DISCUSSION PAPER SERIES

IZA DP No. 3019

Performance Pay, Sorting, and Outsourcing

Fred Henneberger
Alfonso Sousa-Poza
Alexandre Ziegler

August 2007

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Performance Pay, Sorting, and Outsourcing

Fred Henneberger
University of St. Gallen

Alfonso Sousa-Poza
University of Hohenheim and IZA

Alexandre Ziegler
University of Lausanne

Discussion Paper No. 3019
August 2007

IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

IZA Discussion Paper No. 3019
August 2007

ABSTRACT

Performance Pay, Sorting, and Outsourcing*

Implementing performance pay requires that workers' output be measured. When measurement costs differ among firms, those with a measurement cost advantage choose to implement performance pay. They attract the best workers, and both the level and variability of compensation are higher at these firms than at salary firms. Workers may select firms with different compensation methods at different stages of their work life. Productive workers start at performance pay firms and switch to salary firms once their productivity is revealed. The magnitude of the resulting worker flows depends on the payoff from effort and is therefore related to the age profile of the wage differential between performance pay and salary firms. Advantages in measuring worker productivity constitute a plausible explanation for the emergence of specialized business related service (BRS) firms. Accordingly, BRS firms should make a much wider use of performance pay and employ better workers than diversified corporations. Data from the 1998 Swiss Wage Structure Survey confirm the model's predictions both for the economy at large and for BRS firms.

JEL Classification: J22, J29, J50

Keywords: asymmetric information, sorting, incentives, productivity, outsourcing

Corresponding author:

Alfonso Sousa-Poza
Institute for Household and Consumer Economics
University of Hohenheim
Fruwirthstr. 48, Kavaliershaus 4 116
70599 Stuttgart
Germany
E-mail: alfonso.sousa-poza@uni-hohenheim.de

* The authors would like to thank the Swiss Federal Statistical Office for granting access to the Swiss Wage Structure Survey data and Edward Lazear for valuable comments on earlier versions of this paper.

Performance Pay, Sorting, and Outsourcing

1 Introduction

Salaries and piece rates are two alternative methods of compensation widely encountered in practice. Whereas salaries are typically specified in advance and do not depend directly on a worker's output, piece-rate compensation is based on some measure of a worker's output. Previous research has established that firms' choice of compensation method depends on their characteristics and on the environment they face. Lazear [16] shows that piece rates are more likely in an environment with low monitoring costs and high worker heterogeneity. Noting that the prevalence of a method of pay is inversely related to the cost of using it, Brown [5] shows that larger establishments are more likely to use piece rates and that incentive pay is less likely in jobs with a variety of duties than in jobs with a narrow set of routinized tasks.

Theoretical results predict that piece rates have two effects. The first is a sorting effect, derived by Lazear [16]: Productive workers choose to work at piece-rate firms, whereas the less productive ones select salary firms. The second is an incentive effect: Workers on piece rate work harder. Both of these effects imply that piece-rate workers should receive a higher compensation than salary workers, a prediction that has been confirmed empirically in a number of papers.[1]

The existing literature emphasizes the impact of worker heterogeneity and of the costs of monitoring workers in different contexts (for example, depending on their tasks) on firms' choice of compensation methods. Little attention has been paid, however, to the consequences of heterogeneity *among firms* on their choice of compensation methods *for the same tasks.* Workers' output is often hard to measure, and large differences in firms' ability to do so can

[1]Seiler [24] reports that piece-rate workers earn 14% more than salary workers and attributes part of this difference to a direct incentive effect, part to a compensating differential for the risk of variation in income. Distinguishing among three different methods of pay – standard rates, incentive pay and merit pay (an intermediate form in which firms do not measure workers' output directly but link their pay to their supervisors' ratings on past performance) – Brown [6] shows that earnings of incentive-pay workers are on average significantly higher than those of standard-rate workers. Somewhat surprisingly, he also finds that earnings of merit-pay workers are lower than those of standard-pay workers. Based on the National Longitudinal Survey of Youth, Ewing [10] finds that workers whose pay is based on performance earn a substantial wage premium. Using data from the Panel Study of Income Dynamics, Parent [21] finds incentive effects of about 11%. Paarsch and Shearer [20] estimate a gain in productivity of 21% associated with paying piece rates rather than fixed wages. Lazear [17] reports a productivity increase of 44% following a switch from salary to piece-rate compensation. Interestingly, he shows that sorting and incentives each account for about half of the overall increase. Prendergast [22] provides an overview of the theory and evidence on the provision of incentives in firms.

therefore be expected in practice. How do such differences in monitoring costs across firms affect their choice of compensation methods? What are the consequences for the cross-sectional distribution of workers across firms and the wage distribution in salary and piece rate firms? Do workers tend to select firms with different compensation methods at different stages of their work life? This paper presents a model allowing these and other important questions to be answered. Among the results of our analysis are:

1. Only firms with the lowest monitoring costs implement performance pay. Firms with higher monitoring costs select salary as a compensation method. This is because piece-rate workers end up paying for monitoring costs through lower wages and are therefore not willing to work at firms whose monitoring costs are high.

2. Since productive workers self-select into piece-rate firms, these firms have a higher-quality workforce than salary firms. Moreover, since the earnings of workers active at piece-rate firms reflect individual heterogeneity but those at salary firms do not, the variability of compensation across workers is higher at piece-rate firms than at salary firms.

3. Workers select firms with different compensation methods at different stages of their work life. Productive workers select piece rate firms at the beginning of their work life in order to signal their ability to salary firms. As time passes and their productivity is revealed, they switch from piece-rate firms to salary firms. As a result, piece-rate compensation is more likely for young workers than for older ones.

An empirical analysis based on the 1998 Swiss Wage Structure Survey confirms these predictions: Compensation at piece-rate firms is both significantly (about 10%) higher and more variable than that at salary firms and young workers are more likely to receive performance pay than older ones.

The widespread use of outsourcing for some hard-to-measure tasks provides an interesting application of this analysis. As will be shown below, the emergence of business related service (henceforth BRS) firms can be attributed to differences in measurement costs between BRS firms and large diversified corporations (hereafter non-BRS firms). Since they typically specialize in the provision of few services, BRS firms are able to measure their workers' output at a lower cost than non-BRS firms. Moreover, the existence of transactions with customers allows BRS firms to value workers' output more easily.[2] As a result, these firms choose to implement performance pay.

[2] Holmstrom and Tirole [15] examine the role of external market monitoring for transfer pricing and firms' organizational form.

Because of their higher measurement costs, non-BRS firms are unable to compete against BRS firms in attracting high-productivity workers. Those workers choose to work for BRS firms, which measure their output and in effect lease them back to non-BRS firms. This occurs in spite of the fact that nothing in the production technology differs between BRS and non-BRS firms. Because some high-productivity workers switch from BRS firms to non-BRS firms as their productivity is revealed, BRS firms have a higher proportion of young, productive workers.

An empirical analysis of the 1998 Swiss Wage Structure Survey data confirms this sorting interpretation of the emergence of BRS firms: BRS firms have a higher proportion of performance pay than non-BRS firms. Furthermore, even after controlling for observable productivity-influencing characteristics, workers active in BRS firms earn about 8% more than workers active in non-BRS firms, and the cross-sectional dispersion of wages among them is significantly higher. Finally, workers active at BRS firms are significantly younger than those active at non-BRS firms.

The paper is organized as follows. Section 2 presents the model and discusses its empirical implications. Section 3 analyzes the model's predictions for the economy at large using data from the 1998 Swiss Wage Structure Survey. Section 4 describes the theory's implications for the emergence of BRS firms and tests them empirically. Section 5 concludes.

2 The Model

2.1 Sorting with Heterogeneous Measurement Costs

Consider an economy similar in spirit to that analyzed in Lazear [16]. There is a large number of profit-maximizing firms and workers. Workers have ability (or productivity) q which has distribution function $F(q)$ and density $f(q)$. Information about productivity is asymmetric: Workers know their productivity, but firms do not. Firms can, however, observe workers' productivity by incurring some measurement (or monitoring) cost θ.

Assume that although all firms have identical production technologies, they differ in their ability to measure workers' productivity q. Firms of type i can measure workers' productivity exactly at a cost of θ_i per worker.[3] Without loss of generality, assume that the measurement cost θ_i is increasing in i. In order to make the problem interesting, assume that each firm's measurement costs and scale of operation are given. (Otherwise, firms with high measurement costs would simply choose to lower them and firms with low measurement costs to increase

[3] The assumption of perfect observation is made for convenience only and does not affect the results.

their scale of operation.)

Firms can use two different compensation strategies. They can either pay their workers a fixed salary $w = S$ independent of individual output, or they can pay them a piece rate.[4] Workers on piece rate receive the output q they produce minus the firm's measurement cost θ_i, $w = q - \theta_i$, so that the firm makes zero profits.

What is firms' choice of compensation method and the distribution of workers across firms at equilibrium in this heterogeneous measurement cost setting? Letting S denote the equilibrium salary in the economy, workers that can find a piece-rate firm i such that $q - \theta_i > S$ choose to work there rather than at a salary firm. This is the sorting result derived by Lazear [16]: Productive workers self-select into piece-rate firms, which therefore have a higher-quality workforce. Since firms compete for workers, only firms with low measurement costs choose to implement performance pay: There is a critical value of i, $\bar{i}$, such that firms of type $i < \bar{i}$ use piece rates and firms of type $i > \bar{i}$ use salary. Firms of type $\bar{i}$ may use either salary or piece-rate compensation, depending on the distribution of workers' productivity.[5]

Thus, at equilibrium, productive workers self-select into low measurement cost firms. Low-productivity workers are spread in those firms of type $\bar{i}$ which choose to pay a salary (if any) and in firms of type $i > \bar{i}$. Sorting occurs although nothing inherent in firms' production technology makes high-productivity workers more suited to work at firms of type $i \leq \bar{i}$. Productive workers select type $i \leq \bar{i}$ firms only because of their comparative advantage in *measuring* their productivity.

The equilibrium salary S in this economy can be determined in the same way as in the Lazear [16] model, accounting for the fact that the marginal worker must be indifferent between working at a piece-rate firm *of type* $\bar{i}$ and at a salary firm. Thus, given a salary S, a piece-rate firm will be preferred by all workers for whom $S < q - \theta_{\bar{i}}$ and a salary firm preferred by all workers for whom $S > q - \theta_{\bar{i}}$. For a given value of S to be an equilibrium, salary firms must make zero profits given that they employ workers for whom $q - \theta_{\bar{i}} < S$, i.e. $q < q^* \equiv S^* + \theta_{\bar{i}}$. That is, one must have

$$S^* = E(q|q - \theta_{\bar{i}} < S^*) = E(q|q < q^*) = \frac{1}{F(q^*)} \int_0^{q^*} qf(q)dq \tag{1}$$

[4] Fama [11] makes the further distinction between *time* (hourly payoffs) and *salary* (the payoff does not vary with hours) and notes that time will tend to be used when information about the flow of effort per unit time is available to the employer. In this paper, "piece rate" denotes all forms of performance-related pay and "salary" all forms of performance-unrelated pay.

