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Your Money or Your Life?

-An investigation into the prevalence of compensating wage differentials on the Swedish labor market

Abstract

The theory of the hedonic wage model and compensating wage differentials dates back to the times of Adam Smith, and this study attempts to investigate, using econometric analysis, whether the Swedish labor market can give any claim to these theories. A brief background to the health economics discipline is followed by relevant theory and research in the field of compensating wage differentials. Using an alternative approach based on the wage change equation formulated by Charles Brown, and comparing the results to a previous study by Duncan and Holmlund, an econometric analysis is then performed. The empirical results do not yield any clear evidence in any direction regarding the existence of compensating wage differentials, although some indications appear supporting the theory of limited omitted variable bias and measurement error using the wage change equation in place of a conventional wage level equation.

Keywords: Compensating Wage Differentials, Wage Change Equation, Health Economics, Hedonic Wage Function, LNU, SOFI

Author:

Michael Tekle Palm

Tutor:

Ulf Gerdtham

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1. Introduction

This section will begin with a quick introduction to Health Economics. Then the reasons for writing this study as well as its potential use are described. Finally, main findings are described along with the scope and limitations of the study, and the disposition of the essay will be outlined.

1.1. A Short Introduction to Health Economics

The study of Health Economics is a fairly new discipline of economics despite dealing with a good that is immensely important and valuable to us. This is not to say the discussion of economics of health was not pre-existent – on the contrary; the father of modern economics, Adam Smith, formulated reasoning similar to the subject of this paper in his magnum opus, *The Wealth of Nations*, closer discussed in chapter 2. As a subject, Health Economics covers a wide array of angles analyzing the valuation and allocation of health and health care. The ever-increasing share of GDP spent on health care in OECD countries can be used as a clear indicator of its importance – 9% was, on average, spent in OECD countries; up from around 7% in 1990 and 5% in 1970 (OECD.org)[i]. In Sweden, expenditure has risen from 8.9% to 10% of GDP between 2001 and 2010, or roughly from 208 billion SEK to 309 billion SEK (OECD.org)[ii].

Despite being such a universal and familiar good, attempting to study health using the economic framework presents certain challenges. The main difference compared to more conventional goods is the fact that health is very difficultly measured, if truly measurable at all. A common target of investigation, instead, is health care, in which case the *derived demand* or indirect demand for health is examined. It is normally assumed that health care is a good demanded in order to increase the stock of health capital of an individual.

The area where health care valuation is most frequently used is, naturally, in the health care and medical services sector. While the value of a life is often morally considered priceless, the necessary allocation of resources warrants the estimation of the good they will do. This may subsequently affect what patients stand to gain the most and decide who will receive necessary treatment. There are further complications to valuating health. What allocation of health care has the strongest positive welfare effect? In what way should we calculate the results? One example could be curing a patient at half the cost of curing another patient. At a first glance, the selection would be obvious. What if the 'expensive' patient is an adolescent and the 'cheaper' patient is elderly? Accounting for the expected remaining life span of the adolescent shifts the analysis as we could now be faced with the choice of prolonging one life by 20 years and the other by 65 years. The choice, now, is not as clear as it may have appeared at first. This trade-off between health and resources also lies at the core of the labor market mechanism known as compensating wage differentials.

1.2. Aim of the Study

The aim of this study is to test the validity of the compensating wage differentials theory, or in other words to examine whether there appears to be a pecuniary bonus for taking jobs that are in some way unattractive; and in particular using the alternative approach of a wage change equation. This field of study is hardly new, however the approach selected in this paper has characteristics that set it apart from the vast majority of research and as this approach has not been extensively tested either; it makes for an interesting choice of subject. Further, research on the Swedish labor market has not been performed at any great scale. Lastly, the econometric study is a replication of one performed in 1983, and thus the intent is also to investigate the validity of this study as well as any potential changes in the labor market mechanisms between the Duncan and Holmlund study and the current one.

The means of investigation is an econometric analysis. Using extensive survey response material in panel-data form, the data is sorted and adjusted in order to fit the econometric method, and then estimated using first a standard hedonic wage equation to test for any positive effect on wage from several unpleasant work condition variables, from two cross-sections: 1990 and 2000. Then, the difference of the variables is calculated, and a third regression is run using the theory of the wage change equation. The use of this equation is based on its theoretical assumption of diminishing the bias caused by omitted variables and measurement error.

The estimation of compensating wage differentials has been popular due to their useful policy implications, as they can be used to calculate the Value of a Statistical Life (VSL). Guo and Hammitt (2008[iii]) explain that the VSL is the marginal rate of substitution between compensation and mortality risk. The value of life is not a universal constant, but reflects the wage-risk tradeoff pertinent to the preferences of the workers in a particular sample.

Aldy and Viscusi (2002) [iv] describe the use of VSL (page 1): "*These VSL estimates in turn provide governments with a reference point for assessing the benefits of risk reduction efforts. The long history of government risk policies ranges from the draining of swamps near ancient Rome to suppress malaria to the limits on air pollution in developed countries over the past 30 years (McNeill 1976, OECD 2001). All such policy choices ultimately involve a balancing of additional risk reduction and incremental costs.*"

Since the use of compensating wage differentials in calculating the VSL requires the use of a fatality risk measure, and we will be testing an alternative approach without this measure, we will not be going into any VSL measures further during this study. What is the usefulness of this study, then? Its key value is as a diagnostic tool for testing out how valid this conventional hedonic wage method (henceforth also called the *wage level equation*) that is being used by the vast majority of researchers for calculating compensating wage differentials and the VSL is – compared to this novel approach of the wage change equation. If the wage change equation appears to better describe the effects of work characteristics on wage, it could then help push for a change in the current research praxis.

1.3. Scope

The scope of the study encompasses the Swedish labor market. The highest level of most research performed is on a national level, with many being targeted at an industry or labor group. This facilitates inter-research comparison with previous papers written on the subject. Moreover, the population spans most of the adult working population, with a large sample from all industries and labor groups resulting in a fairly realistic sample of the Swedish labor market.

1.4. Limitations

One of the study's chief interest points can also be considered the main limitation – its lack of a conventional risk variable for testing the theory of compensating wage differentials. Since utilizing fatality or injury risk is the praxis in this field of study, there are not many studies with which this study can be compared to. Therefore, with a goal of estimating the bonus effect on wage from unfavorable work conditions as accurately as possible, the inclusion of fatality or injury risk measure may be optimal. The main goal of this paper, however, is to test the validity of the wage change equation approach.

1.5. Main findings

The results of this study did not give any conclusive evidence in any direction. The first tests using the wage level equation did not provide much support for the presence of compensating wage differentials. The wage change equation did not yield results that were much better, although they showed slight improvement in certain areas compared to the wage level equation. By deeper examining the differences in the data sets used and in labor market conditions during the times examined, as well as by using several specification tests, these differences in results are then discussed and potential explanations are offered.

1.6. Disposition of the Essay

The second chapter following this introductory chapter will give a summary of the findings in this field during the last decades, descriptions of the relevant models, as well as some deeper analysis to the components of these models. The research paper that this essay replicates is also introduced. Chapter 3 is the method chapter where the procedure used for estimation of the equation is described along with sensitivity analyses used. Chapter 4 will look over the data used for this study, followed by the results and discussion in chapter 5. Chapter 6 is a summary of the findings with potential continuations of the study and implications of the results. The last chapter contains an appendix with tables, followed by references mentioned in the study.

2. Relevant concepts and theory

This section goes in deeper on the health economic models relevant to the upcoming analysis, goes on to explain the integral concepts of compensating wage differentials and the hedonic wage function. Then previous research is examined in order to study the development in the field over the last decades, simultaneously inspecting the components of the hedonic wage function. The last two sub-chapters lead us into alternative approaches to estimating compensating wage differentials eventually leaving us with the model used in this paper and the paper used as a frame of reference to the empirical results of this paper, as well as its results.

2.1. The Value of Health

This paper will not be discussing health care but rather health in its essence, and the value we place upon it. We will assume that the postulates of the *homo economicus* are valid. Health is considered a **normal good** or a **superior good**. This means that as income rises, the demand for health and the consumption of health care will rise with it; either to a smaller, equal or greater extent. Whether it is a normal or superior good is inconclusive as different scopes yield different results, however we can assume that health is not an inferior good, or that the consumption of health care does not decline with an increase of income (M. Dewar, 2010) [v]. Furthermore, we can assume **risk aversion**, which can somewhat simplified be explained that an individual would prefer a risk-free prospect of lower expected payoff rather than a slightly higher expected payoff coupled with a higher risk. Additionally, it is assumed that a payoff closer in time to the present is valued higher than one that is further away. Having dealt with these basic concepts, we will approach an area more integral to the analysis at hand: the valuation of health and health change. The remaining content of this sub-chapter is a summary of the relevant chapter in the book Economic Analysis in Health Care (Morris; Devlin & Parkin, 2009) [vi].

