III. Wage Determination and Labour Market Discrimination

6. Compensating Wage Differentials

- Very old idea in economics that goes back to Adam Smith

- While compensating wage differentials are typically discussed in the context of work conditions, it can be applied to broader issues in wage determination such as human capital investment

- The basic idea is simple, but empirical progress has been slow because of the challenge untangling work conditions from unobserved characteristics of workers and jobs
Roadmap of today’s lecture

1. Theory of Equalizing Differences

2. Hedonic Models

3. Empirical Studies
6.1. Theory of Equalizing Differences

• The idea of equalizing or compensating wage differentials was first introduced by Adam Smith (1776) to explain the equilibrium between labour demand and labour supply.

• According the Smith, it is not the wage that is equated across jobs in a competitive market ("perfect liberty"), but the “whole of the advantages and disadvantages” of a job.

• Smith (1776, Book I, Chap. X, part I) had identified five counter-balancing circumstances:
  “The five following are the principal circumstances which, so far as I have been able to observe, make up for a small pecuniary gain in some employments, and counter-balance a great one in others:
  first, the agreeableness or disagreeableness of the employments themselves;
  second, the easiness and cheapness, or the difficulty and expense of learning them;
  third, the constancy or inconstancy of employment in them;
  fourth, the small or great trust which must be reposed in those who exercise them; and
  fifthly, the probability or improbability of success in them.”

• The modern equivalent is: 1) undesirable work conditions, 2) human capital requirements, 3) job security, 4) responsibilities and 5) probability of success.
• Differences emerging from 1), 2), 4) and 5) are still in use today in job evaluation scheme of pay equity legislation and in administrative pay systems. 3) has mostly been taken over the unemployment insurance.

• In the traditional labour demand model, the wage guides the allocation of workers across firms as to achieve an efficient allocation of resources by equating the wage to the value of the marginal product.

• Workers and firms are anonymous; it does not matter who works where.

• The introduction of compensating differentials breaks this anonymity:
  o workers differ in their preferences for job characteristics,
  o firms differ in the working conditions that they offer.

• The allocation of labour to firms is no longer random and it's matters who works where.

• With self-selection models, we had tied wages to skill levels.
• In the Roy model workers only care about income, but differ in skills.

• In the simplest version of the compensating wage differential model, workers
  o Have identical skills
  o **Heterogeneity in tastes** for jobs

• The basic idea is that an employer must pay a premium to get you to do some job that you don’t like to do (e.g. pest control workers), and conversely he may get you at a discount if the job is like leisure to you (e.g. ski patrols)

• The theory of equalizing differences is exposed by Rosen (1986) in four parts
  1) workers’ choice,
  2) market supply,
  3) market demand and
  4) market equilibrium.

• Here is a simplified version.
1) Workers’ choice
- Let $D$ represent a disamenity of work like how dangerous it is

- Suppose
  - $D = 0$ represents safe jobs that pay $W_0$
  - $D = 1$ represents dangerous jobs that pay $W_1$

- All safe jobs will pay the same because workers are identical and the labor market is competitive (and frictionless)

- Workers preferences are over consumption (i.e. everything else) and the presence of the disamenity, $U(C, D)$, where

\[
C_0 = Y + W_0 \\
C_1 = Y + W_1
\]

where $Y$ is nonlabor income
• The **market equalizing difference**, \( W_1 - W_0 = \Delta W \), is determined by the individual who is indifferent between the two jobs.

• Remember from welfare analysis, that the **equivalent variation** \( EV \) defined as
  
  \[
  U(C_1, 1) = U(C_0 - EV, 0)
  \]
  
  is used to find the willingness-to-pay for removal of the disamenity.

• While the **compensating variation** \( CP \)
  
  \[
  U(C_0, 0) = U(C_0 + CP, 1)
  \]
  
  is the amount the consumer received after for the introduction of the disamenity. Generally, \( EV \neq CP \) because of an **income effect** (not the same level of utility)

• Take a really simple case with linear utility so that \( U_i(C, D) = C - \delta_i D \), where \( \delta_i \) is the utility of the disamenity
• Then individual $i$ chooses to work in the dangerous sector if

$$U_i(C_0, 0) < U_i(C_1, 1)$$

$$Y + W_0 < Y + W_1 - \delta_i$$

$$\delta_i < W_1 - W_0 = \Delta W$$

• The labour supply curve for worker $i$ looks like this

![Diagram of labour supply curve](image)
• Now suppose that workers have different levels of $\delta_i$, so that in the population there is a distribution $G(\delta)$.

