ESSAYS ON WAGES AND EARNINGS

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ABSTRACT OF THE DISSERTATION

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In this dissertation I first try to explain how the wage is determined from a theoretical perspective. Then I provide a test regarding a phenomenon which has not been well explained so far. Finally I turn to an important issue in studies on taxation.

In the first chapter I provide models considering when firm sets wage *either* above *or* below the market clearing wage although previous models take as granted that the efficiency wage is *above* the market clearing wage. A simple model, the "selection model", is different from previous models in that the firm considers workers' choices on labor supply as an important factor when it makes decisions on wages and employment. I then set up the "effort model", in which the effort function is determined by the worker while the ability function is exogenously given the selection model. As a result, the models produce set of possible choices which resembles backward-bending labor supply curve. The shape helps explain the minimum wage paradox.

In the second chapter I test whether efficiency wage models contribute to explaining interindustry wage differentials. First, I find two variables which could cause firms to pay different wages to seemingly identical workers: the internal and external reference wages. Then, I estimate wage equations with and without those variables, and find that those variables help explain interindustry wage differentials by reducing the standard deviation of wage differentials.

In the final chapter I address a problem that study of the behavioral response to the changes in the individual tax rate always encounters: endogeneity. I first develop novel instruments for the marginal tax rate and net-of-tax rate (1 marginal tax rate). Then, I run regression using the new instruments for the net-of-tax rate and also using either no instrument or an improper instrument. Regressions suggest that the tax rates are endogenous to income and replacing the tax rates with the counterfactual tax rates solves the endogeneity problem. They also imply that the tax rate changes have no significant effect on medium-income earners in the short run.

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Dedication

I would like to dedicate this Doctoral dissertation to my wife, Hyunkyung. There is no doubt in my mind that without her continued support and tolerance I could not have completed this process.

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Chapter 1

Efficiency Wages and Labor Supply: A Synthesis

1.1 Introduction

Efficiency wage models argue that the profit-maximizing firm does not lower its wage when there is an excess supply of workers and so involuntary unemployment may exist, contrary to the conventional competitive economic theories, which assume market clearing wages. Although different efficiency wage models have different reasons for non-market-clearing wages and involuntary unemployment, they share common features: they stress wages above the conventional equilibrium wage to explain the involuntary unemployment; and they ignore the role of labor supply.

In this paper, I develop models with a unified setup that includes labor supply. Although previous models only discuss situations in which the efficiency wage is *above* the market clearing wage, the models in this paper consider outcomes when firm sets wage *either* above *or* below the market clearing wage.[1]

I begin with a simple model, the "selection model". This model has the same features as previous efficiency wage models in that the firm determines both the wage and the employment unilaterally. But the model presented in this chapter is different from these earlier models in that the firm considers workers' choices on labor supply as an important factor when it makes decisions on wages and employment. If labor supply is greater than or equal to the firm's labor demand at its desired (efficiency) wage, the firm does not need to move from its desired wage-employment combination. Otherwise, the firm must move from the optimal point, since its optimal wage-employment combination is not available. In this case, the labor supply schedule plays a role as a constraint on

[1] If a firm does not face a perfectly elastic labor supply curve, it can hire some workers at a wage below the market clearing wage, although the resulting supply will be short of its needs.

the firm's decision.

I then set up a more complex model, the "effort model". In this model, the effort function is determined by the worker while the ability function is exogenously given in the selection model.[2] But, since the effort function is still given exogenously from the perspective of the firm in the effort model, the firm faces the same problem as in the selection model. Therefore, the firm does not change its optimal choice of wage whenever labor supply is equals or exceeds the firm's optimal demand. When the labor supply falls short, the firm's choice is constrained by the labor supply schedule.

The models here produce two interesting implications. One is that the graph of the set of possible outcomes resembles the backward-bending labor supply curve: The reason for the backward-bending shape is that employment and wages are negatively related when the wage is high (relative wage to the conventional market-clearing wage) but they are positively related when the labor is low. The second is that the backward-bending shape can help account for the minimum-wage paradox. If the minimum wage lies on the positive-sloped part of the backward bending graph, an increase in the minimum wage forces the firms to increase employment.

In the next section, I review previous efficiency wage models. Then, I develop the selection model and the effort model, and discuss their implications. In the final section, I summarize.

1.2 Literature Review

The wage at which the cost per effective unit of labor service is minimized is called the efficiency wage. Contrary to conventional competitive economic theory, efficiency wage theory says that, when there is an excess supply of workers at the efficiency wage, the firm has no incentive to lower its wage or to hire a worker who offers his services at a lower wage, since doing so simply increases labor costs. It is well illustrated in figures 1 and 2 of Stiglitz (1987) and in a simple model of Katz (1986). Katz (1986) considers an economy with identical, perfectly competitive firms, each possessing a short-run

[2] The ability function and the effort function enter into the production function as efficiency terms.

production function of the form $Q = aF(e(w)N)$ where e is the effort level of a worker. A profit-maximizing firm solves the following problem

$$\max_{w,N} aF(e(w)N) - wN.$$

The firm sets the wage, w^*, at which the elasticity of effort with respect to the wage is unity and the firm hires workers until its marginal product equals w^*. If the aggregate labor demand falls short of the aggregate labor supply at w^*, equilibrium will entail involuntary unemployment.

Several different models have been developed with different reasons for the existence of efficiency wages. In this section I review some of these models, focusing on the underlying reasons.

Weiss (1980) argues that, under assumptions of a uniform wage within a job classification and positive correlation between acceptance wages and productivity, all workers whose reservation wage w is less than or equal to w^* apply for a job with wage w^*. Then, the expected labor endowment (or productivity) of the applicants (or workers to be hired) is

$$\bar{q}(w*) = \frac{\int_0^{w*} q(w)dF(w)}{\int_0^{w*} F(w)}$$

where $q(w)$ is the labor endowment (or productivity) of a worker whose acceptance (or reservation) wage is w and $F(w)$ is the density function of the population.[3] Note that labor demand cannot be greater than labor supply since there is no equilibrium wage in that situation. If $w/\bar{q}(w)$ has a unique global minimum, the wage at that point, say $\bar{w}$, is the optimal choice. And, when there is excess labor supply, no unemployed worker can be hired by offering a lower wage since a lower wage does not make the firm better off. In this model, a firm decides to pay a high wage to attract more high-quality workers.

Shapiro and Stiglitz (1984) address workers' incentive to shirk. Since effort entails disutility but lowers the possibility of being fired, workers need to find the optimal

[3] One additional crucial assumption is that information is imperfect: the firm cannot screen applicants either before or after applying.

level of effort (or shirking). A high wage increases the worker's cost of separation (lowering the incentive to shirk) although the effect of a high wage could be reduced by better expected outside compensation. Therefore, a profit-maximizing firm chooses a high wage which discourages shirking, which implies the existence of involuntary unemployment.

Salop (1979) sets up a model which entails a trade-off between the wage and turnover cost. The profit maximizing firm chooses a combination of wage and turnover rate which minimizes the cost of labor plus turnover.

Akerlof (1982) proposes a model in which a worker who believes he is treated fairly may not only get more satisfaction from his job, but also may work harder for his employer as a reciprocal gift for the gift given by the firm. So, a worker's effort level depends both on his wage and on the expected wages of his reference group. The profit-maximizing firm sets a high wage expecting a high reciprocal gift.

1.3 A Simple Model: Selection Model

In this section (and also section 4), I set up the efficiency wage models in a unified framework. One feature of these models is that the firm sets both the wage and the level of employment, *considering workers' response*. Thus, workers play an important role relative to previous models.

We begin with a simple model, the "selection model".[4] In this model, (1) the employer chooses the wage, (2) workers are heterogeneous in terms of ability, and (3) employers are heterogeneous in terms of their technology for screening workers.

1.3.1 A Model

We consider an employer j. She maximizes her profit by choosing the optimal wage as well as labor demand. Note that the wage is determined by the employer. There are $\bar{N}$ densely populated and observationally indistinguishable workers who are considering working for the employer j. They maximize their utility by determining consumption

[4] This model is named the selection model because it shares many features with Weiss (1980).

and labor supply at the given wage. Note that labor supply is a function of the wage. As long as the labor supply is sufficient for the employer's demand, she will not change her choice. But, if the labor supply falls short, the labor supply function becomes a restriction on the employer's choice.

A worker faces the usual constrained utility maximization problem as in the conventional competitive theory:

$$\begin{aligned} &\max_{L,C} u(L, C) \\ &\text{s.t. } pC \leq v + w[1 - L] \end{aligned} \tag{1.1}$$

where $L \in \{0, 1\}$ is leisure, $C \in \mathbb{R}^+$ is consumption, p is price, w is wage, and v is wealth. I assume that the worker's only choice on leisure is to set $L = 0$ (work) or $L = 1$ (not work). The utility function is assumed to be increasing and concave in C, with $u(1, C) \geq u(0, C)$ for any C. Workers are assumed to be heterogeneous in terms of wealth (v) or utility function parameters.[5] The resulting optimal choice of leisure is a function of the wage, which is given by the employer.

Rewriting problem (1.1), we have

$$\max_{L} u\left(L, \frac{v}{p} + \frac{w}{p}[1 - L]\right). \tag{1.2}$$

When the worker works, his utility is $u(0, \frac{v}{p} + \frac{w}{p})$. Otherwise, it is $u(1, \frac{v}{p})$. Then, if

$$u\left(0, \frac{v}{p} + \frac{w}{p}\right) \geq u\left(1, \frac{v}{p}\right),$$

the worker is willing to work. So, the worker is more likely to work as the wage increases. Therefore, the labor supply is an increasing function of the wage (say $n^S(w)$). I assume that the workers' distribution and utility function allow the labor supply function $n^S(w)$ to be differentiable.

Unlike competitive theory, in the efficiency wage model the employer has discretion

[5]If workers are homogeneous, they have the same reservation wage and the labor supply curve will be vertical.

in setting the wage as well as in hiring workers. Therefore, the firm faces the following maximization problem:

$$\begin{aligned} &\max_{N,w} pf\left(\phi\left(\frac{w}{w_0}\right)N\right) - wN \\ &\text{s.t. } N \leq n^S(w) \end{aligned} \tag{1.3}$$

where w is the wage, and w_0 is the "reference wage" which is affected by market conditions.[6] I refer to w/w_0 as the "relative wage". $f(\cdot)$ is the production function and $\phi(\cdot)$[7] is the ability function which varies across firms (because of differences in screening technology) and is increasing in the relative wage because a higher relative wage attracts better workers on average.[8]. f and ϕ are assumed to guarantee concavity of (1.3).[9] All functions in this chapter are implicitly assumed to be differentiable up to the appropriate degree.

Workers choose whether or not to work at any given wage and the employer chooses the wage as well as employment. Since the wage is determined not by the market but by the employer, there is no guarantee that labor demand will equal labor supply, which means that either excess supply or excess demand for labor is possible.

1.3.2 Excess Supply

When labor supply is sufficient for labor demand, the constraint in (1.3) is not binding. Therefore, firm faces the following simple problem:

$$\max_{N,w} pf\left(\phi\left(\frac{w}{w_0}\right)N\right) - wN \tag{1.4}$$

---

[6]The market conditions could include labor supply and demand, unemployment rate, and unemployment compensation.

[7]In general, the ability function would be $\phi(w; w_0, v, p)$, but in this paper we assume a specific form and suppress arguments v and p. Summers (1988) assumes $[w - w_0]^\alpha$.

[8]This is the same assumption of Weiss (1980).

[9]The condition for the concavity is

$$pf''\phi^2 pf'^2 \frac{\phi''}{w_0}N - [2pf''\frac{\phi'}{w_0}\phi N + [pf'\frac{\phi'}{w_0} - 1]][pf'\frac{\phi'}{w_0} - 1] > 0.$$

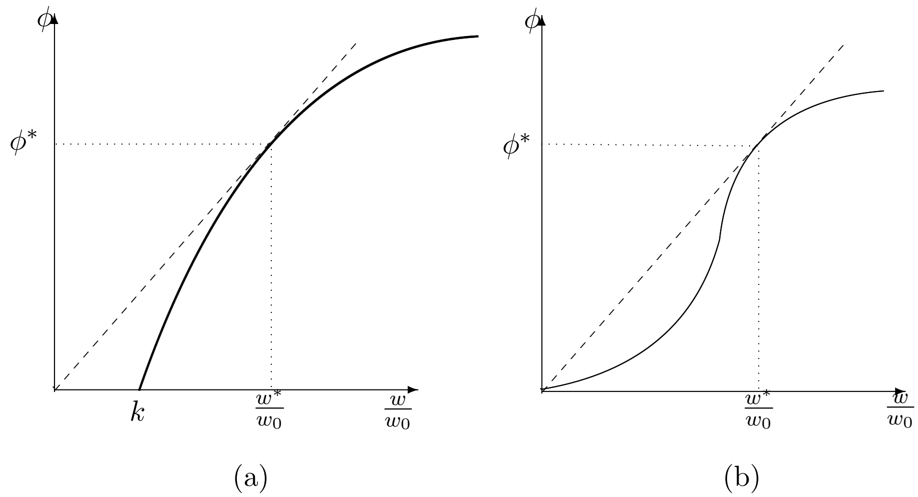


Figure 1.1: Shapes of Ability Function

The first order conditions are

$$pf'\phi - w = 0 \tag{1.5a}$$

$$pf'\frac{\phi'}{w_0}N - N = 0. \tag{1.5b}$$

These conditions imply that the existence of an optimal wage is not guaranteed unless ϕ has a point satisfying following condition:

$$\phi'\left(\frac{w}{w_0}\right) = \frac{\phi\left(\frac{w}{w_0}\right)}{w/w_0}. \tag{1.6}$$

This implies that the optimal wage is not affected by the form of the production function.

Possible shapes of the ability function are illustrated in figure 1.1.[10] In figure 1.1(a), workers do not want to work or are not productive until the relative wage arrives at some level k. Once workers begin to work, their average ability is a concave function

[10]Note that ϕ would also be linear in w/w_0.

of the relative wage. Examples of this type of function are

$$\phi(x) = \begin{cases} 0 & \text{if } x < k \\ \sqrt{x-k} & \text{if } x \geq k \end{cases} \quad \text{and}$$

$$\phi(x) = \begin{cases} 0 & \text{if } x < k \\ \frac{-k}{x} + 1 & \text{if } x \geq k \end{cases}$$

In figure 1.1(b) the expected ability of workers increases with a convex curve in the lower relative wage range but with a concave curve in the higher range. Some examples of figure 1.1(b) are

$$\phi\left(x\right) = \sqrt[3]{x-1} + 1 \text{ and}$$

$$\phi\left(x\right) = \begin{cases} \sin\left(\frac{\pi}{3\sqrt{3}}x\right), & x < 2 \\ \cos\left(\frac{2\pi}{3\sqrt{3}}\right)x, & x \geq 2 \end{cases}.$$

Comparative Statics

How does the optimal choice changes in response to outside shocks such as a change in the reference wage or in product price? In general, an increase in product price is expected to raise both the wage and labor demand. A rise in the reference wage w_0 is expected to increase the optimal wage w^*.

Total differentiation of the first order conditions, (1.5a) and (1.5b) yields

$$\begin{pmatrix} pf''\phi^2 & pf''\frac{\phi'}{w_0}\phi N \\ pf''\frac{\phi'}{w_0}\phi N & pf''\frac{\phi'}{w_0}N^2\frac{\phi'}{w_0} + pf'\frac{2\phi''}{w_0^2}N \end{pmatrix} \begin{pmatrix} dN \\ dw \end{pmatrix}$$
$$= \begin{pmatrix} \frac{w}{w_0}a_{12} + pf'\frac{\phi'}{w_0^2}w & -f'\phi \\ \frac{w}{w_0}a_{22} + pf'\frac{\phi'}{w_0^2}N & -f'\frac{\phi'}{w_0}N \end{pmatrix} \begin{pmatrix} dw_0 \\ dp \end{pmatrix} \qquad (1.7)$$

where a_{ij} is the ith row and jth column element of A when the above equation is expressed as $Ax = Bc$. The first order condition with respect to w, $pf'\frac{\phi'}{w_0} - 1 = 0$, is used to simplify a_{12} and a_{21} of A. We assume that both f and ϕ are concave around the optimal point, which guarantees that (w^*, N^*) is a local optimum.[11]

The effect of w_0 on the optimal wage is

$$\frac{\partial w}{\partial w_0} = \frac{1}{|A|}\left[\frac{w}{w_0}|A| + pf''\phi^2 pf'\frac{\phi'}{w_0^2}\phi N[\phi - \frac{w}{w_0}\phi']\right] = \frac{w}{w_0}. \tag{1.8}$$

where (1.8) simplifies thanks to the first order condition, $\phi - \frac{w}{w_0}\phi' = 0$. The effect of a higher reference wage w_0 on the optimal wage w^* is positive with an elasticity equal to one.

The effect of w_0 on labor demand N is

$$\frac{\partial N}{\partial w_0} = \frac{1}{|A|}\left[\frac{w}{w_0}p\frac{\phi'}{w_0}[f' - f''\phi N]a_{22}\right] < 0. \tag{1.9}$$

since $[f' - f''\phi N] > 0$ and $a_{22} < 0$. Hence, an increase in the reference wage reduces labor demand.

The effect of p on the optimal wage w^* is zero. This follows immediately from the first order condition, in particular equation (1.6): p does not appear. It is also easily verified using equation (1.7). This result means that a shock in the product market has no effect on the optimal wage. But this result holds only if other variables (including w_0, etc.) are constant. If price has a positive effect on labor demand, then price affects the reference wage positively as well. If the reference wage is positively related to the optimal wage, then p will have a positive effect on the optimal wage as a result. That is, although p does not directly affect w^*, it will be positively related to the optimal wage indirectly, through the reference wage.

Moreover, p has a positive effect on labor demand N. By (1.5a), $pf'(\phi N) = \frac{w}{\phi}$. The right-hand side is constant for any change in p. So, $pf'(\phi N)$ should be constant for any change in p as well. Hence, p and $f'(\cdot)$ are inversely related. Then, since $\phi(w/w_0)$ is

[11] The choice of w and N are guaranteed to be a local optimum since

$$pf''\phi^2 < 0$$

and

$$|A| = pf''\phi^2 pf'^2\frac{\phi''}{w_0^2}N > 0.$$

constant and $f''(\cdot) < 0$, f' is decreasing in N. Hence, p and N are positively related. Alternatively, using (1.7),

$$\frac{\partial N}{\partial p} = \frac{1}{|A|}\left[-p[f']^2 \frac{\phi''}{w_0^2}\phi N\right] > 0 \tag{1.10}$$

1.3.3 Excess Demand

When optimal labor demand exceeds the available supply, the employer's choice is limited by the labor supply schedule.

The inequality restriction in equation (1.3) could be replaced with an equality restriction because $N = n^S(w; p, v)$ dominates $N < n^S(w; p, v)$. A smaller shortage of employment is better than a larger shortage of employment for given w since the profit function is concave in N. Rewriting equation (1.3), we have

$$\max_{w}\; pf\left(\phi\left(\frac{w}{w_0}\right) n^S(w; p, v)\right) - wn^S(w; p, v) \tag{1.11}$$

The first order condition is

$$\left[pf' \frac{\phi'}{w_0} n^S - n^S\right] + [pf'\phi n^{S'} - wn^{S'}] = 0. \tag{1.12}$$

If (N^*, w^*) which satisfies (1.5a) and (1.5b) is available, the equality in (1.12) holds with (N^*, w^*). But, since (N^*, w^*) is not available ($n^S(w^*) < N^*$ at w^*), the firm needs to consider other values of w.

Comparative Statics

Taking total differentiation with an assumption of $p = 1$, we have

$$Adw - \frac{w}{w_0} Bdw_0 = 0 \tag{1.13}$$

where

$$
\begin{aligned}
A = & f'' \left[\left[\frac{\phi'}{w_0} n \right]^2 + \frac{\phi'}{w_0} n \phi n' \right] + f' \left[\frac{\phi''}{w_0^2} n + \frac{phi'}{w_0} n' \right] - n' \\
& + f'' \left[\phi n' \frac{\phi'}{w_0} n + [\phi n']^2 \right] + f' \left[\frac{\phi'}{w_0} n' + \phi n'' \right] - n' - w n'' \\
& = f'' \left[\frac{\phi'}{w_0} n \phi n' \right]^2 + f' \left[\frac{\phi''}{w_0^2} n + 2 \frac{\phi'}{w_0} n' + \phi n'' \right] - 2n' - w n''
\end{aligned}
$$

and

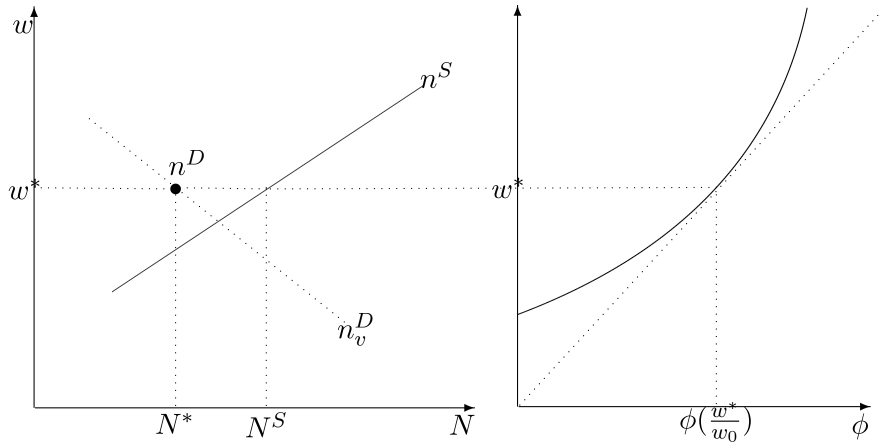
$$
\begin{aligned}
B = & f'' \left[\frac{\phi'}{w_0} n \right]^2 + f' \left[\frac{\phi''}{w_0^2} n + \frac{\phi'}{w w_0} n \right] + f'' \left[\frac{\phi'}{w_0} n \phi n' \right] + f' \frac{\phi'}{w_0} n' \\
& = f'' \left[\left[\frac{\phi'}{w_0} n \right]^2 + \frac{\phi \phi'}{w} n n' \right] + f' \left[\frac{\phi''}{w_0^2} n + \frac{\phi'}{w w_0} +' \frac{\phi'}{w_0} n' \right]
\end{aligned}
$$

If both A and B are negative, more strictly if $\frac{\phi''}{w_0^2} n + 2 \frac{\phi'}{w_0} n' + \phi n'' < 0$ and $\frac{\phi''}{w_0^2} n + \frac{\phi'}{w w_0} +' \frac{\phi'}{w_0} n' < 0$, then the effect of the reference wage w_0 on the optimal wage w^* is positive. However, the signs are not determined unless specific functional forms of ϕ and n assumed.

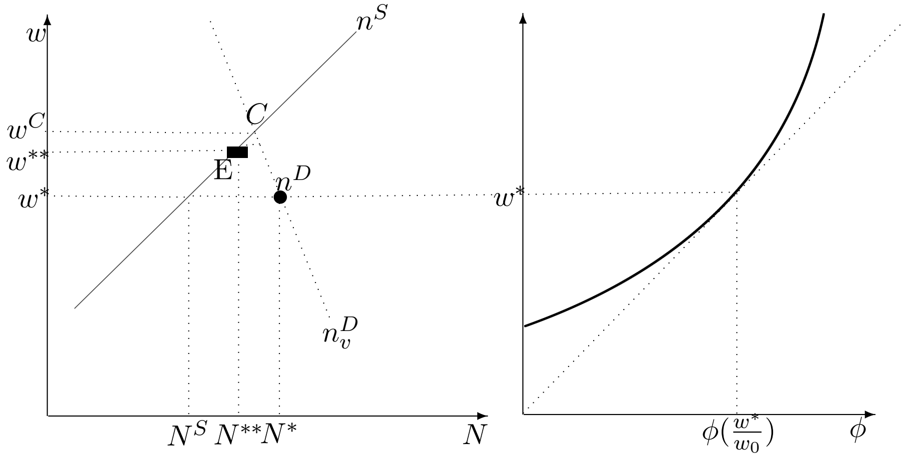
1.3.4 Graphical Illustration

Previous studies paid attention only to the excess labor supply case, and did not analyze the case in which labor supply was less than labor demand. Their major interest was to explain a specific phenomenon, involuntary unemployment. In contrast, this paper considers excess demand as well as excess supply.

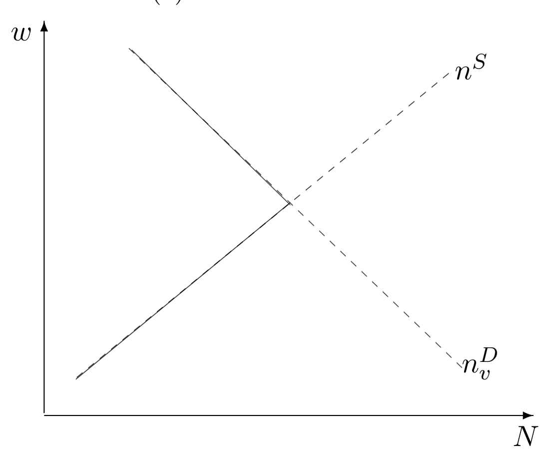
Figure 1.2(a) shows the case of excess supply. The employer does not have an incentive to change her optimal choice because the optimal choice is available and any change is not profitable. As shown in the right panel of figure 1.2(a), we have $\phi'/\phi = w_0/w$ at $w = w^*$, which determines the employer's optimal wage. n^S is the labor supply curve, which shows the number of workers willing to work at each wage w. n_v^D is the virtual labor demand curve which the employer would choose if w were given. The real labor demand at w^* is a point on the virtual labor demand curve, for example n^D, since the employer chooses both the wage and employment. If labor supply is more



(a) Excess Supply



(b) Excess Demand



(c) Set of Possible Outcomes

Figure 1.2: Equilibrium of Selection Model

than labor demand at the employer's optimal point, for example (N^*, w^*), the employer has no incentive to change her decision since (N^*, w^*) is available and most profitable. The difference between n^S and N^* is involuntary unemployment.