The basic framework for welfare economics is consumer choice theory, meaning that each person is assumed to maximize their utility. The utility function can be described as $U = U(x,z)$ where x are all goods the individual wishes to spend his income on, at prices p; and where z is their health status, which can be assumed to be measured on a 0-1 scale. The formal problem is thus to maximize $U = U(x,z)$ subject to $p * x \leq y$.

As utility cannot be measured directly, money is used as the proxy for utility. We should also note that by including z as a variable for utility, we can observe changes in welfare resulting from changes in health care and therefore in health status.

In 1939, John Richard Hicks wrote the classic microeconomic book *Value and Capital*, in which he proposed two distinct means of using money to measure changes in utility: the **compensating variation** (CV) and the **equivalent variation** (EV). The key difference between these two means of measuring is that CV deals with *ex post* changes (meaning a change in income necessary for a return to original utility levels *after* a change in the state of the world) while EV deals with *ex ante* (change in income *before* the change in order to reach a new and expected level of utility).

The action taken upon the affected person can be summarized in this table:

	For a health gain	For a health decrease
Compensating variation	*Take money*	*Give money*
Equivalent variation	*Give money*	*Take money*

The logic behind these responses will be further explained below:

- **CV, health gain**: individual is charged a fee for the increase in health
- **EV, health decrease**: individual is charged to avoid deterioration in health
- **CV, health decrease**: individual gets money to compensate health deterioration
- **EV, health gain**: money given to compensate the individual for not receiving a health gain

The concepts of Willingness to Pay (WTP) and Willingness to Accept (WTA), which will be used principally in this paper, are derived from these concepts of CV and EV. Using the same exogenous conditions as above, Willingness to Pay refers to the maximum amount that can be taken away from the individual in order to make them as well off as if they would have been at the original health level (1) or as well as they would have been after a deterioration in health (2). At the level of WTP, the marginal utility gained from the health status equals the marginal utility of retaining money.

Similarly, Willingness to Accept refers to the minimum amount of money that needs to be paid to an individual to compensate for deterioration in health (3) or missing out on a health improvement (4).

2.2. The Compensating Wage Differential

Let us now return to the Adam Smith segment promised earlier. In discussing inequalities regarding differences in the employment themselves, it was written (A. Smith (2009), p. 72):

> "*Of the five circumstances, therefore, which vary the wages of labour, … (two are) the agreeableness or disagreeableness of the business, and the risk or security with which it is attended*"

and

> "*…the wages of labour vary with the ease or hardship, the cleanliness or dirtiness, the honourableness or dishonourableness, of the employment.*"[vii]

If presented with a choice of two different jobs, ceteris paribus, where one had a higher risk of injury or was dirtier than the other: which one would you choose? It goes without saying that the employer of the less attractive job would have a difficult time hiring staff without presenting some additional benefit in compensation for the risks involved. It is here that the link to the concepts outlined above materializes, in particular one with Willingness to Accept and Compensating Variation.

Given that a job has a higher job risk means that the expected health loss rises with it. The employee therefore can expect deterioration in health, which warrants a pecuniary bonus as compensation in order to remain at the same level of total utility. This presumed bonus lies at the core of this paper and is commonly called a **Compensating (wage) differential** (henceforth occasionally abbreviated ***CWD***). It should, however, be noted that CWD encompasses not only differences in security and risk, but also as hinted in the Adam Smith quote above the degree of *unpleasantness* or *disagreeableness* in a job. This can be estimated either through a measure of non-fatal risk or through a number of other job characteristic variables which will be further described at a later stage.

Smith also highlights the difficulties and ambiguities involved with CWD's as factors other than wage and security may weigh in on the job choice. One example is the case of adventurous or potentially honor-bringing endeavors. Adam Smith writes (A. Smith (2009), p. 71):

> "*Without regarding the danger, however, young volunteers never enlist so readily as at the beginning of a new war; and though they have scarce any chance of preferment, they figure to themselves, in their youthful fancies, a thousand occasions of acquiring honour and distinction which never occur. These romantic hopes make the whole price of their blood. Their pay is less than that of common labourers, and, in actual service, their fatigues are much greater.*"

While this paper will not be going in-depth on the reasoning of young soldiers, it does nonetheless help further illuminate the various obstacles involving CWD, and the contradictions that are always present when the behavior of human beings is analyzed. With this foundation in place, let us delve deeper into the research made on this topic and the progress of the last few decades.

2.3. The Hedonic Wage Method

The foundation to the framework of Compensating Wage Differentials was laid by Sherwin Rosen (1974)[viii] and elaborated upon by Thaler and Rosen (1976)[ix]. In elaborating, they propose that the labor market can be seen as "providing a mechanism for implicit trading in risk". This is to say that each job seeker will choose the employment that best matches his desired level of risk, in accordance with his level of risk averseness. This idea was also formulated by Duncan and Holmlund (1983)[x] stating that in a market where firms are characterized by different production technologies, they will also face different conditions regarding wage cost and in supplying adequate work place security. In market equilibrium however, worker preferences will be the governing force. The basis to the theory of CWD's is the **hedonic wage method**.

The definition of hedonic ([*hee-don-ik], 1. of, characterizing, or pertaining to pleasure: a hedonic thrill.*) does not explain the reasoning all too well, however a more helpful definition in a economic context is available at the Economics section of about.com[xi]:

"Hedonic means of or relating to utility. (Literally, pleasure-related.) A hedonic econometric model is one where the independent variables are related to quality; e.g. the quality of a product that one might buy or the quality of a job one might take."

So hedonism in this case is linked more with utility than with pleasure, and the quality of a job one might take translates directly to what Adam Smith said and which was quoted earlier regarding the "agreeableness or disagreeableness" of a job. This can of course just as well signify the risk one is exposed to while employed. For this reason, the alternative name *quality-adjusted wage method* is a little more suggestive. A very pedagogical and coherent explanation is provided by W. Kip Viscusi, one of the leading researchers in the field of CWD's, both in Viscusi (1993) and in some less detail in Viscusi and Aldy (2002). The following quick explanation was compiled using these two papers.

First of all it should be noted that the hedonic wage model examines risk choices in a state of long-run equilibrium, with conditions such as full competition and an absence of unemployment fulfilled. The market outcome, and subsequently the wage differentials, is a reflection on the dual influence of the demand and supply of labor. In other words, it is a combination of choices made by both employees and employers.

The demand side (for labor) of the mechanism is built on the fact that the cost of hiring a worker is built from several components besides wage; training, vacation, benefits etc. all add up to a total cost. One of these components is the cost of providing safe working conditions for the worker. This means that, for a given level of profit, there is a trade-off between wage and safety where the firm must pay less in wage as the safety level rises. This is depicted in the firm's isoprofit curve, curve OC_1 and OC_2 in Figure 1 (taken from Viscusi (2002)), for firm 1 and 2 respectively. The curve w(p) represents the upper envelope of all the companies' wage offer curves, and is called the market opportunities locus.

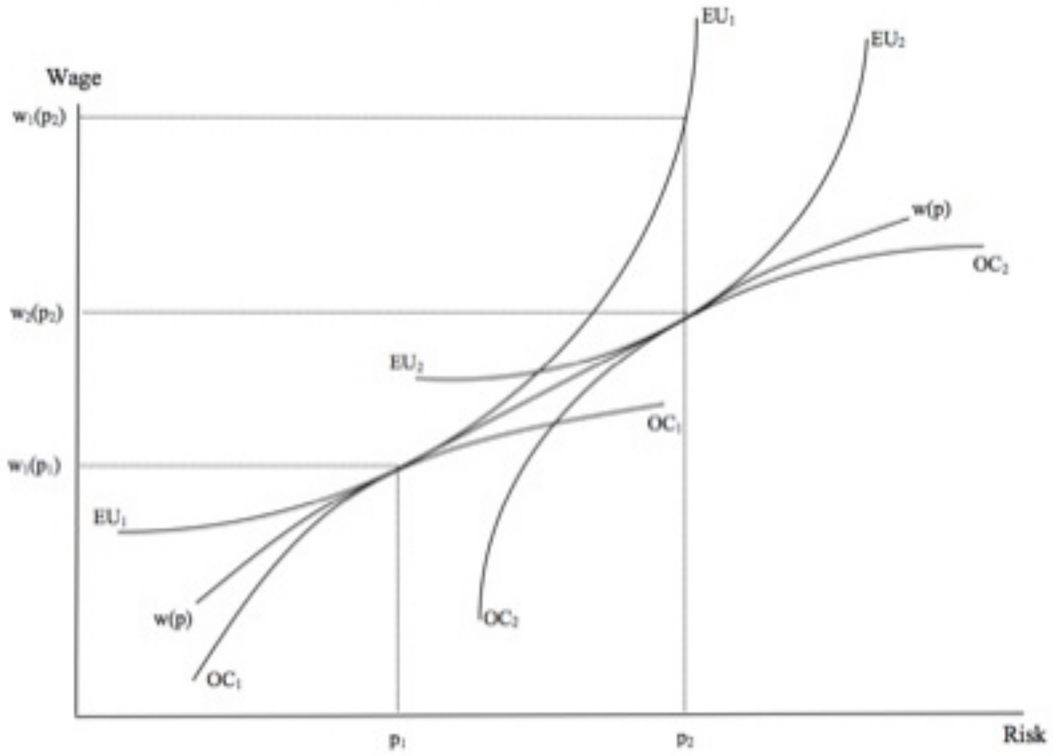

Figure 1: Market Process for Determining Compensating Differentials. Source: Viscusi (2002), page 84

The labor supply side is based on a simplified expected utility function. Now, we will have the utility of being healthy at wage w represented by U(w) and the utility while injured at wage w represented by V(w). Noteworthy in this context is also that workers' compensation is typically a function of the worker's wage, a mechanism which is incorporated into the function V(w).

