94	21.31	18.37	13.35
5	27.38	21.66	19.58	14.12
6	27.75	21.97	20.72	14.86
7	28.07	22.26	21.77	15.57
8	28.35	22.52	22.74	16.26

Table 2b: Dismissal Rates Under Different Correlation Coefficients

	Corr(ξ1,ξ2) = -0.89		Corr(ξ1,ξ2) = 0.89	
Period	*Firm 1*	*Firm 2*	*Firm 1*	*Firm 2*
1	2.34%	1.93%	7.77%	5.61%
2	2.02%	1.76%	7.09%	5.28%
3	1.74%	1.60%	6.43%	4.96%
4	1.50%	1.45%	5.79%	4.65%
5	1.28%	1.32%	5.19%	4.34%
6	1.10%	1.20%	4.62%	4.05%
7	0.94%	1.08%	4.10%	3.76%
8	0.81%	0.98%	3.61%	3.49%

Table 3a: Hourly Wages Under Different Monitoring Rates in Firm 2

	π2=0.1		π2=0.2	
Period	*Firm 1*	*Firm 2*	*Firm 1*	*Firm 2*
1	14.32	10.88	8.06	14.79
2	15.74	11.74	9.37	16.26
3	17.09	12.56	10.70	17.56
4	18.37	13.35	12.06	18.72
5	19.58	14.12	13.44	19.74
6	20.72	14.86	14.81	20.63
7	21.77	15.57	16.16	21.39
8	22.74	16.26	17.47	22.03

Table 3b: Dismissal Rates Under Different Monitoring Rates in Firm 2

	π2=0.1		π2=0.2	
Period	*Firm 1*	*Firm 2*	*Firm 1*	*Firm 2*
1	7.77%	5.61%	10.93%	8.05%
2	7.09%	5.28%	10.29%	6.93%
3	6.43%	4.96%	9.63%	5.91%
4	5.79%	4.65%	8.95%	4.99%
5	5.19%	4.34%	8.27%	4.17%
6	4.62%	4.05%	7.58%	3.47%
7	4.10%	3.76%	6.91%	2.86%
8	3.61%	3.49%	6.26%	2.35%

Table 4: Age and Education Distribution of the Sample

	White Collar	*Blue Collar*	*Total*
Age at the start of labor market experience			
16-18	652 (32%)	1488 (45%)	2140 (40%)
19-21	795 (39%)	1168 (35%)	1963 (36%)
21-25	384 (19%)	390 (12%)	774 (14%)
26-30	146 (7%)	174 (4%)	320 (6%)
31-42	82 (4%)	112 (3%)	194 (4%)
Total	2059	3332	5391
Education at the start of labor market experience			
Less than high school	545 (26%)	1690 (51%)	2235 (41%)
High school	658 (32%)	1071 (32%)	1729 (32%)
Some college	619 (30%)	521 (16%)	1140 (21%)
College	189 (9%)	45 (1%)	234 (4%)
More than college	48 (2%)	5 (0.2%)	53 (1%)

Column percentages are given in parentheses.

Table 5: Dismissal Rates and Ln Wages by Period

	Dismissal Rates			Hourly Wage		
Period	*White Collar*	*Blue Collar*	*Total*	*White Collar*	*Blue Collar*	*Total*
1	9.47%	13.30%	11.83%	9.16	7.97	8.43
2	8.47%	14.59%	12.12%	9.04	8.17	8.52
3	7.95%	12.55%	10.51%	10.19	8.80	9.41
4	4.45%	11.14%	7.93%	11.03	8.99	9.97
5	4.32%	8.33%	6.28%	13.28	9.27	11.32
6	2.71%	8.10%	5.12%	13.21	10.13	11.83
7	1.63%	6.21%	3.60%	15.64	10.77	13.54
8	1.62%	3.97%	2.59%	15.50	13.03	14.47

