2013

# An Analysis Of Shift Work: Compensating Differentials And Local Economic Conditions

Mary Colene Trent
*University of Mississippi*

# AN ANALYSIS OF SHIFT WORK: COMPENSATING DIFFERENTIALS AND LOCAL ECONOMIC CONDITIONS

A Dissertation
presented in partial fulfillment of requirements
for the degree of Doctor of Philosophy
in the Department of Economics
The University of Mississippi

by

COLENE TRENT

May 2013

**ABSTRACT**

The theory of compensating differentials asserts that workers facing undesirable work conditions, such as night shift work, should receive compensating wage differentials. The theory assumes that workers can easily find jobs with desirable characteristics; thus, compensating wages are necessary to induce workers to take jobs with undesirable characteristics. This dissertation considers a variation of the theory of compensating differentials in which labor markets are weak. If workers are more likely to work night shifts in areas with weak economic conditions and if firms are less likely to offer compensating differentials for night shift work in areas with weak economic conditions, weak regional economies may lead to smaller compensating differentials for night shift work.

Using NLSY79 data from 1990-2000, this paper employs an endogenous switching regression model to analyze wages of day and night shift workers and shift choice. The model is estimated using both the Lee two-step method and maximum likelihood. Two measures of local economic conditions, the local unemployment rate and the state leading index, are used. The models provide evidence that shift differentials and local economic conditions significantly impact shift choice. Of the two local economic condition variables used in the analysis, the leading index is a stronger predictor of shift choice. This paper develops a new method of analyzing the impact of the interaction between the shift differential and local economic conditions on shift choice, providing limited evidence that compensating differentials for night shift work may be lower when local economies are weak. The calculated interaction effects are small. Estimated wage premiums for night shift work are negative, and are approximately half of day wages in the 1990 cross-section. Estimated wage differentials for night shift work are smaller in pooled cross-section analysis, ranging from roughly 2% to 11% below day wages. Analyzing cross-sections over time indicates that shift differentials were below day wages throughout most of the 1990's but in 2000, night wages were approximately 7-11% higher than day wages. Overall, the results provide evidence that individuals take both the size of the wage premium and local labor market conditions into account when selecting working hours.

## DEDICATION

To my husband, David Trent, whose daily encouragement, countless prayers, and unfailing support enabled me to persevere. I am forever indebted to him for serving as a loving witness to my life, including all of the struggles and joys that these four years have involved.

To my mother, Deborah Burns, who has served as a beautiful example of strength, sacrificing throughout her life so that I may succeed. She listened as I read Nancy Drew books, quizzed me in preparation for spelling bees, helped to grow an endless amount of salt crystals for my science projects, and proofread countless college essays and this dissertation. My doctoral degree is a direct result of her dedication and support of my academic pursuits.

To my professors who invested their time in me so that I may someday invest in the lives of my students.

To my undergraduate professors who inspired me to attend graduate school and teach economics.

To my family and friends who had faith in my abilities throughout this challenging, yet rewarding journey.

In memory of my father, Howard Burns.

## LIST OF ABBREVIATIONS

| | |
|---|---|
| BLS | Bureau of Labor Statistics |
| CPS | Current Population Survey |
| ML | Maximum Likelihood |
| NLSY79 | National Longitudinal Survey of Youth 1979 |

## ACKNOWLEDGMENTS

I am especially grateful to Dr. Walter Mayer for his continuous advice and encouragement. As my dissertation chair, he has provided a wonderful example of what it means to be a scholar. Without his guidance and his willingness to invest in my research interests, this work would not have been possible. I can never thank him enough for all of the time he took to assist me with this project and with planning for my career.

My committee members, Dr. William Chappell, Dr. Richard Forgette, and Dr. Jon Moen have provided several suggestions that have been crucial to this paper. Their support of my ideas, research, and ambitions is humbling and greatly appreciated.

I am grateful to all those at the University of Mississippi, both professors and students, with whom I have had the pleasure to work during the past four years. I am especially thankful for the opportunities for teaching and research provided by the economics department which will benefit me throughout my academic career.

## TABLE OF CONTENTS

## LIST OF TABLES

Table A23. Interaction Effects, 2000 Cross-Section with Unemployment Rate ..................................... 164

## LIST OF FIGURES

## CHAPTER I

## INTRODUCTION AND MOTIVATION

### 1.1 Introduction

Workers who face difficult working conditions are often compensated for this inconvenience by higher wages. Labor economics literature refers to this phenomenon as the theory of compensating differentials. This theory assumes that workers can easily find jobs with desirable characteristics; thus, compensating wages are necessary to induce workers to take jobs with undesirable characteristics. This dissertation considers a variation of the theory of compensating differentials in which labor markets are weak and workers have difficulty finding jobs. In weak economies, employers have the advantage of a larger number of potential employees and workers are more likely to take jobs that would otherwise be undesirable. Poor economic conditions may thus lower the compensating wage differential offered for undesirable work conditions.