We will assume that being healthy is preferred over being injured or that [U(w) > V(w)] and that the marginal utility of income is positive [U'(w) > 0, V'(w) > 0]. A locus depicting a constant utility function using these conditions is represented in figure 1 by EU_1 and EU_2 for individual 1 and 2 respectively. Along EU_i, it must be the case that each wage-risk combination along the locus satisfies

$$Z = (1-p)U(w) + pV(w)$$

or that there is sufficient increase in wage given an increase, or reversely, sufficient decrease in risk given a decrease in wage, to hold *expected utility constant along the entire locus*.

Every worker will then select a wage/risk offer located along the market opportunities locus w(p) that best fits his personal preference for a wage/risk combination. This is illustrated in Figure 1 as the points of tangency between individual 1 and firm 1, and individual 2 and firm 2. This yields the wage and work risk (p_1, w_1) and (p_2, w_2) for each individual at the tangency point. To put it in plainer terms, we can say that the labor market automatically acts as a broker between workers who can handle risk and firms that have a hard time limiting risk, and vice versa.

Now, the wage-risk tradeoff along this curve is given by

$$\frac{dw}{dp} = -\frac{Z_p}{Z_w} = \frac{U(w) - V(w)}{(1-p)U'(w) + pV'(w)} > 0$$

meaning that the marginal wage rate with respect to price is positive, or that required wage increases with risk. The wage-risk tradeoff will thus be the difference in utility levels in the two states divided by expected marginal utility of income.

So how does this relate to the analysis at hand? Nastis and Michailidis (2011) [xii] explain that the aim of the standard hedonic model is not to estimate the locus of tangencies w(p) or the market opportunities frontier, but rather to investigate *how observed wage-risk tradeoff is affected by variations in revealed risk attitudes*. Estimating the wage-risk tradeoff leads us to the hedonic wage equation.

Viscusi's basic formulation of the wage equation in Viscusi (1993)[xiii] still serves as the basis for most analyses on CWD's. It takes this shape:

$$w_i = \alpha + \sum_{m=1}^{M} \varphi_m x_{im} + \gamma_0 p_i + \gamma_1 q_i + \gamma_2 q_i WC_i + u_i$$

where w_i is the worker i's wage rate, α is a constant term, x_{im} are different personal characteristic and job characteristic variables, p_i is the fatality risk, q_i is the non fatal/injury risk, WC_i represents compensation benefits payable at the event of an injury and where u_i is a random error term. Naturally, this hedonic wage equation takes on countless variations and adjustments depending on available data and theoretical framework of the model investigated.

Viscusi also makes an important notation in this paper, stating that (p. 1924)

"Estimation using industry-wide data sets often encountered difficulty in distinguishing the positive wage premium for job risks. The reliance on aggregative industry data pools workers with heterogeneous preferences and firms with perhaps quite different offer curves so that the estimated tradeoffs at any particular risk level cannot be linked to any worker's preferences or any firm's offer curve."

That is to say, that data at individual level is much preferred over data of several individuals bunched together at industry level, where the potential effects of the risk levels on the respective worker's choice is much more difficult to discern.

2.4. Related Studies and Variable Analysis

Looking closer at the variables, there are some other details that can be mentioned. Job risk measure is obviously the most important explanatory variable. Since it is the perception principally and not the actuarial risks that govern the choices of the individual worker and firm regarding job valuation, the ideal would be subjective assessment of risk from worker and firm both rather than actuarial data on injuries and deaths. Regrettably, the use of such reported risk statistics is quite difficult to come across, and therefore a majority of studies carried out are forced to make use of an alternative means of risk assessment, i.e. occupational injury rates or fatality rates. Several researchers do, however, manage to construct a worker's perceived injury risk, often by narrowing the width of the analysis.

2.4.1. Perceived risk estimates

Nastis and Michailidis (2011) investigate the occurrence of wage-risk tradeoffs in farming, and use self-reported job risk of back pain as the job risk measure, as back pain is the most recurring health risk faced by farmers. Additionally, they investigate the role that individual heterogeneity in risk preference has on the compensating wage differential, by attempting to valuate revealed attitudes toward risk. They use two measures as proxies for discovering these risk attitudes: the use of protective gear and the state of being a smoker or non-smoker.

In order to collect these perceived risk estimates, the researchers use a survey of a randomized sample of 100 farmers from two different agricultural regions, with a structure tailored for the analysis at hand. The use of tailor-made surveys can be quite costly and time-consuming, however it does mean that the researchers are, in best case presented with ideal data upon which to build an analysis, as well as a unique set of data that can present new conclusions.

Their results show strong support for both the theory of CWD's in riskier employments, as well as for the idea that individuals of higher risk averseness have a higher demand for wage compensation than individuals of lower aversion to risk.

Hammitt and Ibarrarán (2006)[xiv] make use of both perceived- and actuarial-risk estimates in their analysis of occupational risk in Mexico City. The perceived-risk estimates again were collected by conducting personal interviews on a randomized sample across various industries so as to achieve a sample population with an even variance of risk faced. The respondents' means of estimating perceived risk was by selecting a point on a ladder ranging from 0-30 based on where they thought they matched in occupational-risk level and industry-risk level. Actuarial data was gathered using government statistics.

They collected data for both fatal and non-fatal risk, and found positive and statistically significant coefficients for both perceived and actuarial risk, when they were used mutually exclusive. When used together, one of the variables was not found statistically significant in both the case of perceived and actuarial risks. This has to do with the collinearity of the variables, as it is feasible to assume that an occupation that has a high injury risk generally also has a proportionally high fatality risk. This is a factor that was also mentioned by Viscusi (1983).

In their job risk survey, conducted by using mail, Gegax et al. (1991) [xv] use a ladder with ten steps, each step representing an increasing risk level and exemplified by a specific job – similar to the method utilized in the paper described above – in a mail survey to estimate the perceived risk level for a number of employees in an assortment of white collar- and blue collar-sectors. There are of course advantages and disadvantages to using a national mail survey as opposed to a personal interview survey. Their initial population was much higher than in the previous two described (6000 instead of 100 and 600 in Nastis and Michailidis (2011) and Hammitt and Ibarrarán (2006), respectively). However, only about 1/3 of the surveys returned in complete form, and after some necessary sorting the final sample of useable responses was 737 observations. Furthermore, the risk of measurement error is higher using this approach compared to using a personal interview survey.

Initially, the empirical results showed very weak support for the theory of compensating wage differentials. A series of calibrations to the hedonic wage equation yielded few improvements, however when occupational groups were separated in the regression, statistically significant and positive values for the risk estimate were obtained – for union members and blue collar workers. This has served to strengthen the notion that unions can be instrumental in securing CWD's.

2.4.2. Actuarial risk estimates

This is not to say that successful analysis is conditional to the usage of perceived risk estimates. Viscusi (1993) also mentions the possibility of using a more refined risk estimate where actuarial and perceived risks are integrated. The literature standard, however, is definitely the use of industry- or occupational-average numbers for fatality over a longer period of time as fatalities are rare events in most industries.

Siebert and Wei (1998)[xvi] estimate the wage compensation for fatal job risk in Hong Kong using actuarial job fatality data. They make use of a 1% sample of the 1991 Hong Kong Population Census merged with Labor Department family data. There is always the risk of mismatch biasing results when samples gathered from different sources are used interlinked. Their results show a positive and highly significant compensating wage differential.

A more recent study of mainland China was carried out by Guo and Hammitt (2008). The researchers also make use of fatality rates in order to estimate an occupational risk, however what is especially interesting with their analysis (apart from being the first one carried out in China) was their addition to the analysis the impact of unemployment in the examined area. This is a rational approach to investigate, as one of the base assumptions of the CWD model is free labor movement. In the case of high unemployment levels, it is needless to say that incentives to leave your job are reduced even if the risk level is at an unsatisfactory level.

Again, the data was prepared by merging national sample information on workers' wages and other characteristics with data on occupational fatalities. The main hazard using this approach, especially in the case of having broadly defined occupational groups, is that the range of risk employees face within a particular group may vary significantly. Take, for example, miners working in the mines and those working in the office above ground. These may both be labeled as working in the 'mining industry' although the risk faced is as different as night and day. This potential discrepancy runs the risk of making the risk differences get lost in the empirical results.

