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METHOD OF PAY IN FINNISH INDUSTRY

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Abstract: In this paper a dynamic model is derived to describe and analyze the decision of the method of pay. Empirical evidence is presented using microeconomic data on the blue-collar workers in Finnish industry. Logit models are used to analyze the factors affecting the choice of incentive wages. Special attention is paid to unobserved heterogeneity across workers. A new estimator based on a small variance approximation of unobserved heterogeneity is derived for this purpose. In the second stage wage equations by the methods of pay with selectivity into different groups are estimated.

KEY WORDS: Method of pay, incentive wages, efficiency, industry

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Tämän tutkimuksen teoreettisessa osassa analysoidaan palkkaustavan valintaa dynaamista palkkaustavan valintamallia käyttäen. Tutkimuksen empiirisessä osassa tarkastellaan palkkaustavan valintaa Suomen teollisuuden työntekijöistä saadun yksilötason aineiston perusteella. Palkkaustavan valintaan vaikuttavia tekijöitä tutkitaan logit-malleja käyttäen. Erityinen huomio kiinnitetään valintamalleissa mahdollisesti puuttuvien valintaa selittävien muuttujien vaikutukseen. Empiirisen tutkimuksen toisessa vaiheessa tarkastellaan palkanmuodostusta ottaen huomioon valikoituminen palkkaustavoittain.

AVAINSANAT: Palkkaustapa, suorituspalkkaus, tehokkuus, teollisuus

Contents

Tiivistelmä:

Tehokkuuteen kannustava suorituspalkkaus on tärkeä keino tehokkuuden ja työmarkkinoiden jouston lisäämiseksi. Tässä tutkimusraportissa johdetaan empiirisen tutkimuksen perustaksi ja palkkaustavan valintaan vaikuttavien tekijöiden analysoimiseksi dynaaminen talousteoreettinen malli. Mallin yhden tuloksen mukaan pitkäksi aikaa yritykseen sitoutuvat henkilöt eivät työskentele suorituspalkkauksella yhtä usein kuin henkilöt, joilla on jostakin syystä rajoitettu työsuhteen pituus. Esimerkiksi opiskelijoiden ja lasten kotihoitoon siirtyvien naisten voidaan odottaa työskentelevän muita useammin suorituspalkkauksella.

Empiirinen tutkimus perustuu Teollisuuden ja Työnantajain Keskusliiton laajaan yksilötason palkka-aineistoon. Tutkimus on tehty käyttäen poikkileikkausotosta vuonna 1990 teollisuuden palveluksessa olleista työntekijöistä. Tutkimuksen kohteeksi on rajattu metalli- ja metsäteollisuuden työntekijät.

Empiirisessä tutkimuksessa palkkaustavan valintaan vaikuttavia tekijöitä tutkitaan logit-malleja käyttäen. Tutkimuksessa löydetään useita palkkaustavan valintaan vaikuttavia tekijöitä. Esimerkiksi aikapalkan lisät ovat negatiivisessa riippuvuussuhteessa suorituspalkan valitsemisen kanssa. Se tukee teoreettisen mallin päätelmää, että korkea aikapalkka vähentää kannustinta työskennellä urakkapalkalla. Aikapalkan suoraa vaikutusta ei saada esiin, sillä kaikki työntekijät eivät saa aikapalkkaa.

Tulosten mukaan naiset työskentelevät miehiä useammin suorituspalkkauksella. Suorituspalkkaukseen osallistuminen lisääntyy iän myötä, mutta keski-iän ohittaneilla osallistuminen vähenee. Vuorotyö on positiivisessa riippuvuus-

suhteessa suorituspalkan valinnan kanssa. Työehtosopimuksissa määritellyt työn vaatimustasot (palkkaryhmät) ovat positiivisessa riippuvuussuhteessa mekaanisen metsäteollisuuden sopimusalalla suorituspalkan valinnan kanssa.

Käytettäessä logit-malleja palkkaustavan analysoimiseen erityinen huomio kiinnitettiin havaitsemattomaan heterogeenisuuteen yksilöiden välillä. Pois jätetyt valintaa selittävät muuttujat voivat johtaa harhaisiin mallin estimoituihin kertoimiin. Sen vuoksi kehitettiin uusi estimaattori, jossa voidaan estimoida kuhunkin valintaan liittyvät havaitsemattomista selittävistä muuttujista aiheutuvat varianssit. Tulosten mukaan havaitsemattoman heterogeenisuuden huomioiminen on tärkeää, vaikka tutkimusaineisto on luotettava ja suhteellisen monipuolinen.

Tutkimuksen toisessa osassa tarkasteltiin palkanmuodostusta palkkaustavoittain. Erityinen huomio kiinnitettiin siihen, että palkan määräytyminen on ehdollinen ensimmäisen vaiheen palkkaustavan valinnalle. Palkanmuodostusta koskevien tulosten mukaan miehet saavat hieman korkeampaa palkkaa kuin naiset. Tämä palkkaero on hieman suurempi tehokkuuteen perustuvassa suorituspalkassa kuin sopimukseen perustuvassa aikapalkassa. Työntekijöiden iän vaikutus palkkaukseen on konkaavi siten, että keski-ikäiset saavat muita korkeimpia ansioita.

Aika- ja suoritystyölle estimoitujen palkkayhtälöiden perusteella työn vaativuuteen (työehtosopimusten palkkaryhmä) perustuvat palkkaerot ovat aikapalkkauksessa suuremmat kuin suorituspalkkauksessa. Tulosten mukaan työehtosopimuksissa sovitut työn vaativuuteen perustuvat palkkaerot ovat liian suuria, että ne perustuisivat yksinomaan työntekijöiden tehokkuuseroihin.

1. Introduction

The choice of the method of pay has many explanations. They centre not only around the monitoring costs but also around all the factors affecting the time-based and incentive-based wages. In this paper a dynamic model of the method of pay is derived in order to predict the choice of the method of pay and to present empirical evidence on the theoretical results.

The model is an extension of Lazear's (1986) static model, where he assumes symmetric information between workers and firms. Both of them are equally uninformed of the productivity of the workers, but know the distribution of the productivity. The dynamic model gives predictions for the effects of many explanatory variables. The probability of working at a particular piece rate is decreased by the time-based wage, monitoring costs and increased by the piece-rate, subjective rate of time preference and distribution and uncertainty of offers. The dynamic nature of the model predicts, for example, that women and students are more amenable to working on a piece-rate basis, because they usually have a limited spell of employment in a firm.

The microeconomic data on the wages of the Finnish industrial workers give support to the theoretical findings. The data are classified by the method of pay. The samples of the study have been made from the large files collected for bargaining purposes by the

Confederation of Finnish Industry and Employers. The data have been obtained directly from the accounting figures of the member firms of the confederation.

The econometric study analyzes the choice of the method of pay and the wage structure by the different methods of pay in the wood, paper and metal industries. The characteristics of the workers, jobs and plants are rather detailed in the data.

This study is organized as follows. In the next section the dynamic model of the method of pay is derived. It serves as a background to the empirical study. The data of this study are presented in section 3. The logit models allowing for unobserved heterogeneity are derived in section 4. The results of the estimations of the wage equations by the method of pay are presented in section 5. Finally the results of the study are summarized and discussed in the concluding section.

2. A Dynamic Model of Method of Pay

A standard goal in the economic studies of the method of pay is to maximize worker's expected wealth subject to a zero profit constraint. An essential characteristic of the piece-rate pay is that it is an incentive device for increased effort. The wage level is determined by the effort E and the cost of effort function c(E). The worker increases his effort as long as the cost of effort per unit of output q is less than the piece-rate p. Hence the efficient effort level is given by $E^* = \arg_E \max\ [pq(E) - c(E)]$.[1] There are, however, a number of other factors which explain why some workers are paid by the piece for their output while the others are paid by the hours worked on their input of working hours. The predictions of the effects of the various factors are derived from an economic model of the method of pay.

The time-based wage $\bar{w}$ depends strictly on the working hours. In the firms there are usually minimum requirements for the effort of time work. A dismissal results only if the required minimum tasks are not fulfilled or serious mistakes are made. While the time-based wage is usually known in advance, an essential feature of the piece-rate wage is that there is uncertainty about the output. It is

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[1] Because the form of the production function q(E) is free, any cost function can always be reduced to c with an appropriate redefinition of q (see Lazear, 1986). Alternatively the production function can be given the interpretations of quality or effort.

assumed that workers and firms are equally uninformed of q, but both of them know the distribution of q. The density and distribution functions are denoted as f(q) and F(q), respectively.

In a simple form the piece rate in Lazer's (1986) static model is determined by an expected output as follows

$$(1) \qquad w = \int_{\bar{w}}^{\infty} qf(q)dq - c,$$

where $\bar{w}$ can be interpreted as the time-based wage. Consequently the expected lifetime wealth can be written as follows

$$(2) \qquad W = \bar{w}F(\bar{w}) + w.$$

The lifetime wealth is determined by the time-based wage with probability $F(\bar{w})$ if the output does not exceed the threshold value of wage $\bar{w}$. Otherwise the wealth is determined by the expected piece-rate wage. Lazear has extended the model introducing the initial monitoring period in order to test the output of each worker and to select the workers for the piece-rate work.

There is not always piece-rate work available in the firms. Therefore the workers are assumed to be offered piece-rate work with probability $a\Delta t$, which weights the alternative choices of time-based and incentive wage. The collective wage agreements, which are made on the union level, bind the firms to maximize the earnings of the workers by offering piecework whenever it is available. In the following the expected discounted worker's time-based wage during an interval of length Δt is evaluated against the prospective new offers of incentive wage.

The value function for an individual who is paid by the time-based wage can be written as follows

$$(3) \qquad V(t+\Delta t) = \frac{1}{1+r\Delta t}\{\bar{w}\Delta t + a\Delta t\, E_F \max[V'(t), V(t)] + (1 - a\Delta t)V(t)\},$$

where r is the subjective rate of time preference. The time concept in the value functions is reversed indicating the worker's remaining time in the labour force. The expectation is taken with respect to the distribution of the quality (or effort) of workers.

The interpretation of (3) is as follows. The workers' compensation for being employed at a time-based wage is proportional to the length of the time interval Δt. With probability $a\Delta t$ a piece-rate offer is received. The value function of the prospective new offer of piece-rate work is denoted by $V'(t)$. The acceptance rule is presumed to maximize the workers value in the labour market. With probability $(1 - a\Delta t)$ the worker will not receive an offer. This alternative leads to a value function of the time-based wage $V(t)$.

The decision on the method of pay can be treated in continuous time. Forming the difference quotient

$[V(t+\Delta t) - V(t)]/\Delta t$, taking the limit as Δt approaches zero and rearranging terms gives

$$\dot{V}(t) = \bar{w} + a\, E_F \max[V'(t), V(t)] - (a + r)V(t). \tag{4}$$

In the case of an infinite horizon equation (4) is equal to zero.

On the piece-rate basis the worker's compensation depends on the piece rate p for producing a unit of output q. The cost of increasing the incentives for a more productive work is that the firm has to establish a monitoring system. A constant amount of the monitoring costs c has to be allocated for each worker. Alternatively one could define the costs to depend on the output, but the conclusions of the analysis would be similar.

The monitoring costs depend on how difficult it is to measure the worker's output. The costs c can be given also other interpretations such as the cost of effort. On the piece-rate basis the workers compensation can be written as follows

$$w = pq - c, \tag{5}$$

where the efficient separation of workers is determined by an acceptance rule. According to the acceptance rule only the workers with $q \geq q'$ are paid at the piece rate. The others are paid at the time rate.