Shift workers work during non-standard work hours; thus it has been hypothesized that these workers are motivated to accept shift work because of higher wages. Compensating wage differentials are commonly analyzed using wage regressions, with worker wages modeled as a function of worker characteristics and job characteristics. This dissertation uses a more general econometric model to analyze shift wages and selection into shift work, improving upon previous studies by including indicators of labor market strength, the local unemployment rate and the state leading index, in the analysis. Shift selection is modeled as a function of local economic conditions and shift differentials. Three major questions are considered in the analysis:

What is the impact of local economic conditions on shift choice?

What is the impact of the shift differential on shift choice?

How does the impact of the shift differential on shift selection depend on local economic conditions?

In the empirical analysis, we find evidence that shift selection is impacted by shift differentials and local economic conditions. We also find weak support for the theory that compensating wages for night shift work have a smaller impact on selection into night shifts in areas with weak economic conditions. Thus, in these labor markets, compensating wage differentials for night shift work may be lower. Estimated wage premiums for night shift work are negative, but increase over time in the sample, and eventually become positive in the last year of the data that is considered. Shift differentials are smaller in pooled cross-section analysis relative to cross-section analysis.

The dissertation is organized as follows. The remainder of Chapter I provides background on the theory of compensating differentials and a discussion of how this theory is applied to shift work. To motivate the econometric model employed in the current analysis, trends in shift work and the inconvenience of shift work are also examined. A brief review of data on shift differentials is also provided. The introduction concludes with a discussion of how the current research contributes to the literature. Chapter II reviews related literature, Chapter III examines the data used in the current analysis, and Chapter IV explains the econometric models. Chapter V provides a summary of the empirical results, and Chapter VI concludes.

## 1.2 Motivation

### 1.2.1 The Theory of Compensating Differentials

The study of wage differences among workers is fundamental to labor economics. Workers are paid differently not only because all workers have different characteristics and different levels of skills and abilities, but also because the jobs they perform vary. This paper considers wage differences between day and night shift workers. The economic motivation for this study is the theory of compensating differentials. Also known as the theory of equalizing differences, the theory of compensating differentials refers to the idea that wage differentials equalize the total monetary and nonmonetary advantages and disadvantages among work activities and among workers themselves (Rosen 1986). In *The Wealth of Nations,* Adam Smith first proposed the idea that working conditions could impact wages and worker preferences for jobs. Jobs differ in the amenities that they offer; thus firms offering amenities should pay lower wage rates while firms offering disamenities should offer higher wages. Smith believed that such compensating differentials equated "the whole of advantages and disadvantages of different employment." The main implication of the theory of compensating differentials is that conclusions on labor market outcomes should be based upon both wages and non-wage job characteristics, not solely upon wages.

Rosen (1986) provides a more detailed treatment of the economics of compensating differentials. According to Rosen's theory of equalizing differences, the wage paid is "a sum of two conceptually distinct transactions, one for labor services and worker characteristics and another for job attributes." Firms purchase labor services and worker characteristics and sell job amenities/disamenities. Workers sell labor services and personal characteristics and purchase job attributes. Wage premiums are paid by firms in order to attract workers to accept job disamenities.  Workers pay a price for positive job attributes, and this price is subtracted from their wage.  Rosen emphasizes that the equilibrium achieved under the theory of equalizing differences, unlike the traditional supply and demand labor market equilibrium, matches specific workers with specific firms.  Because the allocation of labor is non-random, Rosen believes that the theory of compensating differentials is "the fundamental long-run market equilibrium construct in labor economics."  A simple economic model of the theory of compensating differentials is included in Section 1.2.1.1 as applied to shift work.

The theory of equalizing differences requires rather strong assumptions including perfect mobility, homogenous worker preferences, perfect information, and efficient labor markets. Adam Smith qualified conditions necessary for the theory of equalizing differences to hold. "This [the presence of equalizing differences] would at least be the case in a society where things were left to follow their natural course, where there was perfect liberty, and where every man was perfectly free both to choose what occupation he thought proper, and to change it as often as he thought proper" (Smith 1776).  The theory of equalizing differences holds that workers are perfectly mobile, able to choose occupations and change jobs as often as they please, an assumption that is not applicable to the true labor market.   The theory additionally assumes that all market participants have perfect information.  Firms are aware of all worker characteristics and workers are able to identify and evaluate job amenities and disamenities.  This assumption is also unrealistic, thus the theory cannot be expected to explain all variation in wages.

The theory of equalizing differences also holds that the size and sign of the wage premium depends on the underlying distribution of worker tastes and on the demand for certain job characteristics.  For example, if all workers agree that a certain job characteristic is undesirable, that is, if worker preferences are homogenous, the compensating differential should be positive. However, if some workers actually prefer that job characteristic and the demand for such workers is low, the compensating differential may be negative. The existence of negative compensating differentials is highly relevant to the results of the current analysis. A supply and demand model for determining both positive and negative compensating differentials is included in Section 1.2.1.1. Heterogeneous worker preferences may additionally account for some of the inconclusive results obtained in previous studies of compensating differentials. These studies are discussed further in Section 2.3.1.