The authors do, interestingly, find a substantial effect to risk compensation when the level of unemployment is changed. From an estimated 5,5% incremental increase in wage with a 1 per 10,000 risk level increase when there was no unemployment present to nearly zero compensation at 8% unemployment. Their results also support the idea of marginal rate of risk compensation rising with risk level as unskilled and skilled workers receive proportionally higher compensations compared to professionals and office workers.

Marin and Psacharopoulos (1982)[xvii] are creative when creating their risk measure. Their basis is a record of deaths in 223 occupational groups registered over a three-year period from which they create two indices of death per 1000 workers per year. GENRISK is the extra risk of dying in an occupation measured by the actual death rate minus the expected death rate given age social class structure for the workers in each group. The risk one faces if this change were not made is well described by the simile of thinking that the coast of southeast England is a dangerous place because many people die there each year, whereas the underlying reason is that the area is a popular retirement area. ACCRISK is the rate of deaths from an occupational accident minus the rate expected given the occupational age structure. This measure was still better adjusted for capturing the potential presence of CWD's, and indeed, ACCRISK yielded stronger results than GENRISK did.

2.4.3. Other elements of the hedonic wage function

The importance of the human capital segment and other possible determinant variables of the equation is not to be diminished either. Dickens (1984)[xviii] mentions that the human capital measures are crucial in isolating the wage premium and sorting out the mass of personal characteristics able to influence the perception and selection of risk and employment. It is pretty obvious that estimation based solely on wage and risk data would garner a heavily biased result, unless you have a completely homogenous workforce, a scenario that is extremely difficult to imagine. Siebert and Wei (1998) illustrate the issue: unfavorable conditions are an inferior good, meaning that wealthier individuals will be less likely to choose a job with such conditions. Since education (skill) is strongly correlated to wealth; the exclusion of education as a control variable would likely result in a downward bias of the CWD estimate.

An example of the great difficulty in avoiding omitted variable bias – provided by Garen (1998)[xix] - is the fact that a variable such as "coolheadedness" may be a variable with significant influence on the productiveness under a stressful or dangerous job, and may have no influence on another type of job. Furthermore, it is a variable that is very difficult to estimate. The usual human-capital variables are significantly easier to measure and more often than not play a part in the personal characteristics vector. Examples of the most common variables are age, education, work experience, sex and marital status. We will return to this issue in the upcoming chapter.

The job characteristics vector is the controlling variable for the conditions or the 'pleasantness' of the job. This variable can include a whole list of states, some of which are included in the Duncan/Holmlund study (which will be examined closer shortly) are the presence/risk of noise, smoke, poison, heavy lifting, stress, etc.

Another frequent element included in the personal and job characteristic variable is labor union membership. As discussed in Gegax et al. (1991) significant differences in marginal safety values have been observed between union and non-union members. Furthermore, union wage negotiations may also have an impact on the wage variable, as unions may have a better position in negotiations as well as better knowledge of the actuarial risks (which, naturally, could influence the wage in both directions).

2.5. Different Approaches

Analyzing the papers in section 2.4., it becomes obvious that the wage equation formulated by Viscusi and described earlier, is not followed to a tee. The basic equation is principally followed, but among the research papers examined, it was notable that WC_i, the compensation in the event of an accident, had been left out. Especially the more recent papers do not give much mention of the variable.

Furthermore, the original hedonic wage equation is far from the only approach that has been attempted in estimating compensating wage differentials. A paper that presents two alternative approaches to estimating CWD's was presented in Gunderson and Hyatt (2001)[xx]. The authors begin by describing what they call the basic model, e.g. the one described in this paper. Their second approach is the 'endogenous risks' model. This draws upon the assumption that safety is a normal good, and that the level of risk accepted decreases with wealth. Once again, W. Kip Viscusi laid out the basis for the framework. It will not be described in detail, however it entails using two-stage least squares method where the wage-risk condition is taken into account and adjusted for.

The third approach is called the 'self-selection' model. It is a continuation of the endogenous risk model and was elaborated in Garen (1988). It is additionally complex compared to the previous model, as Garen builds a three-equation model in an attempt to control not only for the endogenous aspect of risk but also by attempting to have unobserved factors with respect to productivity in dangerous jobs accounted for. Again, we won't go into detail on the workings of this model, however it can be interesting to mention that the results showed higher coefficients for the risk variable using the endogenous risks model, and higher yet using the self-selection model. This does indeed support the claim that the compensating wage differential in the basic equation is biased down due to omitted variables.

In line with the criticism of the potential risk of omitted variable bias, yet another approach to the hedonic wage framework was developed. Charles

Brown (1980)[xxi] proposed the theory of the **wage *change* model** and in his paper he starts off by stating that he believes the basic model has some inherent flaws and that the results do not give enough support for the theory of equalizing differences. He explains that the most common explanation by far for getting erroneous/insignificant results is omitted variable bias. As an example, he explains that if there was a simple equation of the form

$$W = B_0 + X_1B_1 + X_2B_2 + ZA + u$$

where X_2 was a variable where data was unavailable; then the bias of the estimate of A will have the same direction as the correlation between X_2 and Z. Thus, if there was a negative correlation, A could be biased to the point that it switches signs. He continues by explaining that many of these personal characteristics that are part of the omitted variable bias are not valuated in the basic wage equation. However, they are characteristics that are not liable to change over time, and can therefore be considered personality constants. His idea, then, was to create a wage *change* model instead, where a CWD would be estimated from a change in jobs rather than at a point in time like in the more static standard equation. This would eliminate the bias of personal characteristics. The only prerequisite would be that there is a high level of occupational change during the time period in the sample population – Brown solves this by using a sample of young men where 85% changed occupations once during the sample period.

It should be noted that there is still an impending risk for omitted variable bias if those personal characteristics that are inconstant are not controlled for. This includes marital status, work experience and formal training. This once again points to the importance of the human capital segment of any estimation attempt.

2.6. Was Adam Smith Right After All? Another Test of the Theory of Compensating Wage Differentials

The header above is the title of a research paper written by Greg J. Duncan and Bertil Holmlund and published in October 1983. This paper was a continuation and direct implementation of the wage change model-framework laid down three years earlier by Charles Brown. It appears that there has been very limited research conducted in this field after the publication of this study and I was unable to find any direct comparisons at all. This is one of the factors that make this field of study particularly interesting. Another factor is the fact that the authors have not used any direct measurement of occupational fatal or injury risk in their empirical analysis, but rather a spectrum of factors that pertain to both risks as well as unpleasantness in the work area. This is in line with the original quote from Adam Smith mentioned in the beginning. The last factor that made their analysis interesting was the fact that they use Swedish labor statistics as their basis for analysis – an obvious point of particular interest given my nationality.

They continue building the case of Charles Brown, writing (p. 367) that "*If important but typically unmeasured characteristics such as "motivation" and "intelligence" lead to both higher pay and better working conditions, then the omission of measures of these characteristics may well bias the estimated relationship between wages and working conditions*". The empirical analysis is based on panel data, which is an obvious prerequisite when change in time of individuals is examined. Furthermore, they make use of perceived-risk estimates rather than actuarial-risk estimates. As mentioned in the beginning of chapter 2.4., this is more in line with the theory of wage-risk tradeoff behavior and therefore preferable. They continue by arguing that not only does the wage change equation limit the bias of omitted personal traits, but also it limits the bias resulting from varying frames of reference in answering survey questions and placing values along a scale.

The wage equations took on the following form in the Duncan and Holmlund study; consequently this what my wage equations will imitate:

$$\ln W_t = \beta_0 + \beta_1 X_t + \beta_2 J_t + \varepsilon_t \quad (1)$$

and

$$\Delta \ln W = \beta_1 \Delta X + \beta_2 \Delta J + \eta \quad (2)$$

where X_t is a vector of observed, productivity-related characteristics of the *i*th individual, J_t is a vector of the work characteristics of the *i*th workers job and ε_t is a stochastic error term that is assumed to satisfy the conventional Gauss-Markov conditions. For a full variable list and description, please see Tables, chapter 7.

2.6.1. Empirical Results of the Duncan and Holmlund study

In order to test the validity of the wage change equation in comparison to the wage level equation (standard hedonic wage model); estimations were made using both methods.

First off, the authors estimated a wage level equation with the 1968 population sample. This was done in two steps, both times with the natural logarithm of hourly wage as the dependent variable. First, only the human capital earnings variables (education, experience, experience squared, marital status, handicap and supervisory function) were used as control variables. Secondly, the 12 work conditions variables were also included in the regression (again, note that the 'shake' variable was not included in this study resulting in 11 variables). With the first regression, all human capital earnings variables except for handicap status were significant and showing reasonable signs and coefficient values. In the second regression, 6 out of 12, or half of the work conditions variables displayed positive signs, however three out of four statistically significant variables had negative signs.