For simplicity it is reasonable to assume an infinite horizon. Hence, the discount factor $B = 1/r$ and the discounted earnings are $w/r = (pq - c)/r$. An infinite horizon leads to a stationary solution implying a constant value function. Then the differential equation can be written as follows

$$(6) \qquad \dot{V} = \bar{w} - rV + a \int_{q'}^{\infty} [(pq - c)/r - V]dF(q).$$

The infinite horizon may not always, however, be reasonable. At least this is true when looking from the standpoint of the workers. A worker's time in the labour force may vary with the time set aside for planned education, maternity, house work or age. Assuming a finite horizon of length t the differential equation can be written as follows

$$(7) \qquad \dot{V}(t) = \bar{w} - rV(t) + a \int_{q'(t)}^{\infty} [(pq - c)B(t) - V(t)]dF(q),$$

where $B(t) = [1 - \exp(-rt)]/r$. Differentiating (6) and (7) with respect to the endogenous variable q' gives the optimal dynamic control for accepting the piece-rate work. The stationary and nonstationary solutions can be written as follows

$$(8a) \qquad q' = [V'r + c]/p$$

$$(8b) \qquad q'(t) = \{V'(t)r/[1 - \exp(-rt)] + c\}/p.$$

It is obvious that in a case of finite horizon $q'(t)$ is decreasing when the time is passing. (Technically the remaining time t is approaching zero.) That finding gives an interesting prediction for the persons who can participate in the labour force for only short periods of time. One may expect that, for example, students and women are more amenable to be pieceworkers.

The probability of being paid at a piece rate is a product of the arrival rate of offers and the probability of accepting an offer. It can be written as follows

(9) $\lambda(t) = a[1 - F(q'(t))].$

The selectivity of workers with respect to the offers is determined by the threshold value of $q'(t)$. In a case of nonstationarity a time path of $q'(t)$ determines the corresponding time path of $\lambda(t)$. The effects of exogenous variables on both q' and λ are presented in Appendix 1 of this study. In the following these result are briefly discussed.

The increase of the level of time-based wage $\bar{w}$ increases the threshold value of the productivity of the workers and makes the piecework less probable. This finding is in accordance with the Finnish collective wage agreements, which presumes that the earnings of the piece-rate work have to exceed the time-based wage of the contracts by a certain amount. In the metal industry the wage gain of the incentive wages has to be at least 20 per cent and in the wood industry has to be 17 per cent compared to the contract wage. Usually the contract wage is lower than the true time-based wage. If the piece-rate wage does not exceed the time-based wage, the employer has to pay the time-based wage.

An implication of the effect of the time-based wage is that also all the additional forms of compensation related to the time-based wage, such as overtime and shift-work incrementals and fringe benefits, will have negative effects on the probability of being paid by the piece. A disadvantage of a high time-based wage is that the piece-rate work becomes less attractive.

The piece rate p is equal for all the workers. If the piece rate is high, the workers are eager to seek their ways to piece work and finally there may be few skilled workers left for the piece work. Accordingly, if the firm wants to encourage the workers to apply themselves in an efficient incentive work scheme, the wage differentials should be relatively small in similar type of jobs and reflect the differences of the earnings from piece work.

The monitoring costs of the output have had a central role in the economic literature of incentive wages (see Lazear, 1986 and Brown, 1990). The meaning of the monitoring cost is identical to the difficulty of measuring the output of a worker. For example, it is not easy to monitor the effort of a travel agent, but it is easy to observe the number of items sold. The effects of the monitoring costs are similar to the effects of the time-based wage. When the monitoring costs are high or the increase of effort is costly, the required level of output increases and the probability of paying incentive wage falls. The monitoring costs of the time-based work are usually lower. Therefore it is in many cases worthwhile.

Piece-rate workers are not always available in a firm. The direct effect of the arrival rate on the probability of working on the incentive wage basis is clearly positive. The quality of workers better suits the needs of the firm. On the other hand, the availability of piece-rate workers will increase the selectivity of the firm, because it can choose from a broader set of workers. The indirect effect of the arrival rate is negative. As a consequence of these two reverse effects the sign of the arrival rate on the probability of paying piece-rate wage can not generally be determined. Under reasonable assumptions the effect of the arrival rate is, however, positive. The sufficient conditions for the effect to be non-negative are summarized by van den Berg (1990).

The effect of piece rate p on the selectivity is clearly negative. Since piece-rate work is better paid, it is more attractive. The effect of piece rate on the probability of paying piece rate is positive. The piece rate is an efficient way of encouraging workers to apply themselves more effectively. The piece rate p is determined by the firm. The firms are, however, bound to the collective wage agreements, which stipulates that the earnings from the piece work has to exceed the time-based wage by a certain amount.

Macroeconomic shocks may affect the choice of the method of pay. If the demand for the products of the firm increases, also the piece rate increases in the longer run. That will in turn increase the number of pieceworkers in a firm. Consequently the selectivity of a firm decreases. It may lead in an economic boom to a shortage of skilled workers.

The increase of the discount rate makes the earnings of the present day more valuable compared to the earnings in the future. From the standpoint of corporate finance the required yield from production increases with the discount rate. Therefore the discount rate will decrease the selectivity and increase the probability of piecework.

The distribution of the quality of the workers may have a shift to the right or left. A movement in the distribution to the right may occur, for example, when a firm decides to increase the firm specific skills of the workers by providing training. The shift may occur also due to an improvement in working conditions or technology. The management's skill in removing these obstacles to production have been detailed, for example, in an early work by Slichter (1941). The results are interesting, because the improvement in the distribution of the quality will increase the selectivity of workers and hence the wealth of workers. This leads, however, also to an increasing probability of piecework, because the increase in selectivity is negligible compared to the direct effect of the shift of the distribution.

The heterogeneity across the quality or productivity of workers increases the required productivity of workers and decreases the probability of choosing incentive work.

This result is familiar from the shopping literature. Consumers love bargains, which makes them more selective. Similarly the workers have an option of waiting for offers in the upper tail of the wage distribution. Piece rates are less likely chosen when the uncertainty of the output of the workers increases. If the a firm knows in advance the output of each worker, the need for testing and choosing the best workers is non-existent.

In the previous literature on the methods of pay the effect of a finite job tenure has been given different interpretations. Obviously one reason has been that the previous discussion has not been based on a unified dynamic model of the method of pay. The other reason is that simple explanations have been sought for the empirical findings including, for example, that women work more often on a piecework basis.

Goldin (1986) argues that better performance is rewarded through future promotion and less monitoring is employed. Such a system is efficient for men, who are planning a stable attachment to the firms. The promise of future promotion does not encourage those who are planning a short job tenure in the firm. Brown (1990) argues also that women might avoid the time-based wage, because supervisors have great discretion. Therefore women concentrate in systems with the formal protection offered by either standard rates or piece rates. Using a dynamic model of the method of pay these previous explanations in the literature are not necessarily needed to explain why women would avoid the time-based wage. These explanations may be relevant, but they can be replaced simply by a shorter job tenure.

It is evident that the optimal time path of the required level of ability or effort q'(t) is decreasing as time passes (see Kettunen, 1993a). According to the model the persons who expect their employment to terminate in the near future are expected to be less selective and more likely to work on a piecework basis. For example, students on a summer holiday are presumably willing to be paid by incentive wages. Similarly women often expect an interrupted spell of employment, because they want to work at home and raise children. They are thus probably more attracted to piece work.

The previous discussion has been concentrated upon the pure time-based and piece-rate work. Often in practice a *two-part wage system* is applied. Most jobs fit somewhere in the middle of the time-based and piece-rate work. Consider a capital-intensive production process. With capital it is important for efficiency reason to keep the process running. It means that the wage system must have incentives for that. A two-part incentive wage system is an obvious candidate to satisfy these needs. A time-based wage is paid for the input of workers, but on the other hand it is efficient to pay simultaneously for the quantity or quality of the output.

Suppose for simplicity that each worker operates a machine which increases their productivity by a factor of k_1. On the other hand, workers require their part of the rent of a machine k_c. The compensation of a worker from the output q is equal to $pqk_1 + k_c - c$. The effects of k_1 and k_c are obvious and similar to the previous results of the effects of the piece rate p. The increase in labour productivity k_1 will decrease the required quality of workers and increase the probability of selecting an incentive wage. Increasing labour's share of the rent has similar kind of effects.

3. Description of the Cross-Section Data

The data have been collected for bargaining purposes by the Confederation of Finnish Industry and Employers. The confederation has collected enormous amounts of data starting in the mid 1930's. Nowadays the data consist every year of about 300 000 blue-collar workers and 150 000 white-collar workers (see Kettunen and Marjanen, 1992, Kettunen and Vartiainen, 1993 and Kettunen, 1993b). The information has been collected on every person who has been working in a member firm of the confederation. There is good reason to believe that the data are reliable, because they are not self-reported. The data have been obtained directly from the accounting figures of the firms.

The sample of this study is based on a cross-section of 8458 blue-collar workers. Every 15th worker was randomly drawn from those covered in 1990 by the collective wage agreements of the wood, paper and metal industries. These industries are the most important for Finnish manufacturing. They also have a central role when the wages are negotiated. The industries are analyzed separately, because some of the explanatory variables are not comparable between the industries. The data refer to the last quarter of the year.

The number of workers in the samples of the wood, paper and metal industries are 1122, 2148 and 5188, respectively. Some of the workers in these samples have unbelievable low or high wages. These kinds of outliers can occur if the persons are working during a quarter a small number of hours and receive some part of their earnings in advance or afterwards. The hourly wages have been obtained by dividing the earnings by the hours of work during the quarter. Thus the hourly wages do not necessarily represent the true hourly wage. In this study the observations between FIM 20 and 110 were accepted. About 2.9 per cent of the observations were rejected. The final sample sets include 1095, 2060 and 5054 workers.

The information on the workers include, for example, the earnings, working hours, gender, age and occupation. There are information also on the jobs. The information on the required level of skill is available. The level of skill is ascribed in accordance with the collective wage agreement. There are data also on the overtime and sunday work. Also some of the characteristics of the plants are available. They include the share of men in a plant, average age of the workers, number of workers and the location of a plant.

The earnings and working hours have been decomposed into three methods of pay. Nearly half of the working hours are paid at the time-based wage in manufacturing. The remaining incentive wages have been decomposed into two groups. One group comprises the work based on the quantity of the output. The other group encompasses incentive wages based also on the quality of the output.

The incentive wages are not paid purely on a piece-rate basis, but they may include two parts related to time-based and incentive wages. The pure piece-rate work is usually based on the quantity of output. The incentive wage based on the quantity and quality is partly determined by the time-based wage and partly by the incentive wage. Unfortunately the data have no information on the breakdown between these two parts.

Another often used two part wage system is that, if the output falls below a certain threshold, the earnings of workers are determined using the time-based wage. Otherwise the workers are eligible for the incentive wage or the wage incremental related to the output.

Table 1 illustrates the shares of the working hours by the methods of pay in the different industries of the study. About 45 per cent of all the working hours are based on incentive wage in the wood industry. In the paper and metal industry the corresponding figures are 15 and 36 per cent, respectively. Most of the incentive work in the wood industry is done on a quantity basis. On the other hand, most of the incentive work in the paper industry is not based only on quantity but on both the quantity and quality. The paper industry is a typical example of a capital-intensive business. In the metal industry both of the incentive wages are equally employed.