Figure 1.2(b) illustrates the case in which labor supply is short of labor demand. The employer has to change her optimal choice because the optimal choice is not available any more. Then, for the employer, the labor supply at any given wage is a restriction. The new idea here is that when supply is less than demand *the employer must locate on the labor supply curve*, as shown in figure 1.2(b). n^S, n_v^D, and n^D are the same as above.[12] The difference is that n^D is not available any more since labor supply n^S is short of labor demand N^*. Since the level of employment is restricted to lie on the labor supply curve, employer should choose a point on n^S, for example E.

Then, where E is located? The first order condition of problem (**??**) is

$$[pf'\phi'/w_0 - 1]n + [pf'\phi - w]n' = 0,$$

or

$$\frac{n'}{n} = -\frac{pf'\phi'/w_0 - 1}{pf'\phi - w}, \tag{1.14}$$

if $pf'\phi - w \neq 0$.[13] n is used instead of n^S for simplicity.

If $n' = 0$ (inelastic labor supply), then $pf'\phi'/w_0 - 1 = 0$. Therefore, the new choice or the second best, w^{**}, will be the same as w^*. Now, consider $n' > 0$ (elastic labor supply). $pf'\phi - w = 0$ at $N = n^D$. Then, at $w = w^*$, $pf'\phi - w > 0$ when $N < n^D$ since the profit function is concave in N. So, $pf'\phi'/w_0 - 1 < 0$. Since $pf'\phi'/w_0 - 1 = 0$ at $w = w^*$ and the profit function is concave in w, w^{**} is greater than w^*. Therefore, if $n' \geq 0$ then $w^* \leq w^{**} \leq w^C$. Note that w^{**} cannot be greater than w^C.[14]

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[12] The reason for the upper limit of wage will be given below.

[13] If $pf'\phi - w = 0$ then $pf'\phi/w = 1$ with $n > 0$. This produces the same output as excess supply. It is contradiction.

[14] Here is a note on the upper limit. Any wage on n_v^D above w^C cannot be chosen as a second best. First, since the profit function is concave, a point on n_v^D produces less profit as it is away from n^D. Second, the point C is available. So, any point on n_v^D above w is worse than C. Third, since each point on n_v^D is the best choice for given wage, the point on n_v^D is better than n^S for given w. Hence, any point on n^S above C is worse than C.

By considering both excess and short supply, we get the set of possible choices shown in figure 1.2(c): employment is positively related to the wage in the low wage region; in the high wage region, employment is negatively related to the wage.

1.3.5 Another Specification

Previous specifications of effective labor – as the number of workers times average ability – may be too simple to reflect reality: In some production processes, even thousands of workers are not able to replace a few high-quality workers. In this case, ability in the production function should be regarded as a different factor from the number of workers. Hence, more generally, we express the firm's problem as:

$$\max_{N,w} \; pf\left(N, \phi\left(\frac{w}{w_0}\right)\right) - wN \tag{1.15}$$

Note that the previous model is an example of this problem. The first order conditions are

$$pf_1 - w = 0 \tag{1.16a}$$

$$pf_2\frac{\phi'}{w_0} - N = 0 \tag{1.16b}$$

The equilibrium is obtained in the same way as previous one. If $N^* \leq n^S$, then the optimal employment and wage are chosen by the employer. Otherwise, since the optimal employment level is not available, the employer must choose a point on the labor supply curve.

1.4 A Complex Model: The Effort Model

According to reciprocity theory, workers choose their effort level to reciprocate for the firm's gift (the wage), and the firm sets the wage considering the worker's response. If the wage is high, effort is less painful and so the worker exerts more effort. Otherwise, the worker feels more pain for any given effort level and so exerts less effort. If workers have different expectations about wages across firms, then workers may exert different effort across firms for any given wage.

From the perspective of shirking models, a firm with a better detection technology can readily recognize workers' shirking, or workers' exerting effort at less than the desired level. That is, workers are more likely to be fired when exerting low effort if their employer has a better detection technology. Then, workers' expected reward increases more as their effort level is raised if technology of their employer gets better.

I consider morale and shirking by introducing effort and the relative wage into both the worker's utility function and the firm's reward function. Effort is not only painful, but also beneficial because it provides a greater reward to the worker. Firm will therefore consider the worker's effort response when setting the wage. High wages are a cost to the firm, but they generate more effort and higher profit. In this section, I put effort only into the utility and reward functions. (For discussion on how to introduce the relative wage into the utility and effort function, see the appendix)

1.4.1 A Model

The worker's problem here is different from that in the selection model. First, effort now appears in the utility function. More effort produces more disutility. Therefore, the utility function is

$$u\left(L, M-e, C\right),$$

where L is leisure, which can be 0 or 1, C is consumption, and e is effort. M is the maximum possible level of effort; e is actual effort. We assume that $u_i > 0$, $u_{ii} < 0$ for i= 2, or 3, and $u_{ij} > 0$ if $i \neq j$ for i, j= 2, or 3. For the same worker, $u(\cdot)$ differs across firms.

The budget constraint here is also different from the one in the selection model. The earning function is not simply $w[1-L]$, but $wh(1-L, e)$. Here, the function $h(\cdot)$ is concave and increasing in the first argument $1-L$ and the second argument e. Therefore, earnings depend on effort as well as participation in labor market. So, the budget constraint is

$$pC \leq v + wh([1-L], e).$$

Table 1.1: Worker's choice in the effort model

		e	
		$e = 0$	$e > 0$
L	$L = 1$	$(L = 1, e = 0)$	$(L = 1, e > 0)$
	$L = 0$	$(L = 0, e = 0)$	$(L = 0, e > 0)$

To simplify I assume that the function $h(\cdot)$ is exogenously given.[15] Other assumptions on h are $h(0, \cdot) = h(\cdot, 0) = 0$: without work or effort, earnings are zero.

The worker's problem is

$$\max_{L,e,C} u\left(L, [M - e], C\right) \\ \text{s.t. } pC \leq v + wh([1 - L], e), \tag{1.17}$$

or

$$\max_{L,e} \ u\left(L, [M - e], \frac{v}{p} + \frac{w}{p}h(1 - L, e)\right).$$

There are four possible choices of leisure and the effort level as shown in table 1.1. If $L = 1$ then $e = 0$ since $(L = 1, e = 0)$ dominates $(L = 1, e > 0)$ as $u(1, M, \frac{v}{p}) > u(1, [M - e], \frac{v}{p})$ for any $e > 0$. If $L = 0$ then $e > 0$ since $(L = 0, e = 0)$ is definitely dominated by $(L = 1, e - 0)$ as $u(0, M, \frac{v}{p}) < u(1, M, \frac{v}{p})$. If there is an $e > 0$ such that utility from $(L = 0, e > 0)$ is greater than or equal to utility from $(L = 1, e = 0)$, the worker participates in the labor market. The labor supply, $n^S(w)$, derived from the above maximization problem is assumed to be differentiable in wage and effort.

On the other hand, the firm faces the following profit maximization problem:

$$\max_{N,w,e} pf(eN) - wh(1, e)N \\ \text{s.t. } e = \phi\left(\frac{w}{w_0}\right) \\ N \leq n^S \tag{1.18}$$

[15]In reality, it could be determined by the employer unilaterally or by negotiation between the employer and workers. Without this assumption, we need to solve for a function of a set of functions. Furthermore, this assumption is not unrealistic in a short period since the function is fixed at least for a short time.

where e is effort. Effort is determined by the worker and is assumed to be a function of the relative wage, w/w_0. f and e are assumed to be functions which guarantee the concavity of (1.18).

1.4.2 Excess Supply

The first order conditions are

$$pf'\phi - wh = 0 \tag{1.19a}$$

$$pf'\frac{\phi'}{w_0}N - wh_e\frac{\phi'}{w_0}N - hN = 0. \tag{1.19b}$$

In contrast with the selection model, here the first order conditions are[16]

$$\frac{\phi'}{\phi/\frac{w}{w_0}} = \frac{1}{\left[1 - \frac{h_e}{h/\phi}\right]} > 1. \tag{1.20}$$

This condition is a kind of correction of endogenous labor supply. If $h_e = 0$ then it is the same as the first order condition of the selection model. And, this model shares one property with the selection model: the optimal wage does not depend on the functional form of the production technology; it depends only on the effort function and the reward function.

Comparative Statics

The comparative statics are similar to those of the selection model. Taking total

[16]From the first order conditions

$$\begin{aligned}\frac{\phi'}{\phi/\frac{w}{w_0}} &= \frac{wh_e\frac{\phi'}{w_0} + h}{h} \\ &= \phi'\frac{w}{w_0}\frac{h_e}{h} + 1 \\ &= \frac{\phi'}{\phi/\frac{w}{w_0}}\frac{h_e}{h/\phi} + 1.\end{aligned}$$

It is

$$\left[1 - \frac{h_e}{h/\phi}\right]\left[\frac{\phi'}{\phi/\frac{w}{w_0}}\right] = 1.$$

differentiation of the first order conditions, we have

$$\begin{pmatrix} pf''\phi^2 & a_{12} \\ pf''\phi\frac{\phi'}{w_0}N + pf'\frac{\phi'}{w_0} - wh_e\frac{\phi'}{w_0} - h & a_{22} \end{pmatrix} \begin{pmatrix} dN \\ dw \end{pmatrix}$$
$$= \begin{pmatrix} \frac{w}{w_0}a_{12} + \frac{w}{w_0}h_1 & -f'\phi \\ \frac{w}{w_0}a_{22} + pf'\frac{\phi'}{w_0^2}N & -f'\frac{\phi'}{w_0}N \end{pmatrix} \begin{pmatrix} dw_0 \\ dp \end{pmatrix}$$

where $a_{12} = a_{21}$ and $a_{22} = pf''\frac{[\phi']^2}{w_0^2}N^2 + pf'\frac{\phi''}{w_0^2}N - wh_{ee}\frac{[\phi']^2}{w_0^2}N - wh_e\frac{\phi''}{w_0^2}N - 2h_e\frac{\phi'}{w_0}N$. Note that $a_{12} = a_{21} = pf''\phi\frac{\phi'}{w_0}N$ since $pf'\frac{\phi'}{w_0} - wh_e\frac{\phi'}{w_0} - h = 0$. For simplicity, the above equation is expressed as $Ax = Bc$. The conditions for (w^*, N^*) to be a maximal point are

$$pf''\phi^2 < 0 \text{ and } |A| > 0.$$

$|A| > 0$ holds if

$$pf'\frac{\phi''}{w_0^2}N - wh_{ee}\frac{[\phi']^2}{w_0^2}N - wh_e\frac{\phi''}{w_0^2}N - 2h_e\frac{\phi'}{w_0}N < 0. \tag{1.21}$$

Hereafter, we assume (1.21) holds.

The effect of the reference wage on the wage is

$$\frac{\partial w}{\partial w_0} = \frac{w}{w_0} + \frac{1}{|A|}\left[a_{11}\left[pf'\frac{\phi'}{w_0^2}N\right] - a_{21}\frac{w}{w_0}h\right] = \frac{w}{w_0}. \tag{1.22}$$

exactly as in the selection problem since $a_{11}\left[pf'\frac{\phi'}{w_0^2}N\right] - a_{21}\frac{w}{w_0}h = 0$.

The effect of the reference wage on employment is

$$\frac{\partial N}{\partial w_0} = \frac{1}{|A|}\left[\frac{w}{w_0}ha_{22} - pf'\frac{\phi'}{w_0^2}Na_{12}\right] < 0, \tag{1.23}$$

as in the selection model since (1.21).

The effect of a price change (demand shock) on the wage is

$$\frac{\partial w}{\partial p} = \frac{1}{|A|}\left[-f'\frac{\phi'}{w_0}Na_{11} - f'\phi a_{21}\right] = 0 \tag{1.24}$$

again, as in the selection model.

1.4.3 Excess Demand

If labor supply is less than labor demand, the firm solves the following problem:

$$\max_{w} pf\left(\phi\left(\frac{w}{w_0}\right)n^S\left(\frac{w}{w_0};p,v\right)\right) - wh\left(1,\phi\left(\frac{w}{w_0}\right)\right)n^S\left(\frac{w}{w_0};p,v\right). \tag{1.25}$$

Comparative Statics

The first order condition when $p = 1$ is

$$f'\left[\frac{\phi'}{w_0}n + \phi\frac{n'}{w_0}\right] - \left[hn + wh'\frac{\phi'}{w_0}n + wh\frac{n'}{w_0}\right]. \tag{1.26}$$

Taking total differentiation, we have

$$Adw - \left[\frac{w}{w_0}A + \frac{1}{w_0}B\right]dw_0 = 0 \tag{1.27}$$

where

$$\begin{aligned} A &= f''\left[\frac{\phi'}{w_0}n + \phi\frac{n'}{w_0}\right]^2 + f'\left[\frac{\phi''}{w_0^2}n + 2\frac{\phi'}{w_0}\frac{n'}{w_0} + \phi\frac{n''}{w_0^2}\right] \\ &\quad - \left[2h'\frac{\phi'}{w_0}n + 2h\frac{n'}{w_0} + wh''\left[\frac{\phi'}{w_0}\right]^2 n + wh'\frac{\phi''}{w_0^2}n + 2wh'\frac{\phi'}{w_0}\frac{n'}{w_0} + wh\frac{n''}{w_0^2}\right] \text{ and} \\ B &= f'\left[\frac{\phi'}{w_0}n + \phi\frac{n'}{w_0}\right] \geq 0. \end{aligned}$$

Unfortunately, the sign of A is not determined unless specific functional forms are given. So, the effect of the reference wage on the optimal wage is not certain.

1.4.4 Equilibrium

The effort model is different from the selection model in that the effort function is determined by the worker while the ability function is exogenously determined by the employer's screening technology in the selection model. But, since the effort function is still exogenously given to the employer, the employer faces the same kind of problem as in the selection model. Therefore, *the employer does not change her optimal choice whenever labor supply is sufficient to meet demand. When labor supply is short, the employer's choice is constrained to the available labor supply.*

1.5 Implications

The set of possible outcomes in figure 1.2(c) looks like the backward-bending labor supply curve. However, the reasons for the appearances of the graphs are different – the traditional labor supply curve is backward bending because the substitution effect dominates at low wages and the income effect overrides the substitution effect at high wages, while the shape of the set of possible choices in figure 2(c) is due to very different outcomes when labor supply exceeds or falls short of labor demand. In the efficiency wage model the firm sets the wage and employment unilaterally, while considering workers' response. Once the optimal wage and employment are set, the workers have no freedom in the labor market. In other words, once the firm chooses a point in the set of possible choices then the point is given to workers. The set of possible choices has a backward bending shape.

The other interesting thing is that the backward bending shape can be interpreted as accounting for the minimum wage paradox: the outcomes of some empirical studies differ from, or are opposite to, the predictions of conventional theory. Conventional theory predicts that an increase in the minimum wage causes firms to reduce employment. However, Card and Krueger (1994) suggest that increases in the minimum wage do not necessarily reduce, and may even be associated with increases in, employment.[17] The model developed here has implications which are consistent with these empirical results. The firm paying the minimum wage is more likely to face excess labor demand. Then the firm's set of possible choices to maximize its profit all lie on the increasing part of the backward-bending graph. Now, the minimum wage is increased and the firm faces the positive-sloped portion of the set of possible choices at the increased minimum wage. Then, the only choice of the firm is to increase employment.

[17] For a comprehensive discussion on the minimum wage paradox, see Card and Krueger (1995).

1.6 Conclusion and Discussions

In this paper, I present a simple and then a complex efficiency wage model. These models are different from previous efficiency wage models in that they deal explicitly with labor supply. Previous models ignore workers' role in labor market outcomes since both the wage and employment are unilaterally determined by the firm. Such models ignore the possibility of excess demand for labor, and ignore the possibility that the firm will consider workers' response to its decision.

The models in this paper are developed to remedy these omissions. In particular, these models consider the case in which labor supply is short of labor demand as well as the case in which labor supply exceeds labor demand. As in previous efficiency wage models, labor supply does not play a crucial role in determining the wage or employment when labor supply exceeds labor demand. But when labor supply is short of labor demand, the shortage itself is a restriction on the firm's decision on wage and its employment level. Here, labor supply – workers' decision on whether to work at different wage levels – plays a crucial role in firm's decision on wage and employment.

By dealing explicitly with labor supply, I produce a market outcome which resembles the backward-bending labor supply schedule. Although the shape is similar, the reasons for the shape are totally different. The result of this paper comes from the employer's profit-maximizing behavior under the constraint of workers' utility maximization. Roughly speaking, in the high wage region, labor supply exceeds labor demand, so there is no constraint on its decision, and so the firm chooses its optimal point on the downward-sloping portion of the solid curve in figure 2(c). But, in the low wage region, the firm must choose a point on the upward-sloping portion of that curve because labor supply is less than labor demand. The backward-bending curve in these models can be used in explaining the minimum wage paradox: According to the curve, if the change in the minimum wage happens in the low wage portion of the curve, the increase in the wage could increase employment.

The models developed in this paper may also help explain inter-industry wage differentials. In the selection model, firms are not equally good at screening workers' ability so that the firm with worse screening technology must pay higher wages to hire workers with the same expected ability. In the effort model, a worker has different expectations about the gift to be given by employers so that firms will pay different wages to receive the same effort from the worker. This model also highlights an important caveat. Since different ability functions and/or effort functions lead industries to choose different ability and/or effort levels, workers in different industries cannot easily be compared. This means that one must be cautious about attributing inter-industry wage differentials to efficiency wages.

1.A Utility function with relative wage in the effort model

I consider a worker's utility function who feels pain from his effort exertion. This utility function could be expressed as

$$u(L, [M - e], C)$$

where L and C represent leisure and consumption. e and M represent actual effort and the maximum level of effort.

The disutility (or pain) change derived from effort change could be derived from

$$\frac{\partial u}{\partial e} = -u_2.$$

The absolute value of the partial derivative, $|-u_2| = u_2$, is the amount of the disutility.

Now, I want to allow the worker to feel different level of disutility from his effort exertion. Let the difference be reflected by function $X = X(\frac{w}{w_0})$. Then, the utility function should be

$$u(L, X[M - e], C)$$

Then, The disutility change derived from effort change is derived from

$$\frac{\partial u}{\partial e} = -Xu_2.$$

The disutility is $|-Xu_2| = Xu_2$.

Then, what should be the form of function $X(\frac{w}{w_0})$ if the worker feel less pain from more relative wage or

$$\frac{w_1}{w_0} > \frac{w_2}{w_0} \Rightarrow X(\frac{w_1}{w_0})u_2 < X(\frac{w_2}{w_0})u_2?$$

One simple form of function $X(\frac{w}{w_0})$ is

$$X(\frac{w}{w_0}) = \frac{w_0}{w}.$$

Then, the utility function with the simple form is

$$u\left(L, \frac{w_0}{w}[M - e], C\right).$$

Chapter 2

The Interindustry Wage Differentials: An Explanation Using Efficiency Wage Theory

2.1 Introduction

In this chapter, I test whether efficiency wage models contribute to explaining interindustry wage differentials. First, I find variables which could cause firms to pay different wages to seemingly identical workers. Then, I estimate wage equations with and without these variables, and show how this changes the standard deviation of interindustry wage differentials.

More than a half century ago, Lester (1946) noted an unusual phenomenon; wage rates varied for the same job in the same labor market. Later, Krueger and Summers (1987) and Dickens and Katz (1987) showed that interindustry wage differentials were sizable and stable over time and across countries and were not a phenomenon specific to some groups of workers. They also found that these wage differentials were related to some characteristics of industries, for example profitability and firm size. Then, authors considered alternative explanations for the wage differentials. Krueger and Summers (1988) showed that unobserved ability and compensating differentials did not fully explain interindustry wage differentials and conjectured that efficiency wages could do so. There has been no direct test of this, however.

In this chapter, I provide a direct test of whether efficiency wages explain interindustry wage differentials. I construct two reference wages based on "fair wage" models and add these reference wages to the wage equation. Then, I compare the results of regressions with and without the reference wages. In particular, I focus on how introduction of the reference wages changes the standard deviation of coefficients on the industry dummy variables. I also consider the effect of adding profit variables. I use the current population survey (CPS) March Supplement from 1992 to 2002 and from 1984 to 1991. Profit data come from the NBER-CES Manufacturing Industry Database.

Inclusion of the two reference wages reduces the standard deviation of the industry coefficients by almost 20%. I get similar results in each of the two time periods. Adding the profit variable does not contribute to explaining the interindustry wage differentials, however.

In the next section I review previous studies of interindustry wage differentials and papers related to the reference wages that I consider. In the third section I describe data and econometric specification. In the fourth section, I provide the regression results. In the final section, I summarize my findings and conclusions.

2.2 Literature Review

More than a half century ago, several economists noted an abnormal phenomenon. Lester (1946) find that, instead of a single rate for the same work, there is usually a band or zone of rates ranging from the lowest- to the highest-paying employer in a community. Kerr (1950) and Slichter (1950) find the same pattern in other labor markets.

Since these early works, there have been many efforts to explain this interesting phenomenon. First, the characteristics of the wage differentials were explored. Krueger and Summers (1987) and Dickens and Katz (1987) find that interindustry wage differentials are sizable and stable over time and across countries. Krueger and Summers (1987) show that the correlation between relative wages in major industries is 0.62 during 1900-84 and 0.91 during 1970-84. Cross-country correlations for relative wages are typically between 0.6 and 0.9. These interindustry wage differentials are similar for different age groups, tenure groups, and occupation categories. Gera and Grenier (1994) find similar patterns in Canadian data. Goux and Maurin (1999) obtain similar results using French data.

In trying to unravel this mystery, researchers looked into the relation between the characteristics of industries and interindustry wage differentials. Krueger and Summers

(1987) find that less competitive industries pay higher wages, but this finding is sensitive to the extent of labor quality controls.[1] Profit rates have a strong relationship with average wages in manufacturing industries although profit necessarily reduces as wages increase. The capital-to-labor ratio is positively related to wages. Union density is positively related to industry wages for both union and nonunion employees.[2]

Economists attempted to account for interindustry wage structure from the theoretical perspectives. The natural explanations from conventional economics are unobserved ability and compensating differentials. Krueger and Summers (1988) test whether the differentials are in fact due to unmeasured ability differences by running first-difference regressions. They find that unmeasured ability differences do not explain the wage differentials. They get the same results with displaced workers, which reduces problems due to measurement error and selectivity.[3] Blackburn and Neumark (1992) carry out a more direct test of the role of unobserved ability using the young men's cohert of the National Longitudinal Survey. As a proxy for ability they add to their wage equation the expected values derived from regressing IQ on family background variables. But, adding the more explicitly measured ability (the predicted IQ) affects the interindustry wage differentials by only a limited degree.

Recently, researchers have addressed the question of unobserved individual effects by exploiting the availability of matched employer-employee data. Woodcock (2008) decomposes the interindustry wage differentials into several factors including an unobserved personal effect, finding that the unobserved personal effect accounts for only about 8∼15% of interindustry wage differentials.[4]

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[1] Labor quality controls include education, experience, sex and races.

[2] Krueger and Summers (1987) argue for a causal relation based on historical evidence: The high-wage industries already paid relatively high wages before the advent of wide-scale unionization in manufacturing. In addition, they suspect the direction of causation with the fact that unions tend to concentrate their organizing efforts in industries which have a greater ability to pay high wages. The direction of causation is also unclear in capital-to-labor ratio. High wages encourage firms to speed up investment in capital.

[3] Gibbons and Katz (1992) get similar results.

[4] Goux and Maurin (1999) report that unobserved personal factors explain more than 50% of interindustry wage differentials in French employer-employee matched data. However, these findings are not comparable to the findings for the US. It is noteworthy that Goux and Maurin (1999) do not control for educational attainment. If workers are sorted by educational attainment, the huge reduction in the wage differentials after personal dummy variables are added is possibly attributable to the educational

To test another plausible explanation of interindustry wage differentials based on competitive theory, the theory of compensating differentials, Krueger and Summers add working-conditions variables from University of Michigan's Quality of Employment Survey to the wage equation. But, adding these variables had very little effect on interindustry wage differentials.

Since conventional theory did not succeed in explaining interindustry wage differentials, economists began to turn to new theories. A simple logical explanation is union threat effects. Some evidence is consistent with the union threat model, but high-wage industries already paid high wages even before widespread unionization in manufacturing.[5] Furthermore, the industry wage structure is similar in both countries without much unionization and countries with widespread collective bargaining. This suggests that unionization is probably not a major determinant of the industry wage structure.[6]

The explanation of interindustry wage differentials that has attracted the most attention is efficiency wage theory. Krueger and Summers (1988) mention that interindustry wage differentials can be explained well by efficiency wage theories: when there are differences across firms or industries in the ability to bear the costs of turnover, to supervise and monitor their workers, or to measure labor quality,[7] then the optimal wage will vary. Dickens and Katz (1987) comment similarly as follows.

> Efficiency wage models suggest that the potential benefits to a firm of higher wages include increased effort and reduced shirking by employees, lower turnover costs, a higher quality workforce, and improved worker morale and better group work norms.[8] A basic implication of efficiency wage models is that if the conditions necessitating efficiency wage payments differ across industries, then the optimal wage will differ among industries. This means that workers with identical productive characteristics are paid differently

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attainment, which is usually included in U.S. analyses of interindustry wage differentials.

[5]See Krueger and Summers (1987)

[6]A test of union effects will be provided in this paper.

[7]Salop (1979), Shapiro and Stiglitz (1984), and Weiss (1980) are most cited papers on turnover models, shirking models, and adverse selection models, respectively.

[8]For a fair wage model, see Akerlof (1982).

depending on their industry affiliation.