The 1974 population sample produced very similar results – however handicap was actually statistically significant here, albeit only at 10% level in the first regression; indicating that a higher (more severe) handicap index status meant a lower wage. Again half of work conditions variables displayed positive signs, and yet again the same variable (mentally demanding) displayed a positive and statistically significant effect on wage.

The third part of the empirical analysis was the wage change equation. There was significant contrast between the wage level equation output and the wage change equation output in the Duncan and Holmlund study. Now, as many as 9 out of 12 work conditions variables had positive signs, therein three of the four statistically significant ones.

3. Data & Variables

The first sub-chapter provides a description of the source and design of the data that the econometric analysis is based on. Then, the procedures used in order to adjust the data to the current analysis are described.

3.1. Swedish Level-of-Living Survey (LNU)

The dataset that will be the basis of this paper's analysis is collected from the Swedish Level-of-Living Survey (LNU) compiled by the Swedish Institute for Social Research, SOFI (www.sofi.su.se). It is a highly extensive longitudinal survey encompassing a wide array of topics such as health, education, working conditions, political life etc. The same respondents have been interviewed at later waves. This follow-up interviewing combined with the width of the survey is what makes this dataset ideal for using in a wage change equation. It does not, however, present any data on fatality or injury risk, thus the main explanatory variable instead becomes a collection of job characteristics.

More information on the collection of the data is described at www.sofi.su.se: the first survey was based on a 0.0001 random sample of the Swedish population aged 15 to 75 years of age. The 1968 survey was to be repeated in 1974, and the decision was made to stick to the original sample but also include new cohorts of young people and immigrants arriving to Sweden in between the survey periods. Dropped from the sample were those above 75 years of age and those who had either emigrated or died. In 1981 the third Level of Living Survey was conducted with the same sample design. The 1991 survey was conducted with basically the same design, except for the fact that the youngest age bracket now became 18 instead of 15. For the 2000 survey, detailed information is not provided, thus it must be assumed that it follows the same method as the 1991 edition. In summary: there have been five collection instances of the LNU survey (with a sixth in progress): 1968, 1974, 1981, 1991 and 2000.

3.2. Construction of Variables

Since the publication from Duncan and Holmlund (and consequently the one from Brown) will serve as the basis for the econometrical analysis, the equation will be modeled as close as possible to this one in order to enable an analytical comparison to be made between that paper and this one.

Their study makes use of the 1968 and 1974 publications of the LNU. For my analysis, I will make use of the 1990 and 2000 editions. The first limitation of the data performed in line with the Duncan and Holmlund study is confining the analysis to men. Furthermore, certain consistency prerequisites needed to be filled in the wage change equation, namely change in experience and in education between the observation instances could not exceed 10 or go under 0 for logical reasons. Thus, values above 10 were set to 10 and values under 0 were set to 0. Additionally, change in experience squared also needed to be adjusted at times[1]. These means of adjustment were used following the same methods as the Duncan and Holmlund study.

Two of the variables used in the Duncan and Holmlund study had to be omitted due to their non-inclusion in the newer editions of the survey. The variables in question were “unemployment 1969-1974” and “shake”, both dummy variables in the event of an individual having been unemployed during the period or experiencing significant shaking in his workplace, respectively.

Due to their lack of describing their means of constructing the variables used in the Duncan and Holmlund study, two of the variables whose source or formation were unclear had to be modeled as fittingly as possible. These were “Job change 1969-1974” and “Handicap”. Detailed explanation of how, together with a short note on the wage variable is provided in the Appendix, chapter 7.

4. Method

The procedures used in producing the results of this study are described here, along with the diagnostic methods used to test the strength of the analysis.

The model was estimated with the normal OLS model through a linear regression. For the two wage level equation-regressions, the equation took the form of equation (1) in section 2.6. The dependent variable was the natural logarithm of wage for the year. The explanatory variables consisted of a total of 17 control variables, out of which 6 are human capital earnings variables and 11 are work characteristics dummy variables (for full list consult the Variable List in the Appendix). Regressions were performed using robust standard errors in order to eliminate heteroscedasticity.

The wage change equation took the form of equation (2) in section 2.6. All variables in the wage change equation are described as the change between

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[1] The following formula was used: Let EXP90 and EXP00 denote years of work experience in 1990 and 2000, respectively. If $\Delta EXP = EXP00 - EXP90 < 0$, set $\Delta(EXP)^2 = 0$. If $\Delta EXP > 10$, define $\overline{EXP} = (EXP90 + EXP00)/2$ and set $\Delta(EXP)^2 = (\overline{EXP} + 5)^2 - (\overline{EXP} - 5)^2$.

1990 and 2000. All variables from the wage level equation are included and "Job Change 1990-2000" is added as a human capital earnings variable. This result in a total of 18 control variables for the wage change equation.

The models are based on the hedonic wage equation for estimating compensating wage differentials. Duncan and Holmlund (1983, p. 369) mention that "*there is no compelling reason to believe that f(.) is either log-linear or additive. Cost conditions may lead to a linear or parabolic relationship between working conditions and wages, or to differently shaped relationships for different classes of workers in the labor market*". As this is the industry standard and the method that Duncan and Holmlund choose to use, I will model my equation in the same fashion.

In order to test the durability of the regression, specification tests were performed to test how well the OLS assumptions were satisfied. *White's test* is a test to check for heteroscedasticity. Heteroscedasticity is present when the assumption of equal variance of the residual in all observations is not satisfied. This causes bias of the standard errors and thus may cause false inference regarding the significance of variables (Westerlund, p. 175)[xxii]. Also, it means the Gauss-Markov theorem is not valid and the estimator is not BLUE (Best Linear Unbiased Estimator).

The *Cameron-Trivedi* decomposition of the *information matrix test* is used to test for abnormalities in the shape of the plotted curve of residuals. Residuals are expected to take a normal distribution shape. Skewness is a measure of symmetry, while Kurtosis is a measure of the flatness, or 'peakedness', of the distribution. Their value is expected at 0 and 3, respectively, in a normal distribution. Thus, they give an indication to how well the residuals follow the normal distribution.

The *Variance inflation factor* is estimated to check for significant correlation between explanatory variables. Multicollinearity, which is what is tested for, can cause invalid results regarding the effect of individual predictors (Westerlund, p. 159).

The *Ramsey RESET* (Regression Equation Specification Error Test) *test* and the STATA command *linktest* both test for functional misspecification. This is, by adding non-linear combinations of the explanatory variables, the test checks whether the model appears mis-specified. Misspecification may indicate that there are relevant explanatory variables omitted from the estimated equation, or that the true model in reality is not linear although the regression has a linear form (Westerlund, p. 158).

Several variations of the variables were also made in order to test the robustness of the equation. First of all, each work characteristics variable was estimated individually against the dependent variable. The results of these estimations are outlined in Table 5 in the Appendix. The equation was also re-estimated by changing the sample. The sorted sample had a birth year range from 1929-1965. This means that ages ranged from 35-71 years in the year 2000. Therefore, a second estimation of the wage change equation was made excluding those 65 and older to investigate if this would affect results. Then, in line with the paper written by Gegax et al. (1991), union status was investigated. This was done by including union status as an explanatory variable in the two wage level equations and the wage change equation, and re-estimating the equation. An estimation of the wage change equation using the entire population sample of men and women was also performed in order to see if a bigger sample could help make inference.

5. Results

The Results chapter illustrates the output of the current study, followed by a discussion section where the output is studied using basic economic theory as well as assessed for the presence of CWD's. Finally, a comparison is made between this study and the one of Duncan and Holmlund.

5.1. Empirical Results of This Study

Using the LNU data, both wage level equations for the years 1990 and 2000 were estimated, as well as a wage change equation for the period in between. We will begin with the wage level equations for 1990 and 2000, presented in detail in chapter 7, in tables 1 and 2. Column (1) represents a regression run with only the basic human capital earnings variables while column (2) represents a regression with all control variables included.

For the 1990 sample, we can begin by determining that the human capital earnings variables have a high influence on earnings, all except for the handicap variable being significant. Wage increases with years of schooling, years of work experience and with the number of people supervised. The marriage dummy has a negative impact on wage. The experience-squared variable is also highly significant and takes on a negative sign.

Moving on, and including the working conditions variables in the analysis, we can conclude that only two are statistically significant, and what's more, they both take on a negative sign as opposed to the expected positive sign with the positive effect on wage all work dummies are predicted to have. Additionally, 8 out of the 11 work place dummies take on a negative sign.

The 2000 sample provides us with a little different output compared to the 1990 one. Looking at the human capital earnings variables, education and a supervisory role once again have a positive wage effect. Handicap, yet again, is not significant to earnings. What is noteworthy this time is that marriage now has a positive effect on earnings of about 7%. Experience and experience squared do show expected signs, however they are not statistically significant this time around.

When we include the working conditions variables, 6 out of the 11 variables are statistically significant. However, five out of these have a negative sign in front of the coefficient, in total 8 out of 11 variables, just as in the previous sample. Now, the only variable that appears to be cooperating with general theory is the one describing hectic work – entailing a 4-5% in wage.