Table 1. Shares of the working hours by the methods of pay

(A) Time-based work
(B) Incentive work based on quantity
(C) Incentive work based on quantity and quality

	(A)	(B)	(C)
Wood industry	0.546	0.416	0.038
Paper industry	0.846	0.024	0.129
Metal industry	0.644	0.178	0.178

During a quarter workers can be paid by the hours worked and by the piece. It turns out that these mixed-rate workers can to a large extent be primarily classified into time or piece-rate workers according to their jobs. It is typical that the method of pay depends on whether the compensation is from production or maintenance work. Time-based wages are usually applied temporarily for setup, needed maintenance or during the shifts of production. The monitoring costs in the form of calculating the piece-rate would be too high during these short periods in order to chose the incentive pay (see Chen and Edin, 1992).

The wage of a worker consists of the basic wage, which depends on the method of pay. According to the collective wage agreements the time-based wage has been defined using the wage groups which are classified according to the required level of skill in a job. The basic wage includes also the incrementals related to the high cost areas of residence. These areas have been determined by the government. They include the largest towns, islands and Lapland. The basic wage and wage incrementals based on shift work and work conditions form the regular wage. The regular wage together with the incrementals from the overtime and sunday work form the total wage of the worker. During the period of study the additional compensation constituted on average about 9 per cent of the total wage in the Finnish industry.

To obtain the indicators of the method of pay the workers are classified into time-based or incentive wage workers according to type of hours that they work most during the quarter of the year. This classification is used as a basis of the estimations of the logit models. The classification is reasonable, since according to the data the workers in the plants are classified in one or the other way.

A general view among the experts of the labour market is that the firms are classified according to whether they pay the time-based or piece-rate wage (see Vartiainen, 1993). An interview of the experts confirm that the tasks in the firms are classified as time-based or incentive work. Hence the workers are classified according to the methods of pay. Table 2 shows that 92-98 per cent of all the working hours of the persons who have been classified as time workers are from the time-based work. Similar figures for the two kinds of incentive work are 81-86 and 85-86 percent, respectively.

Table 2. Shares of the working hours by the classification of workers by the method of pay

	Most hours by		
	time work	incentive work based on quantity	incentive work based on quantity & quality
Wood industry:			
Time-based work	0.917	0.170	0.125
Incentive work[1]	0.072	0.826	0.026
Incentive work[2]	0.010	0.004	0.849
Paper industry:			
Time-based work	0.981	0.130	0.142
Incentive work[1]	0.005	0.864	0.003
Incentive work[2]	0.013	0.006	0.854
Metal industry:			
Time-based work	0.948	0.167	0.121
Incentive work[1]	0.028	0.813	0.017
Incentive work[2]	0.024	0.020	0.862

1. Based on quantity. 2. Based both on quantity and quality.

An alternative approach to the discrete choice is to use the individual data on working hours to analyze the choice of the method of pay. The working hours can be used to calculate the shares of working hours by the method of pay. The models of grouped data on the working hours can be estimated using the proportions of working hours instead of the discrete indicators for the choice of the method of pay. One may believe that the shares of working hours are more precise having more information than the indicators. On the other hand, an incentive worker may, however, be temporarily engaged in time-based work, since incentive work is not available at the moment. Therefore the decision to use the indicators or shares in the study is an empirical question. Various experiments were made using the discrete and grouped data. The log-likelihood functions were, however, clearly lower in the models using grouped data. Therefore the approach based on grouped data is rejected and the results are not reported to save space.

The descriptive statistics of the data are presented in Table 3. It turns out the incentive wages are clearly higher than the time-based wage in all the studied industries. The largest differences between the time-based and piece-rate wages are in the paper industry. Most workers are men in industry. The share of men vary between 76 - 81 per cent. The average age of workers in the wood, paper and metal industries are 39, 40 and 38 years, respectively. The largest plants can be found from the paper industry.

There are rather few workers in the forest industry located in the county of Uusimaa compared to the metal industry. About 15-16 per cent of the jobs in the forest industry are situated in the high cost area. In the metal industry the corresponding share is 35 per cent. In the forest industry the work conditions are clearly worse than in the metal industry. Nearly every second worker has been working over their regular working hours. Sunday work is common in the paper industry, where the production is characterized as an ongoing work. This can be seen also from the number of work shifts. Working in three shifts is common in paper industry. The required level of skill is classified so that the most workers are on the middle and high levels.

Table 3. Descriptive statistics of the cross-section data on wages in 1990

Wood industry:

Variables	Mean	Std.Dev.	Minimum	Maximum
Time-based hourly wage[1], FIM	38.04	5.82	24.00	78.20
Incentive hourly wage[2], FIM	41.83	6.16	26.76	92.50
Incentive hourly wage[3], FIM	41.86	8.40	28.89	78.87
Sex, 1=male	0.76	0.43	0.00	1.00
Share of men in a plant	0.76	0.11	0.33	1.00
Age, years	38.75	10.79	16.00	63.00
Average age in a plant, years	38.27	2.28	29.00	47.00
Number of workers in a plant	892.16	1002.49	8.00	2957.00
County of Uusimaa, 1=yes	0.02	0.16	0.00	1.00
High cost area, 1=yes	0.15	0.36	0.00	1.00
Poor working conditions, 1=yes	0.19	0.39	0.00	1.00
Overtime work, 1=yes	0.48	0.50	0.00	1.00
Sunday work, 1=yes	0.15	0.36	0.00	1.00
Required level of skill, 1=yes: 1	0.08	0.27	0.00	1.00
2	0.21	0.41	0.00	1.00
3	0.28	0.45	0.00	1.00
4	0.23	0.42	0.00	1.00
(high) 5	0.20	0.40	0.00	1.00
Number of work shifts, 1=yes: 1	0.42	0.49	0.00	1.00
2	0.30	0.46	0.00	1.00
3	0.19	0.39	0.00	1.00
unknown	0.09	0.29	0.00	1.00

N = 1095, 1. N = 743, 2. Based on quantity, N = 746, 3. Based on quantity and quality, N = 119.

Paper industry:

Variables		Mean	Std.Dev.	Minimum	Maximum
Time-based hourly wage[1], FIM		43.30	5.20	31.25	79.25
Incentive hourly wage[2], FIM		57.50	17.68	38.23	107.50
Incentive hourly wage[3], FIM		47.92	6.51	32.47	95.73
Sex, 1=male		0.81	0.39	0.00	1.00
Share of men in a plant		0.81	0.05	0.30	0.94
Age, years		40.09	10.18	18.00	63.00
Average age in a plant, years		40.17	1.41	32.00	47.00
Number of workers in a plant		3414.48	2252.39	33.00	6584.00
County of Uusimaa, 1=yes		0.01	0.11	0.00	1.00
High cost area, 1=yes		0.16	0.37	0.00	1.00
Poor working conditions, 1=yes		0.41	0.49	0.00	1.00
Over-time work, 1=yes		0.49	0.50	0.00	1.00
Sunday work, 1=yes		0.66	0.47	0.00	1.00
Required level of skill, 1=yes:	1	0.12	0.32	0.00	1.00
	2	0.14	0.34	0.00	1.00
	3	0.21	0.41	0.00	1.00
	4	0.25	0.43	0.00	1.00
(high)	5	0.29	0.45	0.00	1.00
Number of work shifts, 1=yes:	1	0.35	0.48	0.00	1.00
	2	0.14	0.34	0.00	1.00
	3	0.51	0.50	0.00	1.00

N = 2060, 1. N = 1104, 2. N = 92, 3. N = 1123.

Metal industry:

Variables		Mean	Std.Dev.	Minimum	Maximum
Time-based hourly wage[1], FIM		42.86	7.63	20.00	91.41
Incentive hourly wage[2], FIM		50.09	9.47	21.46	108.12
Incentive hourly wage[3], FIM		46.91	7.08	24.00	95.53
Sex, 1=male		0.77	0.42	0.00	1.00
Share of men in a plant		0.77	0.22	0.13	1.00
Age, years		38.30	10.43	16.00	66.00
Average age in a plant		38.05	2.94	25.00	49.00
Number of workers in a plant		981.02	1254.45	5.00	4930.00
County of Uusimaa, 1=yes		0.18	0.38	0.00	1.00
High cost area, 1=yes		0.35	0.48	0.00	1.00
Poor working conditions, 1=yes		0.11	0.31	0.00	1.00
Over-time work, 1=yes		0.47	0.50	0.00	1.00
Sunday work, 1=yes		0.26	0.44	0.00	1.00
Required level of skill, 1=yes:	1	0.40	0.49	0.00	1.00
	2	0.43	0.50	0.00	1.00
(low)	3	0.17	0.38	0.00	1.00
Number of work shifts, 1=yes:	1	0.66	0.47	0.00	1.00
	2	0.20	0.40	0.00	1.00
	3	0.09	0.28	0.00	1.00
	unknown	0.06	0.23	0.00	1.00

N = 5054, 1. N = 4117, 2. N = 1383, 3. N = 1821.

4. Empirical Evidence on the Choice of Method of Pay

4.1. Unobserved Heterogeneity Across Workers in the Logit Models

In this section the logit model of the method of pay is studied. Special attention is paid to the unobserved heterogeneity across workers. The probability of the alternative i given by the well known logit model can be written as follows

$$(10) \qquad p(i|x,\beta) = \frac{\exp(x\beta_i)}{\sum_{j=1}^{J} \exp(x\beta_j)},$$

where x is a (N × k) matrix of explanatory variables having information about N workers and β_i is a (k × 1) vector of k coefficients for a choice i. Note that the explanatory variables are the same for the different choices. In order to avoid singularity of the Hessian matrix one of the alternatives has to be normalized as a reference group. It is done by setting $\beta_J = 0$.

A confusing variant of the logit model (10) is called a discrete choice model, where the J alternatives are characterised by J sets of regressors related to each of the choices and a single parameter vector (see McFadden, 1974, 1976, 1984). Regardless of the number of choices, there is a single (k × 1) vector of parameters to be estimated. That model is sometimes called also the random utility model.[2]

In our logit model there is a single regressor vector and J-1 parameter vectors. The extended logit model developed in this study is inspired by a similar extension by Chesher and Santos Silva (1992) in the context of discrete choice models. Appendix 2 presents the main characteristics of their model. Unfortunately there is no appropriate data on the method of pay in order to estimate a discrete choice model. The differences between the data and formulations of the model are the reasons for

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[2] The alternative discrete choice model can be written as follows

$$p(i|x,\beta) = \frac{\exp(x_i\beta)}{\sum_{j=1}^{J} \exp(x_j\beta)}.$$

Apart from the denominator the discrete choice model resemble the famous Cox's (1972, 1975) model

$$p(i|x,\beta) = \frac{\exp(x_i\beta)}{\sum_{j\in R(t_i)} \exp(x_j\beta)},$$

where $R(t_i)$ is the risk set. It includes the observations which are still in the cohort at the duration t_i. A small variance approximation in the context of Cox's model seems to be a difficult problem and to our knowledge it has not yet been solved.

extending the small variance approximation by Chesher and Santos Silva to our logit model.

Suppose that the model is misspecified in such a way that the explanatory variables do not control completely for the heterogeneity between the workers. This doubt is reasonable, since in the logit model the explanatory variables do not take different values between the alternatives as in the discrete choice model.