[5] Of course, if measurement costs are high even for firms of type 1, it is possible that no firm will choose to use performance pay. But, as shown in Lazear [16], as long as measurement costs are positive, some firms will use salaries.

Since $q^* = S^* - \theta_{\bar{i}}$, the equilibrium salary S^* is given by $S^* = q^* - \theta_{\bar{i}}$, where q^* solves

$$q^* - \theta_{\bar{i}} = E(q|q < q^*) = \frac{1}{F(q^*)} \int_0^{q^*} q f(q) dq \qquad (2)$$

Thus, the equilibrium salary is driven by the distribution of worker abilities and firms of type $\bar{i}$'s measurement costs only. Other firms' monitoring costs are irrelevant.

The empirical implications of this analysis are the following:

1. First, firms' choice of compensation method should be related to their measurement costs, with low-measurement cost firms more likely to implement performance pay than high measurement cost firms. This means that there should be a significant relationship between the use of incentive pay in a given firm and factors that influence measurement costs, such as firm size.[6]

2. Second, piece-rate firms should employ more productive workers than salary firms. Note that although they cannot make the salaries they pay contingent on a worker's output, salary firms can base those wages on workers' observable characteristics (such as the classical human capital variables work experience and education). Therefore, sorting is based on workers' *unobservable* productivity-influencing traits, and the effect of workers' *observable* characteristics on their expected wage must be taken into account when comparing the earnings of salary and piece-rate workers.

3. Third, since compensation at piece-rate firms reflects heterogeneity in worker productivity but compensation at salary firms does not, the cross-sectional variability of compensation should be higher at piece-rate firms than at salary firms. Again, this effect should arise *after conditioning on workers' observable characteristics*. Thus, the variance of the wage function residuals should be higher at piece-rate firms than at salary firms.

2.2 Sorting Through the Work Life and the Role of Effort

The previous section described workers' sorting behavior in a timeless setting. If there are several periods and workers' output is not independent across periods, then firms can make their hiring strategy dependent on the worker's employment history, offering better conditions to workers that are thought to have higher productivity based on their past employment record. Accordingly, when selecting their employer in a given period, workers take the effect of their

[6] As mentioned in the introduction, Brown [5] shows that large firms are more likely to implement performance pay.

choice on subsequent wage offers into account. Hence, one would expect workers to select firms with different compensation methods at different stages of their work life. For example, it is often said that MBA graduates first spend some time at (often renown consulting) firms in which a large portion of their income is performance-based, before moving to firms offering a lower share of performance-related pay. Is there a rationale for such switching behavior? Can one tell who switches from piece rate firms to salary firms and who doesn't? What is the implication for the relationship between workers' age and the form of compensation they receive?

As a first step towards understanding these issues, suppose that the one-period setup in Section 2.1 is simply repeated several times. If worker productivity is perfectly correlated across periods (i.e., constant for a given worker), then salary firms can use the information collected by piece-rate firms in the first period to assess it. High-productivity workers are employed at piece-rate firms in the first period of their work life in order to have their productivity measured; they then switch to salary firms for the rest of their work life. Because they do not incur measurement costs, salary firms are able to attract these workers by offering them higher compensation than piece-rate firms.[7]

Piece-rate firms could obviously mimic salary firms' behavior, measuring workers in the first period only and then paying them a fixed salary for the rest of their work life based on their output in the first period. Why doesn't everybody just switch to salary compensation in the second period? The reason has to do with incentives. When effort has a significant impact on worker productivity, some workers will choose to be measured after the first period as well.

To analyze the impact of incentives on workers' switching behavior, consider a two-period model in which a worker's productivity is driven by both ability and effort. Letting a_j denote worker j's ability and e_j the effort he puts forth, the worker's output is $q_j = a_j + e_j$. Worker j's cost of effort is assumed to be period-independent and given by $C(e_j) = e_j^2/(2N_j)$, where N_j is some parameter known to the worker but unobservable to firms, with a higher N_j implying that the worker is hard-working.[8] Note that the intuition of the previous section that only

[7] Of course, this will only be possible if the incumbent employer does not have a sizable amount of private information about worker productivity. This problem is analyzed by Autor [2] in the context of training provided by temporary help firms. In his model, temporary help firms observe workers' ability during training. They set wages such that high-ability workers self-select to receive free (but unpaid) training and thus reveal their productivity, while low-ability workers do not. Incumbent employers' informational advantage about worker ability generates adverse selection, thereby depressing outside wages and allowing temporary help firms to recoup their training investment.

[8] The structure used here combines the Lazear [16] heterogeneous ability setting with the Brown [5] heterogeneous effort cost setting. Both consider a single-period structure. Lazear [18] uses a similar setup in the context of promotion decisions.

firms with low measurement costs implement performance pay still holds. Hence, we let $\theta = \theta_{\bar{i}}$ denote the measurement cost that is relevant for our analysis.

As a benchmark, consider what would happen in a one-period setting. If paid a salary S, the worker will set effort e_j to maximize $S - e_j^2/(2N_j)$, implying $e_j = 0$, and derive utility S. If paid a piece rate, he will seek to maximize

$$U(e_j) = a_j + e_j - \theta - \frac{e_j^2}{2N_j} \tag{3}$$

implying $e_j^* = N_j$, and achieve utility

$$U(e_j^*) = a_j + \frac{N_j}{2} - \theta \tag{4}$$

Thus, workers for whom

$$a_j + \frac{N_j}{2} - \theta > S \tag{5}$$

choose to work at piece-rate firms, while the others select salary firms. Piece-rate firms now employ a mix of high-ability and high-effort workers. Salary firms understand that they employ lower-ability workers and that workers that are not measured will not put forth effort. They therefore set a wage

$$S = E\left(a_j \middle| a_j + \frac{N_j}{2} - \theta < S\right) \tag{6}$$

which is the equivalent of (1) once the impact of effort on output is accounted for.

In a two-period setting, the fact that a worker chose to work at a piece-rate firm in period 1 tells the salary firm something about his ability and cost of effort. Salary firms can therefore use this information to offer those workers a wage $W > S$ in period 2. To see this, suppose that there are two levels of ability a_L and a_H, and two levels of the effort cost parameter, N_L and N_H. Assume that $N_L/2 - \theta < 0$.[9] The payoff to the four categories of workers depending on the compensation structure they choose (salary in both periods, piece rate in both periods, or piece rate in period 1 and salary in period 2) is summarized in Table 1.[10] Depending on the parameter values, a number of equilibria can arise in this model. What actually happens depends on the payoff from effort (i.e., to what extent effort affects output) and on the degree of heterogeneity in the cost of effort across workers.

[9]This restriction is innocuous, it simply means that the payoff from effort to the low-effort workers is not sufficient to make it worth for them to work on piece rate, i.e. low-effort workers would never wish to be measured if ability were observable. Without it, all workers will want to be measured in every period in order to obtain the payoff from effort.

[10]Obviously, a plan to work at a salary firm in period 1 and switch to a piece-rate firm in period 2 is dominated by working at a piece-rate firm from the start. The corresponding strategy and payoffs are therefore not presented in the table.

	Compensation form		
	Salary twice	Piece rate and then salary	Piece rate twice
Worker type			
(a_L, N_L)	$2S$	$a_L + N_L/2 - \theta + W$	$2(a_L + N_L/2 - \theta)$
(a_H, N_L)	$2S$	$a_H + N_L/2 - \theta + W$	$2(a_H + N_L/2 - \theta)$
(a_L, N_H)	$2S$	$a_L + N_H/2 - \theta + W$	$2(a_L + N_H/2 - \theta)$
(a_H, N_H)	$2S$	$a_H + N_H/2 - \theta + W$	$2(a_H + N_H/2 - \theta)$

Table 1: Payoffs to the four different worker types as a function of the compensation form in both periods.

2.2.1 High Payoff from Effort

When the payoff from effort is high, high-effort workers choose to work at piece-rate firms in both periods regardless of their ability, i.e., both (a_L, N_H) and (a_H, N_H) workers select piece-rate firms. In contrast, (a_L, N_L) workers work at salary firms in both periods, and (a_H, N_L) workers work at piece-rate firms in period 1 and switch to salary firms in period 2. To see why this occurs only when the payoff from effort is high, note that given the wages S and W, the incentive compatibility conditions for workers to self-select in this fashion are

$$\begin{aligned}
2S &> 2\left(a_L + \frac{N_L}{2} - \theta\right) \\
2S &> a_L + \frac{N_L}{2} - \theta + W \\
a_H + \frac{N_L}{2} - \theta + W &> 2S \\
a_H + \frac{N_L}{2} - \theta + W &> 2\left(a_H + \frac{N_L}{2} - \theta\right) \\
2\left(a_L + \frac{N_H}{2} - \theta\right) &> a_L + \frac{N_H}{2} - \theta + W \\
2\left(a_L + \frac{N_H}{2} - \theta\right) &> 2S \\
2\left(a_H + \frac{N_H}{2} - \theta\right) &> a_H + \frac{N_H}{2} - \theta + W \\
2\left(a_H + \frac{N_H}{2} - \theta\right) &> 2S
\end{aligned} \tag{7}$$

Since low-ability, low-effort workers are the only ones working at salary firms in both periods, firms set $S = a_L$. Moreover, since only high-ability, low-effort workers choose to switch to salary firms in period 2, one has $W = a_H$. Inserting these values into the above constraints and removing the redundant ones (the first, fourth, sixth, seventh and eighth), the parameter restrictions for this equilibrium to arise are that

$$-2(a_H - a_L) < \frac{N_L}{2} - \theta < -(a_H - a_L) \tag{8}$$

and

$$\frac{N_H}{2} - \theta > a_H - a_L \tag{9}$$

The first condition guarantees that low-ability, low-effort workers choose to work at a salary firm in both periods, while high-ability, low-effort workers choose to work at a piece-rate firm in the first period and then switch to a salary firm. The second condition says that the payoff from effort is sufficiently high for all high-effort workers to wish to be measured, regardless of their ability. These conditions imply that

$$a_H + \frac{N_L}{2} - \theta < a_L \tag{10}$$

and

$$a_L + \frac{N_H}{2} - \theta > a_H \tag{11}$$

Thus, for this equilibrium to arise, one must have

$$a_H + \frac{N_L}{2} - \theta < a_L + \frac{N_H}{2} - \theta \tag{12}$$

which says that low-ability, high-effort workers must be better off than high-ability, low-effort workers under a piece-rate scheme. The intuition is that when the payoff from effort to high-effort workers is high, they do not want to switch to a salary firm in period 2. High-ability, low-effort workers can therefore distinguish themselves from low-ability, low-effort workers by working at a piece-rate firm in period 1. Since $N_L/2 - \theta < 0$, doing so is costly to them, but it is worthwhile because of the wage gain that can be achieved in the second period.