The wage change equation output obtained is illustrated in Table 3. Again, we shall start with column (1). A change in education during the time period did not have a statistically significant effect on the wage development. Experience did, however, and both experience and experience squared exhibit the expected coefficients and signs. A new variable, the job change dummy, is introduced here. However, it does not seem to have a significant impact on wage. Becoming married does not have an impact either, and just as before, neither does a change in handicap status. Finally, an increase in supervisory responsibilities does entail an increase in wage.

Onward to column (2), we now do now have 5 out of 11 variables with the correct sign instead of 4, and what's more – two of them are statistically significant. We can also note that for the six variables with a negative sign the average coefficient value is -0.0045 while the average for the five with a positive sign is 0.0184.

5.2. Testing the Assumptions of the OLS-model & Durability

In order how well the residuals of our wage change equation fare with the OLS-model assumptions, certain diagnostic tests were run. These are described here. For full tables and detailed results, please see chapter 7.

In order to get a general idea of how the residuals look, it is useful to plot them on a graph and compare them to the normal distribution curve. Figure 2 below is a graph of a kernel density estimate.

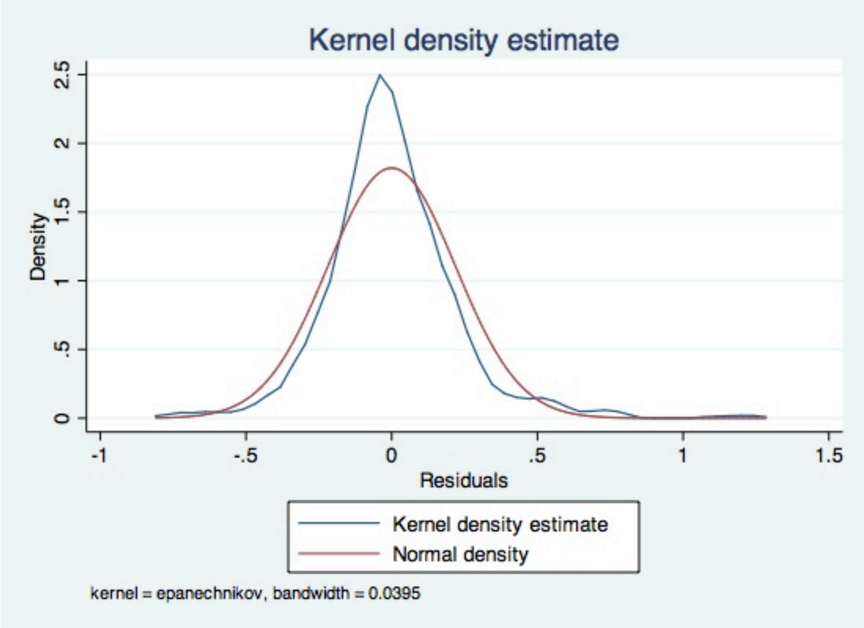

Figure 2: Kernel density estimate of wage change regression residuals

The high peak of the curve indicates that we have Kurtosis. There are no apparent signs of Skewness, though. The *Cameron-Trivedi* decomposition of the *information matrix test* confirms our suspicions indicating the presence of kurtosis while not indicating skewness.

White's test was then run to test for the presence of heteroscedasticity. With a p-value of 0.5556 and a null hypothesis of homoscedasticity, we cannot reject homoscedasticity.

The *variance inflation factors* were then estimated in order to test for multicollinearity. The test results showed no signs of multicollinearity.

In order to test for mis-specification of the estimated equation, two tests were performed. First, the *Ramsey RESET* test was used. From the results, we can reject the null hypothesis that the model has no omitted variables. *Linktest* gave the same indications of mis-specification.

For full sensitivity analysis results of the wage level equations, please consult the Appendix, chapter 7.

The first robustness test was to change the sample population from 35-71 years to 35-64 years. This was done to exclude potential retirees from the population. However, only 5 observations exceeded 65 years of age, and therefore the regression results did not change significantly with this change of sample population.

Secondly, the union status dummy was introduced as an explanatory variable. In the 1990 wage level regression, this variable was not significant and had no significant effect on the other variables. In the 2000 wage level equation, union membership was significant, while the 'punch clock'-variable lost its significance. Union membership had a coefficient of -0.123 indicating 12.3% lower wages for union members than non-union members. In the wage change variable, union membership was not significant and did not affect any other estimation.

Third and lastly, the wage change equation was estimated using the entire sample population of 1607 men and women. 5 out of 11 work characteristics variables showed a positive sign while one variable, 'punch clock', was statistically significant.

5.3. Discussion

To start the discussion off, the general findings of the respective papers' regressions will first be analyzed together, then direct comparisons between the two are made in the next sub-chapter.

The importance of the human capital earnings variables is displayed in the regression results: they appear to have theoretically sound and significant influence on the wage level in both studies. In the 1990 study (1), surprisingly, being married would appear to have a negative effect on wage. As mentioned in Siebert and Wei (1998), it is quite usual for there to be a wage premium for married men. The experience-squared variable is also highly significant and takes on a negative sign. This indicates that earnings over the life cycle exhibit a parabolic path, explained by economic theory by the decline with age of learning on-the-job, a path that is common to most earnings function estimates. We can also conclude that the handicap variable was statistically significant only in the 1974 regression. The value obtained, however, does go well in line with general theory, and the value and sign corresponds fairly well with the 'Disabled' dummy used in the Gegax et al. (1991) study.

In the case of the full wage level equation, results are ambiguous in the Duncan and Holmlund study, and support for the general theory is pretty weak in this study's results. In 1990, 8 out of the 11 work place dummies take on a negative sign – a 'wrong' sign. This is definitely not in line with the theory – in fact, we spot a 4-5% *penalty* for being employed at a job where one is in contact with poison! Marriage now has a positive effect on earnings of about 7% though - more in line with general theory. Generally, it cannot be said that the results are strongly in favor of the compensating wage differentials theory.

Thirdly, we arrive at the final, and most interesting part of the empirical analysis - the wage change equation. As mentioned, there were significant improvements in the Duncan and Holmlund study with regard to support of the compensating wage differentials theory, as 9 out of 12 work conditions variables showed positive signs. Further, three out of four statistically significant variables also had positive signs. These empirical results do appear to affirm the theories developed by Charles Brown.

From this study's results, proponents of the wage change equation may be a little disappointed as there is no stellar support for the theory displayed, since the change between the two methods is not as radical as in the Duncan and Holmlund study. However, the fact that the six variables with a negative sign have an average coefficient value of -0.0045 while the average for the five with a positive sign is 0.0184 implies that the variables that have a positive wage bonus indicate a larger impact on the wage level development. Also, we do have 5 out 11 variables instead of 4 with the 'right' sign, and both of the statistically significant variables fit into this category. It could be argued that, together, these differences give hints of less omitted variable bias and improved results using the wage change equation compared to the wage level equation.

Regarding human capital earnings variables, a change in education during the 1990-2000 interval did not have a statistically significant effect on the wage development. Experience did, however, and both experience and experience squared exhibit the expected coefficients and signs. This is not very surprising, as experience inevitably will increase as time goes by if one is steadily employed at the same time as wage tends to increase naturally with time.

The sensitivity analysis will also be commented on briefly. It is a little worrisome that both tests indicate functional misspecification of the econometric model. As was noted in chapter 4, the relationship between wages and working conditions may not be linear. This could be one reason for both the apparent misspecification of the model, as well as why the results gave poor support for the wage change theory. This is an area that could be investigated further and possible improved upon.

The effect of union membership was non-existent in two of the regressions and had a highly negative effect on wage in the wage level regression for 2000. One possible explanation is that industries that have a high rate of union membership may be blue-collar industries, where wages on average could be lower than in white-collar industries.

Lastly, the estimation of the male and female sample did not yield much different results. There was still indication of misspecification, and the coefficients were fairly similar to those of the first wage change equation with an all-male sample.

5.4. Comparison Between the Studies

There are a couple of differences between the studies that are worth mentioning that could have an impact on results. The number of observations in the regressions performed for this study was 783 – compared to 1226 observations in the Duncan and Holmlund study. Why this was the case is not entirely clear. One possibility is that a bigger portion of the population had to be sorted out in the process of calculating the job change variable. Regardless, the roughly 50% bigger sample might have made inference easier in the previous study. Another point that can be made is that the age of the sample population ranged from 15-75 in the Duncan and Holmlund study, while my study had a range of 18-75 years (mentioned in section 5.2.).