Let us assume that unobserved heterogeneity across workers can be represented by a random term $u = [u_j]$ which is additive to the observed heterogeneity. The term of heterogeneity u can be interpreted as intrinsic heterogeneity between workers or measurement error in the regressors x or the dependent variables y; for a discussion see Lancaster (1983, 1985) and Chesher (1991). The conditional choice probabilities given x and u can be written as follows

$$(11) \qquad p(i|x,\beta,u) = \frac{\exp(x\beta_i+u_i)}{1+\sum_{j=1}^{J-1}\exp(x\beta_j+u_j)}.$$

The conventional logit model assumes that the utilities of different individuals are independently distributed. This assumption is hardly met in the real world, since the unobserved characteristics may be correlated among the individuals who have chosen a certain alternative. Unobserved heterogeneity has usually been neglected for the sake of convenience as pointed out by Amemiya (1981). Apparently one reason is the difficulty in specifying the correct structure of the neglected heterogeneity.

Since u is unobserved the relevant marginal density can be written as follows

$$(12) \qquad \bar{p}(i|x,\beta) = \int_{-\infty}^{\infty} p(i|x,\beta,u) f(u|x) du,$$

where $f(u|x)$ is the density function of u given x. The functional form of $f(u|x)$ is generally unknown.

In order to avoid imposing any specific form for the function $f(u|x)$ a small variance approximation is derived. It is obtained by expanding $p(i|x,\beta,u)$ in a second order Taylor series in u and integrating u. It gives the following approximation

$$(13) \qquad \bar{p}(i|x,\beta) = p_i + 0.5\omega_i p_i^{ii} + o(\omega^2),$$

where ω_i is the variance of the unobserved heterogeneity, $p_i^{ii} = p_i(1 - 3p_i + 2p_i p_i)$ and $p_i = p(i|x,\beta)$. The variance ω_i related to the choice i is a scalar. The remainder term $o(\omega^2)$ is of negligible magnitude. The approximation (13) can not, however, be used in this form as the basis for estimating the unknown parameters, since it does not in general lie in (0, 1).

In order to obtain an expression which lies in (0, 1) and has a first order Taylor series in ω identical to (13) consider the following choice probability

$$(14) \qquad g(i|x,\beta,\omega) = \frac{\exp(x\beta_i + r_i\omega_i)}{1 + \sum_{j=1}^{J-1} \exp(x\beta_j + r_j\omega_i)} .$$

In the appealing formula (14) the puzzling interest is in the new unknown terms r_j, which are worth of examining more closely.

The first order Taylor series expansion of $g(i|x,\beta,\omega)$ can be written as follows

$$(15) \qquad g(i|x,\beta,\omega) = p_i + \omega_i r_i p_i(1 - p_i) + o(\omega^2) .$$

Setting (13) equal to (15) gives the needed expression for the unknown term r_j, which can simply be written as $r_j = 0.5 - p_j$.

Substituting $0.5 - p_j$ for r_j in equation (14) leads to an extended multinominal logit model which can be written as follows

$$(16) \qquad g(i|x,\beta,\omega) = \frac{\exp[x\beta_i + (0.5-p_i)\omega_i]}{1 + \sum_{j=1}^{J-1} \exp[x\beta_j + (0.5-p_j)\omega_i]} .$$

Formula (16) allows one to identify the variances of unobserved heterogeneity ω_i related to the choices $j = 1,\ldots,J-1$. There are as many coefficients of variances as vectors of the structural parameters. The covariances between the alternative choices are zero unlike in the model by Chesher and Santos Silva (1992).

The likelihood contribution of a conventional logit model can be written using the indicators y_j, $j = 1,\ldots,J$, valued zero or unity as follows

$$(17) \qquad L_1 = \Pi \ p(i|x,\beta)^{y_i},$$

where the product is over the choices. Correspondingly for the extended logit model the likelihood function can be written as follows

$$(18) \qquad L_2 = \Pi \ g(i|x,\beta,\omega)^{y_i}.$$

The first order condition of the maximum likelihood in a logit model can be written for each choice i as follows

$$(19) \qquad \frac{\partial \log L_1}{\partial \beta_i} = \Sigma \ (y_i - p_i)x,$$

where $p_i = p(i|x,\beta)$. The first order conditions for the extended logit model can be written as follows

$$(20a) \qquad \frac{\partial \log L_2}{\partial \omega_i} = \Sigma \ (0.5 - p_i)(y_i - g_i)$$

$$(20b) \qquad \frac{\partial \log L_2}{\partial \beta_i} = \Sigma \ [(1 - \omega_i p_i)(y_i - g_i)$$

$$+ \sum_{j=1}^{J-1} \omega_j p_i p_j (y_j - g_j)]x,$$

where $g_i = g(i|x,\beta,\omega)$. It is easy to verify that $\partial \log L_1/\partial \beta_i = \partial \log L_2/\partial \beta_i$ if $\omega_i = 0$. The data consist of the indicators of the method of pay y_i and the explanatory variables x.

For the estimation of the logit models a programme using SAS/IML matrix language was written (SAS/IML, 1985). It is based on Andrew Chesher's SAS/MATRIX programme for estimating censored Weibull models of transition data. The original programme has been used, for example, to estimate models of female fertility (Chesher, 1986).

The maximum likelihood algorithm of the programme is a modification of the well-known Newton-Raphson method. The Newton-Raphson method requires the analytic second derivatives of the log-likelihood function with respect to the unknown parameters. Often the second derivatives are awkward and time consuming to derive. Therefore they are avoided by using the IM-identity. This leads to the algorithm by Berndt, Hall, Hall and Hausman (1974), which in our case requires the analytic first derivatives (19) or (20a and 20b). The variance matrix for the coefficients is the summed outer products of the first derivatives of the log-likelihood function.

The algorithm of the programme uses a line search method in order to determine the size of the step. If a decreasing value of the log-likelihood function is observed near the solution, the size of the step is halved as many times as needed in order to reach the increasing value of the function. The programme is presented in Appendix 3. It has an option of estimating a conventional logit model (SIGMA=0) and a model allowing for unobserved heterogeneity (SIGMA=1). The modified versions of the programme have been used to estimate also the other maximum likelihood models of this thesis.

4.2. Estimation Results

The models for the wood, paper and metal industries have been estimated separately, because the wage agreement and the determinants of wages in the collective agreement vary between these industries. There is a collective wage agreement in the wood and paper industry, but there are also local negotiations on the wages. The firms in the metal industry closely follow the collective wage agreements. The wage incrementals based on overtime, sunday and shift work and the required levels of skill are not comparable between the industries.

The results of estimations for a choice of incentive wage in the wood industry have been reported in Table 4. The time-based and incentive wages are the choices of the binary logit model. There are not enough observations in the data for a three-choice model. It turns out that the estimate of the variance of the unobserved heterogeneity takes a statistically significant value. Allowing for unobserved heterogeneity increases the log-likelihood function considerably. Also the absolute values of the parameter estimates increase. They increase also if additional explanatory variables are included in the model. As a consequence the results based on the conventional logit model are biased. These results are similar to the findings of Lancaster (1979) in the context of unemployment duration models.

According to the results of estimations it is more likely to find female workers engaged in incentive work. Also the share of men in a plant has negative coefficients. These findings support the results based on the dynamic economic model of the method of pay. The limited attachment of women to their employer increases their incentives to seek out the better paying jobs with piecework.

The effect of age is according to the parameter estimates of the model increasing up to 37 years. Thereafter the effect is decreasing. The workers who are near their age of retirement are more seldom paid at a piece rate than the youngest workers. The average age of the workers in a plant is positively related to the probability of choosing incentive work.

The size of a plant is measured using the number of workers in a plant. The incentive wage is most often applied in small plants. This result gives support to the importance of monitoring costs. Oi (1983) and Garen (1985) have argued that the monitoring costs may be high in large firms. Therefore the incentive wage is less attractive in these firms.

The indicator of the county of Uusimaa does not take a statistically significant coefficient in the wood industry. Uusimaa is the richest county including the capital of Finland, but it is not the core area of the wood industry. The wage incrementals due to the high cost area have strong negative effects.

The wage incrementals due to poor working conditions are negatively related to the probability of choosing incentive wage. The wage incrementals based on the high costs and poor working conditions increase the time-based wage. For the persons having a high time-based wage the incentive wage is apparently less attractive. The results give support to the economic model of the method of pay. The time-based wage itself can not be used in these models, because it is not available to the persons who work entirely on an incentive work basis. The indicators for overtime and sunday work do not have statistically significant coefficients.

The required level of skill has been defined in the wage agreement between the trade union of the wood industry workers and the corresponding employers' association. According to the results there is a positive relationship between the required level of skill and the probability of working on an incentive wage basis. Some of the coefficients are statistically insignificant. That is due to the fact that the required level of skill increases the time-based wage, which has a negative effect. Therefore the coefficients of these indicators reflect the negative effect of the time-based wage and the positive effect of the skill.

The number of work shifts is positively related to the choice of the incentive wage. This reflects the effects of monitoring costs. Usually the monitoring of incentive work is easy. Therefore the tasks are not bound to the daytime and can be carried out at any time. The output is usually measured during the day shift.

The coefficients of 14 occupational indicators reflect notable differences between the occupations. These coefficients have been omitted to save space. An investigation of the coefficients indicates that incentive work is used often in production work and rather seldom in maintenance work and service.

Table 4. Results of estimations for a choice of incentive wage in the wood industry from binary logit models [1]

(A) Conventional logit model (B) Extended logit model allowing for unobserved heterogeneity	(A)	(B)
Constant	-6.109 (1.923)	-3.150 (2.896)
Variance of heterogeneity		6.916 (0.407)
Sex, 1=male	-0.495 (0.220)	-1.051 (0.325)
Share of men in a plant	-1.171 (0.849)	-4.511 (1.339)
Age, years	0.097 (0.049)	0.216 (0.072)
Age squared, years/100	-0.131 (0.062)	-0.294 (0.092)
Average age in a plant, years	0.172 (0.038)	0.187 (0.058)
Number of workers in a plant/1000	-0.391 (0.105)	-0.534 (0.142)
County of Uusimaa, 1=yes	0.313 (0.657)	0.587 (0.746)
High cost area, 1=yes	-0.732 (0.208)	-1.115 (0.287)
Poor working conditions, 1=yes	-0.192 (0.188)	-0.924 (0.271)
Overtime work, 1=yes	-0.153 (0.158)	0.097 (0.221)
Sunday work, 1=yes	-0.122 (0.246)	-0.286 (0.350)
Required level of skill, 1=yes:		
1 (reference group)		
2	-0.056 (0.305)	0.482 (0.437)
3	-0.081 (0.308)	0.129 (0.445)
4	0.214 (0.331)	0.959 (0.481)
5 (the highest level)	0.051 (0.363)	1.039 (0.524)
Number of work shifts, 1=yes:		
1 (reference group)		
2	0.583 (0.181)	0.945 (0.253)
3	1.333 (0.277)	1.764 (0.348)
unknown	0.170 (0.249)	0.201 (0.384)
Number of occupational indicators	14	14
Log likelihood	-588.6	-574.9
Number of observations	1095	1095

[1] The standard errors are in the parentheses.

The results of estimations for the choice of incentive wage in the paper industry have been reported in Table 5. The estimate of the variance of the unobserved heterogeneity takes a statistically significant value, which is clearly smaller than the corresponding estimate of the models for the wood industry. The allowance for unobserved heterogeneity increases the log-likelihood function and in most cases also the absolute values of the parameter estimates.

In the paper industry men are more often engaged in incentive work than women. In some of the experiments the effect of sex was insignificant. On the other hand, the share of men is negatively related to the probability of working on an incentive wage basis. This reflects that in the paper industry the decision of starting at a piece rate does not depend primarily on the individuals but rather on the prevalence of working groups. The working groups are rather common in the plants, because the character of the work is to control the processes of a paper mill.