2) Market Supply

• Then the supply of workers to dangerous jobs can be written as

$$N_1^S(\Delta W) = \int_0^{\Delta W} I(\delta_i < \Delta W) \, dG(\delta_i)$$

$$= G(\Delta W)$$

• This is just the cumulative distribution of $\delta_i$

• And the supply of workers to safe jobs is just

$$N_0^S(\Delta W) = 1 - G(\Delta W)$$

• As $\Delta W$ increases, more workers will accept the dangerous job
• Elasticity of supply:
\[
\frac{\partial \ln(N^s_t(\Delta W))}{\partial \ln(\Delta W)} = \frac{\partial \ln(g(\Delta W))}{\partial \ln(\Delta W)} = \frac{\Delta W}{g(\Delta W)} g(\Delta W)
\]

• so the elasticity depends on the density of people who are indifferent; it is decreasing in the variance of the distribution.

• Here is an example of a possible market supply
3) Market Demand

- Thinking about the firm side of the market, it costs money to make the workplace safe
- The cost varies across jobs/firms (this is easier for a university than a construction company)
- Each firm (job) hires one worker and there are as many firms as workers
- Production for the firm $j$ is $Q_j$
- Costs of making the work environment safe is $\beta_j$
- So the profits as a function of working environment are
  \[ \pi = Q_j - (1 - D)(\beta_j + W_0) - DW_1 \]
- Thus if $W_1 < W_0 + \beta_j \Rightarrow \beta_j > \Delta W$, the cost of making the workplace safe is too high, the workplace is left dangerous
• On the other hand, if $\beta_j < \Delta W$, the labour costs savings exceed the cost of increasing safety, and the optimal strategy for the firm is to offer safe jobs.

• Let $F$ be the distribution of $\beta_j$, then the demand for workers in dangerous jobs is

\[
N^D_1(\Delta W) = \int_{\Delta W}^{\infty} I(\beta_j < \Delta W) \ dF(\beta_j)
\]

\[
= 1 - F(\Delta W)
\]

• That is, the number of jobs offered is the area under $F(\beta_j)$ to the right of $\Delta W$ and the demand curve is obtained by varying $\Delta W$.

• So that the demand also looks like an inverted CDF.
4) Market Equilibrium

- In terms of the densities, the market equilibrium, $\Delta W$ will adjust to make the area under $dF(\beta_j)$ to right of $\Delta W$ equal to the area $dG(\delta_i)$ to the left of $\Delta W$ (see Figure 12.2 and 12.3)

- Putting them together, we get a market equilibrium $(\Delta W^*, N_1^*)$
• Firms offering safe jobs will have smaller than average cost of making job safe
  \[ E(\beta_j | D = 0) \leq E(\beta_j) \]

• Workers choosing safe jobs will have larger than average distaste for danger,
  \[ E(\delta_i | D = 0) \geq E(\delta_i) \]
  The average person choosing \( D = 0 \) is far from the margin of indifference and would maintain the same choice if \( \Delta W \) changed marginally.

• Most of the empirical work has tried to establish the magnitude of the market equalizing differences \( \Delta W \),
  - For the risk of fatality
  - For polluted environments

• But this price does not provide a complete picture of valuations because it is a precise reading only for the set of workers who are close to the margin of choice, which may be different from the mean value in the population.
6.2. Hedonic Models

- A generalization of this model would consider a continuous disamenity or a vector of disamenities/amenities as in Rosen’s hedonic price model.

- The key insight of Rosen’s (1974) theoretical work on hedonic prices is that the implicit price of an attribute represents both the marginal valuation to customers and the marginal cost to firms.

- “Hedonic” are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them.

- Products in a class are completely described by a vector of coordinates \( z = (z_1, z_2, \ldots, z_n) \) with price \( p(z) = p(z_1, z_2, \ldots, z_n) \) determined by market clearing conditions: the amounts of commodities offered by sellers at every point in the hedonic space must equal amounts demanded by consumers choosing to locate there.
• Letting $\theta(z; u, y)$ be the consumer’s willingness to pay for $z$ at a fixed utility index and income, the utility maximizing equilibrium will be characterized by $\theta(z^*; u^*, y) = p_i(z^*), \ i = 1, \ldots, n$.