A final assumption of the theory of equalizing differences is that labor markets are efficient and quantity of labor supplied equals quantity of labor demanded. Labor markets are tight, with little to no unemployment. Compensating wages are thus necessary to equalize disadvantages and advantages of employment and attract workers. However, when an excess supply of workers exists, the theory of equalizing differences is weakened. The idea that the size and possibly the sign of compensating differentials may be impacted by local labor market conditions is a primary motivation of the current analysis. A more detailed treatment of the relationship between labor market efficiency and compensating differentials is included in Section 1.2.2.

Applications of the theory of equalizing differences are widespread in economics literature. Models evaluating compensating differentials frequently address selectivity bias since workers sort themselves into different occupations and because firms choose to offer certain amenities or disamenities. For a review of several important studies, see Rosen (1986). Notable applications include studies of compensating differentials for job risks, undesirable working conditions, city and regional amenities, work schedules, fringe benefits, and human capital. Due to the nature of the current analysis, a more detailed discussion of studies related to undesirable working conditions is found in Section 2.3.1.1.

#### 1.2.1.1 The Theory of Compensating Differentials Applied to Shift Work

One job characteristic for which compensating differentials may arise is work-time scheduling, including shift work. Shift workers often work during non-standard shifts such as evening, night, rotating, split, or irregular shifts. A more detailed description of these shifts is provided in Section 3.2.1. Non-standard work hours are often regarded as a job disamenity, and workers may require a compensating differential to be induced to accept shift work. Previous studies have found evidence of compensating wage differentials for shift work. See Section 2.3.1.2 for a review of this literature.

Rosen (1986) includes a discussion of the theory of compensating differentials applied to working hours and shift work that provides the motivation for the current research. Rosen notes that "there is no reason to suppose that a single wage will clear the labor market at all conceivable hours choices by all workers. Instead, it is logically necessary to consider each work-hours opportunity as a separate labor market." In other words, each shift can be treated as a different market with its own wage. Lewis (1969) provides evidence that employers are not indifferent to the number of hours worked by employees because some tasks require teamwork and because there are quasi-fixed hiring costs. Additionally, firms may be motivated to operate multiple shifts in order to maximize capacity utilization. Thus, depending on production goals and the underlying cost structure, firms will provide different combinations of shifts and wages, and workers will select the firm that offers the most desirable combination. Participation in shift work is not random, thus a selection model is the proper method for examining shift work wages.

Following Rosen (1986) and Borjas (2008) a simple theoretical model of compensating differentials is now applied to the current analysis of night shift work. Define a worker's utility function as

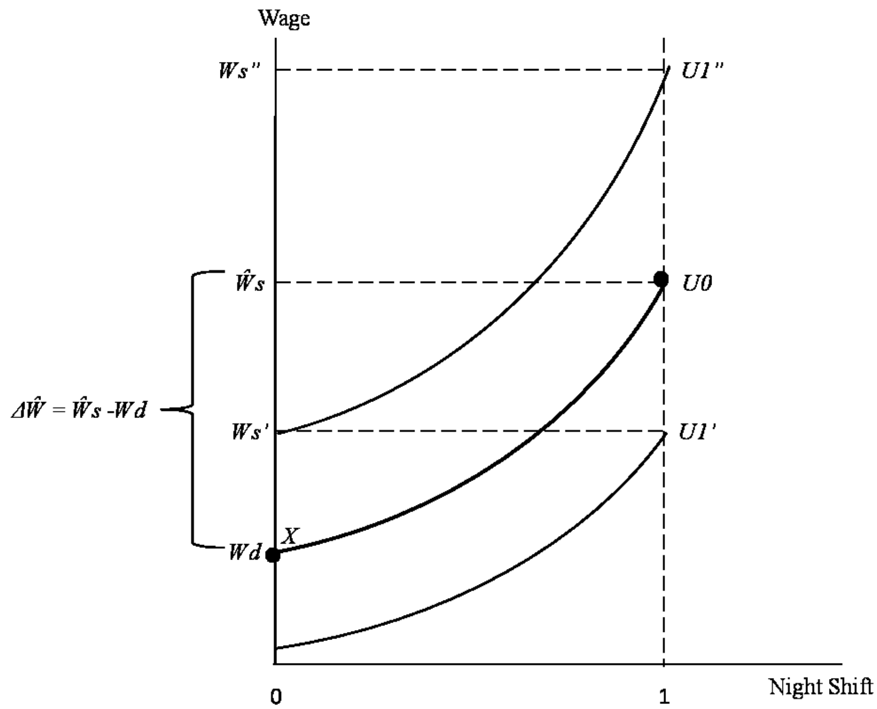
$$\text{Utility} = f\,(W,\ night\ shift)$$

where a worker's utility depends upon both *W*, wages, and on *night shift,* an indicator of whether or not the individual works the night shift. The marginal utility of income is assumed to be positive since higher wages should increase utility, holding constant *night shift*. The marginal utility of *night shift* is assumed to be negative if workers dislike night shift employment. The marginal utility of *night shift* is assumed to be positive, however, if some workers actually prefer and enjoy night shift work. This possibility is explored in Figure 1.3.