Table 6: Maximum Likelihood Estimates of the Parameters

Parameter	*Description*	HC1		HC2	
		ML Estimates	*Asymptotic Standard Errors*	*ML Estimates*	*Asymptotic Standard Errors*
ρ_1	WC output price	15.343	0.215	15.757	0.6605
π_1	WC monitoring rate	0.320	0.048	0.322	0.0687
μ_1	mean of $\log(\xi_1)$	2.098	0.148	2.121	0.1424
α_1	var of $\log(\xi_1)$	1.209	0.136	1.215	0.2415
γ_1	H.C. growth in Firm 1	0.340	0.044	0.396	0.1057
δ_1	Exog. Dis. Rate in F1	0.011	0.002	0.011	0.0011
ρ_2	BC output price	13.609	0.793	13.979	0.1898
π_2	BC monitoring rate	0.249	0.028	0.238	0.0355
μ_2	mean of $\log(\xi_2)$	2.461	0.263	2.381	0.4171
α_2	var of $\log(\xi_2)$	0.899	0.116	0.897	0.2147
σ_ε	std dev of ε	0.526	0.001	0.526	0.0011
γ_2	H.C. growth in Firm 2	0.260	0.057	0.279	0.0637
δ_2	Exog. Dis. Rate in F2	0.035	0.002	0.035	0.0032
α_{12}	$\mathrm{cov}(\xi_1,\xi_2)$	0.871	0.187	0.849	0.304

Table 8: Equilibrium Wages under Random Assignment

	White Collar		Blue Collar	
Period	*With Self-Selection*	*Random Assigment of Workers*	*With Self-Selection*	*Random Assigment of Workers*
1	7.19	6.79	5.26	4.17
2	9.62	9.22	6.97	5.70
3	11.12	10.79	8.21	6.92
4	12.19	11.92	9.23	8.02
5	12.97	12.77	10.08	8.99
6	13.53	13.39	10.78	9.84
7	13.94	13.84	11.35	10.56
8	14.24	14.16	11.81	11.16

Table 9: Dismissal Rates under Random Assignment

	White Collar		Blue Collar	
Period	*With Self-Selection*	*Random Assigment of Workers*	*With Self-Selection*	*Random Assigment of Workers*
1	11.93%	13.05%	15.83%	17.83%
2	9.23%	10.19%	13.90%	15.91%
3	7.05%	7.82%	12.15%	14.04%
4	5.36%	5.96%	10.61%	12.26%
5	4.11%	4.55%	9.31%	10.65%
6	3.19%	3.52%	8.22%	9.23%
7	2.55%	2.77%	7.34%	8.03%
8	2.09%	2.25%	6.64%	7.02%

Table 10: Effect of an Increase in γ1 on Dismissal Rates

Period		Dismissal Rate when γ1=0.34	Dismissal Rate when γ1=1.2
White Collar			
	1	11.93%	9.83%
	2	9.23%	7.41%
	3	7.05%	5.58%
	4	5.36%	4.24%
	5	4.11%	3.27%
	6	3.19%	2.59%
	7	2.55%	2.12%
	8	2.09%	1.79%
Blue Collar			
	1	15.83%	20.43%
	2	13.90%	18.59%
	3	12.15%	16.66%
	4	10.61%	14.75%
	5	9.31%	12.91%
	6	8.22%	11.22%
	7	7.34%	9.72%
	8	6.64%	8.43%

Figure 1a: Marginal Distributions of ξ1 in the Population and in Firm 1 When Corr(ξ1,ξ2) = -0.89

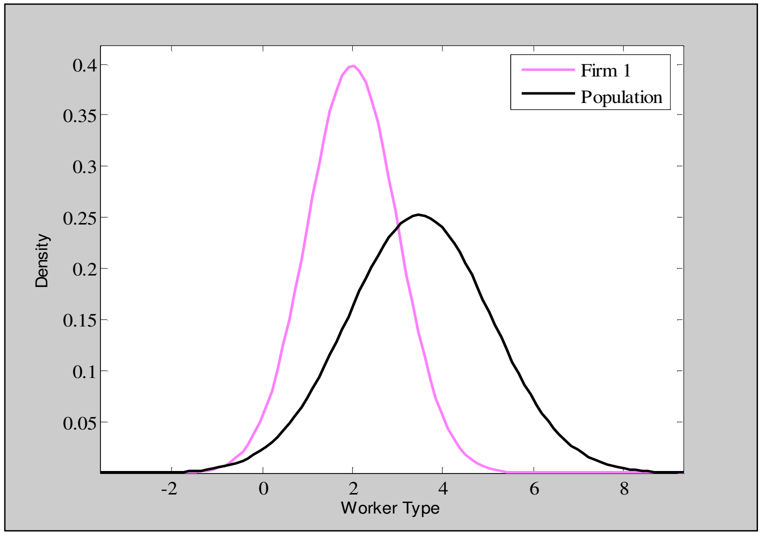

Figure 1b: Marginal Distributions of ξ1 in the Population and in Firm 1 When Corr(ξ1,ξ2)= 0.89