However, there has been no direct test of how much efficiency wage theory explains interindustry wage differentials. This is not surprising because it is hard to obtain measure of the variables that might cause firms to pay efficiency wages. Measures of factors that affect firms' ability to detect shirking, screen better workers, and avoid turnover cost may be difficult or even impossible to obtain. So, in this chapter I carry out a partial test using variables which make firms pay different gifts (or wages) to the same worker. According to the "fair wage" model, if a worker has different expectations concerning gifts across firms, firms should pay different gifts in order to receive the same reciprocal gift (effort). If the fair wage model can help explain interindustry wage differentials, adding variables which cause the different expectations should reduce interindustry wage differentials.

There have been several suggestion concerning what causes the different gift expectations of workers. Adams (1963)'s equity theory implies that workers who do not receive a fair wage for input of effort change their effort.[9] Relative deprivation theory suggests that people's conceptions of fairness are based on comparisons with "salient" others. Although psychological theory offers little guide as to what the salient reference groups are, there are three natural candidates: others in similar occupations in the same firm, those in dissimilar occupations in the same firm, or individuals in other firms. According to an experiment of Martin (1981), when technicians at a factory are asked which pay level, between the highest or lowest pay level, they would most like to know for comparison with their own wage, most of them say they want to know the pay of the highest level of technicians. Martin also finds that, when the difference in pay of the supervisors and in pay of technicians is large, the technicians are more likely to be dissatisfied with their pay and to think it is unjust.

Several recent studies make further suggestions about the cause of workers' different

[9] Walster, Wlaster, and Berscheid (1977) show in their experiment that the response of workers is asymmetric. Agents who feel under-rewarded will supply correspondingly fewer inputs. But, overreward experiments yield ambiguous results.

expectations. Mas (2006) supports the idea that considerations of fairness, disappointment, and, more generally, reference wages affect workplace behavior. In the months after New Jersey police officers lost final-offer arbitration of their compensation disputes, arrest rates and average sentence length declined, and crime reports rose, relative to when police won. Rees (1993) provides anecdotal evidence that the wages of others are important for worker satisfaction. Brown, Gardner, Oswald, and Qian (2008), using UK data, find that satisfaction of a worker depends on the ordinal rank of the wage within the comparison group. Similarly, Groot and Brink (1999) show that satisfaction with earnings is determined by relative wages rather than by absolute wage levels. Campbell and Kamlani (1997) find in their survey that factors which affect a worker's perception of the fairness of his or her pay include the worker's past wages, the profitability of the firm, the wages of workers performing similar jobs at the firm, and the wages of workers in different occupations at the firm. In another survey, Bewley (1999) concludes that only the internal relative wage matters for morale. Kahneman, Knetsch, and Thaler (1986) find that, in a transaction between a transactor and a firm, the history of previous transactions, market prices, and posted prices serve as reference points. Koskela and Schöb (2009) and Danthine and Kurmann (2006) prove that, under a simple efficiency wage framework in which both the internal and external perspectives can affect individual effort determination, the internal reference is essential for the existence of real wage rigidity and the external reference ensures an upward-sloping wage setting curve.

Similar ideas appear in recent theoretical models regarding choice of reference wage. In Akerlof and Yellen (1990), workers compare their pay with that of coworkers in the same firm. On the contrary, in Summers (1988), workers compare their own compensation with that of comparable groups in other firms.

To sum up previous studies, workers evaluate their pay based on their own previous wages and the profitability of their firms. Workers' satisfaction is also affected by the relative wage within the comparison group. The comparison group could be workers with the same job in the firm, workers with different jobs in the firm, or workers in other firms. Workers are concerned, in particular, with the comparison group. Based on these suggestions, I consider several types of reference wage as possible causes of a worker's different expectation across firms. The first is the wage of other jobs in her industry. The second is the wage of her own job in other industries.[10] I also test the importance, for wages, of the profitability of the firm.

2.3 Data and Equation

2.3.1 Data

Most of the variables used in the analyses of this chapter come from the Current Population Survey (CPS) March Supplement. I use pooled data from 1992 to 2002. For comparison I use another pooled CPS data set for 1984 through 1991.[11] The CPS is the U.S. government's monthly survey of unemployment, labor force participation, and earnings. It is the primary source of labor force statistics in the US, including data on employment, earnings, and demographics.

I use only one eighth of the entire observations in the CPS because of its survey schedule. Once a household begins to be surveyed, it continues to be interviewed for four months. For the following eight months it is not included in the survey. Then, the household is surveyed again for the next four months. Finally, it drops out of the survey forever. So, there are different groups in a month: Some will continue to be surveyed in the following month and others will leave the survey temporarily or permanently. The latter is called an outgoing rotation group. It is important to note that only outgoing rotation groups (ORGs) are asked about their weekly earnings, which is required to obtain hourly earnings. Hence, we can use only data for persons in ORGs. Also, since I want to make sure each observation does not appear more than once, I exclude people who will reappear in the next year. Thus, the analyses of this chapter are based only on people in permanent outgoing rotation groups.

[10] In the next section I explain these reference wages in detail.

[11] Between these two periods, industry affiliation and occupation classifications have been changed slightly. So, by applying a minor adjustment to the industry and occupation classifications for 1984-1991 data, I made the 1-digit and 2-digit industry and occupation variables comparable over the two periods. Referring to 3-digit classification, I merge several industries or divide an industry to preserve 1984-1991 definition.

There is one more issue regarding earnings. Because of privacy concerns, weekly earnings are top-coded at 1,923 dollars. I delete all top-coded observations. In addition, I exclude people less than 25 years old or more than 65 years old to control for schooling and retirement effects. I also exclude people in agriculture, forestry or fisheries or in farming, forestry, or fishing occupations.

To obtain data on profits, I use the NBER-CES Manufacturing Industry Database.[12] while examining the effect of profit on wages. Since NBER-CES provides information about *manufacturing industry*, I use only data on persons in manufacturing industry when I examine the effect of the profit variable. For the interest rate, which is also required to calculate profit, I use Moody's yield on seasoned corporate bonds - all industries, AAA.

2.3.2 Equation

The starting point for my analyses is a standard wage equation with industry and occupation dummy variables. I make additional modifications by adding several variables which are expected to explain the interindustry wage differentials.

$$w_i = \alpha + X_i\beta + ID_i\delta + OD_i\gamma + Z_i\theta + \epsilon_i \tag{2.1}$$

where w_i is hourly wage (= weekly earnings / weekly working hours), X_i includes educational attainment dummies, age, age squared, sex, marital status, race, union coverage, and dummies for state of residence. ID_i denotes industry dummies and OD_i denotes occupation dummies. As noted below, certain key variables are included in Z_i.

To see if efficiency wage theory contributes to the explanation of interindustry wage

[12]This database, which is run by a joint effort between the National Bureau of Economic Research (NBER) and U.S. Census Bureau's Center for Economic Studies (CES), contains annual industry-level data on output, employment, payroll and other input costs, investment, capital stocks, TFP, and various industry-specific price indexes. The database covers all 4-digit manufacturing industries from 1958 to 1996, in two versions: 1987 SIC codes and 1972 SIC codes. But, recently NBER posted the beta test version updated through 2005, which covers all 4-digit SIC (and 6-digit NAICS) manufacturing industries from 1958 to 2005, in two versions: 1987 SIC codes and 1997 NAICS codes. But, in the updated version observations some are missing for 1958-1996 or 1997-2005 because some industries enter or leave manufacturing in 1997 when the industry code changed from SIC to NAICS. Despite this disadvantage, I use the updated version since it has already gone through data checking and I need information up to 2002. For details, see http://www.nber.org/nberces.

differentials, I add variables which may affect the efficiency wage and measure the change in interindustry wage differentials derived by the added variables. In this chapter, I test two variables which possibly cause workers' different reciprocal gifts for the same gift by firms: the internal reference wage and the external reference wage. The *internal reference wage* of a person is the median wage of the occupation which has the highest median wage among all occupations in the person's affiliated industry. For example, the internal reference wage of worker i, who is in industry k and is in occupation m, is

$$IRW_{ikm} = \max\{\text{median}(w_{k1}), \text{median}(w_{k2}), \cdots, \text{median}(w_{kM})\},$$

where $\text{median}(w_{km})$ is the median of wages of all workers in industry k and with occupation m. Table (?) shows which occupations play as the internal reference in reality. 2-digit classification is used in the calculation. As generally expected, managerial occupations are considered as the internal reference for more than 40% of workers.

The *external reference wage* of a person is the median wage of the industry which has the highest median wage among all industries in the person's occupation. The external reference wage of worker i, who is in industry k and is in occupation m, is

$$ERW_{ikm} = \max\{\text{median}(w_{1m}), \text{median}(w_{2m}), \cdots, \text{median}(w_{Km})\}.$$

Needless to say, each of the reference wages depends on the industry and occupation classifications that are used. I carry out separate regressions for 1-digit, 2-digit, and 3-digit classifications of industry and occupation. I exclude sparsely-populated occupations and industries in obtaining the reference wages since they are so exceptional that they might not be a good reference. The criterion of sparse population here depends on which industry and occupation coding scheme is used.[13]

This chapter also tests the effect of profit on interindustry wage differentials. There are two main reasons why high-profit firms or industries pay high wages compared to

[13] If the number of workers in industry k and occupation m is less than 10%, 5%, and 1% of all workers for 1-digit, 2-digit, and 3-digit classification, respectively, the group of industry k and occupation m is called sparsely populated.

Table 2.1: Occupations of the Internal Reference

Occupations	Portion of Occ of Int Ref
Other Executive, Administrators, and Managers	0.435
Management Related Occupations	0.036
Engineers	0.077
Mathematical and Computer Scientists	0.058
Natural Scientists	0.003
Health Diagnosing Occupations	0.002
Health Assessment and Treating Occupations	0.086
Teachers, College and University	0.024
Teachers, Except College and University	0.002
Lawyers and Judges	0.016
Other Professional Specialty Occupations	0.023
Health Technologists and Technicians	0.003
Engineering and Science Technicians	0.002
Technicians, Except Health, Engineering, and Science	0.006
Supervisors and Proprietors, Sales Occupations	0.073
Sales Representatives, Finance, and Business Service	0.020
Sales Representatives, Commodities, Except Retail	0.028
Secretaries, Stenographers, and Typists	0.001
Financial Records, Processing Occupations	0.001
Mail and Message Distributing	0.000
Other Admin Support Occupations, Inc Clergical	0.008
Private Household Service Occupations	0.003
Health Service Occupations	0.002
Personal Service Occupations	0.001
Mechanics and Repairers	0.051
Construction Trades	0.003
Other Precision Production Occupations	0.016
Machine Operators and Tenders, Except Precision	0.003
Fabricators, Assemblers, Inspectors, and Samplers	0.005
Motor Vehicle Operators	0.003
Other Transportation Occupations and Material Moving Occupations	0.005
Other Handlers, Equipment Cleaners, and Laborers	0.004

others. One is that the firm is responding to union threats. The other is that the firm is responding to workers' adjustment in reciprocal gifts based on profit of their firm or industry. Therefore, when I test whether higher profit causes workers to adjust their wage expectations higher, I include not only a profit variable, but also a union density variable to control for unionization.

Each industry's profit is calculated as follows.[14]

$$\pi_t = \frac{Vadded_t - Pay_t}{CPI_t} - Depr_t - OppCost_t,$$

where $Vadded$ is value added, Pay is payroll, CPI is CPI in 1987 for urban consumers, $Depr$ is depreciation and $OppCost$ represents opportunity cost, respectively. Depreciation is given by

$$Depr_t = \frac{Inv_t}{Deflator_t} - [Cap_{t+1} - Cap_t],$$

where Inv, $Deflator$, and Cap represent investment, investment deflator, and real capital stock in 1987 dollar. Opportunity cost is the real interest rate times real capital stock:

$$OppCost_t = [IntRate_t - InfRate_t] \times Cap_t,$$

where $IntRate$ and $InfRate$ indicate nominal interest rate and the rate of CPI inflation. Since current profit is likely to be endogenous to the wage, I use profit lagged one, two, and three years.

2.4 Results

Several wage equations are estimated in order to examine whether efficiency wage theory contributes to explaining interindustry wage differentials. As previously noted, the wage equation controls for human capital, demographic variables, industry dummies, and occupation dummies, and uses pooled data from 1994 to 2002. The human capital and demographic background include 7 educational attainment dummies, age/100, and

[14] Blanchflower, Oswald, and Sanfey (1996) calculate profit in this way.

age^2/10000, sex, marital status, 3 race dummies, union coverage, 3 central city dummies, and 51 state dummies. Year dummies are also added as covariates since pooled data are used.

The estimated industry wage differentials are normalized as deviations from the weighted mean:

$$\hat{\delta_k}^* = \hat{\delta_k} - \frac{\sum_l n_l \hat{\delta}_l}{N},$$

where, $\hat{\delta_k}$ is the estimate of the coefficient on the dummy variable for industry k, which is also the kth element of the vector of estimated coefficients on industry dummies $\hat{\delta}$; n_l indicates the number of people in industry l; and N is total of people in all industries. The standard errors of the normalized differentials are adjusted following Zanchi (1998). They are diagonal elements of the covariance matrix

$$V(\hat{\delta}^*) = \ \hat{\delta}^* \ V(\hat{\delta}) \ [\hat{\delta}^*]'.$$

where $\hat{\delta}^* \ = [\hat{\delta_1}^*, \cdots, \hat{\delta}^*]$. As a measure of wage differentials, the weighed standard deviation of differentials is calculated as

$$\text{Weighted Std Dev } = \sum_k \frac{n_k}{N} \hat{\delta_k}^*$$

2.4.1 Interindustry Wage Differentials in the 1990s

The first and second columns of table 2.2 (headed "No Reference Wages") shows results for regressions of the log hourly wage on dummy variables for industry, based on the one digit census industry classification (CIC). The industry dummy variables are jointly significant and most of them are individually significant as well. Estimates of coefficients on other variables are as expected. People are paid more in a nonlinear way as experience grows. Those who have a bachelor's degree make more than less educated people. Women are paid less than men. Whites earn more than other races.

Comparable results for two-digit CIC industries and for three-digit CIC industries

Table 2.2: Interindustry Wage Differentials : 1-digit (1992-2002)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.083		0.056	
Weighted Std Dev for Occupation	0.138		0.107	
External reference wage	-		0.117	0.032
Internal reference wage	-		0.214	0.037
Age / 100	3.887	0.190	3.880	0.190
Age squared / 10000	−4.195	0.228	−4.187	0.228
Female	−0.232	0.005	−0.232	0.005
Married	0.069	0.006	0.069	0.006
White	0.075	0.010	0.076	0.010
Black	0.001	0.012	0.001	0.012
Union Covered	0.176	0.006	0.175	0.006
High school graduate	0.204	0.007	0.204	0.007
Associate degree	0.312	0.009	0.313	0.009
Bachelors degree	0.434	0.009	0.434	0.009
Masters degree	0.494	0.012	0.494	0.012
Professional degree	0.465	0.022	0.466	0.022
Doctoral degree	0.516	0.024	0.515	0.024
Mining	0.191	0.021	0.141	0.023
Construction	0.036	0.009	0.031	0.009
Manufacturing	0.060	0.005	0.019	0.008
Transportation, communications, and other public utilities	0.085	0.007	0.051	0.009
Wholesale and retail trade	−0.128	0.004	−0.075	0.010
Finance, insurance and real	0.043	0.006	0.042	0.006
Services	−0.057	0.004	−0.049	0.004
Occupations (1-digit)	Included		Included	

are presented in tables 2.3 and 2.4,[15] respectively.

Table 2.3: Interindustry Wage Differentials : 2-digit (1992-2002)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.123		0.104	
Weighted Std Dev for Occupation	0.164		0.142	
External reference wage	-		0.088	0.015
Internal reference wage	-		0.085	0.014
Age /100	3.540	0.183	3.526	0.183
Age squared / 10000	−3.751	0.220	−3.737	0.219
Female	−0.198	0.005	−0.197	0.005
Married	0.056	0.005	0.056	0.005
White	0.079	0.010	0.079	0.010
Black	0.009	0.012	0.009	0.012
Union Covered	0.170	0.006	0.170	0.006
High school graduate	0.179	0.007	0.180	0.007
Associate degree	0.243	0.009	0.243	0.009
Bachelors degree	0.379	0.009	0.379	0.008
Masters degree	0.459	0.012	0.459	0.012
Professional degree	0.362	0.026	0.361	0.026
Doctoral degree	0.484	0.025	0.485	0.025
Mining	0.195	0.022	0.175	0.022
Construction	0.037	0.012	0.046	0.012
Lumber and wood products, except furniture	−0.003	0.023	0.003	0.023
Furniture and fixtures	−0.045	0.024	−0.027	0.024
Stone clay, glass, and concrete product	0.050	0.024	0.046	0.024
Primary metals	0.081	0.020	0.071	0.020
Fabricated metal	0.044	0.017	0.045	0.017
Not specified metal industries	−0.056	0.228	−0.048	0.228
Machinery, except electrical	0.092	0.013	0.066	0.013
Electrical machinery, equipment, & supplies	0.079	0.014	0.055	0.014
Motor vehicles and equipment	0.164	0.017	0.135	0.017
Aircraft and parts	0.170	0.028	0.133	0.028
Other transportation equipment	0.158	0.024	0.126	0.024
Prof and photographic equipment,and watches	0.055	0.021	0.023	0.022
Toys, amusements, and sporting goods	−0.142	0.045	−0.136	0.045
Miscellaneous & not specified manufacturing	−0.081	0.025	−0.081	0.025
Food and kindred products	−0.011	0.014	−0.005	0.014
Tobacco manufactures	0.209	0.074	0.190	0.074
Textile mill products	0.033	0.023	0.037	0.023
Apparel & other finished textile products	−0.125	0.019	−0.093	0.020
Paper and allied products	0.154	0.020	0.140	0.020
Printing, publishing & allied industries	0.068	0.014	0.069	0.014
Chemicals and allied products	0.188	0.016	0.158	0.017
Petroleum and coal products	0.286	0.042	0.248	0.043
Rubber & miscellaneous plastics products	0.037	0.020	0.028	0.020

Continued on next page

[15]Full output for the 3-digit CIC is presented in table 2.A.1 in the appendix.

Table 2.3 – continued from previous page

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Leather and leather products	−0.048	0.046	−0.075	0.046
Transportation	0.058	0.011	0.061	0.011
Communications	0.118	0.014	0.099	0.014
Utilities and Sanitary Services	0.213	0.016	0.183	0.017
Wholesale Trade	−0.011	0.010	−0.004	0.010
Retail Trade	−0.129	0.008	−0.092	0.010
Banking and Other Finance	0.066	0.011	0.062	0.011
Insurance and Real Estate	0.038	0.011	0.037	0.011
Private Household Services	−0.254	0.056	−0.172	0.058
Business Services	−0.029	0.010	−0.044	0.010
Repair Services	−0.094	0.016	−0.078	0.016
Personal Services, Except Private Household	−0.107	0.012	−0.080	0.013
Entertainment and Recreation Services	−0.028	0.017	−0.025	0.017
Hospitals	0.021	0.011	0.015	0.011
Health Services, Except Hospitals	−0.031	0.010	−0.024	0.010
Educational Services	−0.108	0.014	−0.108	0.014
Social Services	−0.214	0.014	−0.191	0.014
Other Professional Services	−0.022	0.010	−0.038	0.010
Occupations (2-digit)	Included		Included	

As indicated by the industry dummy coefficients, interindustry wage differentials are clearly substantial. The coefficient for the mining industry in the first and second columns of table 2.3 (headed ”No Reference Wage”), for example, implies that the average worker in the mining industry earns about 20% more than an average worker in all industries. The wage differentials range from 25% below the mean in the private household services industry to 29% above the mean in the petroleum and coal products industry.

To see how much of these large wage differentials could be explained by the reference wages, I add the internal reference wage and external reference wage variables to the existing wage equation. The third and fourth columns of table 2.2, table 2.3, and table 2.4 (headed ”Reference Wage”) show the results of regressions including these reference wage variables. The coefficient estimates on both the internal reference wage and the external reference wage are significant. The effect of the inclusion is indicated by the change in the weighed standard deviation of interindustry wage differentials. It decreases from 0.083 to 0.056, from 0.123 to 0.104, and from 0.149 to 0.123 for the 1-digit CIC, 2-digit CIC, and 3-digit CIC, respectively. These amount to a reduction

Table 2.4: Interindustry Wage Differentials : 3-digit (1992-2002)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.149		0.123	
Weighted Std Dev for Occupation	0.214		0.168	
External reference wage	-		0.193	0.007
Internal reference wage	-		0.103	0.007
Age / 100	3.387	0.179	3.313	0.177
Age squared / 10000	−3.566	0.215	−3.495	0.212
Female	−0.172	0.005	−0.169	0.005
Married	0.051	0.005	0.051	0.005
White	0.065	0.009	0.064	0.009
Black	0.003	0.011	0.003	0.011
Union Covered	0.164	0.006	0.158	0.006
High school graduate	0.157	0.007	0.153	0.007
Associate degree	0.207	0.009	0.203	0.009
Bachelors degree	0.330	0.008	0.323	0.008
Masters degree	0.418	0.012	0.408	0.011
Professional degree	0.321	0.026	0.312	0.026
Doctoral degree	0.453	0.025	0.442	0.025
Industries (3-digit)	Included		Included	
Occupations (3-digit)	Included		Included	

of 15% $\sim$ 20% in the weighted standard deviation.[16] The effect of adding the internal reference wage and external reference wage variables is also observed by the reduction in dispersion of the differentials. The differentials range shrinks from -25.4% $\sim$ 28.6% to -19.1% $\sim$ 24.8% for the 2-digit CIC.

The coefficients on the variables for both the internal reference wage and the external reference wage are positive, consistent with the results of previous chapter. In the previous chapter I concluded that the increase in the reference wage induces a rise in the wage rate.

The worker may consider the profit of the firm where he works as an important reference for his wage. Since the worker will react with a low reciprocal gift to the firm's disappointing gift, the firm is urged to share its high gain with workers if it wants to receive constant effort from the worker. But, there is one problem in using

[16] It is compared with the effect of controlling for unobserved ability variable. Blackburn and Neumark (1992) reported slightly more than 10% reduction in interindustry wage differentials in table 3 of their paper.

Table 2.5: Interindustry Wage Differentials of Manufacturing Industries with Profit: 2-digit (1992-2002)

Variable	None		Profit		Profit & Union	
	Coeff	StdErr	Coeff	StdErr	Coeff	StdErr
Weighted Std Dev for Industry	0.125		0.160		0.157	
Weighted Std Dev for Occupation	0.196		0.196		0.196	
Profit (t−1)	-		−0.054	0.039	−0.053	0.039
Profit (t−2)	-		0.035	0.047	0.035	0.047
Profit (t−3)	-		−0.035	0.041	−0.034	0.042
Union density	-		-		0.021	0.071
Age /100	3.344	0.358	3.346	0.358	3.347	0.358
Age squared / 10000	−3.276	0.426	−3.278	0.426	−3.280	0.426
Female	−0.228	0.009	−0.228	0.009	−0.228	0.009
Married	0.060	0.011	0.060	0.011	0.060	0.011
White	0.066	0.019	0.066	0.019	0.066	0.019
Black	0.016	0.022	0.015	0.022	0.015	0.022
High school graduate	0.198	0.011	0.198	0.011	0.198	0.011
Associate degree	0.265	0.017	0.265	0.017	0.265	0.017
Bachelors degree	0.392	0.016	0.392	0.016	0.392	0.016
Masters degree	0.491	0.023	0.491	0.023	0.491	0.023
Professional degree	0.421	0.086	0.419	0.086	0.420	0.086
Doctoral degree	0.555	0.052	0.555	0.052	0.555	0.052
Industries (2-digit)	Included		Included		Included	
Occupations (2-digit)	Included		Included		Included	

profit as a reference for the wage. Rent-sharing theory suggests that the threat of unionization also could be a main reason for profit sharing. Therefore, in estimation, I include union density as well as profit in the wage equation in order to control for rent sharing.

Table 2.5 shows the results of the regression of the wage on industry dummy variables, profit, and union density. I estimate the effect only for the manufacturing sector since the profit variable is available only for manufacturing industries. The profit variables are not significant, which is consistent with Blanchflower, Oswald, and Sanfey (1996), especially table 3. Moreover, adding profit to the wage equation increases the weighted standard deviation, contrary to the general expectation.[17] Note that I use lagged profit variables due to the endogeneity problem.

I also can evaluate the effect of union threat on the wage differentials from table 2.5. Inclusion of union density does not make any significant change in the weighted standard deviation. The estimate of the coefficient on union density is not significant as well. Estimation with union density only, not including profit variables, produces similar output.[18]

2.4.2 Interindustry Wage Differentials in late 1980s

I estimate the same equations using a new pooled dataset, this time for 1984-91 of the CPS. Tables 2.6-2.8 present the results for regressions of the log wage on dummy variables for the 1-digit, the 2-digit, and the 3-digit CIC, respectively, and are comparable to tables 2.2-2.4, respectively. The estimates of the coefficients on the industry dummy variables are jointly significant and individually significant for most industries.

Continued on next page

[17] Blanchflower, Oswald, and Sanfey (1996) also estimate the regression, for industry cell, of profit variables using 1965-1985 pooled data and found that profit variables positively affect the wage.

[18] This result is not provided in this paper but is available by request.