It is worth noting that (a_H, N_L) workers would *not* work at a piece-rate firm in a single-period context, since $a_H + N_L/2 - \theta < a_L$. The reason they do so in the 2-period setting is that the measurement cost can be spread over two periods. It therefore becomes worthwhile for them to bear it in period 1 in order to distinguish themselves from low-ability, low-effort workers in period 2.[11]

It turns out that this equilibrium arises when differences in effort cost among workers have a stronger impact on their utility than heterogeneity in ability. To see this, combine constraints (10) and (11) to obtain

$$\frac{N_H - N_L}{2} > 2(a_H - a_L) \tag{13}$$

[11] More generally, high-ability workers will be more inclined to temporarily bear the measurement cost, the higher the number of years they expect to work at salary firms once their ability has been revealed. This argument is similar to the classical argument in human capital theory that younger workers benefit most from education because they can amortize it over a longer period of time (Becker [4]).

	Compensation Form		
	Salary twice	Piece rate and then salary	Piece rate twice
Worker type			
(a_L, N_L)	**10**	9	2
(a_H, N_L)	10	**12**	8
(a_L, N_H)	10	17	**18**
(a_H, N_H)	10	20	**24**

Table 2: Payoffs in the numerical example with a high payoff from effort. All high-effort workers work at piece-rate firms all their work life, while high-ability, low-effort workers work at piece-rate firms in the first period to have their ability measured and then switch to salary firms.

One set of parameters satisfying conditions (8) and (9) is $a_L = 5$, $a_H = 8$, $N_L = 4$, $N_H = 20$ and $\theta = 6$. The resulting payoffs to the different workers with $S = a_L = 5$ and $W = a_H = 8$ are summarized in Table 2. The optimal strategies, marked in bold, indeed demonstrate that high-ability, low-effort workers choose to be measured in period 1 in order to reveal their ability. Since their cost of effort is high, however, they choose to switch to a salary firm in period 2.

At any point in time, piece-rate firms employ a mix of workers that just want their ability to be measured and of workers that want to work hard. However, both groups behave differently through time. High-ability, low-effort workers choose to work at piece-rate firms only to reveal their ability and leave after the first period. For them, working at a piece-rate firm has the same function as education in the Spence [25] signalling model. But those workers who work at piece-rate firms in order to capture the payoff of higher effort remain at piece-rate firms all their work life.

This equilibrium has a number of important implications. First, high-ability, but low-effort workers switch from piece-rate firms to salary firms between period 1 and period 2. Second, as workers' age increases, the average ability of salary workers improves, and that of piece-rate workers deteriorates. But the proportion of hard-working individuals among piece-rate workers is higher, the older the workers. Third, piece-rate firms employ younger workers.

How about the age profile of the wage differential between piece-rate and salary workers? Since switching workers have high ability and $a_H + N_L/2 - \theta < a_L + N_H/2 - \theta$, average output per worker rises *both* for piece-rate workers and for salary workers in period 2, and it is in general not clear how the wage differential between both groups of workers depends on their age. However, if overall employment in the economy is significantly smaller at piece-rate firms than that at salary firms, which is the case empirically (see Seiler [24] and Section 3.2 below), then average compensation at salary firms is almost unaffected by switching workers, and the wage differential between salary and piece-rate workers will *increase* with workers' age.

2.2.2 Low Payoff from Effort

The equilibrium behavior of firms and workers is somewhat different when effort only has little impact on output or when heterogeneity in ability is large compared to heterogeneity in effort cost. In this case, low-ability workers choose to work at salary firms in both periods, while high-ability workers choose to work at piece-rate firms in the first period and switch to salary firms in the second, regardless of their effort cost. Intuitively, the equilibrium behavior in this case is similar to the one that arises in a multi-period setting without effort described at the beginning of Section 2.2.

To see why a low payoff from effort is needed for this to occur, note that the incentive compatibility conditions for this equilibrium to arise are

$$\begin{aligned}
2S &> 2\left(a_L + \frac{N_L}{2} - \theta\right) \\
2S &> a_L + \frac{N_L}{2} - \theta + W \\
a_H + \frac{N_L}{2} - \theta + W &> 2S \\
a_H + \frac{N_L}{2} - \theta + W &> 2\left(a_H + \frac{N_L}{2} - \theta\right) \\
2S &> a_L + \frac{N_H}{2} - \theta + W \\
2S &> 2\left(a_L + \frac{N_H}{2} - \theta\right) \\
a_H + \frac{N_H}{2} - \theta + W &> 2S \\
a_H + \frac{N_H}{2} - \theta + W &> 2\left(a_H + \frac{N_H}{2} - \theta\right)
\end{aligned} \tag{14}$$

Again, since only low-ability workers choose to work at salary firms in both periods and only high-ability workers work at piece-rate firms in the first period and salary firms in the second, one has $S = a_L$ and $W = a_H$. Inserting these values into the constraints and removing the redundant ones (the first, fourth, sixth and eighth), the parameter restrictions for this equilibrium to arise are that

$$-2(a_H - a_L) < \frac{N_L}{2} - \theta < -(a_H - a_L) \tag{15}$$

and

$$-2(a_H - a_L) < \frac{N_H}{2} - \theta < -(a_H - a_L) \tag{16}$$

The first condition ensures that low-ability, low-effort workers work at salary firms in both periods and high-ability, low-effort workers switch from piece-rate firms to salary firms. The second ensures the same behavior from low-ability, high-effort and high-ability, high-effort workers, respectively.[12] It is instructive to contrast condition (16) with the corresponding one when the payoff from effort is high, (8). When (16) is satisfied, sorting occurs because high-effort workers would never wish to be measured for effort reasons alone. When (8) is satisfied, on the other hand, sorting occurs because all high-effort workers wish to be measured, regardless of their ability.

Note that constraint (16) implies that

$$a_H + \frac{N_H}{2} - \theta < a_L \tag{17}$$

This condition means that the payoff from effort is so low that no worker would ever choose to work at a piece rate firm in a single-period context. Moreover, workers would never choose to be measured for effort reasons – the only reason they do is to reveal their ability. In the two-period context, measurement takes place because its cost can be spread over two periods. Since high-effort, low-ability workers work at salary firms in both periods, high-ability workers can distinguish themselves by working at a piece-rate firm in period 1. However, since the net payoff from effort (after accounting for measurement costs) is negative, they switch to a salary firm in period 2.

As in the case where the payoff from effort is high, the conditions for the equilibrium to arise can be interpreted in terms of effort cost heterogeneity. Combining (15) and (16), one obtains

$$\frac{N_H - N_L}{2} < a_H - a_L \tag{18}$$

implying that the equilibrium will only arise if heterogeneity in effort cost is small compared to heterogeneity in ability: When effort does not matter too much for output, the fact that a worker selected to work at a piece-rate firm in the first period reveals that his ability is high.

Again, a numerical example is instructive. One set of parameters satisfying (15) and (16) is $a_L = 5$, $a_H = 8$, $N_L = 4$, $N_H = 5$ and $\theta = 6$. The resulting payoffs to the different workers with $S = a_L = 5$ and $W = a_H = 8$ are summarized in Table 3. The optimal strategies, marked in bold, indeed demonstrate that when heterogeneity in effort cost is low, high-ability workers choose to be measured in period 1 in order to reveal their ability, regardless of their effort cost. Since the net payoff from effort is negative, however, they switch to a salary firm in period 2. Low-ability workers work at salary firms throughout.

[12] One can check that there are no parameter values such that high-ability, high-effort workers would choose to stay at piece-rate firms in period 2 and all other workers behave as described here. Indeed, the incentive compatibility constraints for high-ability, high-effort workers would then imply that $N_H/2 - \theta > 0$, contradicting the sixth constraint.

	Compensation Form		
	Salary twice	Piece rate and then salary	Piece rate twice
Worker type			
(a_L, N_L)	**10**	9	2
(a_H, N_L)	10	**12**	8
(a_L, N_H)	**10**	9.5	3
(a_H, N_H)	10	**12.5**	9

Table 3: Payoffs in the numerical example with a high payoff from effort. High-ability workers work at piece-rate firms only to reveal their ability and then switch to salary firms. Low-ability workers work at salary firms throughout.

The implications of workers' equilibrium behavior when the payoff from effort is high are very similar to the ones when the payoff from effort is low. First, high-ability workers switch from piece-rate firms to salary firms in period 2. Second, the ability mix of workers at salary firms improves as workers' age increases. Finally, piece-rate firms employ only young workers. (This is a stronger effect than in Section 2.2.1, but taking the model less literally, the implication is the same: piece-rate firms employ younger workers.) The difference compared to the equilibrium when the payoff from effort is high is that here, the wage differential between piece-rate and salary workers unambiguously *decreases* with workers' age.

2.2.3 Intermediate Payoff from Effort

The equilibria discussed so far arise when the payoff from effort is either very low (so that high-effort workers would never wish to be measured in a one-period context) or very high (so that high-effort workers would always want to be measured). Only then does working at a piece-rate firm in period 1 and being willing to switch to a salary firm in period 2 guarantee that a worker has high ability, thus allowing salary firms to sort workers even if they do not observe the compensation paid those workers by piece-rate firms in the first period. In the intermediate case in which effort is important but does not dominate ability completely, salary firms are unable to distinguish high-ability from low-ability workers based on where they were employed in the first period and face an adverse selection problem. They may, however, be able to separate both groups if the compensation paid by the piece-rate firm is observable.

To see this, suppose again that the condition

$$-2(a_H - a_L) < \frac{N_L}{2} - \theta < -(a_H - a_L) \tag{19}$$

is satisfied, but that neither of the conditions on $N_H/2 - \theta$ are met, i.e., one has

$$a_H - a_L > \frac{N_H}{2} - \theta > -(a_H - a_L) \tag{20}$$

This means that working at a piece-rate firm is neither attractive enough for low-ability, high-effort workers to want to do so anyway, nor is it unattractive enough to deter them from doing so if this allows them to earn $W = a_H$ in the second period.

How could salary firms use the wage to distinguish low-ability, high-effort workers from high-ability, low-effort ones? One way they can do this is to offer $W = a_H$ in period 2 only if the worker achieved some minimum compensation level W^* in period 1 (and offer $S = a_L$ otherwise). The wage standard W^* must be such that high-ability, low-effort workers prefer working hard in period 1 and obtaining $W = a_H$ in period 2 to both (i) getting the salary $S = a_L$ throughout and (ii) working at a piece-rate firm throughout. Using the fact that compensation at piece-rate firms equals $W^* = a_H + e_j - \theta$, one has $e_j = W^* - a_H + \theta$, and this condition can be written as

$$W^* - \frac{(W^* - a_H + \theta)^2}{2N_L} + a_H > \max\left[2\left(a_H + \frac{N_L}{2} - \theta\right), 2a_L\right] = 2a_L \tag{21}$$

where the equality follows from (19).

At the same time, the wage standard W^* must be high enough to deter low-ability, high-effort workers from working hard enough to achieve W^* in the first period in order to obtain a salary $W = a_H$ in the second. These workers' utility from getting the salary $S = a_L$ twice or from working two periods at a piece-rate firm must be higher. Formally,

$$W^* - \frac{(W^* - a_L + \theta)^2}{2N_H} + a_H < \max\left[2\left(a_L + \frac{N_H}{2} - \theta\right), 2a_L\right] \tag{22}$$

This sorting scheme may work because, although effort is more costly to the high-ability, low-effort workers than to the low-ability, high-effort workers, *low-ability workers need to put forth more effort than high-ability workers to achieve a given W^**. This suggests that this scheme will break down when the effort cost of high-effort workers becomes very low, i.e. when N_H exceeds a certain value.