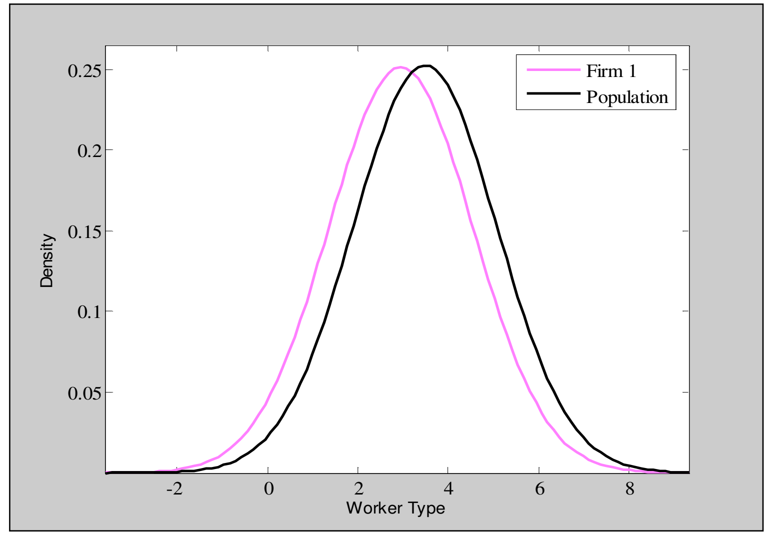

Figure 2a: Marginal Distributions of ξ2 in the Population and in Firm 2 When Corr(ξ1,ξ2) = -0.89

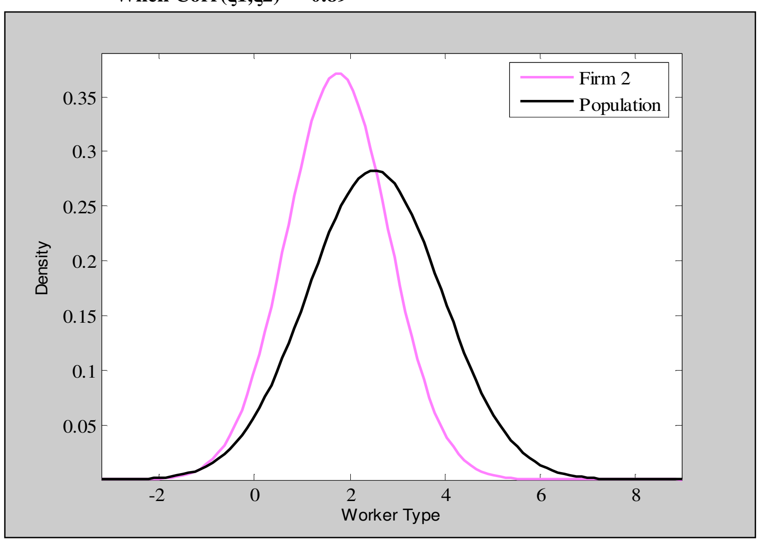

Figure 2b: Marginal Distributions of ξ2 in the Population and in Firm 2 When Corr(ξ1,ξ2)= 0.89