Table 2.7 – continued from previous page

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error

Table 2.7: Interindustry Wage Differentials : 2-digit (1984-1991)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.157		0.135	
Weighted Std Dev for Occupation	0.167		0.139	
External reference wage	-		0.114	0.015
Internal reference wage	-		0.101	0.014
Age / 100	2.871	0.195	2.877	0.194
Age squared / 10000	−2.849	0.235	−2.858	0.235
Female	−0.240	0.005	−0.240	0.005
Married	0.053	0.008	0.053	0.008
White	0.061	0.013	0.061	0.013
Black	−0.013	0.015	−0.013	0.015
Union Covered	0.188	0.007	0.186	0.007
High school graduate	0.117	0.007	0.117	0.007
Associate degree	0.200	0.009	0.200	0.009
Bachelors degree	0.317	0.009	0.316	0.009
Masters and higher degree	0.376	0.012	0.375	0.012
Mining	0.262	0.022	0.232	0.023
Construction	0.085	0.017	0.073	0.017
Lumber and wood products, except furniture	−0.016	0.026	−0.012	0.026
Furniture and fixtures	−0.006	0.026	0.010	0.026
Stone clay, glass, and concrete product	0.085	0.025	0.045	0.026
Primary metals	0.174	0.023	0.154	0.023
Fabricated metal	0.063	0.019	0.054	0.019
Not specified metal industries	0.326	0.382	0.332	0.382
Machinery, except electrical	0.140	0.014	0.106	0.015
Electrical machinery, equipment, & supplies	0.067	0.015	0.044	0.015
Motor vehicles and equipment	0.251	0.020	0.219	0.020
Aircraft and parts	0.168	0.025	0.138	0.026
Other transportation equipment	0.151	0.025	0.119	0.026
Prof and photographic equipment,and watches	0.107	0.024	0.073	0.024
Toys, amusements, and sporting goods	−0.134	0.048	−0.144	0.048
Miscellaneous & not specified manufacturing	−0.035	0.030	−0.067	0.030
Food and kindred products	0.029	0.016	0.027	0.016
Tobacco manufactures	0.061	0.070	0.044	0.070
Textile mill products	0.006	0.024	0.010	0.024
Apparel & other finished textile products	−0.191	0.019	−0.144	0.021
Paper and allied products	0.144	0.024	0.129	0.024
Printing, publishing & allied industries	0.056	0.017	0.045	0.017
Chemicals and allied products	0.195	0.018	0.159	0.018
Petroleum and coal products	0.269	0.040	0.201	0.041
Rubber & miscellaneous plastics products	0.080	0.023	0.067	0.023
Leather and leather products	−0.150	0.045	−0.149	0.045
Transportation	0.092	0.014	0.080	0.014

Continued on next page

Table 2.7 – continued from previous page

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Communications	0.142	0.018	0.113	0.018
Utilities and Sanitary Services	0.248	0.019	0.210	0.020
Wholesale Trade	−0.011	0.013	−0.001	0.013
Retail Trade	−0.161	0.011	−0.115	0.013
Banking and Other Finance	0.061	0.013	0.051	0.013
Insurance and Real Estate	0.035	0.013	0.031	0.013
Private Household Services	−0.412	0.055	−0.319	0.056
Business Services	−0.024	0.013	−0.035	0.013
Repair Services	−0.146	0.026	−0.130	0.026
Personal Services, Except Private Household	−0.141	0.015	−0.103	0.016
Entertainment and Recreation Services	−0.106	0.023	−0.101	0.023
Hospitals	0.049	0.014	0.054	0.014
Health Services, Except Hospitals	−0.024	0.014	−0.001	0.015
Educational Services	−0.133	0.017	−0.129	0.017
Social Services	−0.230	0.019	−0.202	0.019
Other Professional Services	−0.034	0.013	−0.060	0.014
Occupations (2-digit)	Included		Included	

The range of differentials in the 1984-1991 pooled data for the 2-digit CIC becomes wider than that with previous data as -41.2% $\sim$ 26.9%. The weighted standard deviation also becomes bigger with this data. These imply that the interindustry wage differentials fell from the 1980's to the 1990's.

The role of the internal and the external reference wage in explaining the wage differentials is similar in the two periods, 1992-2002 and 1984-1991. The interindustry wage differential falls by about 15$\sim$ 20% with 1984-1991 pooled data when the reference wages are added to the wage equation.

Table 2.9 shows the effect of inclusion of profit variables with 1984-1991 pooled data. Profit variables are not significant and increase the interindustry wage differentials, as in the results with the 1992-2002 pooled data. Furthermore, adding profit to the wage equation increases the weighted standard deviation of differentials.

2.4.3 Summary

Table 2.10 summarizes the results. Adding the internal and external reference wage variables significantly reduces the weighted standard deviation of differentials as shown in the columns under "changes in weighted stan dev". The reference wage coefficients

Table 2.6: Interindustry Wage Differentials : 1-digit (1984-1991)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.127		0.099	
Weighted Std Dev for Occupation	0.145		0.109	
External reference wage	-		0.156	0.047
Internal reference wage	-		0.285	0.053
Age / 100	3.155	0.204	3.172	0.204
Age squared / 10000	−3.199	0.246	−3.221	0.246
Female	−0.290	0.005	−0.290	0.005
Married	0.062	0.008	0.063	0.008
White	0.069	0.013	0.069	0.013
Black	−0.005	0.015	−0.005	0.015
Union Covered	0.196	0.007	0.195	0.007
High school graduate	0.144	0.007	0.144	0.007
Associate degree	0.250	0.009	0.250	0.009
Bachelors degree	0.373	0.009	0.374	0.009
Masters and higher degree	0.406	0.012	0.407	0.012
Mining	0.222	0.042	0.153	0.044
Construction	0.029	0.039	−0.005	0.040
Manufacturing	0.021	0.037	−0.036	0.038
Transportation, communications, and other public utilities	0.068	0.037	0.005	0.039
Wholesale and retail trade	−0.208	0.037	−0.127	0.040
Finance, insurance and real	−0.010	0.037	−0.013	0.037
Services	−0.112	0.037	−0.084	0.037
Occupations (1-digit)	Included		Included	

Table 2.8: Interindustry Wage Differentials : 3-digit (1984-1991)

Variable	No Reference Wage		Reference Wage	
	Coefficient	Std Error	Coefficient	Std Error
Weighted Std Dev for Industry	0.161		0.143	
Weighted Std Dev for Occupation	0.191		0.158	
External reference wage	-		0.157	0.008
Internal reference wage	-		0.078	0.007
Age	2.603	0.190	2.536	0.188
Age squared	−2.540	0.229	−2.472	0.227
Female	−0.210	0.006	−0.207	0.006
Married	0.049	0.008	0.050	0.008
White	0.057	0.012	0.057	0.012
Black	−0.004	0.014	−0.004	0.014
Union Covered	0.175	0.007	0.172	0.007
High school graduate	0.098	0.007	0.096	0.007
Associate degree	0.169	0.009	0.166	0.009
Bachelors degree	0.271	0.009	0.266	0.009
Masters and higher degree	0.347	0.012	0.343	0.012
Industries (3-digit)	Included		Included	
Occupations (3-digit)	Included		Included	

Table 2.9: Interindustry Wage Differentials of Manufacturing Industries with Profit: 2-digit (1984-1991)

Variable	None		Profit		Profit & Union	
	Coeff	StdErr	Coeff	StdErr	Coeff	StdErr
Weighted Std Dev for Industry	0.136		0.139		0.135	
Weighted Std Dev for Occupation	0.219		0.219		0.221	
Profit (t−1)	-		−0.022	0.019	−0.025	0.019
Profit (t−2)	-		0.015	0.017	0.016	0.017
Profit (t−3)	-		0.001	0.011	0.002	0.011
Union density	-		-		0.118	0.070
Age	2.966	0.331	2.968	0.331	2.965	0.331
Age squared	−2.835	0.396	−2.838	0.396	−2.833	0.396
Female	−0.267	0.009	−0.267	0.009	−0.267	0.009
Married	0.066	0.015	0.066	0.015	0.065	0.015
White	0.112	0.022	0.112	0.022	0.112	0.022
Black	0.054	0.025	0.054	0.025	0.054	0.025
High school graduate	0.134	0.011	0.134	0.011	0.133	0.011
Associate degree	0.207	0.015	0.207	0.015	0.207	0.015
Bachelors degree	0.309	0.016	0.310	0.016	0.310	0.016
Masters and higher degree	0.407	0.021	0.407	0.021	0.407	0.021
Industries (2-digit)	Included		Included		Included	
Occupations (2-digit)	Included		Included		Included	

Table 2.10: Interindustry Wage Differentials : A Summary

Period / CIC digit	Changes in Weighted Stan Dev when reference wages added		Coefficients on Reference Wages	
	Industry	Occupation	External	Internal
1992-2002				
1-digit	0.083 → 0.056	0.138 → 0.107	0.117 (0.032)	0.214 (0.037)
2-digit	0.123 → 0.104	0.164 → 0.142	0.088 (0.015)	0.085 (0.014)
3-digit	0.147 → 0.123	0.214 → 0.168	0.193 (0.007)	0.103 (0.007)
1984-1991				
1-digit	0.127 → 0.099	0.145 → 0.109	0.156 (0.047)	0.285 (0.053)
2-digit	0.157 → 0.135	0.167 → 0.139	0.114 (0.015)	0.101 (0.014)
3-digit	0.161 → 0.143	0.191 → 0.158	0.157 (0.008)	0.078 (0.007)

Note: Figures in parentheses are standard errors.

are themselves significant in every type of industry classification and for any period.

Table 2.11: Interindustry Wage Differentials by Sex (1992-2002)

Sex / CIC digit	Changes in Weighted Stan Dev		Reference Wage	
	Industry	Occupation	External	Internal
men				
1-digit	0.081 → 0.061	0.152 → 0.140	0.040 (0.041)	0.182 (0.045)
2-digit	0.108 → 0.090	0.183 → 0.158	0.085 (0.020)	0.196 (0.019)
3-digit	0.159 → 0.125	0.221 → 0.170	0.250 (0.010)	0.121 (0.007)
women				
1-digit	0.088 → 0.052	0.128 → 0.093	0.190 (0.058)	0.288 (0.066)
2-digit	0.144 → 0.129	0.166 → 0.146	0.083 (0.022)	0.066 (0.021)
3-digit	0.168 → 0.159	0.284 → 0.254	0.136 (0.010)	0.076 (0.010)

Note: Figures in parentheses are standard errors.

Additionally, I provide a comparison by sex. Table 2.11 compares the interindustry wage differentials between men and women. Women have slightly higher interindustry wage differentials than men. The effect of adding the reference wage variables on interindustry wage differentials is similar for each sex.

Table 2.12: Change in the Interindustry Wage Differentials Over 20 Years

year	Weighted Stand Dev of Industry		Weighted Stand Dev of Occupation	
	1-digit CIC	2-digit CIC	1-digit CIC	2-digit CIC
1986	0.0713	0.1324	0.1145	0.1426
1991	0.1123	0.1648	0.1275	0.1764
1996	0.1002	0.1465	0.1224	0.1548
2001	0.0809	0.1626	0.1418	0.1968

I attempted to track on interindustry wage differentials for 1986 to 2001 despite the change in definitions of industry and occupation classifications.[19] Table 2.12 shows a trend in wage differentials with 1-digit and 2-digit CIC. There is no increasing or decreasing trend in the wage differentials over 20 years, consistent with Krueger and Summers (1988).

2.5 First-difference Equation

In this section I consider the possibility that interindustry wage differentials are substantially affected by workers' unobserved ability. If unobserved ability is an important factor of wage determination, is correlated with industry dummy variables but it is not controlled for, then a part of interindustry wage differentials come from unobserved ability and so estimates on industry dummy variables are biased. Then any measure of interindustry wage differentials is incorrect.

To control for the unobserved ability, I estimate an extended wage equation with individual dummy variables as follows:

$$w_{it} = \alpha + D_i\zeta + X_{it}\beta + ID_{it}\delta + OD_{it}\gamma + Z_{it}\theta + \epsilon_{it},$$

where D_i is the individual dummy variable for individual i. By taking first differences, I delete this individual dummy variable and have

$$\Delta w_i = \Delta X_i\beta + \Delta ID_i\delta + \Delta OD_i\gamma + \Delta Z_i\theta + \Delta\epsilon_i, \tag{2.2}$$

where ΔX includes age, change in educational attainment, and change in union coverage. ΔID and ΔOD denote changes in industry affiliation and occupation, respectively. If worker i does not change industry affiliation, the ΔID vector is zero. Otherwise, the change in the previous industry variable equals -1 and the new variable for the industry equals 1. ΔZ denotes the changes in the reference wages.

To construct a new data file I match observations in permanent outgoing rotation

[19] Although classification code changes between two periods, I make the classification code comparable by adjusting the 1-digit CIC and the 2-digit CIC for the earlier period.

groups at time t and in temporary outgoing rotation groups at time $t-1$. Then, I pile up all matched observations for all years. Note that the sample does not have any observations in 1996 since data in 1995 and in 1996 are not matchable.

Table 2.13: The First Difference Results: 1-digit (1993-1995 and 1997-2002)

Variables	Level				First Difference			
	No RW (1)		With RW (2)		No RW (3)		With RW (4)	
	Coeff	StdE	Coeff	StdE	Coeff	StdE	Coeff	StdE
Weighted Std Dev for Ind	0.083	.	0.056	.	0.022	.	0.022	.
Weighted Std Dev for Occ	0.138	.	0.107	.	0.060	.	0.073	.
External reference wage	.	.	0.117	0.032	.	.	−0.047	0.041
Internal reference wage	.	.	0.214	0.037	.	.	0.003	0.039
Age	−4.195	0.228	−4.187	0.228	−0.070	0.036	−0.071	0.036
Married	0.069	0.006	0.069	0.006	0.038	0.027	0.038	0.027
Union Covered	0.176	0.006	0.175	0.006	0.035	0.012	0.035	0.012
High school graduate	0.204	0.007	0.204	0.007	0.080	0.027	0.08	0.027
Associate degree	0.312	0.009	0.313	0.009	0.114	0.033	0.113	0.033
Bachelors degree	0.434	0.009	0.434	0.009	0.251	0.036	0.251	0.036
Masters degree	0.494	0.012	0.494	0.012	0.329	0.048	0.329	0.048
Professional degree	0.465	0.022	0.466	0.022	0.136	0.073	0.136	0.073
Doctoral degree	0.516	0.024	0.515	0.024	0.201	0.091	0.202	0.091
Mining	0.191	0.021	0.141	0.023	−0.059	0.056	−0.061	0.056
Construction	0.036	0.009	0.031	0.009	0.028	0.021	0.028	0.021
Manufacturing	0.060	0.005	0.019	0.008	0.026	0.012	0.025	0.014
Transportation, commun	0.085	0.007	0.051	0.009	0.001	0.018	0.001	0.019
Wholesale and retail trade	−0.128	0.004	−0.075	0.010	−0.032	0.011	−0.032	0.015
Finance, insurance and real	0.043	0.006	0.042	0.006	0.016	0.018	0.016	0.018
Services	−0.057	0.004	−0.049	0.004	−0.002	0.009	−0.002	0.010
Occupations (1-digit)	Included							

* For the level, pooled data over 1992-2002 are used

Table 2.13 shows the results of the first-difference model using the 1-digit industry classification. Columns (1) and (2) show results without and with the reference wage variables using the original equation (not including individual dummy variable), respectively; columns (3) and (4) show results without and with the reference wage variables using the first-difference equation (2.2).

By comparing columns (1) and (3) we find that adding individual dummy variables (or first differencing) reduces the weighted standard deviation of interindustry wage differentials by a huge amount. It implies that most of interindustry wage differentials are explained by differences in workers' ability by industry. It is similar to the result of Krueger and Summers (1988) when the measurement error is not fixed.[20]

Table 2.14: The First Difference Results: 2-digit (1993-1995 and 1997-2002)

Variables	Level				First Difference			
	No RW (1)		With RW (2)		No RW (3)		With RW (4)	
	Coeff	StdE	Coeff	StdE	Coeff	StdE	Coeff	StdE
Weighted Std Dev for Ind	0.123	.	0.104	.	0.111	.	0.110	.
Weighted Std Dev for Occ	0.164	.	0.142	.	0.085	.	0.078	.
External reference wage	.	.	0.088	0.015	.	.	0.066	0.018
Internal reference wage	.	.	0.085	0.014	.	.	−0.001	0.017
Age	−3.751	0.220	−3.737	0.219	−0.068	0.036	−0.068	0.036
Married	0.056	0.005	0.056	0.005	0.032	0.027	0.033	0.027
Union Covered	0.170	0.006	0.17	0.006	0.035	0.012	0.036	0.012
High school graduate	0.179	0.007	0.18	0.007	0.077	0.027	0.076	0.027
Associate degree	0.243	0.009	0.243	0.009	0.112	0.033	0.110	0.033
Bachelors degree	0.379	0.009	0.379	0.008	0.243	0.037	0.242	0.037
Masters degree	0.459	0.012	0.459	0.012	0.324	0.048	0.324	0.048
Professional degree	0.362	0.026	0.361	0.026	0.137	0.074	0.137	0.074
Doctoral degree	0.484	0.025	0.485	0.025	0.184	0.091	0.181	0.091
Industries (2-digit)	Included							
Occupations (2-digit)	Included							

* For the level, pooled data over 1992-2002 are used

In contrast with table 2.13, first differencing (or adding individual dummy variables) reduces the weighted standard deviation only by 10% when the 2-digit (or 3-digit) industry classification is used as shown in tables 2.14 (or 2.15).

Through the above three tables we find that the effect of adding individual dummy variable on the interindustry differentials varies across industry classifications. We also find that taking account of the unobserved ability in this way does not reduce the interindustry wage differentials considerably when we use a detailed industry classification. One explanation for the difference between the results for the one-digit industries

[20] Economic variable is frequently measured with error. Krueger and Summers derive a first-difference estimator that is consistent if a set of dummy variables is measured with error in the appendix. When the measurement error is not fixed, the first difference reduces interindustry wage differentials substantially; however, if the measurement error is fixed, interindustry wage differentials from the first-difference regression is similar to interindustry wage differentials from original regression. I do not provide results with fixing measurement error. Instead, I compare the results of first-difference regressions through various industry classifications.

Table 2.15: The First Difference Results: 3-digit (1993-1995 and 1997-2002)

Variables	Level				First Difference			
	No RW (1)		With RW (2)		No RW (3)		With RW (4)	
	Coeff	StdE	Coeff	StdE	Coeff	StdE	Coeff	StdE
Weighted Std Dev for Ind	0.149	.	0.123	.	0.133	.	0.132	.
Weighted Std Dev for Occ	0.214	.	0.168	.	0.221	.	0.215	.
External reference wage	.	.	0.193	0.007	.	.	0.055	0.009
Internal reference wage	.	.	0.103	0.007	.	.	0.031	0.008
Age	−3.566	0.215	−3.495	0.212	−0.078	0.036	−0.078	0.036
Married	0.051	0.005	0.051	0.005	0.025	0.028	0.026	0.028
Union Covered	0.164	0.006	0.158	0.006	0.031	0.012	0.031	0.012
High school graduate	0.157	0.007	0.153	0.007	0.069	0.028	0.067	0.027
Associate degree	0.207	0.009	0.203	0.009	0.095	0.034	0.093	0.034
Bachelors degree	0.330	0.008	0.323	0.008	0.225	0.037	0.22	0.037
Masters degree	0.418	0.012	0.408	0.011	0.310	0.050	0.306	0.050
Professional degree	0.321	0.026	0.312	0.026	0.174	0.076	0.178	0.076
Doctoral degree	0.453	0.025	0.442	0.025	0.209	0.094	0.202	0.094
Industries (3-digit)	Included							
Occupations (3-digit)	Included							

* For the level, pooled data over 1992-2002 are used

and those for the two- and three-digit industries is that there must be a lot of unmeasured heterogeneity in the one-digit industry categories that is taken into account when we control for two- or three-digit industries. Thus, first differencing changes things a lot if we use one-digit categories, but not if we use two- or three-digit categories.[21]

Comparison of columns (3) and (4) of tables 2.13, 2.14 and 2.15 shows that adding the reference wages when the individual dummy variables are already included in the regression has little effect on interindustry wage differentials, which means that the reference wages only capture unobserved ability. However, if we compare columns (2) and (4), we can see the effect of adding industry dummy variables on interindustry wages differentials when the reference wages are already included in the regression. Tables 2.14 and 2.15 show that the effect of adding industry dummy variables has little effect although table 2.13 shows somewhat different results.

It is hard to explain why adding either reference wages or individual dummies does

[21]In the future, it could be worth considering why the effect of the first difference changes across industry and how much fixing measurement error reduces the effect of the first difference with detailed industry classifications.

not change interindustry wage differentials when other is already included although adding only one of the two reduces interindustry wage differentials a lot. One of the reason I guess is that the two reduce interindustry wage differentials in different ways. For example, interindustry wage differentials which would decrease a lot if the reference wages alone are added do not change because additionally included individual dummy variables offset the influence of the reference wages.[22] Therefore, we cannot conclude that the effect of adding the reference wages on interindustry wage differentials is void.

2.6 Conclusion

In this chapter I have considered whether efficiency wage theory could account for the interindustry wage differentials. Because of the difficulty in obtaining appropriate variables which represent reasons for the efficiency wage, this chapter narrows down to a test of whether a "fair wage" model explains a large part of interindustry wage differentials.

I define two reference wages, based on the perspective of fair wage models. The internal reference wage of a worker is the median wage of highest median wage occupation among all occupations in the worker's industry. The external reference wage of a worker is the median wage of the highest median wage industry among all industries in the occupation of the worker. Then, I estimate regressions with and without the two reference wage variables and compare the results of the two estimations. For most of the industries, the wage differentials reduce. The range of dispersion of the differentials shrinks considerably as well. Most of all, the weighted standard deviation of interindustry wage differentials decreases by almost 20% for each of the industry classifications (one-, two-, and three-digit).

[22] For example, there are three industries A, B, and C and their coefficient estimates are 1, 4, and 10 when no controls are added. Then, interindustry wage differentials are 4.59. First, adding the reference wages decreases the coefficient estimates of A and C from 1 and 10 to 0 and 7, respectively. Then, interindustry wage differentials falls from 4.59 to 3.51. Second, adding individual dummy variables increases the coefficient estimate of A and C from 1 and 10 to 3 and 11, respectively. Then, interindustry wage differentials falls from 4.59 to 4.36. Third, adding both the reference wages and individual dummy variables affect the coefficient estimates in opposite directions, producing 1, 4, and 9 for industry A, B, and C, respectively. Then, interindustry wage differentials are 4.04. It is a possible reason for producing tables 2.14 and 2.15.

I conduct additional tests using variables for profit and unionization, which have been considered as important reasons for the industry wage differentials. The regression results say that neither profit nor union threat effects contribute very much to explaining the differentials.

In this chapter, I find that inclusion of only two variables representing efficiency wage theory reduces the interindustry wage differentials by about 20%. It implies that efficiency wage theory can be one of major keys to accounting for the wage differentials. Adding individual dummy variables does not contradict this conclusion although the first-difference regression does not produce clear results.

2.A Tables – Full Output for 3-digit Industry

In this section, I provide full outputs for table 2.4 and table 2.8. The first two columns (headed “no reference”) show regressions without variables reference wages; the next two (headed“reference wage”) present regressions that include both internal and external reference wage variables. The weighted standard deviations of estimated coefficients on industry dummies shrink almost by 20%. Coefficients on the reference wage variables are significant.