To show this formally, note first that the scheme will necessarily fail if, under a piece-rate system, (a_L, N_H) workers have both higher wages and higher utility than (a_H, N_L) workers when both work the efficient amount. This is because additional effort beyond the efficient amount is more costly to (a_H, N_L) workers than to (a_L, N_H) workers, and the former must put forth more effort than the latter to achieve W^*. Thus, salary firms will be unable to sort workers if both the wage condition

$$a_L + N_H - \theta > a_H + N_L - \theta \tag{23}$$

and the utility condition

$$a_L + \frac{N_H}{2} - \theta > a_H + \frac{N_L}{2} - \theta \tag{24}$$

are satisfied. These conditions can be rewritten as

$$\frac{N_H}{2} - \theta > \frac{a_H - a_L}{2} + \frac{N_L}{2} - \theta \tag{25}$$

and

$$\frac{N_H}{2} - \theta > a_H - a_L + \frac{N_L}{2} - \theta \tag{26}$$

Noting that (25) is redundant, the sorting scheme will break down whenever

$$\frac{N_H}{2} - \theta > a_H - a_L + \frac{N_L}{2} - \theta \equiv \phi \tag{27}$$

where $\phi < 0$ since $N_L/2 - \theta < -(a_H - a_L)$. Therefore, the scheme can only work if $N_H/2 - \theta < 0$, which implies that (22) can be rewritten as

$$W^* - \frac{(W^* - a_L + \theta)^2}{2N_H} + a_H < 2a_L \tag{28}$$

Solving (21) and (28) for W^* implies that W^* must satisfy the conditions

$$W^* < W_1^* = a_H + N_L - \theta + \sqrt{2N_L}\sqrt{2(a_H - a_L) + \frac{N_L}{2} - \theta} \tag{29}$$

and

$$W^* > W_2^* = a_L + N_H - \theta + \sqrt{2N_H}\sqrt{a_H - a_L + \frac{N_H}{2} - \theta} \tag{30}$$

Sorting will break down whenever the feasible range for W^* is empty, i.e. whenever $W_2^* > W_1^*$. Since $\partial W_2^*/\partial N_H > 0$, this will occur whenever

$$\begin{aligned} N_H > N_H^* \quad = \quad & \frac{1}{2\left(2(a_H - a_L) - \theta\right)^2}\Bigg(2(a_H - a_L)^3 + (5N_L - \theta)(a_H - a_L)^2 - 6N_L\theta(a_H - a_L) \\ & + 2N_L\theta^2 + (a_H - a_L)(3(a_H - a_L) - 2\theta)\sqrt{2N_L}\sqrt{2(a_H - a_L) + \frac{N_L}{2} - \theta}\Bigg) \end{aligned} \tag{31}$$

In the special case in which $\theta = 2(a_H - a_L)$, this expression simplifies to

$$N_H > N_H^* = \frac{\left(2N_L + \frac{\theta}{2}\right)^2}{4N_L} = \frac{(2N_L + a_H - a_L)^2}{4N_L} \tag{32}$$

Thus, firms are able to use the wage standard to sort workers when $N_H/2 - \theta > -(a_H - a_L)$, i.e. $N_H > 2(\theta - (a_H - a_L))$ but $N_H < N_H^*$. When N_H increases beyond N_H^*, it becomes impossible to prevent (a_L, N_H) workers from pretending to be (a_H, N_L) workers by using a wage standard, and the sorting scheme breaks down.

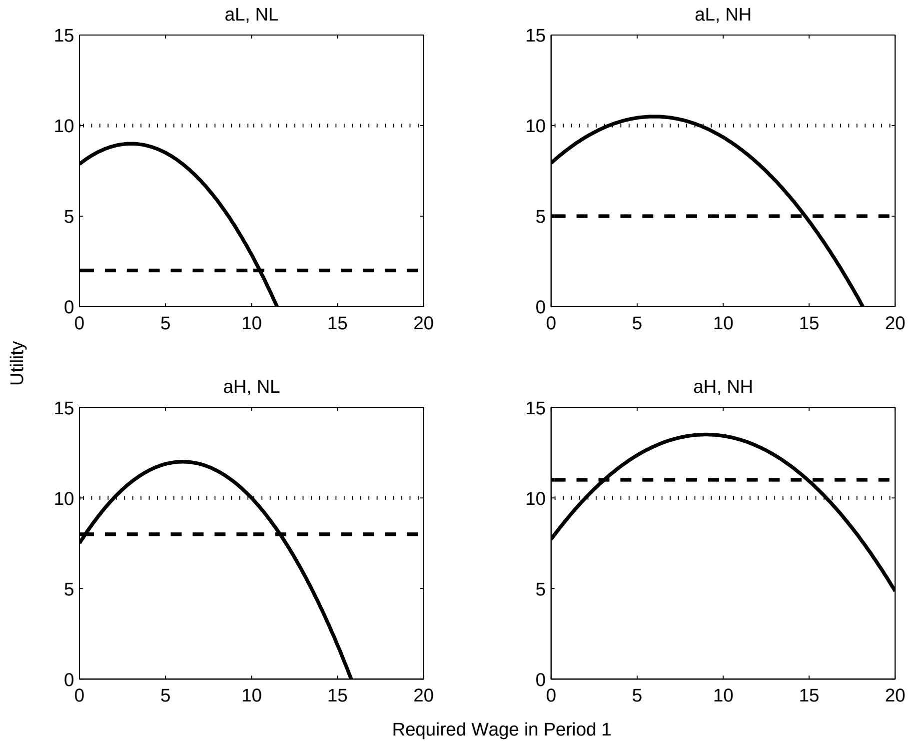

Figure 1: Sorting workers by requiring a minimum compensation level in period 1.

Figure 1 illustrates how the wage standard mechanism works for the case $a_L = 5$, $a_H = 8$, $N_L = 4$, $N_H = 7$ and $\theta = 6$ (note that in this case, $N_H < N_H^* = 121/16 = 7.5625$). For each of the four groups of workers, the solid line depicts the two-period utility for each level of the required wage W^* if workers that achieve W^* in the first period receive a_H in the second. The dashed line shows the utility achieved by working both periods at the piece-rate firm, and the dotted line that from working both periods at the salary firm. The adverse selection problem the salary firm faces arises because, if workers set their effort optimally (i.e., achieve the maximum of the solid line), both high-ability, low-effort workers and low-ability, high-effort workers would choose to work at a piece-rate firm in period 1 and then switch to a salary firm. However, by requiring $W^* > W_2^* = 6 + \sqrt{7} = 8.6458$, which is feasible since $W_1^* = 10$, the salary firm can induce low-ability, high-effort workers to work both periods at the salary firm without deterring high-ability, low-effort workers from working at the piece-rate firm in period 1 and at the salary firm in period 2. At equilibrium, low-ability workers work at salary firms, regardless of their effort cost, while high-ability workers work at the piece-rate firm in period 1 and at the salary firm in period 2.

The implications of equilibrium behavior in this intermediate setting are the same as when the payoff from effort is low: High-ability workers switch from piece-rate firms to salary firms. The ability mix of workers at salary firms improves as workers' age increases. Finally, piece-rate firms employ younger workers than salary firms. A key difference, however, is that high-ability, low-effort workers are induced to put forth too much effort in period 1. Since worker flows are identical to those in the case of a low payoff from effort, one can expect the wage differential between piece-rate and salary workers to *fall* with workers' age.[13]

2.2.4 Empirical Implications

The main empirical prediction of the model for workers' sorting behavior through their work life is unambiguous: Regardless of the payoff from effort, some high-ability workers will switch from piece-rate to salary firms through time. This means that young workers should be more likely to be on piece-rate, a prediction that can be tested empirically.

Although the payoff from effort does not affect the existence of worker flows from piece-rate to salary firms, it does affect their magnitude, the characteristics of switching workers, and therefore the age profile of the wage differential between piece-rate and salary workers. If the payoff from effort is high enough so that high-effort workers do not switch, then the wage differential increases with age. If this payoff is low, then all workers switch once their output has been measured, and the wage differential decreases with age. This means that if worker flows from piece-rate firms to salary firms are high (low), then the wage differential should decrease (increase) with workers' age. This relationship can be investigated empirically.

3 Empirical Analysis

3.1 Data

The data used in this study come from the 1998 Swiss Wage Structure Survey (SWSS, "Lohnstrukturerhebung"). This representative and nation-wide survey is conducted every two years by the Swiss Federal Statistical Office (SFSO). It is an establishment survey, i.e., the questionnaires are filled out by personnel officers in each firm. Firms with 2 to 19 employees must report on all their employees, firms with 20 to 49 employees on at least 50% of their employees, and firms with more than 49 workers on at least 1/6th of their workforce. Employees within firms are selected at random. We restrict our analysis to men between the age of 20 and 65 employed in private-sector firms with at least 10 employees.[14] The sample size is equal to 185,016

[13]Accounting for the fact that not all high-ability workers switch in practice and for the fact that those planning to switch are overworked in the first period does not alter this conclusion.

[14]We restrict our analysis to firms with at least 10 employees since reporting in firms with few employees was not always complete (see Prey [23]). Data on public-sector firms was not available. We omit women from our analysis in order to avoid selection issues associated with women's employment decision. The employment rate of women in Switzerland is about 60% and there is ample evidence that the employment decision is non-random.

individuals of which 72,675 are employed in firms using performance pay. These individuals belong to 3,311 establishments of which 1,282 make use of performance pay. The questionnaire covers a number of topics such as payment, job characteristics, working time, tenure, firm size, and industry (see SFSO [27]). The response rate in the survey is 83%.

This data set has two features which make it particularly valuable for an analysis of the issues we are concerned with in this paper: First, the sample size is very large, thus enabling a detailed analysis of different industries. Second, the wage data come from establishment records (many firms file electronically), are not subject to recall error, and are extraordinarily reliable. This also applies to the information on the characteristics of a certain job.

3.2 Descriptive Statistics

Sample means for firms using and not using performance pay and the result of equality-of-means tests are presented in Table 4. Overall, 61% of firms do not use performance pay. Both the average monthly wage[15] and its standard deviation are higher at firms using performance pay than at salary firms.[16] On average, performance pay firms are significantly larger than salary firms.[17] The average age and the total work experience of workers active at performance pay firms and at salary firms are similar. Although this would at first sight seem to contradict the model's prediction, the data in Table 4 actually support it. Indeed, although the multi-period sorting argument presented in Section 2.2 is cast in terms of worker age, prior work experience provides a better indication of switching behavior than age itself. If performance pay workers tend to switch to salary firms, then one should expect prior work experience of salary workers to be higher than that of performance pay workers. Table 4 shows that such is the case. Thus, the model's predictions are borne out by the simple statistics.