First, we analyze how compensating differentials arise by assuming that night shift work is undesirable for all workers. The indifference curves representing workers' choices between day and night employment are upward sloping since workers prefer higher wages but consider night shift work to be an economic "bad." Following Borjas (2008), Figure 1.1 considers possible indifference curves for one worker. At point *X* the worker receives a day wage of *Wd* and utility of *U0* and is a day worker, as indicated by the horizontal axis. The only way to persuade this worker to work a night shift and hold the worker's utility constant at the same time is to increase the worker's wage. This need for increased wages is the motivating factor for the theory of equalizing differences.

The indifference curves in Figure 1.1 help to illustrate the necessary size of the compensating differential for night shift work by considering three possible wages for night shift work. For example, if night shift work pays a wage of *Ws'*, this worker would still prefer day shift work since utility from working the day shift, *U0*, would be higher than utility from working the night shift, *U1'*. If however, night shift work pays a wage of *Ws'',* the worker

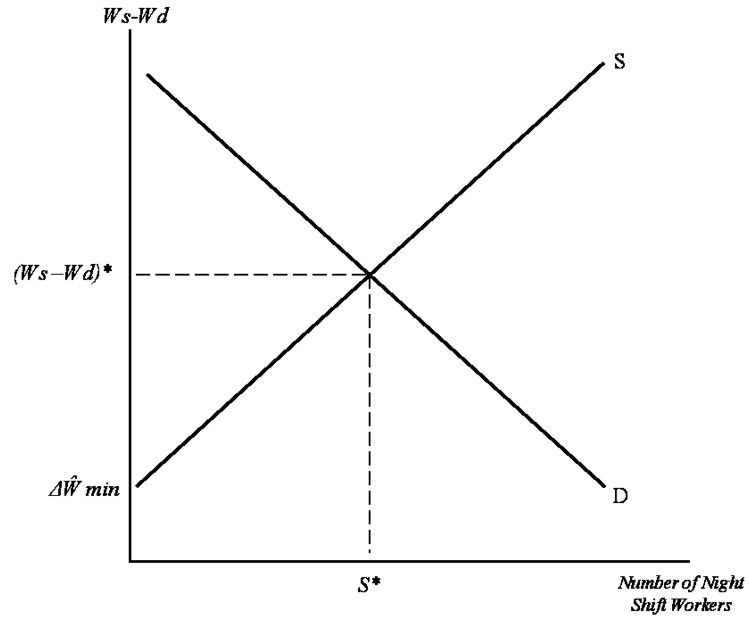
**Figure 1.1 Indifference Curves Relating Wage and Night Shift Employment**




would gain higher utility, *U1''*, from night work. If night shift work pays a wage of $\widehat{W}s$, this worker would be indifferent between day and night work, as illustrated by achieving the same level of utility, *U0*, in both day and night work. At $\widehat{W}s$, this worker has been exactly compensated for the inconvenience of working a night shift. Thus, $\Delta W = \widehat{W}s\text{-}Wd$, is the worker's reservation wage, or the shift differential that must be offered in order to induce this worker to switch from day to night work. The size of $\Delta W$ necessary to induce a worker to work a night shift depends on a worker's preferences for night shift work. The less a worker dislikes night work, the flatter the individual's indifference curves and the smaller the shift differential.

The market for night shift work is shown in Figure 1.2. Maintaining the assumption that all workers dislike night shift work, the wage differential for night shift work, $\Delta W = \widehat{W}s\text{-}Wd$, must be positive. At $\Delta Wmin$, the worker who dislikes night shift work the least is compensated

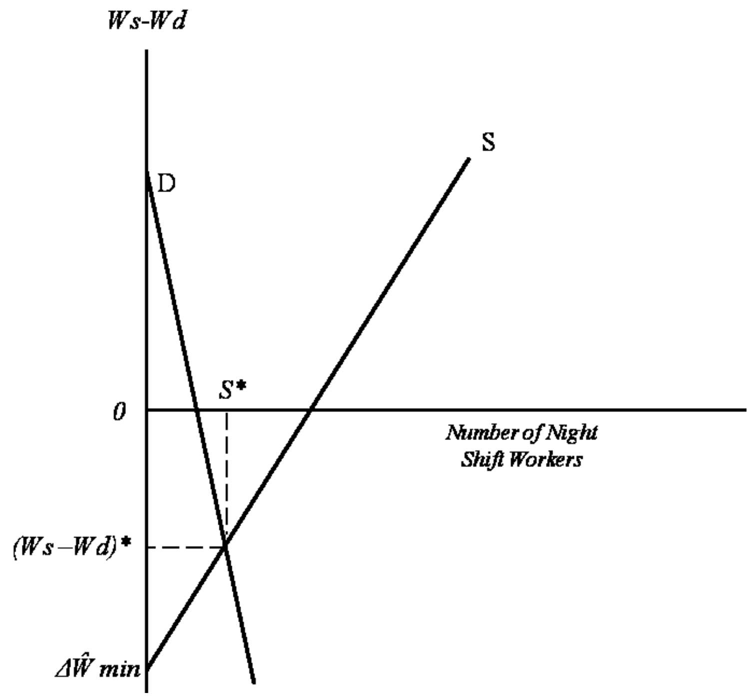
**Figure 1.2 The Market Compensating Differential for Night Shift Work**