Table 2.A.1: Full Output of Interindustry Wage Differentials : 3-digit (1992-2002)

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Weighted Std Dev for Industry	0.149		0.123	
Weighted Std Dev for Occupation	0.214		0.168	
External reference wage	-		0.193	0.007
Internal reference wage	-		0.103	0.007
Age	3.387	0.179	3.313	0.177
Age squared	−3.566	0.215	−3.495	0.212
Female	−0.172	0.005	−0.169	0.005
Married	0.051	0.005	0.051	0.005
White	0.065	0.009	0.064	0.009
Black	0.003	0.011	0.003	0.011
Union Covered	0.164	0.006	0.158	0.006
High school graduate	0.157	0.007	0.153	0.007
Associate degree	0.207	0.009	0.203	0.009

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Table 2.A.1 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Bachelors degree	0.330	0.008	0.323	0.008
Masters degree	0.418	0.012	0.408	0.011
Professional degree	0.321	0.026	0.312	0.026
Doctoral degree	0.453	0.025	0.442	0.025
Metal mining (10)	0.296	0.061	0.266	0.060
Coal mining (12)	0.315	0.050	0.275	0.049
Oil and gas extraction (13)	0.183	0.034	0.125	0.034
Nonmetallic mining and quarrying, except fuel (14)	0.185	0.049	0.172	0.049
Construction (15, 16, 17)	0.078	0.013	0.070	0.013
Meat products (201)	−0.043	0.027	−0.046	0.026
Dairy products (202)	0.072	0.047	0.078	0.046
Canned, frozen and preserved fruits and vegetables (203)	0.019	0.041	0.012	0.041
Grain mill products (204)	0.135	0.052	0.120	0.051
Bakery products (205)	0.020	0.039	0.014	0.039
Sugar and confectionery products (206)	0.130	0.051	0.122	0.050
Beverage industries (208)	0.146	0.040	0.117	0.039
Miscellaneous food preparations and kindred products (207, 209)	0.048	0.038	0.044	0.038
Not specified food industries	0.300	0.273	0.366	0.270
Tobacco manufactures (21)	0.278	0.074	0.271	0.073
Knitting mills (225)	0.010	0.053	0.029	0.052
Dyeing and finishing textiles, except wool and knit goods (226)	0.040	0.083	0.059	0.082
Carpets and rugs (227)	0.091	0.073	0.141	0.072
Yarn, thread, and fabric mills (221−224, 228)	0.089	0.033	0.058	0.032
Miscellaneous textile mill products (229)	0.045	0.070	0.066	0.069
Apparel and accessories, except knit (231−238)	−0.041	0.026	−0.086	0.026
Miscellaneous fabricated textile products (239)	−0.077	0.044	−0.045	0.043
Pulp, paper, and paperboard mills (261−263)	0.337	0.031	0.244	0.031
Miscellaneous paper and pulp products (267)	0.105	0.035	0.086	0.035
Paperboard containers and boxes (265)	0.081	0.040	0.064	0.039
Newspaper publishing and printing (271)	0.008	0.030	−0.019	0.030
Printing, publishing, and allied industries, except newspapers (272−279)	0.088	0.019	0.055	0.019
Plastics, synthetics, and resins (282)	0.154	0.041	0.118	0.041
Drugs (283)	0.261	0.028	0.204	0.028
Soaps and cosmetics (284)	0.151	0.046	0.117	0.046
Paints, varnishes, and related products (285)	0.194	0.075	0.174	0.074
Agricultural chemicals (287)	0.370	0.087	0.348	0.086
Industrial and miscellaneous chemicals (281, 286, 289)	0.270	0.026	0.226	0.025
Petroleum refining (291)	0.326	0.046	0.291	0.046
Miscellaneous petroleum and coal products (295, 299)	0.353	0.108	0.336	0.107
Tires and inner tubes (301)	0.362	0.064	0.338	0.064
Other rubber products, and plastics footwear and belting (302−306)	0.060	0.041	0.056	0.041
Miscellaneous plastics products (308)	0.049	0.024	0.002	0.024
Leather tanning and finishing (311)	0.071	0.117	0.111	0.116
Footwear, except rubber and plastic (313, 314)	0.179	0.082	0.139	0.081
Leather products, except footwear (315−317, 319)	−0.074	0.073	−0.047	0.073
Logging (241)	0.048	0.072	0.031	0.071
Sawmills, planing mills, and millwork (242, 243)	0.084	0.030	0.072	0.030
Wood buildings and mobile homes (245)	−0.013	0.075	0.032	0.074

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Table 2.A.1 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Miscellaneous wood products (244, 249)	−0.032	0.050	−0.016	0.049
Furniture and fixtures (25)	0.002	0.024	−0.012	0.024
Glass and glass products (321−323)	0.048	0.039	0.035	0.039
Cement, concrete, gypsum, and plaster products (324, 327)	0.123	0.038	0.126	0.037
Structural clay products (325)	−0.005	0.089	0.023	0.088
Pottery and related products (326)	0.073	0.104	0.126	0.103
Miscellaneous nonmetallic mineral and stone products (328, 329)	0.164	0.055	0.161	0.054
Blast furnaces, steelworks, rolling and finishing mills (331)	0.135	0.028	0.097	0.028
Iron and steel foundries (332)	0.182	0.061	0.178	0.060
Primary aluminum industries (3334, part 334, 3353−3355, 3363, 3365)	0.154	0.047	0.126	0.046
Other primary metal industries (3331, 3339, part 334, 3351, 3356, 3357, 3364, 3366, 3369, 339)	0.034	0.041	0.037	0.041
Cutlery, handtools, and general hardware (342)	0.044	0.048	0.036	0.047
Fabricated structural metal products (344)	0.103	0.026	0.075	0.026
Screw machine products (345)	0.007	0.076	0.048	0.075
Metal forgings and stampings (346)	0.088	0.048	0.084	0.047
Ordnance (348)	0.101	0.071	0.118	0.070
Miscellaneous fabricated metal products (341, 343, 347, 349)	0.083	0.029	0.065	0.029
Not specified metal industries	−0.010	0.223	−0.002	0.220
Engines and turbines (351)	0.174	0.064	0.156	0.063
Farm machinery and equipment (352)	0.161	0.048	0.159	0.048
Construction and material handling machines (353)	0.174	0.038	0.147	0.037
Metalworking machinery (354)	0.111	0.035	0.088	0.035
Office and accounting machines (3578, 3579)	0.137	0.094	0.122	0.093
Computers and related equipment (3571−3577)	0.198	0.025	0.116	0.025
Machinery, except electrical, n.e.c. (355, 356, 358, 359)	0.112	0.019	0.069	0.019
Not specified machinery	0.104	0.223	0.101	0.220
Household appliances (363)	0.192	0.052	0.172	0.051
Radio, TV, and communication equipment (365, 366)	0.162	0.028	0.114	0.028
Electrical machinery, equipment, and supplies, n.e.c. (361, 362, 364, 367, 369)	0.150	0.017	0.086	0.017
Not specified electrical machinery, equipment, and supplies	0.049	0.137	0.054	0.135
Motor vehicles and motor vehicle equipment (371)	0.213	0.018	0.153	0.018
Aircraft and parts (372)	0.223	0.029	0.176	0.029
Ship and boat building and repairing (373)	0.137	0.044	0.116	0.044
Railroad locomotives and equipment (374)	0.170	0.083	0.158	0.082
Guided missiles, space vehicles, and parts (376)	0.283	0.033	0.227	0.033
Cycles and miscellaneous transportation equipment (375, 379)	0.114	0.069	0.145	0.068
Scientific and controlling instruments (381, 382 except 3827)	0.070	0.036	0.052	0.035
Medical, dental, and optical instruments and supplies (3827, 384, 385)	0.122	0.029	0.075	0.029
Photographic equipment and supplies (386)	0.113	0.053	0.083	0.053
Watches, clocks, and clockwork operated devices (387)	−0.419	0.298	−0.244	0.295
Toys, amusement, and sporting goods (394)	−0.089	0.045	−0.079	0.044
Miscellaneous manufacturing industries (39 except 394)	−0.012	0.028	−0.023	0.028
Not specified manufacturing industries	−0.147	0.059	−0.135	0.058
Railroads (40)	0.161	0.035	0.143	0.035
Bus service and urban transit (41, except 412)	0.095	0.038	0.071	0.038
Taxicab service (412)	−0.061	0.077	−0.013	0.076
Trucking service (421, 423)	0.112	0.016	0.087	0.016

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Table 2.A.1 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Warehousing and storage (422)	−0.086	0.047	−0.043	0.047
Water transportation (44)	0.163	0.049	0.120	0.049
Air transportation (45)	0.073	0.026	0.039	0.026
Pipe lines, except natural gas (46)	0.342	0.137	0.321	0.135
Services incidental to transportation (47)	0.055	0.034	0.040	0.033
Radio and television broadcasting and cable (483, 484)	0.051	0.029	−0.000	0.029
Telephone communications (481)	0.194	0.018	0.145	0.018
Telegraph and miscellaneous communications services (482, 489)	0.249	0.136	0.211	0.135
Electric light and power (491)	0.328	0.025	0.257	0.025
Gas and steam supply systems (492, 496)	0.320	0.038	0.276	0.037
Electric and gas, and other combinations (493)	0.263	0.050	0.225	0.049
Water supply and irrigation (494, 497)	0.130	0.077	0.121	0.076
Sanitary services (495)	0.086	0.041	0.068	0.041
Not specified utilities	0.441	0.384	0.435	0.380
Motor vehicles and equipment (501)	0.029	0.041	0.001	0.041
Furniture and home furnishings (502)	−0.051	0.060	−0.025	0.059
Lumber and construction materials (503)	0.015	0.041	0.017	0.041
Professional and commercial equipment and supplies (504)	0.048	0.029	0.004	0.029
Metals and minerals, except petroleum (505)	0.099	0.065	0.098	0.064
Electrical goods (506)	0.064	0.034	0.043	0.034
Hardware, plumbing and heating supplies (507)	0.066	0.034	0.061	0.034
Machinery, equipment, and supplies (508)	0.088	0.024	0.062	0.024
Scrap and waste materials (5093)	−0.029	0.047	−0.020	0.047
Miscellaneous wholesale, durable goods (509 except 5093)	−0.031	0.053	−0.015	0.052
Paper and paper products (511)	0.116	0.061	0.101	0.061
Drugs, chemicals and allied products (512, 516)	0.153	0.038	0.120	0.038
Apparel, fabrics, and notions (513)	0.012	0.057	0.016	0.056
Groceries and related products (514)	0.025	0.021	−0.001	0.021
Farm−product raw materials (515)	−0.120	0.062	−0.080	0.061
Petroleum products (517)	0.228	0.042	0.201	0.041
Alcoholic beverages (518)	0.073	0.049	0.074	0.049
Farm supplies (5191)	−0.109	0.049	−0.100	0.049
Miscellaneous wholesale, nondurable goods (5192−5199)	−0.061	0.035	−0.055	0.035
Not specified wholesale trade	−0.091	0.136	−0.045	0.134
Lumber and building material retailing (521, 523)	−0.001	0.028	0.000	0.028
Hardware stores (525)	−0.088	0.044	−0.072	0.043
Retail nurseries and garden stores (526)	−0.120	0.064	−0.071	0.063
Mobile home dealers (527)	−0.123	0.107	−0.085	0.106
Department stores (531)	−0.118	0.016	−0.137	0.015
Variety stores (533)	−0.179	0.049	−0.156	0.049
Miscellaneous general merchandise stores (539)	−0.176	0.057	−0.126	0.056
Grocery stores (541)	−0.072	0.015	−0.082	0.015
Dairy products stores (545)	−0.001	0.157	0.056	0.155
Retail bakeries (546)	−0.172	0.048	−0.144	0.047
Food stores, n.e.c. (542, 543, 544, 549)	−0.145	0.052	−0.115	0.051
Motor vehicle dealers (551, 552)	0.082	0.021	0.057	0.020
Auto and home supply stores (553)	−0.078	0.031	−0.069	0.030
Gasoline service stations (554)	−0.237	0.035	−0.176	0.035
Miscellaneous vehicle dealers (555, 556, 557, 559)	0.037	0.057	0.045	0.056
Apparel and accessory stores, except shoe (56, except 566)	−0.024	0.030	−0.028	0.029
Shoe stores (566)	−0.055	0.091	−0.009	0.090
Furniture and home furnishings stores (571)	−0.060	0.033	−0.038	0.032

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Table 2.A.1 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Household appliance stores (572)	0.007	0.073	0.026	0.072
Radio, TV, and computer stores (5731, 5734)	0.036	0.040	0.034	0.039
Music stores (5735, 5736)	−0.185	0.063	−0.162	0.062
Eating and drinking places (58)	−0.144	0.017	−0.087	0.017
Drug stores (591)	−0.054	0.029	−0.077	0.028
Liquor stores (592)	−0.174	0.058	−0.128	0.058
Sporting goods, bicycles, and hobby stores (5941, 5945, 5946)	−0.150	0.037	−0.141	0.037
Book and stationery stores (5942, 5943)	−0.068	0.039	−0.064	0.038
Jewelry stores (5944)	−0.085	0.048	−0.058	0.047
Gift, novelty, and souvenir shops (5947)	−0.194	0.054	−0.148	0.053
Sewing, needlework and piece goods stores (5949)	−0.262	0.083	−0.200	0.082
Catalog and mail order houses (5961)	0.060	0.054	0.058	0.054
Vending machine operators (5962)	0.005	0.067	0.019	0.066
Direct selling establishments (5963)	−0.115	0.062	−0.054	0.061
Fuel dealers (598)	0.071	0.045	0.078	0.045
Retail florists (5992)	−0.324	0.056	−0.287	0.056
Miscellaneous retail stores (593, 5948, 5993−5995, 5999)	−0.091	0.027	−0.098	0.026
Not specified retail trade	0.018	0.076	0.025	0.075
Banking (60 except 603 and 606)	0.097	0.016	0.059	0.016
Savings institutions, including credit unions (603, 606)	0.060	0.035	0.043	0.034
Credit agencies, n.e.c. (61)	0.145	0.025	0.107	0.025
Security, commodity brokerage, and investment companies (62, 67)	0.194	0.026	0.139	0.026
Insurance (63, 64)	0.164	0.016	0.135	0.016
Real estate, including real estate−insurance offices (65)	0.011	0.021	−0.026	0.021
Advertising (731)	0.070	0.037	0.039	0.037
Services to dwellings and other buildings (734)	−0.113	0.027	−0.084	0.026
Personnel supply services (736)	−0.060	0.021	−0.097	0.021
Computer and data processing services (737)	0.147	0.018	0.106	0.018
Detective and protective services (7381, 7382)	−0.146	0.037	−0.134	0.036
Business services, n.e.c. (732, 733, 735, 7383−7389)	−0.021	0.018	−0.071	0.018
Automotive rental and leasing, without drivers (751)	−0.088	0.046	−0.081	0.045
Automotive parking and carwashes (752, 7542)	−0.141	0.057	−0.098	0.056
Automotive repair and related services (753, 7549)	−0.088	0.026	−0.091	0.026
Electrical repair shops (762, 7694)	0.019	0.057	0.036	0.056
Miscellaneous repair services (763, 764, 7692, 7699)	0.024	0.031	0.003	0.031
Private households (88)	−0.209	0.057	−0.141	0.056
Hotels and motels (701)	−0.030	0.019	−0.051	0.019
Lodging places, except hotels and motels (702, 703, 704)	−0.176	0.077	−0.137	0.076
Laundry, cleaning, and garment services (721 except part 7219)	−0.112	0.036	−0.086	0.036
Beauty shops (723)	−0.247	0.060	−0.189	0.059
Barber shops (724)	−0.703	0.285	−0.516	0.282
Funeral service and crematories (726)	0.165	0.103	0.170	0.102
Shoe repair shops (725)	−0.293	0.195	−0.251	0.192
Miscellaneous personal services (722, 729)	−0.173	0.040	−0.186	0.039
Theaters and motion pictures (781−783, 792)	0.102	0.035	0.054	0.035
Video tape rental (784)	−0.174	0.075	−0.112	0.074
Bowling centers (793)	−0.052	0.094	0.012	0.093
Miscellaneous entertainment and recreation services (791, 794, 799)	−0.019	0.022	−0.046	0.022
Offices and clinics of physicians (801, 803)	0.054	0.017	0.026	0.017
Offices and clinics of dentists (802)	0.056	0.040	0.030	0.040

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Table 2.A.1 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Offices and clinics of chiropractors (8041)	0.037	0.064	0.060	0.063
Offices and clinics of optometrists (8042)	0.046	0.081	0.024	0.080
Offices and clinics of health practitioners, n.e.c. (8043, 8049)	−0.031	0.112	0.028	0.110
Hospitals (806)	0.084	0.012	0.058	0.012
Nursing and personal care facilities (805)	−0.048	0.018	−0.054	0.018
Health services, n.e.c. (807, 808, 809)	0.032	0.017	−0.016	0.017
Legal services (81)	0.154	0.023	0.127	0.023
Elementary and secondary schools (821)	−0.043	0.025	−0.057	0.025
Colleges and universities (822)	0.004	0.022	−0.046	0.022
Vocational schools (824)	−0.007	0.073	−0.013	0.072
Libraries (823)	0.020	0.146	0.033	0.144
Educational services, n.e.c. (829)	0.101	0.051	0.079	0.051
Job training and vocational rehabilitation services (833)	−0.277	0.045	−0.256	0.044
Child day care services (part 835)	−0.159	0.037	−0.120	0.037
Family child care homes (part 835)	−0.105	0.194	−0.036	0.192
Residential care facilities, without nursing (836)	−0.086	0.030	−0.081	0.030
Social services, n.e.c. (832, 839)	−0.074	0.024	−0.105	0.024
Museums, art galleries, and zoos (84)	−0.061	0.073	−0.043	0.072
Labor unions (863)	0.123	0.061	0.134	0.060
Religious organizations (866)	−0.130	0.027	−0.133	0.027
Membership organizations, n.e.c. (861, 862, 864, 865, 869)	−0.000	0.031	−0.023	0.030
Engineering, architectural, and surveying services (871)	0.141	0.024	0.100	0.024
Accounting, auditing, and bookkeeping services (872)	0.109	0.027	0.080	0.027
Research, development, and testing services (873)	0.160	0.025	0.101	0.025
Management and public relations services (874)	0.073	0.029	0.037	0.028
Miscellaneous professional and related services (899)	0.055	0.070	0.034	0.069
Occupations (3-digit)	Included		Included	

Table 2.A.2: Full Output of Interindustry Wage Differentials : 3-digit (1984-1991)

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Weighted Std Dev for Industry	0.161		0.143	
Weighted Std Dev for Occupation	0.191		0.158	
External reference wage	-		0.157	0.008
Internal reference wage	-		0.078	0.007
Age	2.603	0.190	2.536	0.188
Age squared	−2.540	0.229	−2.472	0.227
Female	−0.210	0.006	−0.207	0.006
Married	0.049	0.008	0.050	0.008
White	0.057	0.012	0.057	0.012
Black	−0.004	0.014	−0.004	0.014
Union Coverd	0.175	0.007	0.172	0.007
High school graduate	0.098	0.007	0.096	0.007
Associate degree	0.169	0.009	0.166	0.009

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Table 2.A.2 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Bachelors degree	0.271	0.009	0.266	0.009
Masters and higher degree	0.347	0.012	0.343	0.012
Metal mining	0.303	0.060	0.269	0.060
Coal mining	0.441	0.048	0.399	0.047
Crude petroleum and natural gas extraction	0.302	0.032	0.258	0.032
Nonmetallic mining and quarrying, exc. fuel	0.175	0.055	0.169	0.055
Construction	0.120	0.017	0.105	0.017
Meat products	−0.020	0.031	−0.013	0.031
Dairy products	0.129	0.043	0.116	0.042
Canned and preserved fruits and vegetables	0.080	0.033	0.063	0.032
Grain mill products	0.185	0.046	0.170	0.045
Bakery products	0.044	0.041	0.044	0.041
Sugar and confectionery products	0.019	0.053	0.041	0.053
Beverage industries	0.209	0.041	0.184	0.041
Miscellaneous food preparations and kindred products	0.025	0.039	0.007	0.039
Tobacco manufacturers	0.123	0.069	0.120	0.068
Knitting mills	−0.073	0.054	−0.032	0.054
Dyeing and finishing textiles, exc. wool and knit goods	−0.027	0.089	0.012	0.088
Floor coverings, exc. hard surface	−0.054	0.074	−0.046	0.073
Yarn, thread, and fabric mills	0.084	0.031	0.069	0.030
Miscellaneous textile mill products	0.020	0.079	0.035	0.079
Apparel and accessories, exc. knit	−0.099	0.025	−0.123	0.025
Miscellaneous fabricated textile products	−0.105	0.043	−0.078	0.043
Pulp, paper, and paperboard mills	0.266	0.033	0.240	0.033
Miscellaneous paper and pulp products	0.137	0.042	0.127	0.042
Paperboard containers and boxes	0.064	0.046	0.057	0.046
Newspaper publishing and printing	−0.007	0.029	−0.028	0.029
Printing, publishing, allied industries, exc. newspapers	0.118	0.020	0.085	0.021
Plastics, synthetics, and resins	0.200	0.049	0.170	0.049
Drugs	0.233	0.033	0.190	0.033
Soaps and cosmetics	0.191	0.042	0.168	0.042
Paints, varnishes, and related products	0.138	0.060	0.107	0.059
Agricultural chemicals	0.079	0.075	0.061	0.075
Industrial and miscellaneous chemicals	0.288	0.025	0.244	0.025
Petroleum refining	0.393	0.045	0.335	0.044
Miscellaneous petroleum and coal products	−0.012	0.091	−0.014	0.090
Tires and inner tubes	0.352	0.059	0.325	0.059
Other rubber products, plastics footwear and belting	0.133	0.048	0.117	0.048
Miscellaneous plastics products	0.058	0.027	0.033	0.027
Leather tanning and finishing	0.119	0.263	0.132	0.261
Footwear, exc. rubber and plastic	−0.063	0.064	−0.045	0.063
Leather products, exc. footwear	−0.036	0.084	0.012	0.083
Logging	−0.024	0.080	−0.026	0.080
Sawmills, planing mills, and millwork	0.096	0.032	0.075	0.031
Wood buildings and mobile homes	−0.021	0.096	−0.008	0.096
Miscellaneous wood products	−0.089	0.053	−0.078	0.053
Furniture and fixtures	0.035	0.026	0.032	0.025
Glass and glass products	0.199	0.039	0.159	0.039
Cement, concrete, gypsum, and plaster products	0.081	0.040	0.064	0.039
Structural clay products	0.075	0.082	0.094	0.081
Pottery and related products	−0.048	0.098	−0.016	0.097
Miscellaneous nonmetallic mineral and stone products	0.137	0.054	0.129	0.054

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Table 2.A.2 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Blast furnaces, steelworks, rolling and finishing mills	0.256	0.033	0.235	0.033
Iron and steel foundries	0.137	0.053	0.118	0.052
Primary aluminum industries	0.304	0.055	0.294	0.054
Other primary metal industries	0.130	0.039	0.109	0.038
Cutlery, handtools, and other hardware	0.057	0.050	0.058	0.049
Fabricated structural metal products	0.076	0.027	0.059	0.026
Screw machine products	−0.038	0.076	−0.018	0.076
Metal forgings and stampings	0.158	0.053	0.144	0.053
Ordnance	0.239	0.053	0.208	0.052
Miscellaneous fabricated metal products	0.091	0.032	0.077	0.032
Not specified metal industries	0.368	0.371	0.389	0.368
Engines and turbines	0.288	0.051	0.270	0.051
Farm machinery and equipment	0.196	0.052	0.182	0.052
Construction and material handling machines	0.209	0.036	0.187	0.036
Metalworking machinery	0.163	0.035	0.148	0.035
Office and accounting machines	0.226	0.060	0.195	0.060
Electronic computing equipment	0.222	0.021	0.184	0.021
Machinery, exc. electrical, n.e.c.	0.119	0.020	0.096	0.020
Not specified machinery	−0.082	0.215	−0.026	0.213
Household appliances	0.160	0.045	0.163	0.045
Radio, T.V., and communication equipment	0.159	0.026	0.117	0.026
Electrical machinery, equipment, and supplies, n.e.c.	0.119	0.017	0.084	0.017
Not specified electrical machinery, equipment, and supplies	0.062	0.186	0.093	0.185
Motor vehicles and motor vehicle equipment	0.301	0.019	0.257	0.019
Aircraft and parts	0.214	0.025	0.181	0.025
Ship and boat building and repairing	0.191	0.047	0.177	0.047
Railroad locomotives and equipment	0.106	0.103	0.101	0.103
Guided missiles, space vehicles, and parts	0.190	0.031	0.156	0.031
Cycles and miscellaneous transportation equipment	0.154	0.072	0.155	0.071
Scientific and controlling instruments	0.157	0.036	0.129	0.035
Optical and health services supplies	0.114	0.032	0.096	0.032
Photographic equipment and supplies	0.302	0.065	0.268	0.065
Watches, clocks, and clockwork operated devices	0.037	0.169	0.061	0.168
Toys, amusement, and sporting goods	−0.083	0.047	−0.082	0.047
Miscellaneous manufacturing industries	0.021	0.030	−0.014	0.030
Not specified manufacturing industries	−0.520	0.118	−0.427	0.117
Railroads	0.296	0.037	0.265	0.037
Bus service and urban transit	−0.082	0.043	−0.075	0.043
Taxicab service	−0.136	0.085	−0.084	0.084
Trucking service	0.129	0.019	0.111	0.019
Warehousing and storage	0.006	0.050	0.023	0.050
Water transportation	0.191	0.058	0.168	0.057
Air transportation	0.157	0.030	0.115	0.030
Pipe lines, exc. natural gas	0.406	0.113	0.391	0.113
Services incidental to transportation	−0.077	0.038	−0.089	0.038
Radio and television broadcasting	−0.019	0.039	−0.046	0.039
Telephone (wire and radio)	0.272	0.020	0.233	0.021
Telegraph and miscellaneous communications services	0.071	0.049	0.029	0.049
Electric light and power	0.341	0.025	0.294	0.025
Gas and steam supply systems	0.264	0.044	0.252	0.043
Electric and gas, and other combinations	0.248	0.041	0.221	0.041
Water supply and irrigation	0.250	0.083	0.247	0.082
Sanitary services	0.128	0.065	0.117	0.065

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Table 2.A.2 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Not specified utilities	0.411	0.262	0.398	0.260
Motor vehicles and equipment	0.053	0.041	0.061	0.041
Furniture and home furnishings	0.100	0.077	0.118	0.076
Lumber and construction materials	0.064	0.048	0.045	0.048
Sporting goods, toys, and hobby goods	0.109	0.103	0.131	0.102
Metals and minerals, exc. petroleum	0.122	0.059	0.119	0.059
Electrical goods	0.026	0.035	0.017	0.035
Hardware, plumbing and heating supplies	0.012	0.042	0.011	0.042
Machinery, equipment, and supplies	0.055	0.020	0.023	0.020
Scrap and waste materials	−0.207	0.057	−0.176	0.057
Miscellaneous wholesale, durable goods	−0.113	0.084	−0.113	0.083
Paper and paper products	0.088	0.049	0.088	0.048
Drugs, chemicals, and allied products	0.141	0.042	0.113	0.042
Apparel, fabrics, and notions	−0.032	0.059	−0.029	0.059
Groceries and related products	0.046	0.023	0.041	0.022
Farm products − raw materials	−0.028	0.054	−0.009	0.054
Petroleum products	0.142	0.041	0.107	0.041
Alcoholic beverages	0.001	0.046	−0.009	0.045
Farm supplies	−0.062	0.052	−0.053	0.052
Miscellaneous wholesale, nondurable goods	−0.163	0.044	−0.150	0.044
Not specified wholesale trade	0.254	0.151	0.249	0.150
Lumber and building material retailing	−0.052	0.030	−0.048	0.030
Hardware stores	−0.169	0.051	−0.140	0.051
Retail nurseries and garden stores	−0.053	0.084	−0.029	0.084
Mobile home dealers	0.049	0.103	0.070	0.103
Department stores	−0.131	0.017	−0.151	0.016
Variety stores	−0.294	0.059	−0.246	0.059
Miscellaneous general merchandise stores	−0.059	0.058	−0.040	0.058
Grocery stores	−0.044	0.016	−0.037	0.016
Dairy products stores	−0.070	0.096	−0.066	0.095
Retail bakeries	−0.113	0.054	−0.086	0.054
Food stores, n.e.c.	−0.160	0.052	−0.141	0.051
Motor vehicle dealers	−0.006	0.026	−0.017	0.026
Auto and home supply stores	−0.142	0.036	−0.132	0.036
Gasoline service stations	−0.258	0.036	−0.209	0.036
Miscellaneous vehicle dealers	−0.008	0.068	−0.016	0.067
Apparel and accessory stores, exc. shoe	−0.144	0.034	−0.117	0.033
Shoe stores	−0.118	0.062	−0.094	0.062
Furniture and home furnishings stores	−0.083	0.036	−0.073	0.036
Household appliances, TV, and radio stores	−0.058	0.046	−0.070	0.045
Eating and drinking places	−0.225	0.016	−0.179	0.017
Drug stores	−0.112	0.033	−0.123	0.033
Liquor stores	−0.196	0.065	−0.159	0.065
Sporting goods, bicycles, and hobby stores	−0.134	0.044	−0.135	0.044
Book and stationery stores	−0.050	0.051	−0.049	0.051
Jewelry stores	0.030	0.053	0.017	0.053
Sewing, needlework, and piece goods stores	−0.302	0.080	−0.227	0.080
Mail order houses	0.042	0.060	0.038	0.060
Vending machine operators	−0.227	0.083	−0.171	0.082
Direct selling establishments	0.029	0.062	0.093	0.062
Fuel and ice dealers	−0.110	0.061	−0.103	0.060
Retail florists	−0.346	0.053	−0.280	0.053
Miscellaneous retail stores	−0.118	0.031	−0.110	0.031