3.3 Compensation Form and Wages

The model predicts that performance pay should have a positive impact on the level and cross-sectional variability of compensation. These predictions are tested by estimating wage functions for the logarithm of the standardized monthly wage that include a dummy variable identifying firms using performance pay. The results are presented in Table 5. They demonstrate that the

See, for example, Diekmann and Engelhardt [9].

[15]All wages are standardized to monthly, full-time equivalent values by the SFSO, where "full-time" is defined as 4.3 workweeks per month at 40 hours per week. Wages include social security contributions, extra payments (e.g., for shift workers), and bonus pay.

[16]The reported standard deviation is the average value of the within-firm standard deviation, weighted by the number of workers in each firm.

[17]Brown [5] documents a positive relationship between firm size and incentive pay.

	Without perf. pay	With perf. pay	p-Value
Age	40.388	40.645	0.519
Schooling in years	11.874	12.450	0.000
Tenure in years	10.185	11.989	0.000
Prior experience in years	11.538	9.698	0.000
Total work experience in years	21.723	21.687	0.683
Supervisory position[a]	0.348	0.420	0.000
Foreign worker - seasonal worker[a]	0.012	0.002	0.000
Foreign worker - other[a]	0.300	0.238	0.000
Full-time: 90-100% employment[a]	0.924	0.947	0.012
Part-time: 50-90% employment[a]	0.042	0.023	0.000
Part-time: $<$ 50% employment[a]	0.028	0.006	0.000
Standardized monthly wage	5942.511	7774.081	0.000
Standard deviation of monthly wage	2572.016	4047.897	0.000
Performance pay as % of total pay	0	0.060	0.000
Average firm size	142.688	361.252	0.000
Number of workers	112341	72675	
Number of firms	2029	1282	

[a] dummy variables.

Table 4: Sample means for firms using and not using performance pay.

level of compensation is about $\exp(0.101)-1 = 10.6\%$ higher at firms implementing performance pay than at salary firms.[18]

In order to test the prediction that the cross-sectional wage dispersion is larger at firms implementing performance pay than at salary firms, the standard deviations of the wage function residuals for both groups of workers are computed, yielding $\sigma_{\text{piece rate}} = 0.258$ and $\sigma_{\text{salary}} = 0.240$. The quotient $\sigma^2_{\text{piece rate}}/\sigma^2_{\text{salary}}$ follows an F distribution with degrees of freedom equal to the number of observations in both samples minus unity (126,017 and 58,997, respectively). The quotient value of 1.155 is statistically significant at the 5% level, confirming the model's prediction.

3.4 Compensation Form and Age

The model's prediction that younger workers are more likely to be on piece rate is tested by running a logistic regression in which the dependent variable has a value equal to one if the respondent receives performance pay, and equal to zero otherwise. Two regressions are estimated: the first uses age as an explanatory variable, the second prior work experience. The use of prior experience instead of age aims at controlling for the fact that some workers start working later than others because they spend more years in education. Besides age or experience, the likelihood that a worker receives performance pay can be expected to depend on his hierarchical position and his tenure in the firm, as well as on the firm's size. These factors are therefore controlled for in the regressions.

The results of both the age and the experience regressions are presented in Table 6. As predicted by the theoretical model, the inclination to receive performance pay decreases with age. Furthermore, these results are robust to the use of experience instead of age as a regressor. However, both the age and the experience coefficient are small, suggesting that the flows of workers from salary to piece-rate firms are weak.

As mentioned at the end of Section 2.2.4, worker flows are weak when the payoff from effort is high and high-effort workers therefore do not switch to salary firms. In this case, the model predicts that the wage differential between performance pay and salary firms should increase with workers' age. Figure 2, which depicts the average monthly wage for workers active at salary and performance pay firms, confirms this prediction. Estimating wage functions that include an interaction term between performance pay and total work experience – the sum of prior experience and tenure – as an additional regressor reveals that the increase in the wage differential is highly significant, with a t-value of 15.320. Thus, all of the model's predictions

[18] Seiler [24] also reports higher wage levels and dispersion at piece-rate firms, but his wage functions do not include the standard human capital variables.

	Mean	Coefficient
Constant		7.280
		(0.004)
Prior experience in years	9.814	0.023
		(0.001)
Prior experience$^2 \cdot 10^{-3}$	170.682	-0.446
		(0.001)
Tenure in years	12.617	0.018
		(0.003)
Tenure$^2 \cdot 10^{-3}$	259.851	-0.201
		(0.087)
Years schooling	12.356	0.074
		(0.001)
Supervisory position^a	0.312	0.197
		(0.001)
Log firm size	6.858	0.002
		(0.000)
Foreign worker - seasonal worker^a	0.005	-0.129
		(0.009)
Foreign worker - other^a	0.255	-0.026
		(0.001)
Part-time: 50-90% employment^a	0.028	-0.059
		(0.004)
Part-time: $<$ 50% employment^a	0.015	-0.097
		(0.005)
Performance pay^a	0.681	0.101
		(0.001)
Number of observations		185016
Adjusted R^2		0.533

Note: the dependent variable is equal to the natural logarithm of the standardized monthly wage.
^{a} dummy variables.

Table 5: Wages and performance pay (standard errors in parentheses).

	Age regression	Experience regression
Constant	−3.902	−3.920
	(0.039)	(0.037)
Age	−0.003	
	(0.001)	
Prior experience in years		−0.003
		(0.001)
Tenure in years	0.017	0.017
	(0.001)	(0.001)
Years schooling	0.087	0.090
	(0.002)	(0.002)
Supervisory position[a]	0.091	0.091
	(0.012)	(0.012)
Log firm size	0.317	0.317
	(0.003)	(0.003)
Number of observations	185016	185016
Pseudo R^2 (Nagelkerke)	0.133	0.133

[a] dummy variable.

Table 6: The relationship between age/experience and the inclination to receive performance pay (standard errors in parentheses).

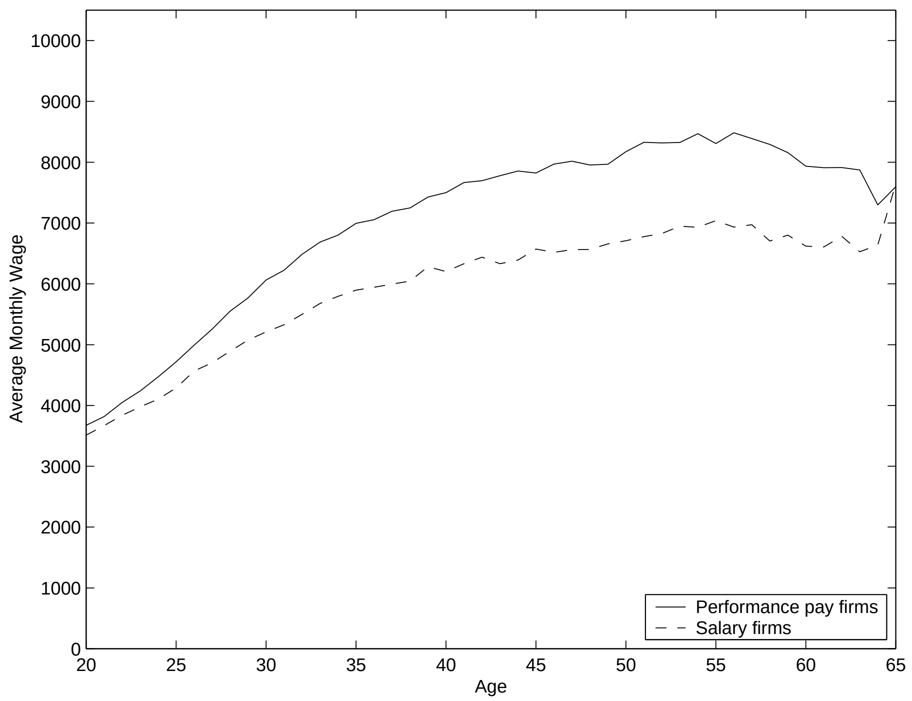

Figure 2: Average monthly wage for workers at salary and performance pay firms.

are borne out in the data.

4 Worker Sorting and Outsourcing in Business Related Services

4.1 Theory

A striking phenomenon of the recent history is the increased purchase by diversified corporations of business related services from specialized firms.[19] The classical explanation for this phenomenon is based on specialization and economies of scale. According to this view, the reason that large diversified corporations hire management consulting and other business related services (BRS) firms is that they do not have enough specialized tasks to perform in order to

[19] Clinton [7] reports that firms have significantly increased their purchases of services relative to directly hiring labor. Employment in business services has grown by 5.8% annually between 1988 and 1996, compared with 1.6% for total U.S. nonfarm employment. Business services account for more than 22% of the 14.3 million jobs created during the period. Along similar lines, Autor [3] notes that, between 1979 and 1995, the temporary help supply industry in the United States grew five times more rapidly than U.S. nonfarm employment.

justify organizing these activities internally.[20]

In an analysis of firms' contracting out behavior, Abraham and Taylor [1] find that smaller establishments are more likely to contract out, suggesting that economies of scale in the provision of business related services do play a role in the emergence of BRS firms. However, many large corporations have budgets for business related services in the hundreds of millions every year, raising doubts as to the validity of the economies of scale argument. Clearly, one could argue that such firms in fact hire many different BRS firms to perform a large number of distinct, very specialized tasks. Although there is certainly some truth to this argument, firms often purchase large amounts of *similar* consulting, programming, catering or janitorial services from the *same* firms for several years. Furthermore, these services are often being produced by the same teams of workers by those firms. This suggests that specialization in many cases does not constitute the actual reason for firms' decision to outsource these tasks.

The analysis presented above can help to shed some light on the reasons for the widespread purchase of business related services. Some of these services, such as accounting and management consulting, are very hard to measure and their production typically requires high-ability individuals. As was shown above, however, such employees will be attracted by firms implementing performance pay. Firms that are highly specialized in the provision of a small number of services will be able to measure performance at lower cost per worker. Imagine an executive of a large diversified corporation trying to measure the output of a very specialized worker. Due to lack of domain knowledge, he will be unable to do so effectively at low cost. However, a manager of a specialized firm spending most of his own time worrying about similar issues will quickly and easily get a sense of the worker's performance.[21] As a result of this measurement cost advantage, specialized firms can use performance pay to attract high-productivity

[20] Grossman and Helpman [13] consider the tradeoff between the costs of running a large and less specialized organization and the costs that arise from the need to search for a trading partner and incomplete contracting to explain firms' choice between outsourcing and in-house production. Along similar lines, Deavers [8] reports that firms' outsourcing decisions are driven by a search for flexibility and a need to focus on core competencies. Transaction costs and incomplete contracts are widespread explanations for outsourcing in the literature (see for example Williamson [28] and Grossman and Hart [14]).