• The profit maximizing product designs will satisfy $p_i(z^*) = \phi(z_i^*, \ldots, z_n^*, \pi^*, \beta), \ for \ i = 1, \ldots, n$, where $\phi(z_1, \ldots, z_n; \pi, \beta)$ is the firm’s offer function indicating unit prices (per model) the firm is willing to accept on various designs at constant profit when quantities produced of each model are optimally chosen.

• The market equilibrium is reached when there exists $p(z)$, such that $Q^d(z) = Q^s(z)$, for all $z$, and buyers and sellers act as described above. That is, equilibrium is described by the intersection of supply and demand functions.

• For a quadratic cost function and a linear utility function, Rosen shows that a closed form solution for $p(z)$ exists. Recently, Ekeland, Heckman and Nesheim (2004) derive more general necessary conditions for identification.
6.3. Empirical Evidence

• In the labour market theory of equalizing differences, a labour market transaction is viewed as a tied sale, where the worker simultaneously sells the services of his labour and buys the attributes of his job.

• The positive price the worker pays for preferred job activities is subtracted from the wage payment.

• Measurable job attributes used in the literature include:
  i) onerous risk conditions, such as risk to life and health, exposure to pollution,
  ii) intercity or interregional wage differences associated with differences in climate, crime, pollution and crowding
  iii) special work-time scheduling and related requirements, including shift work, inflexible work schedules, and possible risks of layoff and subsequent unemployment.
  iv) the composition of pay packages, including vacations, pensions, and other fringe benefits as substitutes for direct cost payments.

• The use of that the compensating differential framework has been extensively used for the “valuation of life” issues which often arises in litigation
o mining accident
o exposure to carcinogenic products.

- Most researchers estimate the wage-risk relationship in labor markets by specifying a wage equation along the lines of the following:

\[ w_i = \alpha + H_i \beta_1 + X_i \beta_2 + \gamma_1 p_i + \gamma_2 q_i + \gamma_3 WC_i + p_i H_i \beta_3 + \varepsilon_i \]

where \( w_i \) is the worker \( i \)'s wage rate, \( \alpha \) is a constant term, \( H \) is a vector of personal characteristic variables, \( X \) is a vector of job characteristic variables, \( p_i \) is the fatality risk associated with worker \( i \)'s job, \( q_i \) is the nonfatal injury risk, \( WC_i \) is the workers' compensation benefits payable for a job injury suffered by worker \( i \).

- Viscusi and Aldy (2003) perform a meta-analysis of the estimates and find half of the studies of the U.S. labor market reveal a value of a statistical life (VSL) range from $5 million to $12 million, with a median value of $7 million.
  - They also find that union members in U.S. labor markets appear to enjoy greater risk premiums than non-members, but not in other developed countries.
• The empirical analysis of **less onerous** job characteristics than risk of injury or death has been **less successful**.

• The theory of equalizing differences asserts that workers should receive compensating wage premiums when they accept jobs with undesirable nonwage characteristics.

• Much of the empirical support however provides **inconsistent support** for the theory, with **wrong-signed** or insignificant estimates of the wage premiums fairly common.

• Hamermesh (1999) finds support for the argument that **income effects** lead to difficulties in measuring the price of a disamenity.

• The disamenity being an inferior good, a higher skilled worker’s higher full earnings lead him to buy less of the disamenity. There is a negative correlation between full earnings, the combination of the wage and the disamenity, and the disamenity itself.

• In other words, the error term in the wage equation ($\varepsilon_i$) likely reflect unobserved characteristics correlated with work conditions $WC_i$. OLS estimates are inconsistent.
Getting at causal effects

- An early attempt at going beyond OLS to estimate the causal effect of work conditions on wages is Brown (1980). He uses data from the National Longitudinal Survey of Young Men (age 14-24 in 1966…) to estimate fixed effect models that control for the time-invariant component of the error term \( \varepsilon_{it} = \theta_i \)

\[
\begin{align*}
\text{\( w_{it} = \alpha_t + H_{it} \beta_1 + X_{it} \beta_2 + \gamma_1 p_{it} + \gamma_2 q_{it} + \gamma_3 W_{it} + p_{it} H_{it} \beta_3 + \theta_i + \nu_{it} \)}
\end{align*}
\]

- 470 individuals in the NLS, and Brown estimates the model using the fixed effect method (difference from means)

- Note this is a computational trick that makes it easier to estimate the model than putting dummies for each individuals. Irrelevant these days but Brown mentions that