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Table 2.A.2 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Banking	0.095	0.016	0.071	0.016
Savings and loan associations	0.085	0.041	0.065	0.041
Credit agencies, n.e.c.	0.076	0.026	0.065	0.026
Security, commodity brokerage, and investment companies	0.220	0.030	0.187	0.030
Insurance	0.152	0.016	0.134	0.016
Real estate, including real estate−insurance−law offices	−0.021	0.022	−0.037	0.022
Advertising	0.149	0.046	0.128	0.046
Services to dwellings and other buildings	−0.156	0.031	−0.126	0.031
Commercial research, development, and testing labs	0.169	0.035	0.130	0.035
Personnel supply services	−0.046	0.025	−0.078	0.025
Business management and consulting services	−0.004	0.033	−0.032	0.033
Computer and data processing services	0.161	0.024	0.124	0.024
Detective and protective services	−0.193	0.041	−0.199	0.041
Business services, n.e.c.	0.002	0.022	−0.038	0.022
Automotive services, exc. repair	−0.159	0.042	−0.128	0.042
Automotive repair shops	−0.117	0.045	−0.095	0.045
Electrical repair shops	−0.132	0.131	−0.120	0.130
Miscellaneous repair services	0.019	0.044	0.025	0.044
Private households	−0.381	0.055	−0.328	0.055
Hotels and motels	−0.115	0.020	−0.120	0.020
Lodging places, exc. hotels and motels	−0.211	0.076	−0.193	0.076
Laundry, cleaning, and garment services	−0.116	0.034	−0.120	0.033
Beauty shops	−0.065	0.087	−0.026	0.086
Barber shops	0.238	0.212	0.262	0.211
Funeral service and crematories	−0.112	0.090	−0.083	0.090
Shoe repair shops	−0.319	0.286	−0.231	0.284
Miscellaneous personal services	−0.095	0.042	−0.084	0.042
Theaters and motion pictures	−0.026	0.042	−0.046	0.042
Bowling alleys, billiard and pool parlors	−0.188	0.080	−0.123	0.079
Miscellaneous entertainment and recreation services	−0.071	0.029	−0.095	0.029
Offices of physicians	0.066	0.023	0.057	0.023
Offices of dentists	0.040	0.040	0.024	0.039
Offices of chiropractors	−0.098	0.090	−0.086	0.089
Offices of optometrists	−0.091	0.097	−0.084	0.097
Offices of health practitioners, n.e.c.	0.203	0.125	0.217	0.124
Hospitals	0.088	0.014	0.084	0.013
Nursing and personal care facilities	−0.075	0.021	−0.082	0.020
Health services, n.e.c.	0.050	0.021	0.022	0.021
Legal services	0.162	0.024	0.157	0.023
Elementary and secondary schools	−0.113	0.028	−0.108	0.028
Colleges and universities	−0.030	0.025	−0.077	0.025
Business, trade, and vocational schools	0.146	0.070	0.119	0.070
Libraries	−0.138	0.118	−0.095	0.117
Educational services, n.e.c.	−0.071	0.077	−0.045	0.077
Job training and vocational rehabilitation services	−0.254	0.060	−0.211	0.059
Child day care services	−0.258	0.040	−0.254	0.040
Residential care facilities, without nursing	−0.169	0.037	−0.166	0.037
Social services, n.e.c.	−0.067	0.029	−0.106	0.029
Museums, art galleries, and zoos	−0.152	0.075	−0.124	0.074
Religious organizations	−0.045	0.030	−0.074	0.030
Membership organizations	−0.019	0.026	−0.033	0.026
Engineering, architectural, and surveying services	0.149	0.025	0.109	0.025
Accounting, auditing, and bookkeeping services	0.138	0.029	0.122	0.029

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Table 2.A.2 – continued from previous page

Industry	No Reference		Reference Wage	
	Coeff	StdErr	Coeff	StdErr
Noncommercial educational and scientific research	0.160	0.061	0.117	0.061
Miscellaneous professional and related services	0.215	0.104	0.190	0.103
Occupations (1-digit)	Included		Included	

Chapter 3

Testing the Effect of Tax Reform on Income: Do We Need Instruments?

3.1 Introduction

In this paper, I present an empirical study of the effect of the change in the individual income tax rates on income. First, I propose new instrumental variables for the tax rates. Then, I compare the results using the new instruments for the tax rate with results using either no instrument or an improper instrument.

Changes in the individual income tax system have spawned a lot of empirical studies on the effect of taxation on working hours and income. Studies regarding the behavioral response to the changes in the individual income tax rates always encounter an endogeneity problem since the tax rates are determined by income or working hours. But, because of difficulty in finding appropriate instrumental variables, the severity of endogeneity problem has not been properly appreciated. Some studies simply ignore the problem and others use dubious instrumental variables.

I develop novel instrumental variables for the marginal tax rates, derived from on analyses of rotation groups in successive years of the Current Population Survey (CPS). I identify both (a) rotation groups whose appearance in the data comes either exclusively before or exclusively after the 1986 tax reforms (the "non-matched" rotation groups), and (b) rotation groups who appear in the data both before and after the reforms (the "matched" rotation groups). I then use the two sets of non-matched rotation groups to get the estimates of the coefficients from ordered probit analysis of the marginal tax rates. Next, I use these ordered probit coefficient estimates to predict the pre- and post-reform marginal tax rates of the matched rotation groups. I then use these predicted marginal tax rates as instruments for actual marginal tax rates in analysis of the behavioral response of the matched rotation groups to the Tax Reform Act of 1986.

Regression results imply that the tax rates are endogenous to income and replacing the tax rates with the counterfactual tax rates solves the endogeneity problem. The regressions using the instruments proposed here also imply that the tax rate changes have no significant effect on medium-income earners in the short run.

In the next section, I review previous studies. In the third section, I explain how I carry out the estimation. In the fourth section, I present the regression results. In the final section, I summarize this paper.

3.2 Literature Review

3.2.1 Theoretical Background

There have been a lot of studies on behavioral responses to the changes in the tax rates. The changes in the tax rates raise or reduce the real wage rates and bring about the changes in working hours as well as participation rates. Therefore, researchers initially focused on the responses of labor supply to the changes in the tax rates. Recently, however, researchers pointed out that the labor supply responses were only one component of what the changes in the tax rates drive. The changes in the tax rates could affect the form of compensation and distribution of working hours among jobs as well. Therefore, economists paid attention to an elasticity which measures all these changes: the elasticity of taxable income with respect to the tax rate. And, empirical studies on taxation these days clustered on measuring the elasticity.[1]

I begin this section with providing a simple model. Workers face following utility maximization problem:

$$\begin{aligned} &\max_{c,l}\, u(c, 1-l) \\ &\text{s.t.} c \leq wl[1-\tau(wl)], \end{aligned} \tag{3.1}$$

where c is consumption, l is working hours, and time endowment are normalized to

[1] Saez, Slemrod, and Giertz (2011) provide a great review on elasticity of the taxable income.

1. w is before-tax wage rate. $\tau(\cdot)$ is the tax schedule, which is a function of taxable income. We assume that there is no tax deduction and no tax shelter. So, entire income is taxable.[2]

The solution to this problem is

$$c = c([1 - \tau(\cdot)], w) \text{ and}$$
$$l = l([1 - \tau(\cdot)], w).$$

Then, income is by definition

$$y = wl = y([1 - \tau(\cdot)], w^*). \tag{3.2}$$

w^* indicates the equilibrium wage at which labor supply, $l = l([1 - \tau(\cdot)], w)$, and labor demand cross. Equation (3.2) implies that income is a function of the tax schedule and the market wage. And, the change in the tax rate induces income change only through change in labor supply if there is no change in market wage. According to this simple model, therefore, it is enough to test the labor supply responses if we want to see behavioral responses to the changes in the tax rates.

I make the problem more realistic by allowing for the tax deduction and the tax shelter. Then, the budget constraint will be

$$c \leq b[wl + E][1 - \tau(b[wl + E])] + [1 - b][wl + E] \tag{3.3}$$
$$\text{or } c \leq bwl[1 - \tau(bwl)] + [1 - b]wl + E[1 - t]. \tag{3.4}$$

Right hand sides of (3.3) and (3.4) are after-tax disposable income when non-labor income is put in the taxable account and the shelter account, respectively. b represents the portion of taxable income among income in the taxable account or tax base. In reality the portion will be a function of income but it is simplified to a constant. E

[2]Other studies provide model with flat tax rate. But, it is not realistic and, does not provide any equation appropriate for empirical tests. In regression equation, the flat tax rate is perfectly correlated to constant. In the first difference form, which is used in empirical studies in general, the change in the flat tax rate is not separately recognized from the time trend.

is non-labor income and it is assumed to be able to be freely moved to tax shelter. When some income is in a tax shelter like municipal bond, gains from the income are discounted. t symbolizes the discount factor. The tax schedule, $\tau(\cdot)$, is assumed to be progressive. Note that putting some portion of non-labor income in the taxable income and others in the non-taxable income cannot be an maximization solution. The solution to this new problem is (c, l) such that $\max\{u(c^*, 1-l^*), u(c^{**}, 1-l^{**})\}$ where $(c^*, 1-l^*)$ and $(c^{**}, 1-l^{**})$ are solutions to max $u(c, 1-l)$ under the constraint (3.3) and under the constraint (3.4), respectively. Since disposable income in (3.3) gets smaller relative to that in (3.4) as the realized tax rate increases for given E, b, $\tau(\cdot)$, and t, rich people are more likely to put their non-labor income in the tax shelter.

Then, total income is

$$y = wl([1-\tau(\cdot)], b, t, E, w) + E. \tag{3.5}$$

Taxable income is

$$y* = b[wl([1-\tau(\cdot)], b, t, E, w) + E] \text{ or } bwl([1-\tau(\cdot)], b, t, E, w). \tag{3.6}$$

The tax base, b, affects both total income and taxable income indirectly through labor supply. It also has a direct effect on taxable income. In reality, the tax rate deduction and the tax base broadening occur simultaneously. When we consider to measure the effect of the change in the tax schedule on income, we can measure exactly the effect on total income if the indirect effect of the tax base change is ignorable. But, the effect of the tax schedule change on taxable income becomes upward biased even if we ignore the indirect effect because broadened tax base increase the taxable income directly. Therefore, if we want to see income response to the change in the tax schedule, studying total income will be a better choice. If we want to use taxable income, we need to control for the direct effect of the change in the tax base.

The effect of the tax schedule change on income can be tested by regression of the change in total income on the change in the tax schedule if other things do not change or those changes are ignorable. Since income change could be different according to people's demographic types, we need to add variables which represent those types. Then, the regression equation will be

$$\Delta \log(y_i) = \gamma \Delta \log(1 - \tau(\cdot)) + X_i \beta + \Delta \epsilon_i. \tag{3.7}$$

One remaining issue is how to measure the tax schedule. Most empirical studies use actual tax rate as a proxy for the tax schedule. The individual tax rates well illustrate the tax schedule since they are outcome of the tax schedule. Furthermore, using tax rate provides an interesting economic measure: the elasticity of income with respect to the tax rate, which shows how people change their income in response to the change in the tax rate. But, it necessarily entails a problem: *endogeneity*. Basically, an individual's tax rate is calculated from his income while he responds to the tax rate changes by changing his income. That is, income and the tax rate are simultaneously determined. Hence, in the equation (3.7), the tax rate is endogenous to income. Accordingly, without proper instruments for the tax rate, γ will be biased. This issue is addressed in the next section.

3.2.2 Empirical Studies

The U.S. experienced three waves of tax reform recently. In 1980s, both Economic Recovery Tax Act of 1981 (ERTA) and Tax Reform Act of 1986 (TRA86) decreased the highest federal income marginal tax rate from 70% to 28%. In 1990s, Clinton administration increased tax rate by Omnibus Budget Reconciliation Act of 1993 (OBRA93). And, in 2000s, Bush administration drove two tax cuts through Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA) and Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA). Studies on elasticity of taxable income with respect to the tax rate consider those tax reforms, for example Feldstein (1995), Auten and Carroll (1999), Moffitt and Wilhelm (2000) Gruber and Saez (2002), Kopczuk (2005), and Giertz (2007).

Feldstein (1995) triggers the studies on the effect of tax rate changes by measuring elasticity of taxable income with respect to the tax rate using difference-in-differences method. Auten and Carroll (1999) estimate the elasticity by running two stage least square. Their most influential contribution is that they use the counterfactual tax rate as an instrument for the actual tax rate. This instrument has been used by most of subsequent researchers to fix the endogeneity of the tax rate. Moffitt and Wilhelm (2000) suggest to include log of base-year income to control for the mean reversion. Since 1983-1989 Panel Survey of Consumer Finances do not provide real tax information, they calculate the tax rate by themselves. And, they . Gruber and Saez (2002) control for any tendency in income for a short period by using a long panel which covers ERTA and TRA86. They decomposed the behavioral responses to substitution and income effects, finding no income effect. In addition, they explored the variation of the elasticity along the income distribution. When people with very high income are excluded, the elasticity is not significant and becomes negative when broad income is used instead of taxable income. And, their estimation strategy has been followed by coming researchers by using long panels, employing three year spread, controlling for the mean reversion, and reporting both results using broad income and using taxable income. Kopczuk (2005) emphasizes the effect of tax base. A tax reform under a broad tax base produces less sensitive response than that under a narrow one. Including tax base broadness reduces the elasticity significantly. Giertz (2007) uses data which cover two decades including ERTA, TRA86, and OBRA93. He compares the elasticity in 1980s with that in 1990s. Auten, Robert, and Gee (2008) provide a introduction to EGTRRA and JGTRRA and analyze the effect of the two tax reforms on taxable income. Heim (2009) also considers the two tax reforms in 2000's but he uses different data and different tax calculator but produces similar results to previous ones. Table 3.1 summarizes these studies.[3]

[3] Saez, Slemrod, and Giertz (2011) provide a comprehensive review on empirical studies. In addition, they calculate revenue-maximizing tax rate either when there is no restriction or when there is income shifting. They further discuss income shifting considering how people change their choice between individual income tax and corporate income tax by shifting their corporation's legal form responding to a tax reform. They also discuss how the length of period of analysis (short-term vs. long-term) affects the elasticity.

Table 3.1: Summary of Previous Studies

Author	Feldstein (1995)	Auten and Carroll (1999)	Moffitt and Wilhelm (2000)
DATA			
- Event	TRA86	TRA86	TRA86
- Data	NBER tax panel	SOI	1983-89 Panel SCF
- Years	1985-1988	1985-1989	1982-1988*
- Type	panel	panel	panel
- Sample	married only; τ (in 1985) $\geq$ 22%; no S Corporation	income (in 1985)>$21K(joint), $15.6K(single); no AMT; no S corporation; age 22-55	low income dummy included in regression
METHODOLOGY			
- Method	DID	2SLS	2SLS
- Equation	$\gamma = \frac{\Delta \log(y_t) - \Delta \log(y_c)}{\Delta \log(1-\tau_t) - \Delta \log(1-\tau_c)}$	$\Delta \log(y) = \gamma \Delta \log(1-\tau) + \delta MR + X\beta$	$\Delta \log(y) = \gamma \Delta \log(1-\tau) + \delta MR + X\beta$
- Spread in years	3 years	4 years	6 years
- Income	taxable income‡	gross income (=broad income†)	Adjusted Gross Income (AGI)
- Tax rate	federal τ	federal τ+state τ	federal τ
- Tax Calculator	none	CBO	Authors calculation
- Instrument for τ	none	counterfactual τ**	log 1983 house value and life insurance
- Mean Reversion	none	log of 1985 income	none [I]; 1982 AGI [II]
RESULTS			
- Elasticity	[[high minus medium]]1.10 ; [[highest minus high]]3.05; [[highest minus medium]]2.14	.57 (.12)	[I] .552 (.224); [II] 1.006 (.443)
- Medium income only	see above	not calculated	not calculated
- One-year spread	not calculated	not calculated	not calculated

§Combinations of numbers of letters in [ ] in RESULTS means that the elasticity is the output when related DATA and METHODOLOGY are used. For example, [II]1.006 under Moffitt and Wilhelm (2000) is the regression output when 1982 AGI is used to control for mean reversion.

* Moffitt and Wilhelm (2000) use 1983-1989 panel data, but the survey data provide previous year's tax information.

** $\hat{\tau_{86}} = \tau_{86}$ and $\hat{\tau_{87}}$ is obtained by applying year t tax law to year $t-1$ income.

†: Broad income = total income in 1040 - capital gains or losses (- social security benefits)

†† Broad income = total income in 1040 - capital gains or losses - supplemental income or loss (Schedule E)

Table 3.1: Summary of Previous Studies - continued

Author	Gruber and Saez (2002)	Kopczuk (2005)	Giertz (2007)
DATA			
- Event	TRA86	TRA86	TRA86 [A]; and OBRA93 [B]
- Data	CWHS	Univ. Michigan Tax Panel	CWHS [a]; and SOI [b]***
- Years	1979-1990	1979-1990	1979-2001
- Type	panel	panel	panel
- Sample	base-year broad income > $10K		base year broad income > $10K
METHODOLOGY			
- Method	2SLS	2SLS	2SLS
- Equation	$\Delta\log(y) = \gamma\Delta\log(1-\tau) + \delta MR + X\beta$	$\Delta\log(y) = \gamma\Delta\log(1-\tau)$ $+\delta MR + \theta TB + X\beta$	$\Delta\log(y) = \gamma\Delta\log(1-\tau) + \delta MR + X\beta$
- Spread in years	3 years	3 years	3 years
- Income	broad income† [i]; taxable income‡ [ii]	broad income† [i]; taxable income‡ [ii]	broad income†† [i]; taxable income‡‡ [ii]
- Tax rate	federal $\tau^\star$+state τ	federal $\tau^\star$+state τ	federal τ+state τ
- Tax Calculator	NBER TAXSIM	NBER TAXSIM	CBO internal calculator
- Instrument for τ	counterfactual τ**	counterfactual τ**	counterfactual τ**
- Mean Reversion	none [I]; log of base-year income [II]; a ten-piece spline of the income [III]	log of base-year income	none [I]; log of base-year income [II]; a ten-piece spline of the income [III];
RESULTS			
- Elasticity	[I-i] -.30 (.120); [I-ii] -.462 (.194); [II-i] .17 (.106); [II-ii] .611 (.144); [III-i] .12 (.106); [III-ii] .40 (.144)	[i] .096 (.112) [ii] .197 (.218)	[A-a-III-i] .124 (.11); [A-a-III-ii] .373 (.160); [B-a-III-i] .148 (.097); [B-a-III-ii] .195 (.144); [A-b-III-i] .210 (.048); [A-b-III-ii] .425 (.081); [B-b-III-i] .125 (.037); [B-b-III-ii] .198 (.060);
- Medium income only	[[10-50K]] [III-i]-.044(.085);[III-ii].18(.164) [[50-100K]] [III-i]-.065(.154);[III-ii].106(.219)	not calculated	[[100 out of 54136 dropped]] [A-a-III-ii] .084
- One-year spread	[III-i] .192 (.106); [III-ii] .400 (.144)	not calculated	not calculated

*** Baseline regression in Giertz (2007) uses SOI, including age, age^2, age^3, and itemized deduction status.

‡ Taxable income = taxable income in 1040 - capital gains or losses (- social security benefits)

‡‡ Taxable income = taxable income in 1040 - capital gains or losses - supplemental income or loss

* EITC and other characteristics are taken into account.

Table 3.1: Summary of Previous Studies - continued

Author	Auten, Carroll and Gee (2008)	Heim (2009)
DATA		
- Event	EGTRRA and JGTRRA	EGTRRA and JGTRRA
- Data	SOI	1999-2005 Edited Panel****
- Years	1999-2005	1999-2005
- Type	panel	panel
- Sample	base-year total income > \$50000	age > 25; base-year gross income > \$10000 |tax liability by calculation - tax liability in given dataset|< \$10000;
METHODOLOGY		
- Method	2SLS	2SLS
- Equation	$\Delta\log(y) = \gamma\Delta\log(1-\tau) + \delta MR + X\beta$	$\Delta\log(y) = \gamma\Delta\log(1-\tau) + \delta MR + X\beta$
- Spread in years	3 years	3 years
- Income	taxable income‡	gross income (=broad income†) [i]; taxable income‡ [ii]
- Tax rate	federal τ +state τ	federal τ +FICA τ +state τ
- Tax Calculator	CBO internal calculator	Bakija's calculator*****
- Instrument for τ	counterfactual τ**	counterfactual τ**
- Mean Reversion	log of base-year income	none [I]; log of base-year income and its change [II]; a ten-piece spline of above two [III];
RESULTS		
- Elasticity	0.389 (.075)	[I-i] -0.113 (.099); [I-ii] -0.048 (.141); [II-i] 0.198 (.073); [II-ii] 0.331 (.112); [III-i] 0.184 (.071); [III-ii] 0.317 (.111)
- Medium Income only	not calculated	[[10-50K]] [III-i]0.027(.052);[III-ii]0.320(.121); [[50-100K]] [III-i]0.043(.055);[III-ii]-0.091(.096)
- One-year spread	not calculated	not calculated

**** For details, see Weber and Bryant (2005).
***** For details, see Bakija (2008).

3.2.3 Issues in Empirical Analysis

Measuring behavioral response to the change in the tax rate requires to manage several problems. In this section, I review these issues confining the discussion to endogeneity, the tax base, income distribution, and mean reversion.[4]

Tax base indicates the room for adjustment of income in response to the tax rate changes. If deductions are allowed to a high amount, people can reduce their taxable income by putting more income to the deductions in response to the increase in the tax rate. Therefore, the elasticity of taxable income heavily depends on tax base broadness. Kopczuk (2005) measures the tax base broadness by the ratio of income subject to taxation to total income.

Income distribution is another big issue. Income inequality has steadily increased since 1980s.[5] And, TRA86 reduced high-income earners' tax rate more than other people. In this case, the income increase of high-income earners is captured as the response to the tax rate change although the income increase is mainly driven by other sources.

Mean reversion is also called regression-to-the mean, which means that people with unusually high income yesterday are likely to earn less today and vice versa. If this effect is not controlled for, the estimated elasticity of taxable income will be biased. Most of recent studies include income as a covariate in the regression to control for the effect. The inclusion of income is also considered to play a role in controlling for the income distribution.

Endogeneity is a classical issue. The change in the tax rate could affect work effort and so income level. But, the tax rate is determined by income, along with other demographic variables. Therefore, the tax rate or the net-of-tax rate $(1-\tau)$ are endogenous to income. I look into the endogeneity problem by reviewing a couple of papers.

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[4]For details of more issues, refer to Giertz (2007) and Giertz (2009)

[5]The reason for the rise in the income inequality is still disputable. Some argue that the phenomenon happened because of a secular rise in demand for skill. Import expansion has eaten the demand for unskilled workers through 1980s. Others argue that it was driven by episodic non-market factors. For example, lowered power of labor union and reduced tax rate for high-income earners were raised. For detail, see Autor, Katz, and Kearney (2008), Card and Dinardo (2002), and Piketty and Saez (2003).

Eissa (1995) has often been cited as a representative paper using difference-in-differences (DIDs) method. Eissa (1995) tries to identify the labor supply responsiveness of married women to tax rate changes using TRA86 with equation (3.8).

$$y_{jt} = \alpha + \beta d_t + \delta d_j + \gamma d_t d_j + \epsilon_{jt} \tag{3.8}$$

where t=0 or 1 and j=0 (for the control group) or 1 (for the treatment group). d_t and d_j are a time dummy and a group dummy, respectively. $d_t = t$ and $d_j = j$. y_{jt} is working hours for group j. The difference between the change in the treatment group and the change in the control group is

$$[y_{11} - y_{10}] - [y_{01} - y_{00}] = \gamma + [\epsilon_{11} - \epsilon_{10}] - [\epsilon_{01} - \epsilon_{00}],$$

which – provided the differences in ϵ have zero expectation – equals the effect of the event, γ.[6]

She uses CPS March Supplements from 1984 to 1986 and from 1990 to 1992. Criterion on grouping is income in each year: The control group consists of people whose income is at or above 99th percentile since high income earners are assumed to be more influenced by TRA86; The treatment group consists of people whose income is between 75th and 80th percentile or between 90 and 95 percentile. An obvious problem is that the group dummy variable d_i is *endogenous* to the dependent variable, y_i. Those who work more tend to earn more, and then are more likely to be included in the treatment group. In fact, she recognized that using family income as grouping criterion raises the endogeneity problem, so she substituted other household income for family income. But, since the labor supply decision may be made at the household level, other household income may not be a good replacement for the family income.

Feldstein (1995) estimates the income response to tax rate changes resulting from TRA86. He divides all observations into three groups, medium income (group 1), high income (group 2), and highest income (group 3) based on 1985 federal income tax rate.

[6]This argument is valid only if several assumptions are satisfied, for example ϵ is not serially correlated.