It is mentioned in Brown (1980) that one of the essentials to using the wage change equation in place of the wage level equation is that the population sample has a high level of occupational change during the period examined. Therefore it is interesting to analyze what the mean value is for the "job change" dummy variable. The 1968-1974 sample population has a job change mean of 0.35 (35%) while the 1990-2000 sample (Table 4) population's mean is 0.56 (56%). It goes without saying that the newer study has a better job change rate than the older one, and for apparent reasons as the time period in this study is 10 years instead of 6; but the question is whether either of these mean values are sufficient for accurate inference to be made from the regression results. In the case of Brown (1980), the corresponding value for the sample population is 85%. In an attempt to check the robustness of the analysis, another regression was performed sorting out those from the sample who had not changed jobs during the period, ending up with 442 observations. This regression yielded 7 out of 11 work conditions variables with a positive sign, however not one of all the work condition variables was statistically significant. Thinking that the lower number of observations could be hindering inference, I had the sample expanded to both males and females and repeated the regression. Again 7 out of 11 work conditions variables had a positive sign, however the one statistically significant variable, punch clock, showed a negative sign. The sample population was now 948, so it was still lower than that of the Duncan & Holmlund sample. This would indicate that a high rate of job change is not necessary, or even particularly beneficial, to analysis using a wage change equation.

Comparing the means further, it can also be noted that the 68-74 period saw an increase in all the dangerous and stressful work variables as well as in the punch clock and heavy lifting variables. The 90-00 period meanwhile, maintained a positive change in the stressful work category, however all of the other work conditions variables saw a decrease during the period. Generally, the means are higher during the earlier period except for the mentally demanding variable, indicating the societal labor trends during the last few decades with a shift from industry to office work. It could be expected that the dangerous work and hard physical work categories are the ones to see a decrease as the sample population increases in age.

One of the two omitted variables for this study may also have had an impact: unemployment 1990-2000. As I mentioned earlier, this variable was not surveyed in the newer editions of LNU and therefore could not be integrated into the study. We can look back to section 2.2. where it was stated that a lack of unemployment was one of the basic assumptions of the hedonic wage model. The study by Guo and Hammitt mentioned in section 2.3.2. tests this assumptions and results indicate an estimated 5.5% compensating wage differential at near full employment – to approximately 0 in compensated wage at 8% unemployment. This implies that unemployment may indeed be an important control variable. The suggestion that the omission of this variable in my study may be accountable for some of the differences is further strengthened by the fact that the first survey was collected in 1990 – therefore coinciding with the Swedish financial crisis of 1990-1994. The crisis was the result of a housing bubble deflating caused by changes in credit market regulations and the transition from fixed to floating currency. GDP fell for three consecutive years

1990-1993 after having been steadily rising since the beginning of 1981. The crisis had similar cause and effect to the American sub-prime mortgage crisis of recent, although not escalating to the same level.

The crisis had severe effects on the labor market. In 1992, unemployment had reached 10% compared to 2-3% during the end of the 1980's. This spike in unemployment, coupled with the shrinking GDP and massive bailouts paid to the failing banks meant the state had a budget deficit of around 110% during these years. This led to many state employees being let go and unemployment increasing further to 12% in 1994. Unemployment didn't stabilize at 6% until 1996, around which the average remained until the recent financial crisis[xxiii]. Note that even this 6% is close to the level of 8% in which there was no indication of CWD's in the study mentioned above. Another source claims that the total unemployment level was as high as 13,5% even in 1997[xxiv]. It can also be noted that those hit hardest by the crisis were those in their late teens and early twenties – the same group that Brown (1980) mentions is the most frequent at job changing. Regardless of what the exact numbers for the period were, the effect the crisis had on the labor market between 1990-2000 cannot be ignored.

There is also the possibility that wages have dropped generally in the blue-collar sector compared to the wages in white-collar sector. This is not unreasonable, as demand for labor in the white-collar sector has been increasing steadily since the 60's. This could have a biasing effect on the estimates for work characteristics variables, pushing them toward a negative sign instead of a positive sign.

6. Summary

What conclusions can we, then, draw from this updated study of compensating wage differentials and the wage change equation? The initial segment stated (through the words of Adam Smith) that in a state of market equilibrium, the job preferences of the workers would be the decisive factor. This led us to the compensating wage differential, or the price for our Willingness to Accept risk; the 'broker' of the labor market. While we can not conclusively say that there is such a thing judging from our results, the wide array of successful research conducted in the field coupled with indications present in our empirical results do point toward CWD's being present.

Our theoretical hypothesis stated that the analysis of the change in a constant population instead of a cross-section analysis would decrease the risk for omitted variable bias and measurement error. It is difficult to make any strict judgments considering the empirical results; however there do seem to be certain indications of the wage change equation resulting in output more in line with theory than the wage level equation.

This reasoning could also be one of the possible explanations as to why the results of the two wage level equations did not fit in well with the theory of CWD's. I will repeat that the praxis when calculating CWD's is still using fatality, or in some cases, injury rates as the proxy for risk rather than using various measures of disagreeableness and risk such as in this study. Judging from the results of this study there might be a case for choosing the standard wage level equation with fatality rates over this, alternative, one.

There are, however, numerous ways in which the conditions for analysis could be improved, and given that the wage change equation theory has a simple and intuitive framework and makes sense; there's no reason to reject it and be limited to using the routine methods. One could make a point, for example, of wondering whether the wage variable perhaps should have been discounted to eliminate the effect of the natural wage growth of the industries due to technological advances, inflation, etc.

The look of the equation could also be re-specified as indicated by the results for the misspecification tests described in section 5.2. It would be interesting to see some of the conventional risk measures integrated as well to see if this could strengthen results. There is also room for improvement regarding the data. In all its glory, LNU could still be improved on with a tailored survey aimed at preparing optimal data for an analysis of this sort.

In closing, it is my hope that this paper has served some purpose in further illuminating this interesting field of behavioral labor economics, and in particular this alternative approach to estimating compensating wage differentials.

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7. Tables & Appendix

Data details mentioned in chapter 3.2: Preparation of the Data

The job change dummy had no apparent source in the LNU questionnaire, and therefore was modeled by selecting the number of jobs each individual had taken in total at both points in time, and constructing a dummy variable that resulted in 1 where this value had changed (thus implying a job change having taken place during the period) and 0 if it had not changed. This did, however, entail sorting the sample further as certain answers were not viable, therefore diminishing the sample population somewhat.

The second variable was constructed by Duncan and Holmlund as an index taking an integer value between 1-4. The underlying variables were described as (walking, running, etc.), and fitting questions were found for constructing a similar index; the only change med was making the range 1-5 instead of 1-4, as this was much easier to construct. As earlier, 1 means at normal health and 5 means drastically reduced health.

Apart from this, all the control variables were identical to those of the older studies and demanded little effort in adapting to the econometrical analysis. The one last point to be made is the fact that the dependent variable, wage, was not calculated in the exact same fashion. The 1990 and 2000 surveys did have the exact same formula for equating the hourly wage, meaning that the use of the two in calculating the wage change formula did not involve any problems. Creation of the gross hourly wage made use of monthly salary before tax, weekly salary before tax, hourly wage, individual piece-work, group piece-work, monthly salary incl. bonuses, compensation for odd working hours and 'other' form of salary. These were then summed and transformed to a gross hourly wage using the 'normal weekly work hours' variable.

The 1968 survey on the other hand, used one variable where the individual specified to which category he belonged, and another where the wage level was specified. The 1974 survey used a system more like the one in the two most recent editions, only using some more categories. The categories are essentially the same for all surveys, but the slight differences in categories and data input could nonetheless have an effect on results.

Results of sensitivity analysis tests described in chapter 5.2.

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	783	0.94269	28.935	8.249	0.00000

Shapiro-Wilk test results

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(188)    =    184.64
         Prob > chi2  =    0.5556

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	184.64	188	0.5556
Skewness	16.63	18	0.5489
Kurtosis	7.01	1	0.0081
Total	208.28	207	0.4620

White's test & Information Matrix-test

Variable	VIF	1/VIF
Experience~d	1.77	0.565223
Experience	1.52	0.658596
Sweat	1.19	0.842611
Physical	1.18	0.850563
JobChange	1.16	0.859988
Mental	1.15	0.871994
Hectic	1.13	0.887540
Smoke	1.11	0.896946
Supervisor	1.10	0.912406
Noise	1.09	0.919311
Inflexible	1.07	0.934775
Errands	1.06	0.942255
Poison	1.06	0.947804
Heavy	1.05	0.951054
Education	1.05	0.955142
Marriage	1.05	0.955808
Punchclock	1.03	0.973693
Handicap	1.02	0.984815
Mean VIF	1.15	

Variance Inflation Factors (note: VIF-values over 10 and 1/VIF under 0.1 normally indicate that variable merits further investigation)

```
Ramsey RESET test using powers of the fitted values of LogWage
       Ho:  model has no omitted variables
                 F(3, 761) =      5.67
                  Prob > F =      0.0008
```

Ramsey RESET test

```
      Source |       SS       df       MS              Number of obs =     783
-------------+------------------------------           F(  2,   780) =   63.78
       Model |  6.02765281     2  3.01382641           Prob > F      =  0.0000
    Residual |  36.8593226   780  .047255542           R-squared     =  0.1405
-------------+------------------------------           Adj R-squared =  0.1383
       Total |  42.8869754   782  .05484268            Root MSE      =  .21738

------------------------------------------------------------------------------
     LogWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        _hat |  -1.617503   .6771248    -2.39   0.017    -2.946706   -.2883003
      _hatsq |   3.524328   .9028169     3.90   0.000      1.75209    5.296567
       _cons |   .4620851   .1237672     3.73   0.000     .2191287    .7050414
------------------------------------------------------------------------------
```

Linktest (note: if _hatsq is significant, the test indicates variables are omitted from the equation)

Sensitivity test results, wage level equations

Test name	1990	2000
Shapiro-Wilks test	0.0000	0.0000
Information Matrix:		
Heteroscedasticity	0.0409	0.0000
Skewness	0.0949	0.0000
Kurtosis	0.0026	0.0474
Variance Inflation Factors	Experience 18.28	Experience 30.37
	Experience Sq. 18.20	Experience Sq. 30.35
Ramsey RESET test	0.0006	0.0000
Linktest	0.020	0.898

Sensitivity test results for wage level equations in 1990 and 2000. Shapiro-Wilks test values represent Prob>z. Information Matrix values represent p-values for Cameron & Trivedi's decomposition of IM-test. VIF variables are included if value is over 10 (noteworthy). All remaining variables had values below 2. Ramsey RESET test values represent Prob > F values. Linktest values represent P>|t| value for _hatsq variable.