[21] The literature provides a number of reasons for this. Geanakoplos and Milgrom [12] analyze the impact of the limits to people's ability to process information on the design of hierarchical structures. McAfee and McMillan [19] show that under asymmetric information, employees capture informational rents that become larger, the larger the number of levels in the hierarchy. Since diversified firms will require additional hierarchical levels, an immediate implication of their analysis is that production costs of diversified firms will be larger than those of specialized ones. Another result they establish which, although not based on measurement cost considerations, is relevant to the present study is that smaller organizations are more likely to use piece-rate compensation than large ones. Stigler [26] makes a similar prediction, arguing that large employers have a significant disadvantage in monitoring workers. Brown [5] provides an empirical analysis of the issue.

workers and then in effect lease them back to diversified corporations by providing business related services.[22] Thus, outsourcing of tasks to specialized firms can occur in spite of the fact that nothing inherent to the production technology makes external production more advantageous; external production arises *solely because of differences in measurement costs* between specialized and diversified firms.

The widespread use by BRS firms of non-compete clauses preventing their employees to accept job offers from one of the firm's customers is completely in line with this interpretation. Such clauses would be redundant if outsourcing were driven by real differences in production technology. In this case, workers would have a higher productivity at BRS firms than at non-BRS firms and would therefore have no incentive to leave a BRS firm for a non-BRS firm. However, because of the worker flows discussed in Section 2.2, non-compete clauses become especially important if BRS firms' main role consists in measuring workers' productivity.

Although such non-compete clauses do restrict worker mobility across firms, they are often hard to enforce, and some flow of measured workers from piece-rate to salary firms can be expected to occur through time as productivity is revealed. Such flows are especially likely from BRS firms to some of their customers due to the fact that in many jurisdictions, non-compete clauses can only be enforced against the firm's *competitors* but not against its *clients*.[23]

The existence of these flows, which is confirmed by anecdotal evidence in these markets, has an important empirical implication: the mix of workers should differ between BRS firms and non-BRS firms, with the former having a higher proportion of young, highly productive workers. Furthermore, and as mentioned in Section 2.2.4, whether the wage differential between piece-rate and salary workers increases or decreases with workers' age will depend on how strong worker flows are.[24]

To sum up, the empirical implications of differences in measurement costs and practices between BRS and non-BRS firms are the following:

1. BRS firms have a higher degree of specialization than non-BRS firms, which is reflected in a narrower range of tasks.

[22] Fama [11] makes the interesting observation that professional-service firms in law and business consulting usually pay their workers a combination of salary and an incentive payoff, but charge their clients for worker services on an *hourly* basis. He interprets billing for hours as a simple way to signal the firm's perception of output to its clients.

[23] This is for example the case in California and in Switzerland.

[24] A further consequence of these worker flows is that the variability of compensation for the switching workers should be larger than that of workers who were working at salary firms from the beginning, but lower than that of workers active at piece-rate firms. This is because although past performance is valuable in predicting future performance, it does not allow to do so perfectly. However, testing this prediction accurately would require a panel with which one could identify the switching workers.

2. The share of performance-related compensation is higher at BRS firms than at non-BRS firms.

3. Workers employed in BRS firms have higher productivity and therefore higher income than those active in non-BRS firms.

4. Workers employed in BRS firms have a compensation which has higher cross-sectional variation than those active in other firms.

5. Workers employed in BRS firms tend to be younger than those active in other firms.

4.2 Empirical Analysis

4.2.1 Descriptive Statistics

Table 7 presents descriptive statistics for BRS and non-BRS firms. Employees at BRS firms are younger, have more years schooling, lower levels of both prior work experience and tenure, and are more seldom foreigners. Both the average standardized monthly wage and its standard deviation are higher in BRS firms than in non-BRS firms. Furthermore, performance pay accounts for a larger share of total pay in BRS than in non-BRS firms, and BRS firms tend to be smaller. Thus, here again, the model's predictions are confirmed by the descriptive statistics.

4.2.2 Task Specialization in BRS and Non-BRS Firms

BRS firms should have a higher degree of specialization than non-BRS firms, which should be reflected in a narrower set of tasks performed by their workers. In order to test this hypothesis, firms' degree of specialization is measured using both the Herfindahl index and the entropy of the distribution of the number of workers performing each task in the firm. Letting $n_{i,j}$ denote the number of workers performing tasks of type j in firm i and n_i the total number of workers employed by firm i, the entropy of firm i, E_i, is given by

$$E_i \equiv -\sum_j \frac{n_{i,j}}{n_i} \ln\left(\frac{n_{i,j}}{n_i}\right) \tag{33}$$

Note that in contrast to the Herfindahl index, higher entropy implies lower specialization.

Table 8 reports both the unweighted and weighted average entropy and Herfindahl index values of BRS and non-BRS firms. As can be seen, the average entropy of BRS firms is lower than that of non-BRS firms, while the Herfindahl index values are higher (some differences are, however, only significant at the 10% level based on standard t-tests). This suggests that BRS

	BRS firms	Non-BRS firms	p-Value
Age	39.467	40.990	0.028
Schooling in years	13.483	12.103	0.000
Tenure in years	8.943	10.885	0.000
Prior experience in years	10.206	11.199	0.000
Total work experience in years	19.149	22.084	0.000
Foreign worker - seasonal worker[a]	0.003	0.098	0.000
Foreign worker - other[a]	0.209	0.290	0.000
Full-time: 90-100% employment[a]	0.878	0.944	0.000
Part-time: 50-90% employment[a]	0.060	0.036	0.000
Part-time: $<$ 50% employment[a]	0.062	0.020	0.000
Standardized monthly wage	7428.252	6478.698	0.000
Standard deviation of monthly wage	5060.655	3252.496	0.000
% receiving performance pay[a]	0.411	0.392	0.002
Performance pay as % of total pay[a]	0.024	0.016	0.000
Average firm size	134.008	235.100	0.000
Number of workers	6582	178434	
Number of firms	255	3056	

[a] dummy variables.

Table 7: Sample means for BRS and non-BRS firms.

	BRS Firms	Non-BRS Firms	Difference	p-Value
Unweighted Average Entropy	0.7864	0.8706	0.0842	0.032
Weighted Average Entropy	0.9367	1.2148	0.2781	0.101
Unweighted Herfindahl Index	0.5804	0.5482	-0.0322	0.080
Weighted Herfindahl Index	0.5462	0.3503	-0.1959	0.091

Table 8: Entropy and Herfindahl index values for BRS and non-BRS firms.

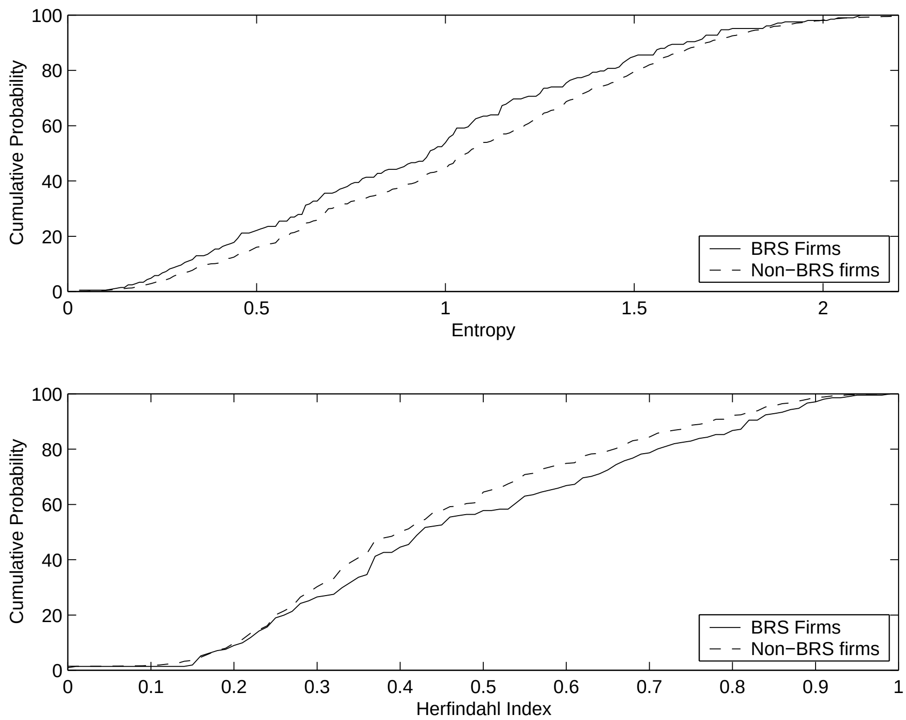

Figure 3: Distribution of the entropy and Herfindahl index values of tasks in BRS and in non-BRS firms.

firms indeed have a higher degree of task specialization than non-BRS firms, i.e. BRS firms' workforce performs a narrower set of tasks than workers active at non-BRS firms.

Closer examination of this data, however, reveals that entropy and Herfindahl index values are not normally distributed, as can be seen in Figure 3. The Smirnov-Kolmogorov normality test statistic has a value of 5.995 and 6.532 for the entropy and Herfindahl measures, respectively, which are significant at the 1% level. The plot also suggests that the entropy distribution of BRS firms lies to the left of that of non-BRS firms, and the Herfindahl index distribution to the right. For entropy, a Smirnov-Kolmogorov test for first-order stochastic dominance yields a χ^2_2 value of 10.27, which is significant at the 1% level, confirming that entropy is lower at BRS firms than at non-BRS firms. For the Herfindahl index, the χ^2_2 statistic is 6.50, which is significant at the 5% level, confirming that the Herfindahl index values are higher at BRS firms than at non-BRS firms. Thus, the conclusion that BRS firms are more specialized than non-BRS firms is robust to the non-normality of the data.

4.2.3 Proportion of Incentive Pay

In order to test the hypothesis that the share of performance-related pay is higher at BRS firms than at non-BRS firms, the empirical distribution of the share of performance-related compensation (defined as the sum of provisions, bonuses contingent on profits or sales, and

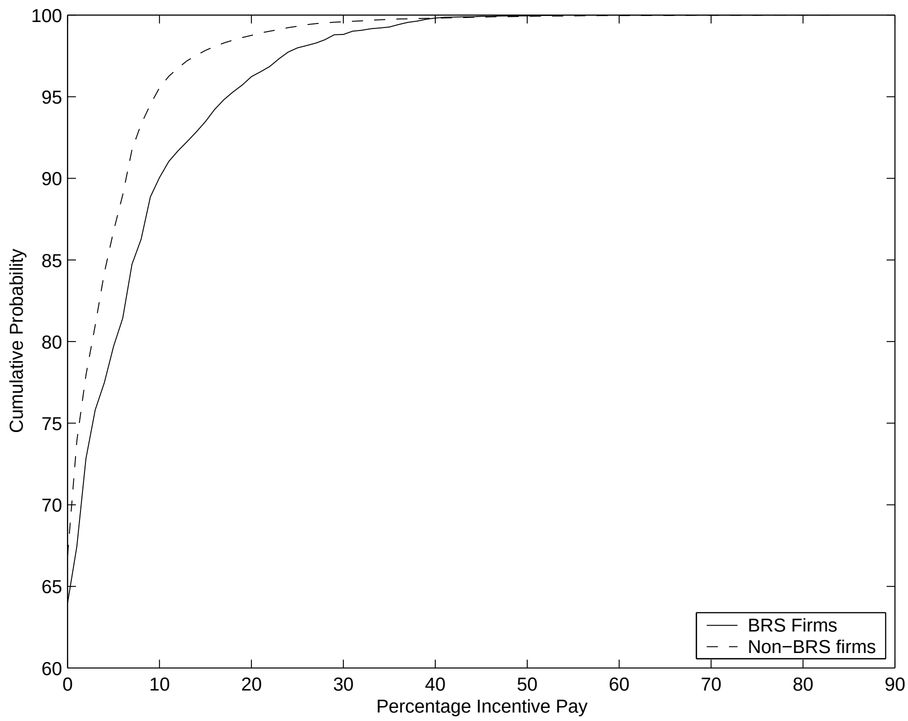

Figure 4: Distribution of the proportion of incentive pay for workers in BRS and in non-BRS firms.

other performance-related payments) to total compensation for each worker is computed. If the hypothesis is true, then the distribution for BRS workers should lie to the right of that for non-BRS workers.