Then, he calculates taxable income elasticity with respect to the marginal tax rate by comparing the difference between two groups in the changes of the net-of-tax rate and the difference in the changes of taxable income. The elasticity by the calculation is[7]

$$\begin{aligned}\epsilon_{y,1-\tau} &= \frac{dy/y}{d[1-\tau]/[1-\tau]} \\ &= \frac{[dy_1/y_1]-[dy_0/y_0]}{[d[1-\tau]_1/[1-\tau]_1]-[d[1-\tau]_0/[1-\tau]_0]} \\ &\approx \frac{[\log(y_1^1)-\log(y)_1^0)]-[\log(y_0^1)-\log(y_0^0)]}{[\log([1-\tau]_1^1)-\log([1-\tau]_1^0)]-[\log([1-\tau]_0^1)-\log([1-\tau]_0^0)]},\end{aligned}$$

where subscripts indicate control or treatment group and superscripts represent before or after the event. Note that $\log(x^1)-\log(x^0)$=$\log(\frac{x^1}{x^0})$≈$\frac{x^1}{x^0}-1$=$\frac{dx}{x^0}$.

The elasticity is the same as γ from applying DIDs method to following equation:

$$\log(y_{jt}) = \phi + \psi d_j + \alpha d_t + \gamma \log(1-\tau_{jt}) + X_j\beta + \epsilon_{jt} \tag{3.9}$$

where j(=0 or 1) indicates group. y_{it} and τ_{jt} are taxable income and tax rate of group j, respectively. X_j includes other covariates. Applying the DIDs,

$$\begin{aligned}&[\log(y_{11})-\log(y_{10})]-[\log(y_{01})-\log(y_{00})] \\ =&\gamma[[\log(1-\tau_{11})-\log(1-\tau_{10})]-[\log(1-\tau_{01})-\log(1-\tau_{00})]] \\ &+[[\epsilon_{11}-\epsilon_{10}]-[\epsilon_{01}-\epsilon_{00}]].\end{aligned}$$

Then,

$$\gamma = \frac{[\log(y_{11})-\log(y_{10})]-[\log(y_{01})-\log(y_{00})]}{[\log(1-\tau_{11})-\log(1-\tau_{10})]-[\log(1-\tau_{01})-\log(1-\tau_{00})]},$$

provided the differences in ϵ have zero expectation. Therefore, Feldstein's calculation is the same as using DIDs method.

Equation (3.9) brings about the endogeneity problem since the net-of-tax rate is obviously endogenous to taxable income (y). Those who earn more tend to be imposed on higher tax rate, or lower net-of-tax rate. But, I could not find any indication of the

[7]Since Feldstein has three groups, he gets three elasticity.

steps (if any) he took to fix this problem.[8]

Auten and Carroll (1999) test income response to tax rate changes employing the first difference of the extended wage equation:

$$\Delta \log(y_{it}) = \alpha + \gamma \Delta \log(1 - \tau_{it}) + X_i \beta + \Delta \epsilon_{it} \tag{3.10}$$

where y is gross income. X_i includes variables which do not change over time but could affect change in tax rate, for example occupation dummies.

They recognize the endogeneity problem in their study and designed a new type of instrumental variable for the net-of-tax rate. They constructed the counterfactual marginal tax rate for the second year by applying the second year tax law to the first year income.

$$\tau_{89}* = \tau_{89} \text{ when 1985 income is applied}$$

Then, they use the change in the *counterfactual* log the net-of-tax rate [the counterfactual marginal tax rate - the *real* log net-of-tax rate for first year] as an instrument for the change in the real log net-of-tax rate.[9]

$$\log(\tau_{89}\widehat{) - \log}(\tau_{85}) = \log(\tau_{89}*) - \log(\tau_{85}*)$$

Most of subsequent studies use this instrument. However, the instrument is still suspected to be endogenous. Since the first year tax rate is endogenous to the first year income, the change in the counterfactual log net-of-tax rate is correlated to the change in income.

Moffitt and Wilhelm (2000) tested income and labor supply decisions responding to the change in the tax rate using 1983-1989 Panel Survey of Consumer Finances

[8] Tax incidence is a similar example. Suppose that one is interested in how much of tax burden is shifted between workers and employer and y is set as log wage and z as tax rate. The tax rate is endogenous to the wage. Recent examples of study on tax incidence are Kubik (2004) and Gruber (1997)

[9] In fact, $\log(\tau_{89}\widehat{) - \log}(\tau_{85})$ is the prediction from regression of following equation:

$$[[1 - \log(\tau_{89})] - [1 - \log(\tau_{85})]] = \xi + \eta[[1 - \log(\tau_{89}*)] - [1 - \log(\tau_{85})]] + X_i \kappa + \Delta \nu_i$$

(SCF). They tested several instruments for the change in the tax rate: dummies for 1983 marginal tax rate groups, high 1983 income dummy, high 1983 house value of life insurance value, 1983 marital status, 1983 household size, post-college, or professional-manager. The first three candidates are likely to be endogenous to income. Dummy variables for post-college or professional-manager are more likely to be included in the regression equation as covariates, which implies that exclusion restriction is not satisfied. 1983 marital status is not able to be used if married couple only are tested.[10]

In sum, empirical studies on taxation suffer from endogeneity problems unless proper instruments are used for the tax rate. Some do not use instrument for the tax rate at all, whereas others use improper instrument. Furthermore, there have not been any attempts to test the severity of the endogeneity problem since proper instrumental variables are hard to find. In this paper, I address the endogeneity problem by devising new instruments and comparing results using the new instrument with ones using either no instrument or counterfactual tax rate.

3.3 Estimation

3.3.1 Tax Reform Act of 1986 (TRA86)

This paper estimates the response of gross income to the changes in the tax rate resulting from TRA86. TRA86 significantly reduced individual and corporate federal income tax rates while broadening the tax base by eliminating or restricting a lot of tax deductions and credits.[11]

In particular, TRA86 reduced the top tax rate from 50% to 28% while it consolidated individual federal income tax rate brackets from fifteen to four. (see figure 3.2) In addition to this compression of marginal tax rates, the reform eliminated many tax deductions and shelters. It repealed the 60 percent exclusion for long-term capital gains, limited the use of losses from passive activity to offsetting income from passive activity,

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[10]Moffitt and Wilhelm (2000)'s most influential effect on empirical studies on taxation is their discussion regarding issues raised by using difference-in-differences method. They consider identification and endogeneiry problem with various type of equations.

[11]For more comprehensive discussion, see Auerbach and Slemrod (1997)

Table 3.2: Transition of Tax Brackets from 1986 to 1988 (Joint Filer)

1986			1987			1988		
Tax rate	Taxable Income		Tax rate	Taxable Income		Tax rate	Taxable Income	
	Over	Not Over		Over	Not Over		Over	Not Over
0	0	3,670	11	0	3,000			
11	3,670	5,940						
12	5,940	8,200						
14	8,200	12,840						
16	12,840	17,270				15	0	29,750
18	17,270	21,800	15	3,000	28,000			
22	21,800	26,550						
25	26,550	32,270						
28	32,270	37,980	28	28,000	45,000			
33	37,980	49,420				28	29,750	71,900
38	49,420	64,750						
42	64,750	92,370	35	45,000	90,000			
45	92,370	118,050				31	71,900	149,250
49	118,050	175,250	38.5	90,000	-			
50	175,250	-				28	149,250	-

repealed the second-earner deduction which has been allowed up to $3,000, limited the mortgage interest payment deduction, repealed the consumer interest deduction, lowered the Keogh retirement plan deduction from $30,000 to $7,000, and repealed IRA deduction for high income earners.

The radical change in the tax rate provides a good opportunity for measuring people's income response to tax rate change and brings some implications. First, high-income earners are most affected by the change in the tax rate. Second, because of the big change in the tax base, taxable income could respond more sensitively than total income. Third, individual response could be affected by other provisions of TRA86, for example the changes in the corporate income tax rates.

3.3.2 Data

I use the current Population Survey (CPS) March supplements for 1987 and 1988, which includes sufficient socio-demographic information. Since CPS does not provide tax information, I use NBER TAXSIM to calculate the federal income tax rate and taxable income since [12]

[12]Since 1990 CPS has provided tax information including federal marginal tax rate, which is calculated using internal information.

The CPS is the U.S. government's monthly survey of unemployment and labor force participation. The basic monthly data are the primary source of labor force statistics in the U.S., including data on employment, earnings, and demographics. CPS March supplements have an annual demographic file in addition to the basic monthly files.

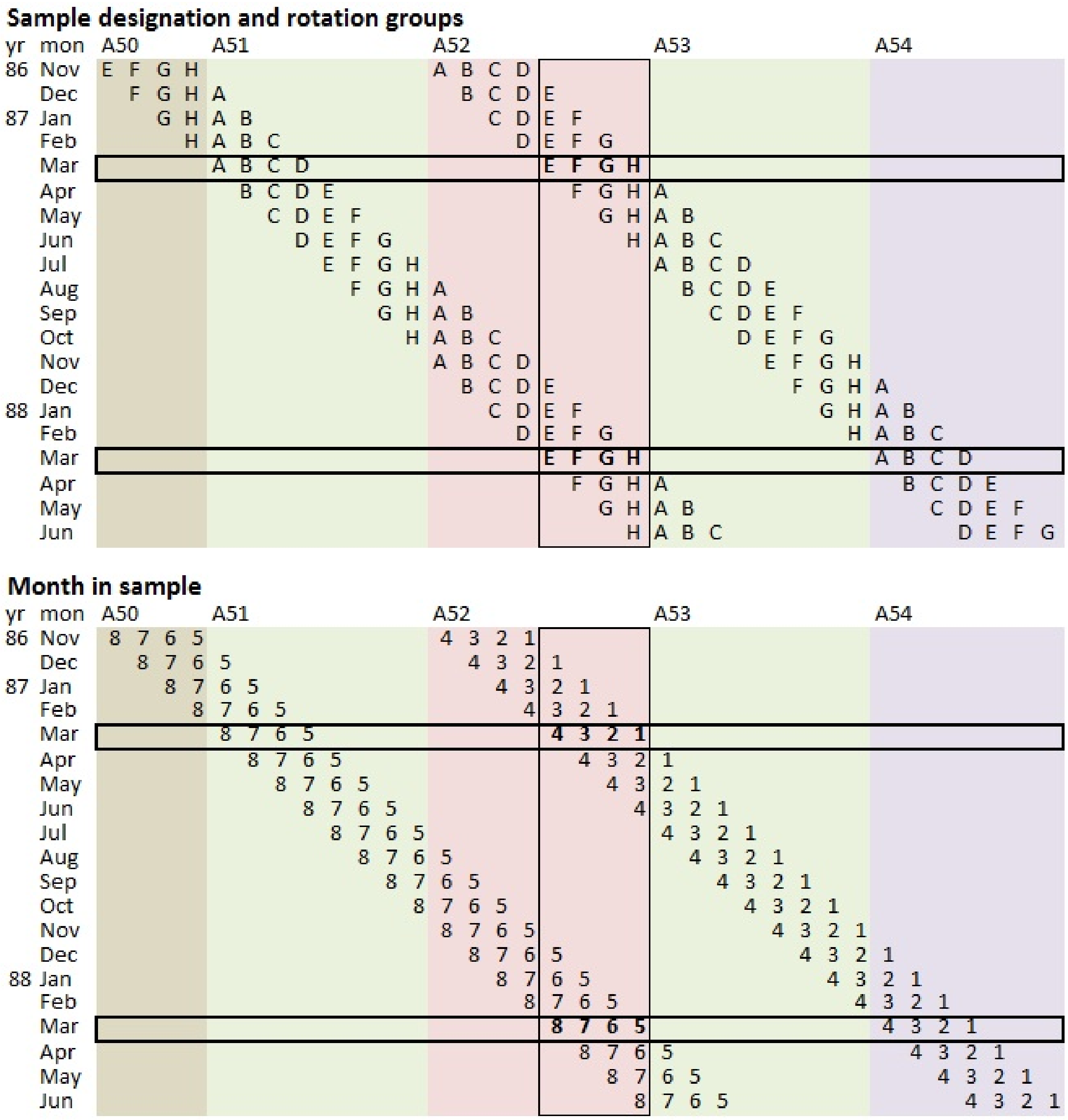
A problem with the CPS is that each observation stays in the survey only for two years, which means we are not able to use the same observation for more than two years. Once any observation[13], for example A, debuts in the CPS, it stays for four months. For the next 8 months it disappears. Then, it shows up again, is interviewed, and stays in the CPS for four months. And, it disappears forever. Therefore, any observation stays in the CPS for four months for each of two consecutive years and the four months are the same for the two years. For example, the sample H in rotation group A52 is in the CPS during March through June for both 1987 and 1988. Therefore, the maximum number of years each individual can be matched is two. Therefore, we are able to measure only short-term effect of tax rate changes.[14]

Matching the CPS for two years inevitably entails loss of half of the data at least. In the CPS March supplement of 1987, there are two groups as shown in figure 3.1: A, B, C, and D in A51, which has already appeared in March 1986, and E, F, G, and H in A52, which will appear again in March 1988. The CPS March supplement of 1988 consists of two groups in the same way: E, F, G, and H in A52, which appeared in 1987, and A, B, C, and D in A54, which will appear in 1989. Therefore, E, F, G and H in A52 appear both in 1987 and in 1988. But other samples, A, B, C, and D in A51 and A, B, C, and D in A54, are not shown for both years and so are excluded from the matching. E, F, G, and H are called "matched" rotation groups and A, B, C, and D in A51 and A, B, C, and D in A53 are called "non-matched" rotation groups. The key by which we recognize the samples is 'months in sample' (MIS). I match 1, 2, 3, and 4

[13]A50, A51, $\cdots$, and A54 in figure 3.1 are called rotation groups and each rotation group consists of eight samples, which are denoted A, B, $\cdots$, and H. A in A51 is different from A in A52. A's in A52 are the same sample.

[14]If we want to measure the full effect of TRA86, we need data at least for 1986 and 1988 since the TRA86 was fully phased in by 1988. Furthermore, other studies compare change at least between three years. It is because (1) people can response to the tax reform before the new tax law takes effect but when all people know all of the tax law changes and (2) a tax reform is in general fully phase in several years later.

Figure 3.1: CPS rotation chart: November 1986 - July 1988



in MIS of 1987 CPS March supplements with 5, 6, 7, and 8 in MIS of 1988 CPS March supplements. I discard 5, 6, 7, and 8 in MIS in 1987 CPS March Supplements and 1, 2, 3, 5 in MIS in 1988 CPS March Supplements.

Note that I use CPS 1986 and CPS 1987 to analyze the change between 1985 and 1986. Annual demographic file in CPS March Supplement have previous year's information. For example, annual income in 1987 CPS is income during 1986.

I rely on TAXSIM to calculate federal and state income tax liabilities Once data is given, the NBER TAXSIM program returns the tax rates from NBER server in seconds.[15] But, there is several problem in using TAXSIM with CPS data: One is that the information in CPS is not exactly fitting to TAXSIM input. In some cases, I sum two values in CPS and give it to an TAXSIM input. In other cases, I assign a value, which relates to multiple inputs of TAXSIM, to an input. For example, I need separate information regarding "dividends" and "rents and trust" as TAXSIM inputs. However, CPS provides a value in "Dividends, Rents, and Trust" item. In this case, if the taxpayer receives dividend and the value of "Dividends, Rents, and Trust" is positive, then the entire amount is assigned to the dividend. If not so, the amount is assigned to the rents. All pension incomes are assumed to be taxable. Once child support is received, all amount of "Alimony, Child Support, Other income" is assigned to child support.

Another issue is that CPS does not provide any information for some TAXSIM inputs. In this case, I use the average by AGI group. IRS provides tables of deductions by each income group based on AGI in Individual Income Tax Return 1986 and Individual Income Tax Return 1987. But, I try to estimate more accurate value of mortgage interest payment because it is the most important deduction and is likely to vary by region as well as by income. First, using NBER Consumer Expenditure Survey family-level extracts, I run regression of mortgage interest payment on 5 regions (rural, Northeastern city, Southern city, Midwestern city, and Western city) and 5 income groups (less than \$20,000, \$20,000-\$40,000, $\cdots$, more than \$80,000) and get the estimates of the

[15] For the details of TAXSIM, see Feenberg and Coutts (1993) or visit TAXSIM website, http://www.nber.org/taxsim.

coefficients on dummy variables. Then, I calculate the mortgage payment using the coefficient estimates and CPS data. In this calculation, I assume that all house owners pay the mortgage interest.[16]

This paper analyzes married family's response. So, the observation unit is family and each observation includes information both of head of household and of spouse. If either head's income or spouse's income is top-coded for a year, the family is deleted from data. Anybody with income over $99,999 is top-coded for either year.[17] Family with income less than $20,000 in 1985 dollar is also deleted because of controlling for mean reversion and better imputation of expenditure information.[18] I limit the data to family whose head's age is between 25 and 60. Taxpayers 60 years old and older are more likely to be affected by retirement decisions and the income of workers 25 years old and younger may be affected by schooling. Therefore, the estimate of the income response to the tax rate changes reflects the short-term effect of middle-income earners.

3.3.3 Econometric Specification

In this paper, I assume that income is explained by five factors: individual characteristics that do not change over time, but whose relationship with income may change over time; individual characteristics that do not change over time, even in relation to income; an individual-specific effect, which captures all individual characteristics not explicitly expressed above; a time specific effect; and the taxpayer's marginal tax rate. Then, income is expressed as

$$\begin{aligned} \log(y_{it}) = \phi + \psi d_i + \alpha d_t + \gamma \log(1 - \tau_{it}) \\ + S_i\zeta + d_t X_i \beta + SS_i \zeta_S + d_t X S_i \beta_S + \epsilon_{it}, \end{aligned} \tag{3.11}$$

[16]Most of home owners 65 years old and over do not have mortgage and account for half of no-mortgage home owners. So, the assumption that all home owners 60 years old or below have mortgage seems to be reasonable. For details, see The Department of Commerce and The Department of Housing And Urban Development (1989).

[17]I include a selection-bias correction for top coding, and find that the results concerning the effect of tax rate changes are essentially unchanged.

[18]Since low income family is less likely to use itemized deduction, using the expenditure data in the itemized deduction table for the low income family is not appropriate.

where y_{it} is gross family income, which is equivalent to total income minus capital gains or losses, τ is the marginal tax rate, $1-\tau$ is the net-of-tax rate, d_t is a time dummy with 0 or 1, d_i is an individual dummy. S_i includes variables whose effects on y do not change over time while X_i includes all variables whose effects on y change over time. For example, if income of college graduates rose much more than that of high school graduates over the two periods, educational attainment would be included in X_i. SS_i and XS_i include spouse's information regarding S_i and X_i, respectively. X_i and XS_i includes educational attainment, experience/100, experience^2/10000, race, sex, number of children, occupation, industry affiliation, and residential state. The effect of the net-of-tax rate on family income is measured by γ:

$$\gamma = \frac{\partial \log(TI)}{\partial \log(1-\tau)} = \frac{\frac{dTI}{TI}}{\frac{d[1-\tau]}{[1-\tau]}},$$

which is the elasticity of income with respect to the net-of-tax rate.

The equation I use in the test is the first difference form of the equation (3.11):

$$\Delta \log(y_i) = \alpha + \gamma \Delta \log(1-\tau_i) + \delta \log(y_{i,t-1}) + X_i\beta + XS_i\beta_S + \Delta\epsilon. \tag{3.12}$$

where Δ denotes the difference between period t and period $t-1$. $\log(y_{i,t-1})$ is added to control for the mean reversion and income distribution. As I mentioned above, equation (3.12) has the endogeneity problem. The net-of-tax rate is endogenous to income. So, I use 2SLS method and $\Delta \log(1-\tau_i)$ is replaced with the value predicted in the first stage regression, $\Delta \widehat{\log(1-}\tau_i)$.

The first stage regression equation is

$$\Delta \log(1-\tau_i) = \xi + \eta \Delta \log(1-\tau_i^*) + X_i\kappa + XS_i\kappa_S + \Delta\nu_i, \tag{3.13}$$

where τ_{it}^* is an instrument for τ_{it}, which should be correlated to τ_{it} and not be correlated to ϵ_{it}. $\Delta \log(1-\tau^*) = \log(1-\tau_{i86}^*) - \log(1-\tau_{i85}^*)$. How τ_{i85}^* and τ_{i87}^* are devised will be explained in the next subsection.

3.3.4 Instrument for the Tax Rate

In this section, I develop a novel instrument for the marginal tax rate for each year. It is a function of socio-demographic variables such as education, experience, occupation, and the number of children.

In reality, the tax rate is determined ty income under a deterministic ordered structure. Since everybody know the structure, one knows which tax rate is applied to him for given his income. For example, we assume that the current structure is

$$\tau = \begin{cases} \tau^1 \text{ if } y < 10 \\ \tau^2 \text{ if } 10 \leq y < 20 \\ \vdots \\ \tau^K \text{ if } 90 \leq y \end{cases},$$

where y is taxable income. Then, if a person has $y = 13$, then he knows that the tax rate being applied to him will be $\tau = \tau^2$. But, to obtain an instrument for τ, I make a trick.

We assume that all we know is that τ is determined by income under an ordered structure like

$$\tau = \begin{cases} \tau^1 \text{ if } y^* < c^1 \\ \tau^2 \text{ if } c^1 \leq y^* < c^2 \\ \vdots \\ \tau^K \text{ if } c^{K-1} \leq y^* \end{cases} \tag{3.14}$$

where the cut-off points, c^k's, are unknown. And $y*$ is assumed to have following functional form:

$$y_i^* = X_i\beta + \epsilon_i \tag{3.15}$$

where X include all socio-demographic variables which are in equation (3.11). And, the error term has standard normal distribution like

$$\epsilon \sim N(0,1). \tag{3.16}$$

Mean zero assumption is not a problem since X includes constant term. The assumption of variance one can be justified by rewriting the function $X\frac{\beta}{\sigma} + \frac{\epsilon}{\sigma}$ when variance is σ.

If we run separate ordered probit using the "non-matched" rotation groups for each year, we can get estimates of β and c^k's (say $\hat{\beta}$) and $\hat{c^k}$'s, respectively. Then, we know all the ordered structure except for the error term, ϵ. If we input each "matched" person's information into X_i of (3.14) given $\hat{\beta}$ and $\hat{c^k}$'s, we can calculate the probability of that person being in each tax bracket.

$$\begin{cases} P(\tau = \tau^1) = F(\hat{c^1} - X_i\hat{\beta}) \\ P(\tau = \tau^2) = F(\hat{c^2} - X_i\hat{\beta}) - F(\hat{c^1} - X_i\hat{\beta}) \\ \vdots \\ P(\tau = \tau^K) = 1 - F(\hat{c^{K-1}} - X_i\hat{\beta}) \end{cases}$$

Then, we derive two alternative instruments for the tax rate using the probability. The first instrument is

$$\tau_{M,i} = \{\tau^k \text{ such that } \pi_i^k = \max\{\pi_i^1, \pi_i^2, \cdots, \pi_i^K\}\}$$

and is called "most probable marginal tax rate". The second instrument is

$$\tau_{E,i} = \pi_i^1\tau^1 + \pi_i^2\tau^2 + \cdots + \pi_i^K\tau^K.$$

and is called "expected marginal tax rate".

There are two issues in obtaining above instruments for the tax rate. The first issue is misspecification of functional form. According to Angrist and Krueger (2001), if the instrument is nonlinear, the misspecification could be crucial. They also say, however, this problem is able to be avoided by including other exogenous variables which are used in the second stage. Therefore, I circumvent the problem by including all variables in the second stage regression in the first stage regression.

Another issue is the exclusion restriction. Note that the second stage regression is the first difference form of equation (3.11) and the instrumental variables for the tax rates which are used in the first stage regression are nonlinear functions. So, if there is a variable which is constant during the two years, the variable is deleted from the second stage regression equation (3.12) in the middle of the differencing, but it is not deleted from the first stage regression equation (3.13) since $\tau*$ is a nonlinear function of the variable. The number of children included in this analysis does not change over time

3.4 Results

The results of ordered probit for each year are presented in table 3.3. For the full regression results, see the table 3.A.1 in the Appendices. The dependent variable is the marginal tax rate.[19] The observations used in the probit are those who are deleted in the middle of the matching. The coefficient estimates are used to derive the instrument for the tax rate.

For both years, high educational attainment is positively related to the tax rate. It is because well-educated people on average make more money. Experience is also positively related to the tax rate. But, the relation is not linear since earnings are nonlinearly increasing as experience grows. Men earn more than women in 1986, but it changes in 1987. The effect of race is not clear. Earnings vary according to industry affiliation. For example, a person in the mining industry earns more than a worker in agriculture. So, the former pays more tax than the latter. But, in 1987 the tax rate of workers in other industries increased relative to those in the farm industry. People with some occupation pay more tax than others. Since executive, administrative, and managerial occupations, which are reference for other occupations, are rewarded most

[19] In 1986, there are 14 cutoffs since there are 15 tax brackets for joint tax filers. In 1987, the complex tax system was simplified to 5 tax brackets. But, the number of tax brackets in 1987 tax year could be considered as 6 since tax rate of a tax filer with 0 taxable income could be told 0.

Table 3.3: Results of Ordered Probit

	1986			1987		
Variable	Coefficient	Std Err	p-value	Coefficient	Std Err	p-value
Highschool graduate	0.257	0.042	0.000	0.115	0.049	0.018
Some college	0.401	0.048	0.000	0.259	0.056	0.000
Bachelor degree	0.793	0.054	0.000	0.662	0.063	0.000
MA and higher degree	1.136	0.065	0.000	0.967	0.073	0.000
Experience	4.936	0.649	0.000	4.256	0.782	0.000
Experience^2	−7.757	1.273	0.000	−6.504	1.505	0.000
Male	0.301	0.090	0.001	0.260	0.320	0.417
Black	0.015	0.159	0.926	−0.464	0.201	0.021
Other races	−0.147	0.100	0.143	0.007	0.109	0.946
Children: 1	−0.154	0.030	0.000	−0.178	0.035	0.000
Children: 2	−0.318	0.030	0.000	−0.262	0.035	0.000
Children: 3	−0.426	0.039	0.000	−0.483	0.046	0.000
Children: 4	−0.554	0.062	0.000	−0.601	0.075	0.000
Children: 5	−0.856	0.123	0.000	−0.842	0.147	0.000
Children: 6	−0.854	0.159	0.000	−1.483	0.170	0.000

note 1: Above output is only of head of household
note 2: The same variables for spouse are also included in probit.
note 3: Occupation, industry, and state dummies are included as well.

high, coefficient estimates on other occupations have negative signs. One of the most important variables are dummy variables for the number of children. Since additional children directly reduce taxable income, they tend to reduce the marginal tax rate. The tax rate decreases rapidly in 1987 compared to in 1986 as the number of children increases. This is probably because the increase in the personal exemption in 1987.