enough to induce the worker to accept night shift work. The supply curve for night shift work slopes upward since more workers accept night shifts as the wage differential between night and day shift rises. Since fewer firms offer night shifts as the compensating wage they must pay for night shift work rises, the demand curve for night shift work is downward sloping. The market wage differential for night shift work is *(Ws-Wd)**, and it equates supply and demand. *S** is the equilibrium number of night shift workers. Borjas (2008) notes that it is important not to interpret the market wage differential as the average reservation wage for night shift work. Instead, it should be interpreted as the wage differential required to attract the marginal worker into night shift work. At the market wage differential, all workers except for the marginal worker are overcompensated for accepting night shift work.

An important modification of the above market equilibrium occurs in the event that some workers actually derive utility from working at night. In this case, the reservation wage for night shift work is negative. Figure 1.3 indicates the market for night shift work when some workers

**Figure 1.3 Negative Market Equilibrium Night Shift Wage Differential**




prefer night shifts. The supply curve depicts the presence of negative reservation wages for those who consider it a job amenity to work at night. For the market equilibrium wage differential to be negative, demand for night shift work must be relatively small. For example, firms may not desire to incur the costs of operating a night shift, or weak economic conditions may lead firms to cancel night shifts. In this case, the market demand curve intersects the market supply curve at a negative compensating differential for night shift work. The firms who did require the use of night shift work would hire workers who prefer to work at night. The models provided above indicate an important implication of the theory of compensating differentials: the size and sign of the compensating differential rely on worker preferences.

### 1.2.2 Impact of Local Economic Conditions on Compensating Differentials

As mentioned previously, an implicit assumption of the theory of equalizing differences is that labor markets are efficient. In order to attract workers to accept jobs, firms must offer compensating differentials. However, when labor markets are weak and more workers are seeking jobs, the need to offer compensating differentials is reduced. This caveat of the theory of equalizing differences provides the impetus for the current research. This paper seeks to determine if local labor market conditions impact the size of compensating differentials for night shift work. The local unemployment rate and the state leading index are included in hedonic wage regressions to serve as measures of labor market efficiency.

Bender and Mridha (2011) provide the basic model for the effect of the local unemployment rate on compensating wages. They note that the inclusion of the unemployment rate in hedonic wage regressions and studies of compensating differentials is not new; however, the focus of previous research was upon determining the presence of compensating differentials for job insecurity. A review of this literature is provided in Section 2.3.3. Bender and Mridha's research is innovative in that it attempts to determine the impact of the local unemployment rate on the size of compensating differentials for work conditions. Their research seeks to isolate the interaction between the local unemployment rate and the compensating wage differential for injury risk on the job. DeBeaumont and Nsiah (2010) analyze the impact of local unemployment rates on compensating wages for shift work. A more detailed account of Bender and Mridha's research as well as its relationship with the work of DeBeaumont and Nsiah is included in Section 2.3.3. This dissertation builds upon these papers, employing a more general econometric model to explore possible interactions between the local unemployment rate and the compensating wage differential for night shift work. In addition to the local unemployment rate, interactions between the shift differential and an alternate measure of local economic conditions, the leading index, are considered.

### 1.3 Trends in Shift Work

An investigation of shift work would be incomplete without considering the prevalence of shift work in America. According to BLS estimates, the percentage of the population working during non-standard hours increased from 15.9% (11.6 million workers) in 1985 to 17.7% (21 million workers) in 2004. Today, approximately one-fifth of all employed Americans work largely on evening, night, or rotating shifts (McMenamin 2007). Presser and Ward (2011) note that “widespread employment at nonstandard times is a significant social phenomenon,” and that “much attention has been paid to the *number* of hours which Americans work, but the issue of *which* hours Americans work has generally gone unnoticed.” This dissertation is therefore relevant, because it adds to the small but growing literature on work during nonstandard hours. Shift work is formally defined as a work schedule that occurs outside regular daytime hours. Shift work helps firms achieve continuous production and more efficient capital utilization. Because many industries operate at non-standard hours, other services have increased their operating hours to accommodate shift workers. The increase in expanded-time hours from grocery stores, restaurants, and gas stations has allowed for new job markets for shift workers. Rosa and Colligan (1997) describe the phenomenon of a “24-hour society” accurately: “Because there are so many shift workers, society now needs more shift workers.”

The current analysis focuses on a comparison of day and night shift workers. Day shift workers typically work between the hours of 6:00 a.m. to 6:00 p.m. while night shift workers typically work between the hours of 9:00 p.m. to 8:00 a.m. Despite the widespread nature of shift work, the data available on shift workers is relatively sparse. A majority of the data on shift work in America is provided by the Bureau of Labor Statistics. Surveys examining shift work have been conducted periodically for the BLS by the Census Bureau as special supplements to the Current Population Survey. The most recent supplements on shift work are available from 1985, 1997, 2001, and 2004. Mellor (1986), Beers (2000), and McMenamin (2007) author detailed BLS reports from the 1985, 1997, and 2004 CPS supplements, respectively, that provide a clear comparison of trends in shift work during a twenty year time span. Although information is available on day, evening, night, rotating, irregular and other shifts, the present discussion will only consider findings relevant to day and night shifts. The following pages consider two categories of CPS data: general trends and reasons for selecting shift work.