Figure 4 depicts the distribution of the proportion of incentive pay to total compensation for workers active at BRS and non-BRS firms. Overall, BRS firms tend to pay a higher proportion of compensation in the form of incentive pay. A Smirnov-Kolmogorov test confirms that the proportion of incentive pay is higher at BRS firms than at non-BRS firms, with a highly significant χ^2_2 value of 144.91.

4.2.4 Productivity and Income

The model predicts that workers active at BRS firms should have higher unobserved productivity than those active at non-BRS firms. In order to test this hypothesis, we estimate an extended wage equation including the standard human capital variables (education, experience, tenure, and management position), controlling for other observable factors (working time, firm size and foreigner status) and including a dummy variable that identifies workers active at BRS firms. The results are presented in Table 9. The coefficient of the BRS-dummy variable is positive and highly significant (coefficient = 0.076; t-value = 23.175). Thus, after controlling for observable characteristics, workers active at BRS firms earn on average $\exp(0.076) - 1 = 7.9\%$

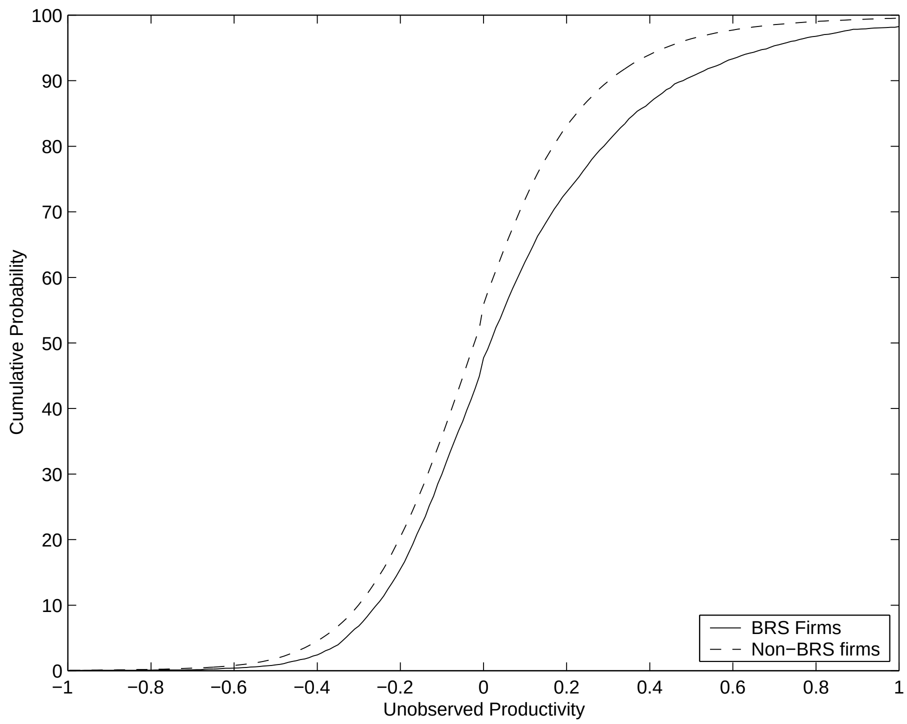

Figure 5: Distribution of unobserved productivity for workers in BRS and in non-BRS firms.

more than those active at non-BRS firms. This effect is illustrated in Figure 5, which depicts the distribution of workers' unobserved productivity in BRS and non-BRS firms. (For the former, unobserved productivity is taken to be the sum of the BRS dummy variable and of the wage equation residual.) Figure 5 also suggests that the variability of unobserved productivity is larger at BRS firms than at non-BRS firms. This prediction of the model will be tested formally in Section 4.2.5.

If measurement costs are the reason for wage differences between BRS and non-BRS firms, then one would expect these differences to be stronger for tasks or jobs where productivity is difficult to measure. Table 10 reports the average wage differential between workers active at BRS and non-BRS firms both for all tasks as well as for those tasks in which a sufficient number of observations is available.[25] As mentioned earlier, averaged over all tasks, BRS firms pay about 7.9% more than non-BRS firms. If the individual tasks are considered, it becomes apparent that BRS firms pay significantly more for those tasks which are hard to measure – accounting, finance, consulting, research and computer programming – with wage premia ranging from about 6 to over 11%. However, there is no significant wage premium for transportation and

[25] Table 10 considers the 13 tasks for which at least 50 observations are available in the BRS firms sample. The tasks not included in Table 10 are the following: (1) strategic management, (2) medical care and social work, (3) body care (e.g. hairdressers) and dry cleaners, (4) pedagogical activities, (5) catering and housekeeping, (6) activities in the field of culture, information, entertainment and sport, (7) other activities.

	Mean	Coefficient
Constant		7.259
		(0.004)
Prior experience in years	9.814	0.023
	(8.624)	(0.000)
Prior experience$^2 \cdot 10^{-3}$	170.682	-0.045
	(264.525)	(0.001)
Tenure in years	12.617	0.019
	(10.033)	(0.000)
Tenure$^2 \cdot 10^{-3}$	259.851	-0.214
	(359.169)	(0.001)
Years schooling	12.359	0.075
	(2.527)	(0.000)
Supervisory position[a]	0.312	0.192
	(0.463)	(0.001)
Log firm size	6.858	0.029
	(1.898)	(0.000)
Foreign worker - seasonal worker[a]	0.005	-0.144
	(0.067)	(0.009)
Foreign worker - other[a]	0.255	-0.026
	(0.436)	(0.001)
Part-time: 50-90% employment[a]	0.028	-0.069
	(0.166)	(0.004)
Part-time: 50-90% employment[a]	0.015	-0.104
	(0.122)	(0.005)
BRS firm[a]	0.036	0.076
	(0.185)	(0.003)
Number of observations		185016
Adjusted R^2		0.521

Note: the dependent variable is equal to the natural logarithm of the standardized monthly wage.
[a] dummy variables.

Table 9: Wage function including a dummy variable identifying workers active at BRS firms.

	Coefficient	p-Value
Accounting, Finance, Personnel	0.0757	0.000
Secretariat and Back Office	0.1685	0.000
Other administrative jobs	0.0661	0.000
Logistics	0.1090	0.000
Consulting	0.0936	0.000
Purchases and sales of raw materials and investment goods	0.1632	0.000
Sales of consumption goods and services	0.2589	0.000
Research and Development	0.0772	0.000
Analysis and Programming	0.1021	0.000
Planning, Construction, Design, Organization	−0.0168	0.084
Transportation and Shipping	−0.0225	0.121
Security services	−0.1416	0.000
Cleaning services	−0.0909	0.000
All Tasks	0.0761	0.000

The table shows the coefficients of the interaction terms between BRS-firm and task dummies. The regressions include the same explanatory variables as in Table 9.

Table 10: Average wage differential between workers active at BRS and at non-BRS firms for different tasks.

shipping, a task which is physical and therefore quite easy to measure. In the case of security and cleaning services, BRS firms actually pay less than non-BRS firms. These are also activities which, in general, are easy to measure. Together, these results suggest that sorting of workers is indeed taking place between BRS and non-BRS firms, but it is occurring only for workers performing intellectual, hard-to-measure tasks.

It is interesting to compare these results with those in Abraham and Taylor [1]. In their study of contracting out behavior, they find evidence that contracting out for janitorial services is positively related to the average level of wages in an establishment. For accounting and computer services, on the other hand, the likelihood of contracting out is negatively related to an establishment's wage level. Their interpretation is that internal equity constraints both preclude high-wage establishments from paying low wages for peripheral, easily-monitored work, and preclude low-wage establishments from paying high wages for highly skilled work even when it may be attractive to do so. The picture that emerges from Table 10 is consistent with this interpretation. In the context of our model, wage compression is also the underlying factor leading to outsourcing, but it is not driven by equity considerations. Rather, wage compression occurs in salary firms because of their inability to measure workers' output at low cost. As a result, it would not be profitable for them to attempt to hire high-productivity workers. In the Abraham and Taylor study, outsourcing occurs because of wage compression *between* different types of jobs (i.e., based on *observables*), while in the model considered here, it is driven by salary firms' wage compression *within the same* type of job, i.e. because of *unobservables*.

Although disentangling these two potential explanations – equity or measurement costs – based on a comparison of average wage levels is difficult, the fact that the proportion of incentive pay is significantly higher at BRS firms does suggest that sorting plays a role for their emergence. Furthermore, if equity considerations were the only driver of outsourcing practices, then income dispersion at BRS and non-BRS firms should be comparable. The next section shows that this is not the case.

4.2.5 Cross-Sectional Income Variation

The sorting model predicts that workers employed in BRS firms should have a compensation which has higher cross-sectional variation than those active at non-BRS firms. In order to test this prediction, the standard error of the wage function residuals for BRS and non-BRS workers around their respective means is computed. The respective values of 0.2967 and 0.2541 suggest that income variation is sizably larger at BRS firms. The quotient $\sigma^2_{\mathrm{BRS}}/\sigma^2_{\mathrm{Non\text{-}BRS}}$ follows an F distribution with degrees of freedom equal to the number of observations in both samples minus unity (6,581 and 178,433, respectively). The quotient value of 1.354 is statistically significant at the 5% level.

4.2.6 Worker Age Distributions and Age Profile of the Wage Differential

In order to test the hypothesis that workers employed in BRS firms tend to be younger than those in other firms, we compute the age distribution both for workers in BRS firms and those in non-BRS firms. If the hypothesis is true, then the cumulative age distributions of workers in BRS firms should lie to the left of that of workers in non-BRS firms. Whether such is the case can be tested using standard procedures. Figure 6 depicts the age distribution of workers active in BRS and in non-BRS firms. Overall, BRS firms employ a larger proportion of young workers than non-BRS firms. A Smirnov-Kolmogorov test that the age of BRS firm workers is lower than that of non-BRS firm workers yields a highly significant χ^2_2 value of 77.55. These results thus suggest that some migration of workers from BRS firms to non-BRS firms is indeed taking place through time as worker productivity is revealed.