The effect of age on the individual level is concave and it peaks at 37 years of age. The propensity of working on a piecework basis is slightly smaller for the older than the younger workers. The average age of workers in the plant has a negative and significant coefficient. Possibly it reflects the decisions of working groups. Older groups may be inclined to avoid piece-rate work in order to protect some weak members of the group. The size of the plant measured as the number of workers does not have a statistically significant effect on the choice of incentive work.

The indicator for the county of Uusimaa has a negative and significant coefficient. The wage incrementals due to the high cost area are negatively related to the probability of choosing the incentive wage.

The wage incrementals based on the poor working conditions are negatively related to the probability of choosing the incentive wage. Because the wage incrementals are contributions to the time-based wage, the negative coefficients were expected by the economic model. The indicators of the overtime and sunday work have statistically insignificant coefficients in these models.

The required level of skill does not have a statistically significant effect. It reflects according to the theoretical model the negative effect of time-based wage and the positive effect of skills. The indicators of working in two or three shifts have significant and positive coefficients with respect to the incentive wage. The indicators for the occupations of the paper industry show clearly smaller differences between the occupations than in the models for the wood industry.

Table 5. Results of estimations for a choice of incentive wage in the paper industry from binary logit models [1]

(A) Conventional logit model
(B) Extended logit model allowing for unobserved heterogeneity

	(A)	(B)
Constant	7.758	14.947
	(2.000)	(3.667)
Variance of heterogeneity		3.992
		(0.619)
Sex, 1=male	0.216	0.663
	(0.169)	(0.323)
Share of men in a plant	-3.377	-4.020
	(1.170)	(1.923)
Age, years	0.078	0.143
	(0.037)	(0.071)
Age squared, years/100	-0.105	-0.183
	(0.045)	(0.089)
Average age in a plant, years	-0.176	-0.360
	(0.040)	(0.078)
Number of workers in a plant/1000	-0.006	0.010
	(0.023)	(0.049)
County of Uusimaa, 1=yes	-1.498	-4.726
	(0.513)	(1.131)
High cost area, 1=yes	-2.658	-5.846
	(0.213)	(0.767)
Poor working conditions, 1=yes	-0.159	-0.381
	(0.120)	(0.222)
Overtime work, 1=yes	-0.091	0.056
	(0.111)	(0.196)
Sunday work, 1=yes	0.056	0.058
	(0.146)	(0.275)
Required level of skill, 1=yes:		
1 (reference group)		
2	0.108	0.277
	(0.212)	(0.385)
3	-0.074	-0.064
	(0.203)	(0.378)
4	-0.082	-0.066
	(0.208)	(0.386)
5 (the highest level)	-0.046	-0.437
	(0.229)	(0.448)
Number of work shifts, 1=yes:		
1 (reference group)		
2	0.685	1.660
	(0.179)	(0.375)
3	0.301	1.273
	(0.182)	(0.404)
Number of occupational indicators	17	17
Log likelihood	-1192.2	-1185.4
Number of observations	2060	2060

[1] The standard errors are in the parentheses.

The results of estimations for a choice of incentive wage in the metal industry have been reported in Table 6. The three choices of the model are: 1) incentive wage based only on quantity, 2) incentive wage based both on quantity and quality and 3) the time-based wage. The time-based wage is the reference choice of the model.

The estimates of the variances of the unobserved heterogeneity related to the both types of incentive wages take statistically insignificant values. Hence, as a consequence, it can be concluded that there is no need to correct for neglected heterogeneity in these models and the conventional logit models can be used to draw the conclusions. In addition, it can not be observed that the absolute values of the parameter estimates would increase when unobserved heterogeneity is allowed in these models. This finding is in line with the previous models where the neglected heterogeneity biased the parameter estimates towards zero.

Men have negative but statistically insignificant coefficients regarding the choice of incentive wages. The share of men in a plant is positively related to the probability of choosing the incentive wage based on quantity. The effect of age on an individual level has a concave relationship with both types of the incentive wages. The effects peak at the 43 and 41 years of age in the first and second alternatives of the choices, respectively. The effects of age are slightly smaller for the older workers compared to the younger workers. The average age of the workers in the plant has a positive relationship for both types of incentive wages.

The number of workers in a plant is positively related to the incentive wage based on quality and quantity. Brown (1990) argues that in large firms the monitoring costs for a worker are usually lower (see also Cleland, 1955 and ILO, 1984). Therefore the incentive work would be more attractive.

In Uusimaa the propensity of working on an incentive work basis is lower than in the other parts of the country. The indicators of the high cost area are negatively related to the probability of choosing the incentive wage based on quantity and quality, but an unexpected result is that it is positively related with respect to incentive wage based on quantity. The indicators of the overtime and sunday work do not take statistically significant coefficients.

The required level of skill has a statistically significant and positive effect on the choice of incentive wage based on quantity. Working in two or three shifts are positively related to the choice of incentive wages. The parameter estimates of the occupational indicators show that there are notable differences between the occupations. The incentive wage is seldom used in the maintenance departments of the factories, but it is often used in the production work.

Table 6. Results of estimations for a choice of the method of pay in the metal industry from multinominal logit models[1]

(A) The conventional logit model
(B) The extended logit model allowing for unobserved heterogeneity

	(A)	(B)
Incentive wage based on quantity:		
Constant	-8.383	-2.912
	(1.082)	(0.961)
Variance of heterogeneity, ω_1		-4.921
		(3.543)
Sex, 1=male	-0.189	-0.112
	(0.153)	(0.077)
Share of men in a plant	0.616	0.062
	(0.295)	(0.135)
Age, years	0.051	0.030
	(0.028)	(0.015)
Age squared, years/100	-0.060	-0.036
	(0.036)	(0.020)
Average age in a plant, years	0.081	0.043
	(0.016)	(0.012)
Number of workers in a plant/1000	0.053	0.367
	(0.058)	(0.117)
County of Uusimaa, 1=yes	-0.616	-0.103
	(0.124)	(0.059)
High cost area, 1=yes	0.327	-0.109
	(0.102)	(0.073)
Overtime work, 1=yes	-0.159	-0.010
	(0.100)	(0.050)
Sunday work, 1=yes	0.097	0.089
	(0.124)	(0.064)
Required level of skill, 1=yes:		
1 (reference group)		
2	0.356	0.035
	(0.102)	(0.053)
3 (the lowest level)	0.366	-0.045
	(0.162)	(0.086)
Number of work shifts, 1=yes:		
1 (reference group)		
unknown	0.581	-0.358
	(0.180)	(0.183)
2	0.611	0.585
	(0.114)	(0.160)
3	0.182	0.487
	(0.252)	(0.185)
Number of occupational indicators	23	23

Incentive wage based on quantity and quality:

Constant	-4.707	-4.168
	(0.762)	(2.011)
Variance of heterogeneity, ω_2		-6.182
		(5.166)
Sex, 1=male	-0.207	-0.090
	(0.124)	(0.078)
Share of men in a plant	0.081	0.252
	(0.243)	(0.184)
Age, years	0.044	0.031
	(0.025)	(0.016)
Age squared, years/100	-0.054	-0.036
	(0.033)	(0.020)
Average age in a plant, years	0.060	0.049
	(0.015)	(0.016)
Number of workers in a plant/1000	0.705	0.152
	(0.037)	(0.040)
County of Uusimaa, 1=yes	-0.123	-0.263
	(0.104)	(0.123)
High cost area, 1=yes	-0.234	0.086
	(0.090)	(0.084)
Overtime work, 1=yes	0.022	-0.073
	(0.088)	(0.061)
Sunday work, 1=yes	0.159	0.068
	(0.107)	(0.063)
Required level of skill, 1=yes:		
1 (reference group)		
2	-0.023	0.160
	(0.094)	(0.088)
3 (the lowest level)	-0.156	0.134
	(0.144)	(0.112)
Number of work shifts, 1=yes:		
1 (reference group)		
unknown	-0.816	-0.096
	(0.195)	(0.167)
2	1.038	0.432
	(0.097)	(0.094)
3	0.997	0.197
	(0.176)	(0.130)
Number of occupational indicators	23	23
Log likelihood	-4213.8	-4211.1
Number of observations	5054	5054

[1] The standard errors are in the parentheses.

5. Wage Equations by Method of Pay

5.1. Problem of Selectivity

In this section the wage equations are estimated by the method of pay. Special emphasis is devoted to the selectivity of workers to be paid on an incentive wage basis. Consider for simplicity a two-equation model of wages, one for the time-based wage and the other for the incentive wage. A multinominal extension is straightforward. For a random sample of workers the wage equations of an unobserved underlying response variables w_{1n}^* and w_{2n}^* are defined by the equations

$$(21a) \qquad w_{1n}^* = z_{1n}\gamma_1 + u_{1n}, \quad \text{if } x_n\beta \geq u_n$$

$$(21b) \qquad w_{2n}^* = z_{2n}\gamma_2 + u_{2n}, \quad \text{if } x_n\beta < u_n,$$

where z_1 and z_2 are exogenous variables and u_n is a latent variable. The dependent variables w_{1n}^* and w_{2n}^* are the logarithms of the hourly wages and they are not observed for the whole sample. At any point in time the choices of the method of pay, $j = 1, 2$, define an exhaustive set of mutually exclusive possibilities for each of the workers, $n = 1,...,N$. It is assumed that u_n are correlated with u_{1n} and u_{2n}.

The model outlined above is called a switching regression model with endogenous switching in two regimes as suggested by Maddala and Nelson (1975). The two-stage estimation method was suggested by Heckman (1974, 1976, 1979) and further extended by Lee (1978, 1979) and Amemiya (1978, 1979). An indicator for the choice of possible alternatives is defined as follows

(22a) $I_n = 1, \quad \text{if } x_n\beta \geq u_n$

(22b) $I_n = 0, \quad \text{if } x_n\beta < u_n.$

It is assumed that u_{1n}, u_{2n} and u_n have a trivariate normal distribution. In the following the appropriate covariances are denoted by σ_{1u} and σ_{2u}. Let ϕ and Φ be the normal density and distribution functions. The expected values of the residuals u_{1n} and u_{2n} can be written as follows (see Johnson and Kotz, 1972)

(23a) $$E(u_{1n}|x_n\beta \geq u_n) = E(\sigma_{1u}u_n|x_n\beta \geq u_n)$$

$$= -\sigma_{1u}\lambda_{1n}$$

(23b) $$E(u_{2n}|x_n\beta < u_n) = E(\sigma_{2u}u_n|x_n\beta < u_n)$$

$$= \sigma_{2u}\lambda_{2n},$$

where

(24a) $\lambda_{1n} = \phi(x_n\beta)/\Phi(x_n\beta)$

(24b) $\lambda_{2n} = \phi(x_n\beta)/[1 - \Phi(x_n\beta)].$

Equations (21a) and (21b) can then be written as follows

(25a) $w_{1n} = z_{1n}\gamma_1 - \sigma_{1u}\lambda_{1n} + \epsilon_{1n}$

(25b) $w_{2n} = z_{2n}\gamma_1 + \sigma_{2u}\lambda_{2n} + \epsilon_{2n}$.

The first stage of the original procedure is to obtain an estimate of β using the probit maximum likelihood method, based on the indicators I_n, and then compute the predicted values of λ_{1n} and λ_{2n}. In the second stage the OLS equations with λ_{1n} and λ_{2n} are estimated to obtain consistent estimates of γ_1, γ_2, σ_{1u} and σ_{2u}.