### 1.3.1 Demographic Characteristics

It is necessary to consider what worker characteristics might determine participation in night shift work. The CPS supplements provide statistics on shift work for different categories of workers, classifying workers based upon sex, race, sector of work, and marital status. Table 1.1 details the percentage of each of these categories working day and night shifts.

**Table 1.1 Percentage of Workers by Category Working Day and Night Shifts, CPS Supplements**

| | % of Category Working Day Shift | | | | % of Category Working Night Shift | | | |
|---|---|---|---|---|---|---|---|---|
| Category | 1985 | 1997 | 2001 | 2004 | 1985 | 1997 | 2001 | 2004 |
| *All Workers* | 84.1* | 82.9 | 84.8 | 82.3 | 2.7** | 3.5 | 3.3 | 3.1 |
| *Men* | 82.2 | 80.5 | 82.9 | 80.9 | 3.0*** | 4 | 3.6 | 3.5 |
| *Women* | 87 | 86.1 | 87.3 | 83.9 | 2.3 | 2.8 | 3 | 2.6 |
| | | | | | | | | |
| *Ethnicity* | | | | | | | | |
| *White* | 84.7 | 83.6 | 85.8 | 83.3 | 2.6 | 3.2 | 3 | 2.9 |
| *Black* | 80.1 | 78.5 | 79.3 | 76.8 | 3.5 | 5.5 | 5 | 4.4 |
| *Hispanic* | 84.6 | 83.6 | 84.3 | 81.9 | 2.5 | 3.2 | 3.4 | 3.5 |
| *Sector* | | | | | | | | |
| *Private Sector* | 83.5 | 82.3 | 84.1 | | 2.9 | 3.5 | 3.5 | |
| *Public Sector* | 87.2 | 86.1 | 88.3 | | 2 | 3.2 | 2.5 | |
| *Marital Status* | | | | | | | | |
| *Single* | 80.9 | 78.2 | 80.8 | | 3.1 | 4.2 | 3.8 | |
| *Married* | 85.7 | 85.1 | 87.4 | | 2.4 | 3.1 | 3 | |

Sector and Marital Status were not reported in the BLS report in 2004. The number of individuals in the sample by year are as follows: 1985: 73,395 workers. 1997: 90,549 workers. 2001: 99,631 workers. 2004: 123,167 workers.
*For example, calculated as total# of workers working day shifts in 1985 / total # of workers in 1985.
**For example, calculated as total # of workers working night shifts in 1985 / total # of workers in 1985.
***For example, calculated as total # of male workers working night shifts in 1985 / total # of male workers in 1985.

Overall, these percentages remained relatively stable from 1985 to 2004; only slight variations are observed. The first row in Table 1.1 indicates the percentage of all workers in the CPS sample that were employed on day or night shifts. From 1985 to 2004, employment in day shifts ranged from 82.3% to 84.8% of workers while employment in night shifts ranged from 2.7% to 3.5% of workers. The incidence of night shift work was highest in 1997. In years with lower percentages of day workers there were higher percentages of night workers, indicating that some workers may have switched from day to night work in these years. Although the data do not allow for a year by year comparison, the fluctuations in the percentages of night shift workers provide a hint of the cyclical nature of shift work. In each supplement year, men were more likely than women to be night shift workers. Additionally, blacks were more likely to work night shifts than whites or Hispanics. The incidence of night shifts was also higher for single workers. Higher percentages of private sector workers were employed on night shifts when compared to public sector workers.

Participation in night shift work is also partially determined by a worker's industry and occupation. The 1985, 1997, and 2001 CPS reports provide detailed information on the percentage of workers in each major occupational and industry group by shift. These CPS supplements use the 1980 and 1990 occupational and industrial classification system, which are similar and easily comparable. Detailed data on industry and occupation by shift are not available from the 2004 report. Additionally, for the 2004 survey, the CPS switched from using the 1990 occupation and industrial classification system to using the 2002 occupation and industrial classification system; therefore, it is difficult to compare the 2004 CPS supplement's contents to those from 1985, 1997, and 2001. Only data from the 1985, 1997, and 2001 supplements are included in the current discussion. These data are displayed in Table 1.2 and