Further insights into the nature of worker flows can be gained by looking at the age profile of

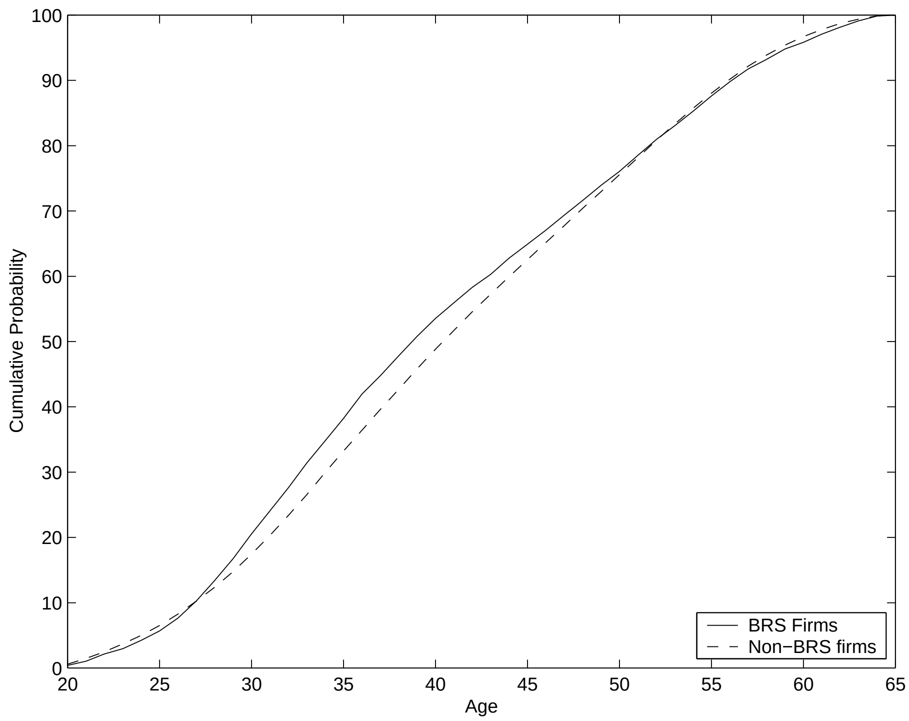

Figure 6: Age distribution for workers in BRS and in non-BRS firms.

the wage difference between both groups of workers. Recall that the model predicts that, when the payoff to effort is high, hard-working employees will not switch to salary firms as their productivity is revealed, and the wage differential will therefore increase with age. The age earnings profiles reported in Figure 7 suggest that such is the case. Wage functions including the interaction of the BRS dummy variable and age as an additional regressor yield the same conclusion, with a coefficient value of 0.00190 and a highly statistically significant t-value of 6.501. Thus, the picture that emerges from the wage data is consistent with the notion that effort is important in BRS firms and only few workers switch to non-BRS firms after their productivity has been revealed.

5 Conclusion

When measurement costs differ among firms, only firms with low measurement costs use performance pay. Because productive workers choose to work at performance pay firms and their compensation reflects their individual productivity, both the level and variability of compensation are higher at performance pay firms than at salary firms. Furthermore, as time passes and workers' productivity is measured by performance pay firms, it becomes at least partially observable to salary firms through the amount of compensation these workers receive. As a result, some workers switch from performance pay firms to salary firms as their productivity is

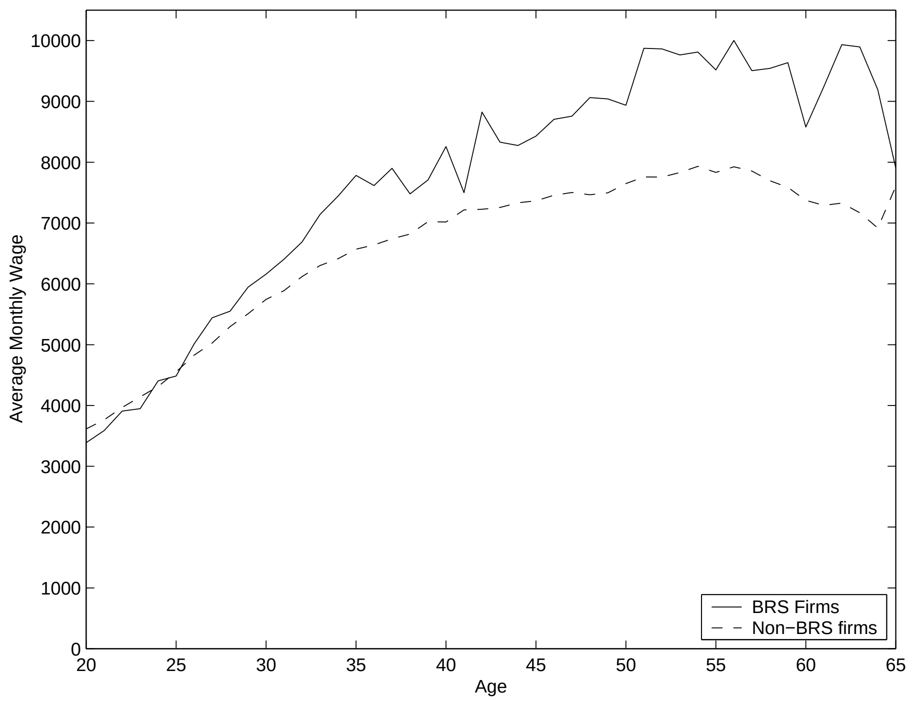

Figure 7: Log wages for workers in BRS and in non-BRS firms.

revealed. Which workers switch depends on the payoff from effort. When this payoff is high, hard-working workers do not switch and the wage differential between performance pay and salary firms increases with age. When it is low, even hard-working workers switch once their productivity has been measured and the wage differential decreases with age. As a result, there is a relationship between the strength of worker flows from performance pay to salary firms and the age profile of the wage differential between performance pay and salary firms.

An empirical analysis of the 1998 Swiss Wage Structure Survey data confirms the model's predictions: After controlling for observables, workers active at performance pay firms earn on average about 10% more than workers active at salary firms and the variability of their compensation is higher. The distribution of worker age at salary and performance pay firms is quite similar, suggesting that the flows from performance pay firms to salary firms taking place through time are relatively weak. Consistent with this result, the wage differential between both groups of firms is strongly increasing in workers' age.

Because they are much more specialized than diversified corporations, business related service (BRS) firms have lower measurement costs, which constitute a rationale for their emergence. Data from the 1998 Swiss Wage Structure Survey confirm this interpretation: BRS firms make a much wider use of performance pay than other firms. After controlling for observables, their workers have compensation that is on average about 8% higher than that at non-BRS firms. The wage differential tends to be higher for intellectual tasks which are hard to measure and zero or even negative for some physical tasks which are easier to measure. Furthermore, workers at BRS firms exhibit a compensation that is more variable than workers at non-BRS firms and tend to be younger. Finally, the wage differential between BRS and non-BRS firms is increasing in age, suggesting that the payoff of effort is large for those workers.

References

[1] Abraham, Katharine G. and Susan K. Taylor (1996): "Firms' Use of Outside Contractors: Theory and Evidence," *Journal of Labor Economics* 14, 394-424.

[2] Autor, David H. (2001): "Why do Temporary Help Firms Provide Free General Skills Training," *Quarterly Journal of Economics* 116, 1409-1448.

[3] Autor, David H. (2003): "Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing," *Journal of Labor Economics* 21, 1-42.

[4] Becker, Gary S. (1993): *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, 3rd Ed., Chicago - London.

[5] Brown, Charles (1990): "Firms' Choice of Method of Pay," *Industrial and Labor Relations Review* 43, Special Issue, 165S-182S.

[6] Brown, Charles (1992): "Wage Levels and Method of Pay," *RAND Journal of Economics* 23, 366-375.

[7] Clinton, Angela (1997): "Flexible Labor: Restructuring the American Work Force," *Monthly Labor Review* 120, 3-27.

[8] Deavers, Kenneth L. (1997): "Outsourcing: A Corporate Competitiveness Strategy, Not a Search for Low Wages," *Journal of Labor Research* 18, 503-519.

[9] Diekmann, Andreas and Henriette Engelhardt (1995): "Einkommensungleichheit zwischen Frauen und Männern. Eine ökonometrische Analyse der Schweizer Arbeitskräfteerhebung," *Schweizerische Zeitschrift für Volkswirtschaft und Statistik* 131, 57-83.

[10] Ewing, Bradley T. (1996): "Wages and Performance-based Pay: Evidence from the NLSY," *Economics Letters* 51, 241-246.

[11] Fama, Eugene F. (1991): "Time, Salary, and Incentive Payoffs in Labor Contracts," *Journal of Labor Economics* 9, 25-44.

[12] Geanakoplos, John and Paul Milgrom (1991): "A Theory of Hierarchies Based on Limited Managerial Attention," *Journal of the Japanese and International Economies* 5, 205-225.

[13] Grossman, Gene M. and Elhanan Helpman (2002): "Integration versus Outsourcing in Industry Equilibrium," *Quarterly Journal of Economics* 117, 85-120.

[14] Grossman, Sanford J. and Oliver D. Hart (1986): "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 94, 691-719.

[15] Holmstrom, Bengt and Jean Tirole (1991): "Transfer Pricing and Organizational Form," *Journal of Law, Economics, and Organization* 7, 201-228.

[16] Lazear, Edward P. (1986): "Salaries and Piece Rates," *Journal of Business* 59, 405-431.

[17] Lazear, Edward P. (2000): "Performance Pay and Productivity," *American Economic Review* 90, 1346-1361.

[18] Lazear, Edward P. (2003): "The Peter Principle: A Theory of Decline," *Journal of Political Economy* 112, S141-S163.

[19] McAfee, R. Preston and John McMillan (1995): "Organizational Diseconomies of Scale," *Journal of Economics and Management Strategy* 4, 399-426.

[20] Paarsch, Harry J. and Bruce S. Shearer (2000): "Piece Rates, Fixed Wages, and Incentive Effects: Statistical Evidence from Payroll Records," *International Economic Review* 41, 59-92.

[21] Parent, Daniel (2001): "The Effect of Pay-for-Performance Contracts on Wages," Working Paper, McGill University.

[22] Prendergast, Canice (1999): "The Provision of Incentives in Firms," *Journal of Economic Literature* 37, 7-63.

[23] Prey, Hedwig (2002): "Bonus Pay in Switzerland: A Discriptive Analysis," Discussion Paper No. 83, Research Institute for Labor Economics and Labor Law, St. Gallen.

[24] Seiler, Eric (1984): "Piece Rate vs. Time Rate: The Effect of Incentives on Earnings," *Review of Economics and Statistics* 66, 363-376.

[25] Spence, A. Michael (1973): "Job Market Signaling," *Quarterly Journal of Economics* 87, 355-374.

[26] Stigler, George (1962): "Information in the Labor Market," *Journal of Political Economy* 70, Investment in Human Beings, 94-105.

[27] Swiss Federal Statistical Office (SFSO) (2000): *Lohnstrukturerhebung 1998*, Bern.

[28] Williamson, Oliver E. (1975): *Markets and Hierarchies: Analysis and Antitrust Implications*, New York, Free Press.