Table 1

Wage level equation for 1990, men
Dependent variable: ln(1990 wage)
Standard errors are in parentheses.

	(1)	(2)
Hours constraints:		
Inflexible hours		-0.026
		(0.018)
Punch clock		-0.027
		(0.017)
Difficult to run errands		-0.065
		(0.019)**
Hard physical work:		
Heavy lifting		0.014
		(0.021)
Otherwise physically demanding		-0.028
		(0.021)
Daily Sweating		-0.004
		(0.025)
Dangerous work:		
Noise		-0.009
		(0.023)
Smoke		0.010
		(0.023)
Poison		-0.046
		(0.020)*
Stressful work:		
Mentally demanding		0.011
		(0.018)
Hectic		-0.020
		(0.018)
Control variables:		
Education	0.034	0.030
	(0.003)**	(0.003)**
Experience	0.015	0.015
	(0.004)**	(0.004)**
$(\text{Experience})^2/1{,}000$	-0.198	-0.196
	(0.087)*	(0.086)*
Married	-0.053	-0.037
	(0.021)*	(0.021)†
Handicap	-0.003	-0.008
	(0.017)	(0.017)
Supervise others	0.079	0.069
	(0.007)**	(0.008)**
Intercept	8.428	8.534
	(0.057)**	(0.017)**
R^2	0.3645	0.3948
MSE	0.22891	0.22499

† Significant at 10% level
* Significant at 5% level
** Significant at 1% level

Table 2

Wage level equation for 2000, men
Dependent variable: ln(2000 wage)
Standard errors are in parentheses.

	(1)	(2)
Hours constraints:		
Inflexible hours		-0.050
		(0.023)**
Punch clock		-0.035
		(0.021)*
Difficult to run errands		-0.047
		(0.026)*
Hard physical work:		
Heavy lifting		-0.059
		(0.026)**
Otherwise physically demanding		-0.037
		(0.025)
Daily Sweating		-0.044
		(0.029)
Dangerous work:		
Noise		0.032
		(0.027)
Smoke		-0.094
		(0.026)**
Poison		-0.036
		(0.024)
Stressful work:		
Mentally demanding		0.026
		(0.021)
Hectic		0.048
		(0.022)**
Control variables:		
Education	0.019	0.013
	(0.002)**	(0.002)**
Experience	0.006	0.005
	(0.006)	(0.005)
$(\text{Experience})^2/1{,}000$	-0.089	-0.071
	(0.095)	(0.090)
Married	0.070	0.050
	(0.026)**	(0.025)**
Handicap	-0.020	-0.013
	(0.015)	(0.015)
Supervise others	0.107	0.084
	(0.008)**	(0.008)**
Intercept	9.030	9.194
	(0.091)**	(0.091)**
R^2	0.2871	0.3730
MSE	0.28255	0.26688

* Significant at 5% level
** Significant at 1% level

Table 3

Wage change equation 1990-2000, men
Dependent variable: ln(wage 2000) – ln(wage 1990)
Standard errors are in parentheses.

	(1)	(2)
Hours constraints:		
Inflexible hours		-0.004
		(0.016)
Punch clock		-0.005
		(0.017)
Difficult to run errands		0.031
		(0.017)*
Hard physical work:		
Heavy lifting		-0.007
		(0.020)
Otherwise physically demanding		-0.001
		(0.017)
Daily Sweating		-0.005
		(0.020)
Dangerous work:		
Noise		0.013
		(0.018)
Smoke		0.019
		(0.018)
Poison		0.003
		(0.018)
Stressful work:		
Mentally demanding		-0.005
		(0.016)
Hectic		0.026
		(0.015)*
Control variables:		
Education	0.008	0.009
	(0.006)	(0.007)
Experience	0.020	0.020
	(0.005)**	(0.004)**
$(\text{Experience})^2/1{,}000$	-0.370	-0.373
	(0.052)**	(0.053)**
Job Change 1990-2000	0.021	0.023
	(0.017)	(0.017)
Married	0.018	0.016
	(0.012)	(0.012)
Handicap	-0.010	-0.010
	(0.011)	(0.011)
Supervise others	0.026	0.024
	(0.006)**	(0.006)**
Intercept	0.328	0.330
	(0.037)**	(0.037)**
R^2	0.1145	0.1238
MSE	0.22137	0.22178

* Significant at 5% level
** Significant at 1% level

Table 4

Mean of variables (N = 783)

	Mean 1990	Mean 2000	Mean of the change 1990-2000
ln wage	9.09	9.46	0.374
Human capital variables:			
Education	12.16	12.40	0.24(0.50)
Experience	19.47	28.19	8.72 (8.44)
Married	0.20	0.81	0.60
Handicap (1-5)	1.09	1.20	0.10
Supervise others (0-5)	0.76	0.79	0.03
Job change 1990-2000			0.56
Hours constraints:			
Inflexible hours	0.45	0.35	-0.10
Punch clock	0.39	0.31	-0.08
Difficult to run errands	0.32	0.23	-0.10
Hard physical work:			
Heavy lifting	0.27	0.25	-0.02
Otherwise physically demanding	0.40	0.36	-0.02
Daily Sweating	0.20	0.20	-0.00
Dangerous work:			
Noise	0.24	0.24	-0.00
Smoke	0.40	0.38	-0.03
Poison	0.30	0.26	-0.05
Stressful work:			
Mentally demanding	0.46	0.50	0.03
Hectic	0.65	0.68	0.02

Note: values adjusted for consistency (variable used in regression) in parentheses.

Definition of Variables

Wage	Wage level (Swedish Kronor)
Education	Years of schooling
Experience	Years of labor market experience
Married	Dummy for married workers
Handicap	Index (1,2,3,4,5) built on a sum of four questionnaire variables: ability to walk 100m, run 100m, walk in stairs and to turn a tap
Supervise others	Index (0,1,2,3,4,5) for the number of workers supervised. 0 No supervisory function 1 1-5 workers 2 6-10 workers 3 11-30 workers 4 31-100 workers 5 more than 100 workers
Job change 1990-2000	Dummy for changing employers based on an observed difference in the "number of jobs"(Y10/X325) variable during the observation period
Working conditions (all dummy variables)	
Inflexible hours	Punctuality is important at the job
Punch clock	The use of a punch clock is required
Difficult to run errands	Not possible to run an errand for 30 minutes without informing superior
Heavy lifting	Need to lift 60kg sometimes, once a week or daily
Otherwise physically demanding	Physically demanding in other ways
Daily Sweating	Work causes daily sweating
Noise	The work is sometimes or always ear-deafeningly noisy
Smoke	Sometimes, often or always exposed to gas, dust or smoke
Shake	Sometimes, often or always exposed to strong shakes or vibrations
Posion	Sometimes, often or always exposed to poison, acids or explosives
Mentally demanding	The work is mentally demanding
Hectic	The work is hectic

Note: variable descriptions based on information from the Codebooks for the Swedish Level-of-Living Surveys, 1990 and 2000, Institute for Social Research, Stockholm, Sweden.

Table 5

Work characteristics variables tested against dependent variable one at a time
Standard errors are in parentheses.

Hours constraints:	
Inflexible hours	-0.007 (0.016)
Punch clock	-0.002 (0.018)
Difficult to run errands	0.019 (0.018)
Hard physical work:	
Heavy lifting	-0.004 (0.020)
Otherwise physically demanding	-0.013 (0.016)
Daily Sweating	-0.017 (0.020)
Dangerous work:	
Noise	0.015 (0.019)
Smoke	0.017 (0.018)
Poison	0.009 (0.019)
Stressful work:	
Mentally demanding	0.025 (0.015)
Hectic	0.038 (0.015)**

** Significant at 1% level
Dependent variable: ln(wage 2000) – ln(wage 1990)

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