**Table 1.2 Percentage of Workers by Industry & Occupation on Day and Night Shifts, CPS Supplements**

| | % of Category Working Day Shift | | | % of Category Working Night Shift | | |
|---|---|---|---|---|---|---|
| Industry Category | 1985 | 1997 | 2001 | 1985 | 1997 | 2001 |
| Agriculture | 89.4* | 93.1 | 92.2 | 2.2** | 0.3 | 1.2 |
| Mining | 78.1 | 74.6 | 74.4 | 1.6 | 2.3 | 4.6 |
| Construction | 97.5 | 95.9 | 96.7 | 0.4 | 0.2 | 0.4 |
| Non-Durable Manufacturing | 79.1 | 76.0 | 76.3 | 4.4 | 7.9 | 8.4 |
| Durable manufacturing | 84.0 | 83.0 | 83.4 | 2.5 | 5.0 | 4.9 |
| Transportation, Communications, & Public Utilities | 79.4 | 73.8 | 78.2 | 3.5 | 3.3 | 3.5 |
| Wholesale Trade | 91.9 | 89.7 | 92.0 | 2.1 | 2.6 | 2.0 |
| Retail Trade | 73.7 | 71.1 | 73.0 | 3.7 | 3.6 | 4.1 |
| Finance, Insurance, and Real Estate | 93.9 | 94.8 | 94.8 | 1.0 | 0.7 | 0.5 |
| Business and Repair Services | 87.4 | 86.0 | 88.7 | 2.4 | 3.6 | 3.2 |
| Personal Services | 74.0 | 74.9 | 79.3 | 3.8 | 4.1 | 2.1 |
| Entertainment and Recreation Services | 66.6 | 63.9 | 71.0 | 2.2 | 2.8 | 4.2 |
| Professional and Related Services | 81.3 | 86.0 | 87.6 | 4.4 | 3.3 | 3.3 |
| Public Administration | 87.2 | 86.1 | 88.3 | 2.0 | 3.2 | 2.5 |
| | | | | | | |
| Occupation Category | | | | | | |
| Managerial and Professional Specialties | 91.4 | 90.4 | 92.8 | 1.2 | 1.3 | 1.2 |
| Technical | 84.5 | 80.4 | 83.9 | 3.3 | 3.8 | 4.2 |
| Sales | 82.8 | 81.4 | 84.3 | 2.2 | 1.1 | 1.3 |
| Administrative Support/Clerical | 92.0 | 91.0 | 91.1 | 1.7 | 2.3 | 2.4 |
| Service | 61.6 | 62.1 | 68.0 | 6.1 | 6.5 | 5.7 |
| Farming, Forestry, and Fishing | 89.9 | 93.8 | 93.5 | 1.4 | 0.0 | 0.8 |
| Precision Production, Craft, and Repair Occupations | 87.0 | 86.2 | 87.4 | 2.2 | 4.0 | 3.6 |
| Operators, Fabricators, and Laborers | 76.3 | 72.5 | 73.6 | 4.6 | 7.4 | 8.0 |

1985 data classified according to 1980 industry and occupation codes. 1997 and 2001 data classified according to 1990 industry and occupation codes.
The number of individuals in the sample by year is as follows: 1985: 73,395 workers. 1997: 90,549 workers. 2001: 99,631 workers. 2004: 123,167 workers.
*For example, calculated as total # of agriculture workers working day shifts in 1985 / total # of agriculture workers in 1985.
**For example, calculated as total # of agriculture workers working night shifts in 1985 / total # of agriculture workers in 1985.

provide information on the percent distribution of each industry and occupation between day and night shifts. During the three survey years, the use of night shift work was most prevalent in the non-durable manufacturing industry. There were also relatively high percentages of durable manufacturing workers employed on night shifts, with manufacturing likely requiring night shift work to ensure continuous production processes. Night shift work was also more common in the transportation, retail trade, personal services, business and repair services, and entertainment and recreation services industries. These industries have operations that take place outside the traditional daytime hours. Additionally, the professional and related services category features relatively large percentages of night shift workers, due to the fact that "hospital" workers, who frequently work at night, are included in this category. Low percentages of night shift workers were employed in the agriculture, construction, finance, insurance, and real estate industries. When analyzing night shift work by occupation, the service, operator, fabricator, and laborer occupations featured the highest percentages of night shift work. Service occupations include food service and protective service workers. Managerial and professional occupations, as well as sales, farming, forestry, and fishing occupations were least likely to use night shift workers.

### 1.3.2 Reasons for Selecting Shift Work

Also included in the CPS supplements is information on why individuals choose to work a shift. Respondents who worked non-day shifts were asked "What is the main reason you work this type of shift?" This information is highly relevant to the current econometric analysis since a selection model is employed. Since data on shift workers is limited, this survey question allows for the unique opportunity to understand workers' primary motivation for working a shift. The 1985 report only includes information on all workers with non-standard shifts, while the 1997, 2001, and 2004 reports include information on specific categories of shift work such as evening, night, rotating, split, and other shifts. Because the current analysis focuses on night shift workers, statistics on night shift workers are compared to statistics on all workers on non-standard shifts. Reasons for choosing to work a shift are classified as either voluntary or involuntary. Table 1.3 provides a summary of the available statistics on shift choice. Information on the main reason for choosing shift work is extremely limited in the 1985 report. 28% of all non-standard shift workers cited voluntary reasons such as "better arrangements for child care or care of other family members, more time for school, and better pay." 64.8% of workers accepted their shift schedule because it was "a requirement of the job" (Mellor 1986). The 1997, 2001, and 2004 reports allow for a more detailed comparison of the main reason for choosing shift work for non-standard and night shift workers. A few general trends apply to both groups. From 1985 to 2004, workers became more likely to choose shift work for voluntary reasons. The most common reason cited for shift work is "the nature of the job," with roughly 50% of non-standard shift workers and 30% of night shift workers selecting this reason. The percentages of workers choosing shift work because of child care arrangements, better pay, and because they could not get any other job remained roughly steady. In 1997, approximately 13% of non-standard shift workers and 10% of night workers reported that employer mandated pollution controls influenced them to work a shift. Larger percentages of non-standard and night workers cited "allows time for school" as their reason for selecting shift work in 2004.