> Including several hundred individual-specific intercepts in the X-matrix would exceed the capacity of almost any computer program that calculates regressions. Fortunately, there is a computationally feasible alternative.
• Results are mixed. Likely problem is that work characteristics are based on occupations, and occupation choice (or changes) are likely endogenous even after taking account of fixed effects
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<th>0.091</th>
<th>-0.374*</th>
<th>-0.091'</th>
<th>-0.060*</th>
<th>-0.071*</th>
<th>-0.076*</th>
<th>-0.080*</th>
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<td>Time now in part-time sch</td>
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<td>-0.361*</td>
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<td>(0.071)</td>
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<td>Ln (usual hours)</td>
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<td>-0.369*</td>
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<td>Low GED requirement</td>
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<td>Low SVP requirement</td>
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<td>Standard error of estimate</td>
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* = Statistically significant at the 0.05 level.
• Running an experiment would be an ideal way of measuring the importance of compensating differentials, but far from clear how one could do this

• Randomly assign workers to jobs with good and bad work conditions does not work as there can be other confounding factor (job characteristics).

• Manipulating the characteristics of jobs in different plants sounds problematic too (e.g. given for free some equipment to improve work quality). Wage adjustments would likely happen slowly as the results of bargaining, mobility, etc. making it hard to detect in the data

• Ashenfelter and Greenstone (2004) address this problem by looking at the willingness to pay for safety (lower death probability) in a context other than the labour market.

• They use as a natural experiment the abolition of the federal 55mph speed limit on US rural highways in 1987. States that decided to keep the 55mph speed limit are used as controls.
• The idea is to look at the tradeoff between the value of time saved by driving faster (multiply time saving by the opportunity cost of time, i.e. the wage) and the higher probability of death.

• They find that 125,000 hours were saved per additional fatality, resulting in a value of statistical life of $1.54M (using average wages)
Fig. 3.—Trends in fatality rates on rural interstate roads, by adoption of 65-mph speed limit, 1982–95. The fatality rate is calculated as the weighted mean of the number of fatalities per 100 million VMT, where the weight is VMT.
In 1987 States were Allowed to Adopt the 65 Mph Speed Limit on Rural Interstates

Fig. 4.—Trends in mean speeds on rural interstate roads, by adoption of 65-mph speed limit, 1982-93. Mean speed is calculated as the weighted mean, where the weight is VMT.
### TABLE 2

**DIFFERENCE IN DIFFERENCES (DD) ESTIMATES OF 65-MPH SPEED LIMIT ON FATALITY RATES AND SPEEDS**

<table>
<thead>
<tr>
<th></th>
<th>DD of Levels Normalized by Preperiod Level in Adopting States (%)</th>
<th>DD of Natural Logarithms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Fatality rate</td>
<td>.185</td>
<td>.13</td>
</tr>
<tr>
<td>Speed</td>
<td>2.8</td>
<td>.047</td>
</tr>
</tbody>
</table>

**A. Rural Interstates (Affected Road Type)**

<table>
<thead>
<tr>
<th></th>
<th>DD of Levels Normalized by Preperiod Level in Adopting States (%)</th>
<th>DD of Natural Logarithms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality rate</td>
<td>-.052</td>
<td>-.05</td>
</tr>
<tr>
<td>Speed</td>
<td>-.5</td>
<td>-.000</td>
</tr>
</tbody>
</table>

**B. Urban Interstates (Unaffected Road Type)**

<table>
<thead>
<tr>
<th></th>
<th>DD of Levels Normalized by Preperiod Level in Adopting States (%)</th>
<th>DD of Natural Logarithms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality rate</td>
<td>-.123</td>
<td>-.032</td>
</tr>
<tr>
<td>Speed</td>
<td>.5</td>
<td>.001</td>
</tr>
</tbody>
</table>

**C. Rural Arterials (Unaffected Road Type)**

*NOTE.—See the note to table 1. The entries represent three difference in differences estimates of the effects of the 65-mph speed limit on fatality rates and speeds. The col. 1 entries are the raw difference in differences estimates. In col. 2, the col. 1 entries are normalized by the preperiod level in adopting states. The col. 3 entries are calculated with the mean of ln(fatality rate) and ln(speed) for adopters and nonadopters in the pre- and postperiods. The entries are equal to the post–pre difference of weighted means among adopters minus the post–pre difference of weighted means among nonadopters, where the weight is VMT. The preperiod is defined as 1982–86 and the postperiod as 1988–93.*