Rather than estimating a probit model in the first stage a logit model is estimated in our case, because the logit model has obvious advantages in the estimation of multinominal cases. The multinominal probit model is computationally complicated with many categories. Following Lee (1983) the two-stage method for the switching regression model can be extended for generalized selectivity models. Replacing the probit by the logit equation leads to a two-stage-logit-ols procedure.

Let $u^* = J_1(u) = \Phi^{-1}(\mathbf{F}(u))$, where Φ^{-1} is the inverse of the standard normal distribution function and $\mathbf{F}$ the marginal distribution function of u. A trivariate distribution of (u, u_1, u_2) is derived assuming that the transformed variable u^* is normally distributed with zero means and covariances σ_{1u} and σ_{2u}.

When the logit model is used in the first stage as a choice equation the wage equations can be written using the functions $J_1 = \Phi^{-1}\mathbf{F}$ as follows

$$(26a) \quad w_{1n} = z_{1n}\gamma_1 - \sigma_{1u}\phi(J_1(x_n\beta))/\mathbf{F}(x_n\beta) + \epsilon_{1n}$$

$$(26b) \quad w_{2n} = z_{2n}\gamma_2 + \sigma_{2u}\phi(J_1(x_n\beta))/[1 - \mathbf{F}(x_n\beta)] + \epsilon_{2n}.$$

The multinominal case is a straightforward extension. The needed additional terms in the index function based on the selectivity are $-\sigma_{ju}\phi(J_{1j}(x_n\beta_j))/\mathbf{F}_j(x_n\beta_j)$, $j=1,...,J-1$. The additional terms for the normalized reference group are $\sigma_{Ju}\phi(J_{1J})/[1 - \Sigma\, \mathbf{F}_j(x_n\beta_j)]$, where $J_{1J} = \Phi^{-1}F_J$ and $j=1,...,J-1$.

5.2. Wage Equations

Since w_1 and w_2 are the logarithms of the hourly basic wages, the estimated coefficients of the indicators in the wage equation are the contributions of that explanatory variable on the wage level expressed in the logarithm form. In the discussion of the results of estimations it is, however, more reasonable to use the conventional percentages. They are obtained as $P = 100(\exp(\gamma)-1)$. The coefficients of the continuous variables express the relative change of the wage level when the explanatory variable changes by one unit. In other words the coefficients are the average prices of the factors of wages which are paid in the labour market.

The results of estimations of the wage equations for the workers in the wood industry are presented in Table 7. The wage concept is the basic wage of the workers. It does not include the incrementals based on the shift work, work conditions, overtime and sunday work, which are known from the wage agreements.

The effect of sex is slightly larger on the time-based wage. In the time-based work men receive an 8 per cent higher wage than women, but in the incentive work the difference is 6 per cent. The share of men in a plant has a statistically insignificant coefficient.

The age on the individual level increases the wage, but the effect turns decreasing for the elderly workers. The effect is slightly larger with respect to the time-based wage. The effect peaks at 40 years for the time-based wage and at 45 years for the incentive wage. The effect of age does not differ very much between the younger and older workers. The average age of workers in a plant is positively related to the wage. It is surprising that the larger plants in the wood industry pay lower incentive wages.

The capital of Finland is situated in the county of Uusimaa. According to the previous results (Kettunen, 1993b) the wage level in Uusimaa is generally higher in manufacturing, but there are notable differences between the industries. In the wood industry Uusimaa has no effects on the time-based wage, but the incentive wage is 6 per cent lower in Uusimaa than in the other parts of the country. The negative effect of the high cost area on an incentive wage is 2 per cent.

The indicator for the poor working conditions takes a negative but statistically insignificant coefficient. On the other hand, the overtime and sunday work have positive coefficients. Their economic importance is, however, small.

The wage groups of the workers are defined using the required levels of skill in the collective wage agreements. The required level of skill in a job increases the wage level much more in the time-based work than in the incentive work. These results support the argument that the wage groups of the wage agreements have too much dispersion to be in line with the productivity of the workers. The indicators for the number of work shifts have only minor effects on the wages.

The estimate of the coefficients of the selectivity variables indicate no statistically significant sample selection bias in these models. Consequently, ordinary least squares techniques give consistent parameter estimates. It turned out using various experiments that a rich set of explanatory variables reduces the need to correct the model for the sample selection bias. This finding can be verified by dropping out explanatory variables in turn. Using rather few explanatory variables leads to models with a significant sample selection bias.

Table 7. Results of estimations for the wage equations of the workers in the wood industry[1]

(A) Time-based wage
(B) Incentive wage

	(A)	(B)
Constant	2.922	3.318
	(0.135)	(0.104)
Sex, 1=male	0.075	0.060
	(0.016)	(0.011)
Share of men in a plant	0.080	0.036
	(0.061)	(0.042)
Age, years	0.016	0.010
	(0.003)	(0.003)
Age squared, years/100	-0.020	-0.011
	(0.004)	(0.003)
Average age in a plant, years	0.006	0.003
	(0.003)	(0.002)
Number of workers in a plant/1000	-0.009	-0.030
	(0.006)	(0.005)
County of Uusimaa, 1=yes	-0.005	-0.057
	(0.043)	(0.024)
High cost area, 1=yes	0.008	-0.020
	(0.010)	(0.012)
Poor working conditions, 1=yes	-0.015	-0.012
	(0.014)	(0.010)
Overtime work, 1=yes	0.027	0.006
	(0.012)	(0.008)
Sunday work, 1=yes	0.026	0.024
	(0.017)	(0.013)
Required level of skill, 1=yes:		
1 (reference group)		
2	0.020	0.024
	(0.022)	(0.017)
3	0.051	0.036
	(0.022)	(0.017)
4	0.094	0.056
	(0.023)	(0.018)
5	0.164	0.098
	(0.023)	(0.019)
Number of work shifts, 1=yes:		
1 (reference group)		
unknown	-0.009	0.006
	(0.018)	(0.016)
2	0.024	0.019
	(0.014)	(0.010)
3	-0.039	0.010
	(0.018)	(0.013)
σ	-0.006	-0.011
	(0.017)	(0.016)
R^2	0.471	0.285
Number of observations	373	722

[1] The dependent variables are the logarithms of the hourly wages. The standard errors are in the parentheses.

The wage equations for the workers in the paper industry are presented in Table 8. According to the results men earn 8 per cent more than women in the incentive work, but in the time-based work they earn only 3 per cent more than women. This indicates a notable difference in the productivity between men and women. The share of men in a plant has a larger effect on the time-based wage.

The age of workers on an individual level and the average age in the plant do not have significant effects on the wages. The framework of the wage contacts in the paper industry are made on the union level, but the actual wages are negotiated on the firm level. Also the piece-rates are determined on the firm level. One plausible explanation is that the wage negotiations on the local level lead to small differences between the age groups. The small plants are able to pay slightly higher wages than the large plants.

The time-based wage is 3 per cent lower and the incentive wage is 19 per cent lower in Uusimaa than in the other parts of the country. This reflects the fact that Uusimaa is not the core area of the Finnish forest industry, which is situated in the middle part of the country. The high cost area has a positive effect on the time-based wage.

The poor working conditions decrease the incentive wage by 4 per cent. According to this result the working conditions are important in order to increase the earnings and also the productivity of the workers. The overtime or sunday work do not have remarkable effects on the wages.

The required level of skill increases both the incentive and time-based wage. The effect is clearly higher as regards the time-based wage. The number of work shifts decrease slightly the wage level in the incentive work. A plausible explanation is that the productivity of workers is lower during the night shifts.

The selectivity variable does not take a statistically significant coefficient. Consequently, there is no need to correct the models of ordinary least squares for the sample selection bias.

Table 8. Results of estimations for the wage equations of the workers in the paper industry[1]

(A) The time-based wage
(B) The incentive wage

	(A)	(B)
Constant	3.180	3.514
	(0.168)	(0.125)
Sex, 1=male	0.033	0.082
	(0.010)	(0.009)
Share of men in a plant	0.523	0.203
	(0.081)	(0.064)
Age, years	0.002	0.002
	(0.002)	(0.002)
Age squared, years/100	-0.002	-0.001
	(0.003)	(0.003)
Average age in a plant, years	-0.000	0.001
	(0.003)	(0.003)
Number of workers in a plant/1000	-0.004	-0.006
	(0.001)	(0.001)
County of Uusimaa, 1=yes	-0.030	-0.172
	(0.027)	(0.041)
High cost area, 1=yes	0.042	-0.017
	(0.022)	(0.032)
Poor working conditions, 1=yes	-0.005	-0.044
	(0.006)	(0.007)
Overtime work, 1=yes	-0.003	0.001
	(0.006)	(0.007)
Sunday work, 1=yes	-0.000	0.024
	(0.008)	(0.008)
Required level of skill, 1=yes:		
1 (reference group)		
2	0.039	0.018
	(0.013)	(0.012)
3	0.058	0.043
	(0.012)	(0.012)
4	0.095	0.076
	(0.012)	(0.012)
5	0.147	0.116
	(0.012)	(0.013)
Number of work shifts, 1=yes:		
1 (reference group)		
2	0.002	-0.006
	(0.012)	(0.012)
3	-0.010	-0.023
	(0.009)	(0.010)
σ	0.036	0.001
	(0.027)	(0.027)
R^2	0.363	0.306
Number of observations	925	1135

[1] The dependent variables are the logarithms of the hourly wages. The standard errors are in the parentheses.

The wage equations for the metal industry are presented in Table 9. According to the results the sex of workers has notable effects on the wages. Men earn about 6 per cent more than women in the time-based work. It is slightly more than in the incentive work. The share of men in a plant is positively related to the wage in all the wage equations.

The age of an individual has small positive effects in all the methods of pay. Again the effect of age is the largest with respect to the time-based wage as it was in the wood industry. The concave effect of age comes to a halt at 46 years of age in the time-based wage, at 41 years in the incentive wage based on quantity and at 44 years in the incentive work based on quantity and quality. The effect of age for the older workers is clearly higher than for the younger workers in the time-based wage. In the incentive work the effect does not differ very much between the younger and older workers. The average age of workers in a plant does not have remarkable effects.

The size of the plant measured as a number of workers has a positive effect on the incentive work based on quantity and a negative effect on the incentive work based on quantity and quality. In the county of Uusimaa the workers have about 6 per cent higher wages in the time-based work than in the other parts of the country. The effect is 2-4 per cent with respect to the incentive wages. The high cost area has positive effects of 2-4 per cent on the wages.

The poor working conditions and overtime work have only minor effects on the wages. The persons who work over their regular working hours or the persons who work on sundays have on average 1-2 cent higher regular wages than the others.

The required level of skill in a job has the largest effects in the time work. In this respect the result is similar to that in the wood and paper industries. The indicators for the number of work shifts have in many cases negative coefficients. The largest negative effect is in the three-shift work in the incentive wage based on quantity and quality.

The selectivity variable takes statistically significant coefficients in all the methods of pay. The correction for the selectivity bias has a great importance in the wage equations for the metal industry. In this respect there are differences between the forest and metal industries. There is a great dissimilarity between the metal and the forest industry in the sense that the wages are negotiated quite often on the local level in the forest industry. The importance of the negotiations on the choice of the method of pay needs, however, a more rigorous investigation to draw strong conclusions.

As a remark based on the logit models it can be concluded that there was unobserved heterogeneity in the choice models for the workers in the forest industries but not in the models for the workers in the metal industry. This result was obtained from an extended logit model based on the small variance approximation of the unobserved heterogeneity. The number of choice alternatives is a plausible factor affecting the unobserved heterogeneity.