Spouse's demographic information is added to the equation since spouse's income is a part of income of joint filers. Coefficient estimates on spouse's educational attainment, experience, sex, and races are almost the same as those on variables of head of household.

Table 3.4: Summary of 2SLS Results

Equation: $\Delta \log(y_{it}) = \alpha + \gamma \Delta \widehat{\log(1-\tau_{it})} + X_i\beta + XS_i\beta_S + \Delta\epsilon_{it}$
Dependent Variable: Gross Income

Instrument for τ	Coefficient	Std Error
Most Probable Rate (τ_M)	-0.57	0.39
Expected Rate (τ_E)	***-1.05	0.21
Counterfactual Rate(τ_{AC})	-0.92	0.26
No instrument (τ)	***-1.90	0.03

*, **, and ***: significant at 10%, 5%, and 1%.

The table 3.5 reports the estimates of coefficient on the net-of-tax rates obtained using four different instrument for the tax rate: the most probable tax rate (τ_M), the expected tax rate (τ_M), the counterfactual tax rate (τ_{AC}), and no instrument. Full output is presented in the Appendices. The regression results are very sensitive to which instrument is used. When the most probable tax rate is used for the tax rate, the estimated coefficient of the net-of-tax rate is not significant. But, if another instrument, τ_E, is used, $\hat{\gamma}$ is significant and negative. When the counterfactual tax rate is used, the estimate is not significant. If the endogeneity is ignored and not instrument is used, the regression produces highly significant negative estimate of coefficient on the net-of-tax rate. Although two estimates are significant and other two estimates are not significant, all estimates have negative sign. It does not look reasonable because theory suggests that the estimate should be non-negative.

There are a lot of people who do not experience the change in the tax rate through the tax reform. First, I check the influence of those people in the unreasonable tax rate. Each row shows the results using people who experience the change in the most probable tax rate, expected tax rate, counterfactual tax rate, and tax rate, respectively. One notable change is that the estimate of elasticity with the counterfactual tax rate is significantly positive. In any other cases, there are no notable changes.

Table 3.5: Results when people with no change in the tax rate are deleted

Dependent Variable: Gross Income

Instrument for τ	Coefficient	Std Error
Most Probable Rate (τ_M)	-0.57	0.39
Expected Rate (τ_E)	***-1.04	0.21
Counterfactual Rate(τ_{AC})	0.25	0.03
No instrument (τ)	***-1.93	0.03

*, **, and ***: significant at 10%, 5%, and 1%.

The estimate of the elasticity of income is measuring a medium-income earner's short-run response. Although considering only one-year change may cause different results of this paper from of others, it seems not to be an important issue according to Gruber and Saez (2002).[20] But, including only medium-income earners could not be a trivial issue. So, I test the effect of top-coding by adding the first difference in inverse

[20]Regarding comparison of the results over various spread in years, refer to table 3.1

Mills ratios ($\Delta\lambda_i$) to equation (3.12).[21] The result is almost the same as one before $\Delta\lambda_i$ is added. Since the very high income earners have different pattern of response from other people, adding $\Delta\lambda_i$ seems not to affect the estimate of elasticity. But, looking at previous studies, we can find that the estimated coefficient on the net-of-tax rate is very sensitive to sample selection. For example, Gruber and Saez (2002) report $\hat{\gamma} = -0.65$ with standard error = 0.15 when only medium-income earners with income between \$50,000 and \$100,000 are included in the data. Giertz (2007) find that, when 100 out of 54,136 observation (less than 0.2%) are dropped from the analysis, $\hat{\gamma}$ fell from 0.373 to 0.084, which is consistent with the results when τ_M or τ_{AC} are used.[22]. So, we can say that the results in this paper are not uncommon.

Although the results are not uniform with two instruments devised in this paper, by comparing the results with those two instruments and results with either no instrument or counterfactual tax rate, we can find followings: The coefficient estimate on the tax rate when no instrument is used is significantly different from those when instruments are used; and the coefficient estimated on the tax rate when the counterfactual tax rate is used is similar to those when τ_M or τ_E are used. Therefore, we could conclude that since the tax rate is endogenous to income, using no instrument is likely to produce biased estimate for the elasticity. But, replacing the tax rate with the counterfactual tax rate solves the endogeneity problem.[23]

What do the coefficient estimates on the net-of-tax rate when the new instruments are used mean with respect to the elasticity of gross income? Theory suggests that the estimate of the elasticity should be non-negative as I mentioned above. Therefore, the

[21] λ is

$$\lambda = -\phi(-X\beta)/\Phi(-X\beta), \tag{3.17}$$

where β is estimated from probit on top-coding status against X. X include the same variables as those in probit run for getting τ except for regional dummy variables.

[22] Giertz shows that the elasticity gets close to 0 as high income earners are deleted from calculation. It does not have any statistical meaning. However, this paper produces output that the elasticity is not nonzero statistically when τ_M or τ_{AC} are used. So, strictly speaking, we cannot conclude that these two say the same thing.

[23] In order to further investigate the endogeneity, I run Durbin-Wu-Hausman Test. The test result is dependent on what is used as an instrument. When τ_E is used, both τ and τ_{AC} are found to be endogenous. On the contrary, when τ_M is used as an instrument for the test, neither τ nor τ_{AC} are found not to be endogenous. But, the p-value is close to 0.1 for both cases.

null hypothesis and the alternative hypothesis for the test should be

$$H_0 : \gamma = 0$$
$$H_1 : \gamma > 0.$$

Under these hypotheses, both of estimates with τ_M and τ_E do not reject the alternative hypothesis. Therefore, we cannot say that the increase in the net-of-tax rate raises the gross income.

3.5 Conclusion and Discussion

Empirical studies of taxation usually have an endogeneity problem. But, the severity of the endogeneity problem has not been fully appreciated. So, I devised new instruments which are exogenous by definition. And, I compared the estimates obtained using them with estimates obtained either without any instrument or with a counterfactual instrument.

I find that the endogeneity problem is severe unless an appropriate instrument is used for the tax rate. And, the counterfactual tax rate is an acceptable instrument for the tax rate. And, the estimates of elasticity suggest that the increase in the net-of-tax rate does not raise the gross income.

Using CPS has both bright side and dark side. It allows construct instrumental variables for the tax rate exogenous to income. But, It does not provide either direct tax information or enough information for calculating the tax rate for each person.

3.A Appendix: Full Output of Regressions

Table 3.A.1: Results of Ordered Probit

	1986			1987		
Variable	Coeff	StdErr	p-value	Coeff	StdErr	p-value
Intercept	1.364	0.249	0.000	1.184	0.390	0.002
cutoff 2	0.352	0.030	0.000	0.348	0.016	0.000
cutoff 3	0.795	0.037	0.000	2.809	0.030	0.000
cutoff 4	1.590	0.040	0.000	3.705	0.036	0.000

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Table 3.A.1 – continued from previous page

	1986			1987		
Variable	Coeff	StdErr	p-value	Coeff	StdErr	p-value
cutoff 5	2.107	0.041	0.000	4.984	0.062	0.000
cutoff 6	2.589	0.042	0.000			
cutoff 7	3.091	0.043	0.000			
cutoff 8	3.563	0.044	0.000			
cutoff 9	3.982	0.045	0.000			
cutoff 10	4.527	0.047	0.000			
cutoff 11	5.025	0.051	0.000			
cutoff 12	5.785	0.065	0.000			
cutoff 13	6.154	0.081	0.000			
cutoff 14	6.708	0.130	0.000			
G12, finished	0.257	0.042	0.000	0.115	0.049	0.018
some college	0.401	0.048	0.000	0.259	0.056	0.000
bechelor	0.793	0.054	0.000	0.662	0.063	0.000
MA and higher	1.136	0.065	0.000	0.967	0.073	0.000
experience	4.936	0.649	0.000	4.256	0.782	0.000
experience^2	−7.757	1.273	0.000	−6.504	1.505	0.000
male	0.301	0.090	0.001	0.260	0.320	0.417
black	0.015	0.159	0.926	−0.464	0.201	0.021
other races	−0.147	0.100	0.143	0.007	0.109	0.946
children: 1	−0.154	0.030	0.000	−0.178	0.035	0.000
children: 2	−0.318	0.030	0.000	−0.262	0.035	0.000
children: 3	−0.426	0.039	0.000	−0.483	0.046	0.000
children: 4	−0.554	0.062	0.000	−0.601	0.075	0.000
children: 5	−0.856	0.123	0.000	−0.842	0.147	0.000
children: 6	−0.854	0.159	0.000	−1.483	0.170	0.000
mining	0.314	0.147	0.032	0.343	0.175	0.051
construction	0.004	0.129	0.974	0.058	0.150	0.702
durable goods	0.154	0.126	0.223	0.319	0.148	0.031
nondurable goods	0.147	0.129	0.253	0.250	0.150	0.097
transport	0.293	0.128	0.022	0.368	0.150	0.014
wholesale trade	0.036	0.134	0.786	0.157	0.156	0.316
retail trade	−0.077	0.130	0.555	−0.073	0.151	0.630
finance	0.203	0.132	0.125	0.308	0.154	0.045
business and repair	−0.126	0.132	0.338	0.016	0.154	0.915
personal services	−0.284	0.156	0.069	−0.422	0.179	0.019
entertainment	0.029	0.176	0.870	−0.049	0.187	0.793
professional and related	−0.145	0.127	0.252	−0.075	0.149	0.616
public administration	−0.118	0.130	0.365	0.060	0.154	0.697
not work or in armed force	−1.358	0.142	0.000	−2.007	0.167	0.000
professional specialty	−0.198	0.041	0.000	−0.224	0.046	0.000
technicians	−0.209	0.068	0.002	−0.356	0.076	0.000
sales	−0.216	0.046	0.000	−0.247	0.053	0.000
admin support	−0.639	0.051	0.000	−0.749	0.062	0.000
protective service	−0.208	0.077	0.007	−0.403	0.093	0.000
service	−0.733	0.069	0.000	−0.934	0.081	0.000
farming	−0.753	0.130	0.000	−0.668	0.149	0.000
precision production	−0.449	0.039	0.000	−0.490	0.044	0.000
machine operators	−0.570	0.054	0.000	−0.643	0.063	0.000
transportation	−0.670	0.055	0.000	−0.657	0.063	0.000
handlers	−0.665	0.068	0.000	−0.718	0.088	0.000
G12, finished (spouse)	0.270	0.043	0.000	0.180	0.049	0.000
some college (spouse)	0.371	0.049	0.000	0.277	0.056	0.000
bechelor (spouse)	0.500	0.056	0.000	0.287	0.064	0.000

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Table 3.A.1 – continued from previous page

Variable	1986 Coeff	1986 StdErr	1986 p-value	1987 Coeff	1987 StdErr	1987 p-value
MA and higher (spouse)	0.681	0.070	0.000	0.443	0.079	0.000
experience (spouse)	3.004	0.571	0.000	1.090	0.686	0.112
experience^2 (spouse)	−6.026	1.106	0.000	−1.388	1.322	0.294
sex (Spouse)	0.483	0.082	0.000	−0.684	0.317	0.031
black (spouse)	−0.187	0.161	0.243	0.207	0.202	0.305
other races (spouse)	0.032	0.095	0.738	−0.156	0.100	0.119
mining (spouse)	1.088	0.257	0.000	−0.335	0.301	0.267
construction (spouse)	0.501	0.202	0.013	−0.127	0.198	0.523
durable goods (spouse)	0.595	0.192	0.002	−0.412	0.184	0.025
nondurable goods (spouse)	0.331	0.192	0.086	−0.483	0.186	0.009
transport (spouse)	0.614	0.194	0.002	−0.352	0.187	0.059
wholesale trade (spouse)	0.403	0.199	0.043	−0.313	0.194	0.105
retail trade (spouse)	0.119	0.190	0.529	−0.188	0.181	0.297
finance (spouse)	0.338	0.190	0.075	−0.337	0.181	0.063
business and repair (spouse)	0.286	0.193	0.139	−0.049	0.185	0.789
personal services (spouse)	0.243	0.197	0.216	−0.211	0.191	0.269
entertainment (spouse)	0.177	0.222	0.426	−0.444	0.222	0.046
professional and related (spouse)	0.280	0.187	0.135	−0.376	0.177	0.034
public administration (spouse)	0.344	0.195	0.078	−0.415	0.186	0.026
not work or in armed force (spouse)	−0.249	0.191	0.193	0.333	0.181	0.065
professional specialty (spouse)	−0.165	0.049	0.001	0.019	0.056	0.734
technicians (spouse)	−0.172	0.074	0.020	0.029	0.085	0.736
sales (spouse)	−0.191	0.054	0.000	−0.016	0.062	0.792
admin support (spouse)	−0.297	0.042	0.000	0.017	0.048	0.724
private household service (spouse)	−0.678	0.175	0.000	0.151	0.223	0.498
protective service (spouse)	−0.257	0.171	0.134	−0.122	0.188	0.517
service (spouse)	−0.576	0.054	0.000	0.035	0.062	0.568
farming (spouse)	−0.372	0.208	0.074	0.056	0.209	0.789
precision production (spouse)	−0.356	0.072	0.000	−0.083	0.090	0.354
machine operators (spouse)	−0.502	0.068	0.000	−0.010	0.082	0.904
transportation (spouse)	−0.530	0.107	0.000	0.154	0.131	0.240
handlers (spouse)	−0.532	0.108	0.000	0.050	0.122	0.680

Table 3.A.2: Results with Most probable tax rate and Expected tax rate

Variable	Most probable tax rate Coeff	Most probable tax rate StdErr	Most probable tax rate p-value	Expected tax rate Coeff	Expected tax rate StdErr	Expected tax rate p-value
Intercept	5.063	0.125	0.000	0.049	0.027	0.071
$\Delta\,\widehat{\log(1-\tau)}$	−0.566	0.389	0.145	−1.045	0.209	0.000
$\log(income)$	−0.448	0.010	0.000	−0.449	0.009	0.000
G12, finish	−0.004	0.013	0.740	−0.002	0.005	0.739
some college	0.027	0.015	0.070	0.001	0.006	0.922
bechelor	0.062	0.017	0.000	−0.004	0.006	0.514
MA and more	0.098	0.020	0.000	−0.021	0.008	0.006
experience	0.563	0.205	0.006	0.025	0.077	0.750
experience^2	−0.905	0.394	0.022	−0.063	0.149	0.671
male	−0.246	0.032	0.000	0.014	0.012	0.248
black	0.017	0.064	0.794	−0.008	0.024	0.734
other races	−0.016	0.033	0.637	0.018	0.013	0.142
mining	0.007	0.047	0.879	0.013	0.018	0.459

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Table 3.A.2 – continued from previous page

Variable	Most probable tax rate Coeff	StdErr	p-value	Expected tax rate Coeff	StdErr	p-value
construction	−0.011	0.040	0.786	0.011	0.015	0.490
durable goods	0.023	0.040	0.555	0.003	0.015	0.851
nondurable goods	0.029	0.040	0.474	0.004	0.015	0.775
transport	0.056	0.040	0.160	0.002	0.015	0.908
wholesale trade	0.017	0.041	0.689	0.009	0.016	0.589
retail trade	−0.003	0.041	0.948	0.010	0.016	0.535
finance	0.048	0.041	0.243	0.003	0.016	0.858
business and repair	0.024	0.042	0.556	0.016	0.016	0.315
personal services	−0.018	0.050	0.714	0.024	0.019	0.200
entertainment	−0.059	0.053	0.269	−0.011	0.020	0.600
professional and related	0.002	0.040	0.969	0.005	0.015	0.723
public administration	0.003	0.041	0.950	0.012	0.016	0.454
not work or in armed force	−0.126	0.048	0.009	0.058	0.017	0.001
professional specialty	−0.003	0.012	0.805	0.015	0.005	0.001
technicians	−0.033	0.019	0.079	0.004	0.007	0.579
sales	−0.008	0.014	0.535	0.008	0.005	0.120
admin support	−0.074	0.016	0.000	0.024	0.006	0.000
protective service	−0.021	0.025	0.396	0.024	0.009	0.007
service	−0.082	0.022	0.000	0.013	0.008	0.130
farming	−0.052	0.042	0.213	−0.007	0.016	0.634
precision production	−0.058	0.012	0.000	0.019	0.004	0.000
machine operators	−0.067	0.016	0.000	0.012	0.006	0.045
transportation	−0.062	0.016	0.000	0.014	0.006	0.023
handlers	−0.075	0.022	0.001	0.016	0.008	0.053
G12, finish (spouse)	0.014	0.013	0.310	−0.002	0.005	0.679
some college (spouse)	0.044	0.015	0.005	0.000	0.006	0.952
bechelor (spouse)	0.055	0.018	0.002	0.002	0.007	0.822
MA and more (spouse)	0.095	0.024	0.000	0.012	0.008	0.150
experience (spouse)	0.537	0.180	0.003	−0.015	0.069	0.829
experience^2 (spouse)	−1.173	0.348	0.001	0.016	0.132	0.903
sex (Spouse)	−0.174	0.037	0.000	0.038	0.011	0.001
black (spouse)	−0.055	0.065	0.399	0.013	0.025	0.601
others (spouse)	−0.031	0.031	0.313	−0.005	0.012	0.674
mining (spouse)	−0.007	0.079	0.925	−0.017	0.030	0.575
construction (spouse)	−0.041	0.055	0.465	−0.035	0.021	0.101
durable goods (spouse)	0.044	0.052	0.395	−0.029	0.020	0.142
nondurable goods (spouse)	−0.004	0.052	0.939	−0.030	0.020	0.129
transport (spouse)	0.031	0.054	0.565	−0.004	0.020	0.851
wholesale trade (spouse)	−0.019	0.054	0.729	−0.014	0.021	0.488
retail trade (spouse)	−0.033	0.052	0.519	−0.037	0.019	0.055
finance (spouse)	0.002	0.051	0.965	−0.030	0.019	0.121
business and repair (spouse)	−0.024	0.053	0.653	−0.037	0.020	0.064
personal services (spouse)	−0.052	0.054	0.337	−0.038	0.021	0.064
entertainment (spouse)	−0.016	0.064	0.805	−0.047	0.024	0.050
professional and related (spouse)	−0.027	0.050	0.593	−0.040	0.019	0.038
public administration (spouse)	−0.010	0.052	0.850	−0.026	0.020	0.200
not work or in armed force (spouse)	−0.123	0.066	0.064	−0.086	0.020	0.000
professional specialty (spouse)	−0.020	0.015	0.177	0.000	0.006	0.970
technicians (spouse)	−0.006	0.024	0.803	−0.013	0.008	0.124
sales (spouse)	−0.038	0.020	0.059	−0.020	0.006	0.001
admin support (spouse)	−0.047	0.021	0.026	−0.029	0.005	0.000
private household service (spouse)	−0.160	0.050	0.001	0.005	0.019	0.782
protective service (spouse)	−0.032	0.060	0.589	−0.039	0.022	0.069

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Table 3.A.2 – continued from previous page

	Most probable tax rate			Expected tax rate		
Variable	Coeff	StdErr	p-value	Coeff	StdErr	p-value
service (spouse)	−0.092	0.026	0.000	−0.023	0.007	0.001
farming (spouse)	−0.128	0.066	0.052	−0.059	0.022	0.009
precision production (spouse)	−0.073	0.024	0.002	−0.010	0.008	0.260
machine operators (spouse)	−0.108	0.028	0.000	−0.022	0.008	0.009
transportation (spouse)	−0.026	0.036	0.469	−0.010	0.013	0.425
handlers (spouse)	−0.053	0.037	0.159	−0.028	0.012	0.019

Table 3.A.3: Results with no instrument and counterfactual tax rate

	no instrument			counterfactual τ		
Variable	Coeff	StdErr	p-value	Coeff	StdErr	p-value
Intercept	2.620	0.115	0.000	0.077	0.027	0.004
$\Delta\,\widehat{\log(1-\tau)}$	−1.895	0.033	0.000	−0.919	0.259	0.000
$\log(income)$	−0.198	0.010	0.000	−0.444	0.009	0.000
G12, finish	−0.016	0.011	0.170	0.004	0.005	0.468
some college	0.001	0.013	0.918	0.005	0.006	0.375
bechelor	0.010	0.015	0.484	0.002	0.006	0.812
MA and more	0.009	0.018	0.622	−0.010	0.008	0.183
experience	0.215	0.179	0.229	0.080	0.077	0.300
experience^2	−0.382	0.346	0.270	−0.140	0.150	0.349
male	−0.320	0.028	0.000	−0.007	0.012	0.567
black	0.036	0.056	0.519	0.018	0.024	0.470
other races	−0.011	0.029	0.695	0.011	0.013	0.369
mining	−0.005	0.041	0.897	0.011	0.018	0.529
construction	−0.016	0.036	0.643	0.006	0.015	0.722
durable goods	−0.003	0.035	0.937	−0.003	0.015	0.836
nondurable goods	0.010	0.035	0.786	0.000	0.015	0.991
transport	0.027	0.035	0.448	0.001	0.015	0.954
wholesale trade	0.003	0.036	0.934	0.001	0.016	0.972
retail trade	0.006	0.036	0.866	0.005	0.016	0.752
finance	0.028	0.036	0.444	−0.002	0.016	0.918
business and repair	0.025	0.037	0.491	0.005	0.016	0.750
personal services	0.000	0.043	0.991	0.021	0.019	0.273
entertainment	−0.052	0.047	0.259	−0.013	0.020	0.526
professional and related	0.007	0.035	0.850	−0.001	0.015	0.953
public administration	−0.001	0.036	0.976	0.001	0.016	0.971
not work or in armed force	−0.002	0.040	0.965	0.050	0.017	0.004
professional specialty	0.020	0.010	0.060	0.011	0.005	0.019
technicians	−0.001	0.017	0.951	0.002	0.007	0.802
sales	0.009	0.012	0.429	0.003	0.005	0.519
admin support	−0.019	0.014	0.172	0.012	0.006	0.042
protective service	0.028	0.021	0.176	0.027	0.009	0.002
service	−0.025	0.019	0.202	0.004	0.008	0.615
farming	−0.025	0.036	0.489	−0.021	0.016	0.174
precision production	−0.016	0.010	0.126	0.011	0.004	0.013
machine operators	−0.009	0.014	0.518	0.004	0.006	0.510
transportation	−0.013	0.014	0.358	0.003	0.006	0.654
handlers	−0.018	0.019	0.357	0.005	0.008	0.531
G12, finish (spouse)	0.006	0.012	0.624	0.002	0.005	0.627
some college (spouse)	0.033	0.013	0.014	0.006	0.006	0.282

Continued on next page

Table 3.A.3 – continued from previous page

	no instrument			counterfactual τ		
Variable	Coeff	StdErr	p-value	Coeff	StdErr	p-value
bechelor (spouse)	0.043	0.015	0.005	0.015	0.007	0.020
MA and more (spouse)	0.085	0.019	0.000	0.030	0.008	0.000
experience (spouse)	0.469	0.158	0.003	0.045	0.069	0.511
experience^2 (spouse)	−1.145	0.303	0.000	−0.116	0.131	0.377
sex (Spouse)	−0.171	0.026	0.000	0.058	0.011	0.000
black (spouse)	−0.054	0.057	0.345	−0.011	0.025	0.649
others (spouse)	−0.000	0.027	0.990	0.003	0.012	0.801
mining (spouse)	0.014	0.068	0.834	0.055	0.030	0.063
construction (spouse)	−0.034	0.049	0.492	−0.004	0.021	0.838
durable goods (spouse)	0.055	0.045	0.230	0.012	0.020	0.545
nondurable goods (spouse)	0.006	0.046	0.900	0.001	0.020	0.955
transport (spouse)	0.059	0.046	0.196	0.039	0.020	0.053
wholesale trade (spouse)	−0.006	0.047	0.907	0.016	0.021	0.428
retail trade (spouse)	−0.041	0.045	0.359	−0.025	0.019	0.197
finance (spouse)	0.003	0.045	0.938	−0.002	0.019	0.924
business and repair (spouse)	−0.033	0.046	0.470	−0.018	0.020	0.366
personal services (spouse)	−0.058	0.047	0.217	−0.021	0.021	0.301
entertainment (spouse)	−0.042	0.055	0.447	−0.028	0.024	0.248
professional and related (spouse)	−0.022	0.044	0.618	−0.013	0.019	0.483
public administration (spouse)	0.004	0.046	0.936	0.003	0.020	0.899
not work or in armed force (spouse)	−0.190	0.045	0.000	−0.109	0.020	0.000
professional specialty (spouse)	−0.026	0.013	0.042	−0.009	0.005	0.094
technicians (spouse)	−0.014	0.019	0.462	−0.022	0.008	0.008
sales (spouse)	−0.053	0.014	0.000	−0.032	0.006	0.000
admin support (spouse)	−0.071	0.011	0.000	−0.044	0.005	0.000
private household service (spouse)	−0.136	0.043	0.002	−0.033	0.019	0.082
protective service (spouse)	−0.079	0.050	0.112	−0.048	0.022	0.028
service (spouse)	−0.111	0.015	0.000	−0.051	0.006	0.000
farming (spouse)	−0.172	0.052	0.001	−0.074	0.022	0.001
precision production (spouse)	−0.078	0.019	0.000	−0.027	0.008	0.001
machine operators (spouse)	−0.117	0.019	0.000	−0.047	0.008	0.000
transportation (spouse)	−0.053	0.029	0.071	−0.042	0.013	0.001
handlers (spouse)	−0.085	0.027	0.002	−0.055	0.012	0.000

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