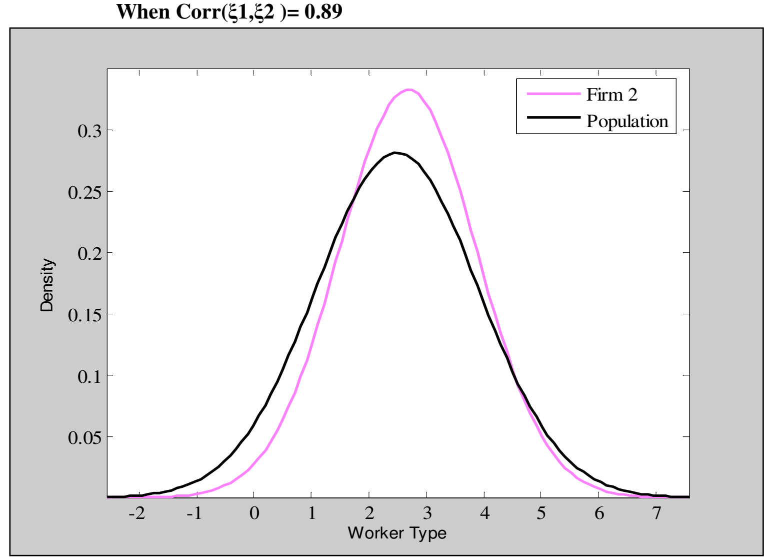

Figure 3: Dismissal Rates in White Collar Occupation

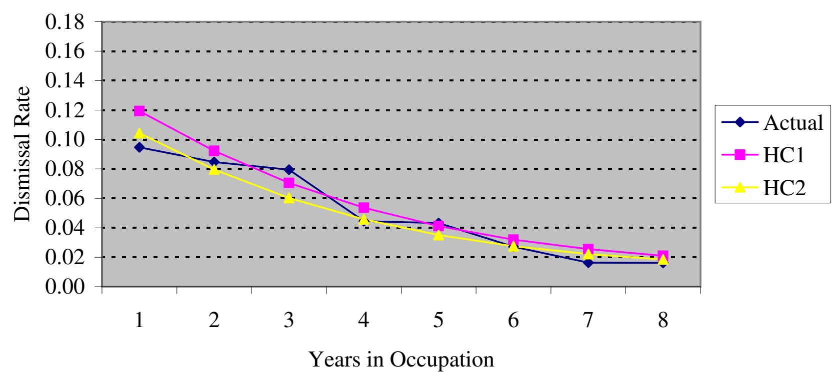

Figure 4: Dismissal Rates in Blue Collar Occupation

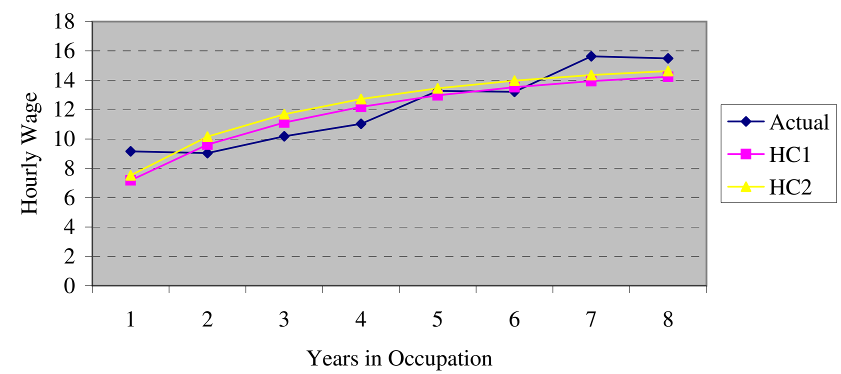

Figure 5: Wages in White Collar Occupation

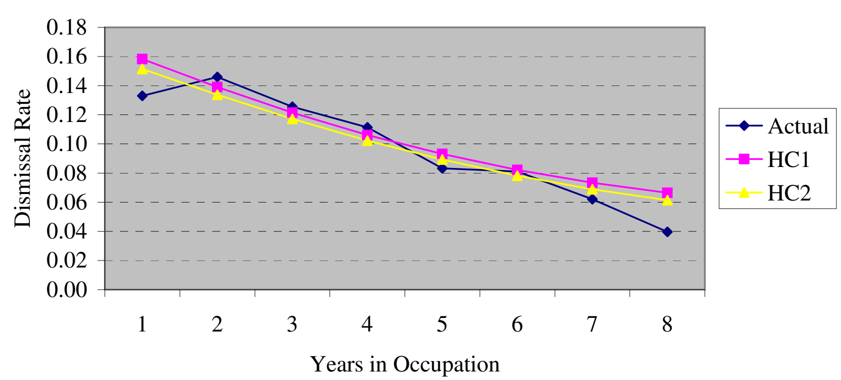

Figure 6: Wages in Blue Collar Occupation

Fig 7: Marginal Distributions of ξ1 in the Population and Among White Collar Workers Under Parameter Estimates