Another remark is that the wage equations were not biased for the workers in the forest industries. On the other hand, the wage equations for the workers in the metal industry were found to be biased. It can be concluded that the inclusion of relevant explanatory variables and the specification of the choice model is of great importance. A well specified choice model is essential for estimating well specified wage equations in the second stage of the procedure.

Table 9. Results of estimations for the wage equations of the workers in the metal industry[1]

(A) The time-based wage
(B) The incentive wage based on quantity
(C) The incentive wage based on quantity and quality

	(A)	(B)	(C)
Constant	2.303	3.551	3.796
	(0.034)	(0.087)	(0.058)
Sex, 1=male	0.064	0.051	0.060
	(0.006)	(0.015)	(0.188)
Share of men in a plant	0.122	0.185	0.188
	(0.010)	(0.026)	(0.017)
Age, years	0.014	0.009	0.006
	(0.001)	(0.003)	(0.002)
Age squared, years/100	-0.015	-0.011	-0.007
	(0.002)	(0.003)	(0.002)
Average age in a plant, years	0.000	0.002	-0.002
	(0.001)	(0.002)	(0.001)
Number of workers in a plant/1000	0.002	0.013	-0.019
	(0.003)	(0.006)	(0.003)
County of Uusimaa, 1=yes	0.059	0.036	0.018
	(0.006)	(0.012)	(0.008)
High cost area, 1=yes	0.023	0.040	0.018
	(0.005)	(0.009)	(0.006)
Poor working conditions, 1=yes	0.006	0.016	-0.004
	(0.007)	(0.015)	(0.007)
Overtime work, 1=yes	0.017	0.016	-0.006
	(0.004)	(0.010)	(0.006)
Sunday work, 1=yes	0.011	0.017	0.009
	(0.006)	(0.012)	(0.007)
Required level of skill, 1=yes:			
1 (reference group)			
2	-0.110	-0.092	-0.081
	(0.005)	(0.009)	(0.006)
3 (the lowest level)	-0.210	-0.153	-0.168
	(0.007)	(0.016)	(0.010)
Number of work shifts, 1=yes:			
1 (reference group)			
unknown	-0.010	-0.053	0.028
	(0.009)	(0.016)	(0.015)
2	-0.004	-0.014	-0.023
	(0.007)	(0.010)	(0.008)
3	-0.040	-0.010	-0.085
	(0.010)	(0.023)	(0.010)
σ	0.060	0.045	0.092
	(0.007)	(0.016)	(0.014)
R^2	0.616	0.509	0.534
Number of observations	2554	982	1518

[1] The dependent variables are the logarithms of the hourly wages. The standard errors are in the parentheses.

6. Conclusions

This paper extended the static model of the method of pay presented by Lazear (1986) to a dynamic model. The results of the extended model are in concordance with the previous model, but it brings also new explanations based on the limited time horizon. The model gives a prediction that the persons who have no possibility of planning a stable and long lasting attachment to the firm are more apt to engage in incentive work. For example, women can not in many cases stay as long time in the firm as men. This finding sheds new light on the discussion of sex discrimination and career planning of women.

The econometric part of the study used a large cross-section data set which was collected for this study from the files of the Confederation of Finnish Industry and Employers. The data are fairly rich in individual, job and plant specific characteristics. The access to the administrative data is clearly an advantage of this study. The data are reliable, since they are obtained directly from the bookkeeping of the firms.

Logit models were used to examine the effects of various explanatory variables on the probability of a person engaging in a piece-rate work. There are tens of factors affecting the choice of the method of pay and individual wages. It is plausible that all the factors are not available in the data set or the importance of some variables can not be even suspected. Therefore special attention is paid on unobserved explanatory variables. An extended logit model was derived. It is based on a small variance approximation of unobserved heterogeneity. The results of estimations show that allowing for unobserved heterogeneity in the logit models is of great importance in getting better estimates even though the data are rich and reliable.

The logit models support the findings based on the theoretical model. The incrementals of the time-based wage were negatively related to the probability of working on the incentive wage basis. According to some of the models women work more frequently than men on an incentive wage basis. The age has an increasing effect which turns decreasing for the elderly persons. The required level of skill is in many cases positively related to the probability of working on an incentive wage basis, as is to be expected according to economic theory. Also shift work is positively related to the choice of incentive work.

In the estimation of the wage equations special attention is paid to the selectivity of the method of pay. A two-stage-logit-ols procedure was used to estimate the effects of various factors conditional on the presumption that the person is working in accordance with the chosen method of pay.

According to the wage equations men have higher wages than women. The difference is even larger in the incentive wage. One interpretation is that men are more effective. It is well known that the wage contracts have been used to decrease the wage differentials between men and women during the 1980's. This has led to smaller differences between men and women in the time-based wage.

The age has a concave effect on the wage level. The required level of skill has a positive effect on the wage level. This is no wonder, since the wage groups are defined by the collective wage agreements. An interesting result is that the required level of skill has larger effects on the time-based wage than on the incentive wage. It seems that in all the studied industries the defined wage dispersion related to the wage groups is too wide to reflect the differences in the productivity between workers.

There was unobserved heterogeneity in the choice models for the workers in the forest industries but not in the models for the workers in the metal industry. The wage equations were not biased for the forest industries, but they were biased for the metal industry. The inclusion of relevant explanatory variables and the use of the multinominal choice model instead of a binary model is of great importance in the estimation of the choice model. A well specified choice model is essential for obtaining well specified wage equations in the second stage of the procedure.

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Appendix 1. Comparative Static Results

For simplicity the effects of exogenous variables are solved in the case of an infinite horizon. Setting (6) to zero, substituting V = (pq - c)/r and rearranging the terms gives

$$(27) \qquad q' = \{\bar{w} + c + a \int_{q'}^{\infty} [(pq - c)/r - V]dF(q)\}/p.$$

$$= (\bar{w} + c + aQ/r)/p, \text{ where } Q = \int_{q'}^{\infty} (q' - q)dF(q).$$

The comparative static results can be written as follows

$$(28) \qquad \frac{\partial q'}{\partial \bar{w}} = 1/p > 0 \qquad \text{and} \quad \frac{\partial \lambda}{\partial \bar{w}} = -af(q')\frac{\partial q'}{\partial \bar{w}} < 0$$

$$(29) \qquad \frac{\partial q'}{\partial c} = 1/p > 0 \qquad \text{and} \quad \frac{\partial \lambda}{\partial c} = -af(q')\frac{\partial q'}{\partial c} < 0$$

$$(30) \qquad \frac{\partial q'}{\partial a} = Q/rp > 0 \qquad \text{and} \quad \frac{\partial \lambda}{\partial a} = [1 - F(q')] - f(q')\frac{\partial q'}{\partial a}$$

$$(31) \qquad \frac{\partial q'}{\partial p} = -q'/p < 0 \qquad \text{and} \quad \frac{\partial \lambda}{\partial p} = -af(q')\frac{\partial q'}{\partial p} > 0$$

$$(32) \qquad \frac{\partial q'}{\partial r} = -aQ/pr^2 < 0 \quad \text{and} \quad \frac{\partial \lambda}{\partial r} = -af(q')\frac{\partial q'}{\partial r} > 0.$$

The effects of the exogenous variables on the probability of working on a piecework basis $\lambda = a[1 - F(q')]$ have reverse effects except for the arrival rate of offers. Its effect is generally ambiguous, since the direct effect is positive, but the indirect effect via q′ is negative.

To solve the effects of the offer distribution a translation of F to the right is made so that $F(q) = G(q + \mu)$, for all q and $\mu > 0$. This method was used by Mortensen (1986). The translation is said to first order stochastically dominate F(q). Substituting the following useful transformation

$$(33) \qquad \int_{q'}^{\infty} (q - q')dF(q) = E_F(q) - q' + \int_{0}^{q'} F(q)dq$$

and $F(q) = G(q + \mu)$ into (27) and noting that $E_G(q) = \mu + E_F(q)$ gives

$$(34) \qquad q' = \bar{w} + c + a[\mu + E_F(q) - q' + \int_{0}^{q'} F(q - \mu)dq]/r,$$

where the effect of offer distribution on the required level of quality is solved as

$$(35) \qquad \frac{\partial q'}{\partial \mu} = \lambda/(r + \lambda) > 0.$$

where $\lambda = a[1 - F(q' - \mu)]$. The effect of μ on λ is

(36) $$\frac{\partial\lambda}{\partial\mu} = af(q' - \mu)(1 - \frac{\partial q'}{\partial\mu}) > 0,$$

since $\partial q'/\partial\mu < 1$.

Next the effect of uncertainty of job offers is studied. Rothschild and Stiglitz (1970) have introduced uncertainty into economics under the name 'mean preserving spread'. The distribution H is a mean preserving spread of F given that they have the same mean if and only if

(37) $$\int_0^{q_1} H(q)dq \geq \int_0^{q_1} F(q)dq, \text{ for all } q_1 > 0.$$

Substituting (33) and $F(q) = H(q, \sigma)$ into (27) gives

(38) $$q' = \bar{w} + c + a[E_F(q) - q' + \int_0^{q'} H(q, \sigma)dq]/r,$$

where σ is the parameter of relative dispersion. The effect of uncertainty on the required level is then

(39) $$\frac{\partial q'}{\partial\sigma} = a \int_0^{q'} H_\sigma dq/(r + \lambda) > 0.$$

The effect of σ on $\lambda = a[1 - H(q', \sigma)]$ is

(40) $$\frac{\partial\lambda}{\partial\sigma} = -aH_{q'}\frac{\partial q'}{\partial\sigma} - aH_\sigma < 0.$$

Appendix 2. An Extended Model of Discrete Choice

The probability that a choice is made in a random utility model can be written as follows

$$(41) \qquad p(i|x,\beta) = \frac{\exp(x_i\beta)}{\sum_{j=1}^{J}\exp(x_j\beta)}.$$

A derivation based on the small variance approximation of unobserved heterogeneity leads to an extended discrete choice model by Chesher and Santos Silva (1992)

$$(42) \qquad g(i|x,\beta,\omega) = \frac{\exp(x_i\beta+0.5\omega_{st}p_i^{st}/p_i)}{\sum_{j=1}^{J}\exp(x_j\beta+0.5\omega_{st}p_j^{st}/p_j)},$$

where the parameters ω_{st} are the variances and covariances of the unobserved utility components and the Einstein summation convention is used over indices that appear raised and lowered. The additional terms in the index function based on the second derivatives can be written as follows

$$(43) \qquad p_i^{st}/p_i = \delta_{is}\delta_{it} - \delta_{is}\delta p_t - \delta_{it}p_s - \delta_{st}p_s + 2p_sp_t,$$

where the Kronecker delta $\delta_{is} = 1$ if $i = s$ and 0 otherwise. Clearly the discrete choice model is more demanding with respect to the data, because for each observation there must be J values of the explanatory variable x_i, which are related to the choices.

Appendix 3. A SAS/IML Programme for Estimating Logit Models of Three Choices

```
* A LOGIT MODEL ALLOWING FOR UNOBSERVED HETEROGENEITY;
* VMS OPERATING SYSTEM;
OPTIONS LS=80 PS=500;
LIBNAME SASLIBR '[JKETTUNEN.SASFILES]';
FILENAME RAWDATA 'MET90.ASC';
DATA SASLIBR.ADATA;
INFILE RAWDATA;
INPUT Y1 Y2 Y3 CONSTANT HIGHCOST AGE AGE2 SEX TIMEH PIECE1H
  PIECE2H HOURS COND SHIFTW WAGET WAGEP1 WAGEP2 SHIFTD CONDD
  TOTWAGE REGGWAGE NOWORKER SHAREMEN AVAGE WAGEG1 WAGEG2 WAGEG3
  WAGEG12 SHIFTS0 SHIFTS1 SHIFT2 SHIFT3 TAM23 YLITYO SUNTYO
  UUSIMAA A01 A02 A03 A10 A11 A12 A13 A20 A21 A22 A23 A30 A31 A32
  A33 A34 A41 A42 A50 A60 A61 A62 A63 A64 A65 A66 A70 A71 A72
  A80;
PROC IML WORKSPACE=3000;
START;
*POS OF Y DATA;          IND1={6 7 8};
                         IND2={4 5 6 7 8 13 22 23 24 26 27 29 31 32
                               34 35 36 40 41 42 43 44 45 46 47 49
                               50 51 52 53 54 55 56 58 59 60 61 62
                               63 64 };
*LINE SEARCH LIMIT;      LLS =100;
*ITERATION LIMIT;        LIT =300;
*ACCY REL FUN;           ACC1=0.01;
*ACCY GRAD;              ACC2=0.01;
*STEP ADJUSTMNT;         ALPHA=1;
*SUPRESS LINE SEARCH;    SUPRESLS=1;
*SUPRESS ITERATION;      SUPRESIT=0;
*ESTIMATE SIGMA;         SIGMA=0;
*START POINT;
IF SIGMA=0 THEN
B={-4.795447 -0.224574  0.0435685 -0.000529 -0.19322   -0.167024
    0.7078354 0.0337136 0.0614143 -0.008406 -0.125614 -0.81346
    1.0310616 1.0125758 0.0269138  0.158475 -0.128033  0.2454417
    0.1007722 1.4218021 0.2515838  0.4263327 0.1580005 0.5715267
    1.4233164 0.492516 -0.013536   0.6406517 1.1065724 0.8125356
    0.4876416 0.6243476 0.4697076  0.394200 -0.573642 -1.526388
   -0.612142 -0.432936 -0.68943   -0.157879 -8.436945  0.3336512
    0.049062 -0.000569 -0.193023  -0.311617  0.054845  0.5998789
    0.082641  0.3602892 0.3692047  0.5868867 0.6252224 0.1908671
   -0.156279  0.094889 -0.613154   0.6114095 2.7003294 3.2856467
    2.7484809 3.3716904 3.4667883  3.5779798 4.0701065 0.1283841
    2.8942342 2.7788763 3.5507101  3.2361216 2.5282209 2.6027545
    2.667636  2.2249067 1.1387676  2.432473  3.4396509 2.150753
   -2.270741  0.5557055};
IF SIGMA=1 THEN
B={-4.920894 -6.181794 -2.912492  -0.109122  0.029898 -0.000359
   -0.112251 -0.111714  0.3665742  0.0623268 0.043195  0.0349804
   -0.045331 -0.358245  0.5850103  0.487058 -0.010435  0.0886148
   -0.103188  0.1444813 0.3314687  1.0223564 0.5791117 0.554055
    0.4344414 0.6953964 1.1896892  0.2525661 0.2583204 0.596254
    0.9274092 0.7335701 0.4973468  0.5676474 0.4957673 0.405121
   -0.22593  -0.621746  0.058099 -0.023955  -0.470078 -0.066892
   -4.168477  0.0855997 0.031007 -0.000358  -0.089541 -0.163542
```

```
     0.1515053 0.251739  0.0489124 0.1595082  0.1338529 0.0964775
     0.431594  0.196695 -0.073447  0.067635  -0.262529  0.2840384
     1.3503344 1.8058228 1.5354183 1.6801836  1.6906405 1.8230352
     2.1828494 0.1297709 1.3957262 1.4544289  1.8752143 1.6934593
     1.3121626 1.3739706 1.376872  1.1440761  0.503657  1.0091878
     1.5704963 1.012789 -1.565204  0.2660239};
 PRINT 'MAXIMUM LIKELIHOOD ESTIMATION: BHHH MODIFIED NEWTON
 RAPHSON METHOD';
        USE SASLIBR.ADATA;
        READ ALL INTO A;
        CALL DELETE('SASLIBR','ADATA');
        X=A(|,IND2|); Y1=A(|,1|); Y2=A(|,2|); Y3=A(|,3|);
        FREE A;
 NAMES1={'SEARCH NO' ' OLD L' 'NEW L' 'ALPHA'};
 NAMES2={'OLD B' 'NEW B'};
 NAMES3={'ITER NO' L};
 NAMES4={PARAMETR GRADIENT};
 NAMES5={PARAMETR 'S.ERROR' 'T STAT' GRADIENT};
 NAMES9={ACC1 ACC2 ALPHA 'NO OBS' 'NO PARS'};
 NAMES13={Y1 Y2 Y3 CONSTANT HIGHCOST AGE AGE2 SEX TIMEH PIECE1H
          PIECE2H HOURS COND SHIFTW WAGET WAGEP1 WAGEP2 SHIFTD
          CONDD TOTWAGE REGGWAGE NOWORKERS SHAREMEN AVAGE WAGEG1
          WAGEG2 WAGEG3 WAGEG12 SHIFTS0 SHIFTS1 SHIFT2 SHIFT3
          TAM23 YLITYO SUNTYO UUSIMAA A01 A02 A03 A10 A11 A12 A13
          A20 A21 A22 A23 A30 A31 A32 A33 A34 A41 A42 A50 A60 A61
          A62 A63 A64 A65 A66 A70 A71 A72 A80};
 OBS=NROW(X);
 PAR=2#(NCOL(X));
 VARNAME=NAMES13(|,IND2|)||NAMES13(|1,IND2|);
 PRINT 'ACCURACY REQUIREMENT:STEP LENGTH PROPORTION:NO OF OBS &
 PARAMETERS';
 PRINT '********************************************************';
 PRT=ACC1||ACC2||ALPHA||OBS||PAR;
 PRINT PRT (| COLNAME=NAMES9 |);
 FREE PRT NAMES9;
 PRINT B;
 NIT=1;
 BOLD=B;
 LINK LIKEF;
 MAR4: LOLD=LL; BOLD=B;
       LINK LIKED;
       IF SUPRESIT=0 THEN DO;
          LOGLIK =NIT||LL;
          PARAMS =B`||DL;
          IF NIT=1 THEN DO;
             PRINT '*****************';
             PRINT 'ITERATION MONITOR';
             PRINT '*****************'; END;
          PRINT LOGLIK (| COLNAME=NAMES3 |);
          PRINT PARAMS (| COLNAME=NAMES4 |);
          FREE LOGLIK PARAMS; END;
       NLS=1;
       FAC = DL`*INV(CL);
 MAR3: B=BOLD-ALPHA#FAC;
       IF NLS>1 & SUPRESLS=0 THEN DO;
          NLS1=NLS-1;
          IF NLS=2 THEN DO;
             PRINT 'LINE SEARCH SUBITERATION';
```

```
            PRINT '************************'; END;
         LOGLIK =NLS1||LOLD||LL||ALPHA;
         PARAMS =BOLD//B;
         PRINT LOGLIK (| COLNAME=NAMES1 |);
         PRINT 'PARAMETER VALUES';
         PRINT PARAMS (| ROWNAME=NAMES2 |);
         FREE LOGLIK PARAMS; END;
      LINK LIKEF;
      IF LL > LOLD THEN GOTO MAR1;
      NLS=NLS+1;
      IF NLS < LLS THEN GOTO MAR2; FREE LLS;
      PRINT '******************************';
      PRINT '*SORRY - LINE SEARCH FAILURE*';
      PRINT '******************************';
      PRINT BOLD B DL CL FAC LOLD LL NLS NIT;
      GOTO MAR7;
MAR2: ALPHA=ALPHA/2; FREE V L;
      GOTO MAR3;
MAR1: NIT=NIT+1;
      IF ABS((LL-LOLD)/LOLD)<ACC1*ALPHA
         & SQRT(DL(|##,|))<=ACC2 THEN GOTO LEN;
      IF NIT > LIT THEN GOTO MAR5;
      GOTO MAR4;
MAR5: PRINT '**************************';
      PRINT '*ITERATION LIMIT EXCEEDED*';
      PRINT '**************************';
      PRINT BOLD B DL CL FAC LOLD LL NLS NIT; FREE NLS;
      GOTO MAR7;
LEN:  PRINT '***********************************************';
      PRINT '*CONGRATULATIONS ACCURACY REQUIREMENT ACHIEVED*';
      PRINT '***********************************************';
      FREE ACC1 ALPHA ACC2 ;
MAR7: LINK LIKED;
      PRINT 'LOG-LIKELIHOOD FUNCTION AT SOLUTION';
      PRINT '***********************************';
      PRINT LL; FREE LL;
      VAR  =INV(-CL);
      SERR =SQRT(VECDIAG(VAR));
      TSTAT=B`/SERR;
      SOLN =B`||SERR||TSTAT||DL; FREE VAR SERR TSTAT;
      PRINT 'PARAMETER VALUES AT SOLUTION';
      PRINT '****************************';
      PRINT SOLN (| COLNAME=NAMES5 ROWNAME=VARNAME |);
      FREE SOLN NAMES5 VARNAME;
      PRINT NIT;
      STOP;
LIKEF:
IF SIGMA=0 THEN DO;
      BETA1= B(|1,1:(PAR/2)|);
      BETA2= B(|1,(PAR/2+1):PAR|);
      XB1  = X*BETA1`; XB2=X*BETA2`;
      Z1   = EXP(XB1);  Z2=EXP(XB2);
      Z    = 1 + Z1 + Z2;
      L    = Y1#XB1 + Y2#XB2 - LOG(Z);
      LL   = L(|+,|); FREE L; END;
IF SIGMA=1 THEN DO;
      W1   = B(|1,1|);
      W2   = B(|1,2|);
```

```
        BETA1= B(|1,3:(2+(PAR-2)/2)|);
        BETA2= B(|1,(3+(PAR-2)/2):PAR|);
        XB1   = X*BETA1`;
        XB2   = X*BETA2`;
        E1    = EXP(XB1);
        E2    = EXP(XB2);
        E     = E1 + E2 + 1;
        P1    = E1/E;
        P2    = E2/E;
        P3    = 1/E;
        Z1    = EXP(XB1+W1#(0.5-P1));
        Z2    = EXP(XB2+W2#(0.5-P2));
        Z     = Z1 + Z2 + 1;
        L     = Y1#LOG(Z1) + Y2#LOG(Z2) - LOG(Z);
        LL    = L(|+,|); FREE E1 E2 G XB1 XB2 L; END;
RETURN;
LIKED:
IF SIGMA=0 THEN DO;
       V    = ((Y1 - Z1/Z)#X)`
            //((Y2 - Z2/Z)#X)`;
       DL   = V(|,+|);
       CL   = V*V`; FREE V;
       CL   = -CL; END;
IF SIGMA=1 THEN DO;
       G1   = Z1/Z;
       G2   = Z2/Z;
       V    = ((0.5-P1)#(Y1-G1))`
            //((0.5-P2)#(Y2-G2))`
           //(((1-W1#(P1-P1#P1))#(Y1-G1)+P1#P2#W2#(Y2-G2))#X)`
           //(((1-W2#(P2-P2#P2))#(Y2-G2)+P1#P2#W1#(Y1-G1))#X)`;
       FREE G1 G2 Z1 Z2 Z P1 P2 ;
       DL   = V(|,+|);
       CL   = V*V`; FREE V1 V2 V3 V4 V;
       CL   = -CL; END;
RETURN;
FINISH; RUN;
```

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