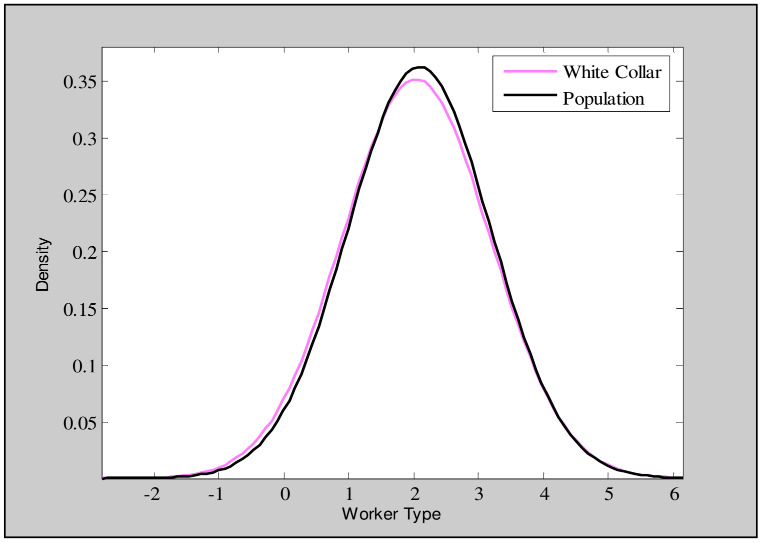

Fig 8: Marginal Distributions of ξ2 in the Population and Among Blue Collar Workers Under Parameter Estimates

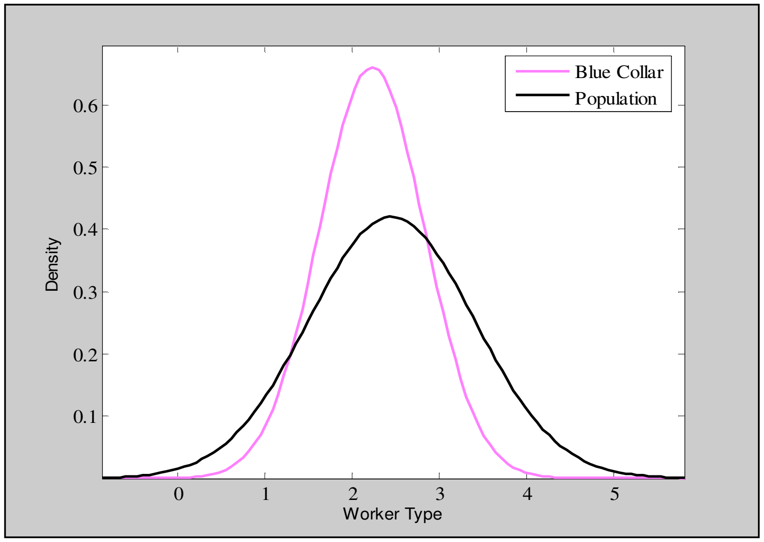

Fig 9: Marginal Distributions of ξ1 in the Population and Among White Collar Workers When γ1=1.2

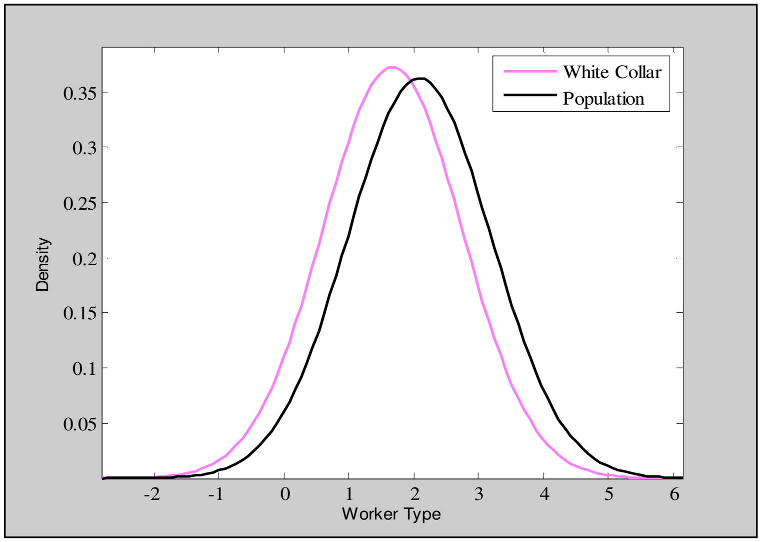

Fig 10: Marginal Distributions of ξ2 in the Population and Among Blue Collar Workers When γ1=1.2