The most striking difference between non-standard shift workers and night shift workers is that night shift workers are more likely to choose their shift schedule for voluntary reasons,

**Table 1.3 Main Reason for Working Shift: Percentage of Non-Standard Shift and Night Workers, CPS Supplement**

| | % Dist. of Non-Standard* Shift Workers | | | | % Dist. of Night Shift Workers | | | |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 1997 | 2001 | 2004 | 1985 | 1997 | 2001 | 2004 |
| Voluntary Reason | 28.0** | 16.61 | 32.4 | 38 | N/A | 28.2 | 50.1 | 50.57 |
| Better arrangements for family or child | | 6.96*** | 8.9 | 8.4 | | 14.92^ | 14.9 | 16.43 |
| Better pay | | 6.06 | 6.9 | 5.15 | | 10.46 | 11.2 | 9.58 |
| Allows time for school | | 2.87 | 3.3 | 14.87 | | 1.96 | 2.5 | 5.35 |
| Personal preference | | | 13.3 | 9.75 | | | 21.5 | 19.21 |
| Involuntary Reason | 72 | 69.82 | 59.9 | 55.58 | N/A | 52.19 | 40.9 | 40.83 |
| Employer Mandate for pollution control | | 12.96 | | 0.12 | | 10.33 | | 0.05 |
| Could not get any other job | | 5.7 | 6.6 | 7.46 | | 7.51 | 8.9 | 8.06 |
| Nature of the job | 64.8 | 51.16 | 53.3 | 48 | | 34.35 | 32 | 32.72 |
| Some other reason/Not Reporting | | 14.31 | 6.2 | 6.36 | | 20.44 | 7.2 | 8.66 |
| | 100 | 100 | 100 | 100 | | 100 | 100 | 100 |

Some questions were unavailable or omitted from the survey in 1985, 1997, and 2001. *Non-standard shifts include evening, night, rotating, split, irregular, and other shifts. The number of individuals on non-standard shifts by year are as follows: 1985: 11,670 workers. 1997: 15,183 workers. 2001: 14,461 workers. 2004: 21,762 workers. The number of individuals on night shifts by year are as follows: 1985: 1,982 workers. 1997: 3,156 workers. 2001: 3,318 workers. 2004: 3,811 workers.

**Example: calculated as total # of non-standard shift workers citing voluntary reasons for shift work 1985 / total # of non-standard shift workers 1985.

***Example: calculated as total # of non-standard shift workers citing better arrangements as reason for shift work 1997 / total # of ns shift workers 1997.

^ Example: calculated as total # of night shift workers citing better arrangement for child as reason for shift work 1997 / total # of night shift workers 1997.

with approximately half of night workers selecting voluntary reasons in 2001 and 2004 compared to only 40% of night workers selecting involuntary reasons. In contrast, approximately 32%-38% of non-standard shift workers chose their shift for voluntary reasons, while approximately 55%-60% chose their shift for involuntary reasons. The reason for selecting shift work that differs most between non-standard and night workers is "personal preference," a category that was only included in the 2001 and 2004 surveys. In 2001 and 2004, approximately 10-13% of all non-standard shift workers cited this as their primary motivation for working a shift compared to 20% of night shift workers. These statistics provide evidence that preferences of night shift workers may be different from non-standard shift workers as a whole. It should be noted that during 1997, respondents were not given the option to select "personal preference" as a reason for choosing shift work. This omission most likely explains why the "some other reason/not reporting" category is high in 1997 relative to other years. Additionally, this explains why it appears as if percentages of workers choosing shift work for voluntary reasons declines in 1997.

The BLS data from the 1985, 1997, 2001, and 2004 surveys provide evidence of recent trends in shift work and motivate the current analysis. The data indicate the relevance of this dissertation since shift work impacts a significant portion of the population. The CPS data analyzed in Tables 1.1, 1.2, and 1.3 also aid in constructing the wage and selection equations employed in this paper by indicating which persons are more likely to work shifts and what reasons workers may have for choosing shift work. The data also demonstrate that night shift workers' preferences may differ from all non-standard shift workers; thus, this paper's focus on a comparison of day and night workers is economically interesting. The theory of equalizing differences relies on homogenous worker preferences, particularly the assumption that all workers dislike night shift work. Table 1.3 indicates, however, that a significant number of night shift workers actually prefer night shift work. The reasons cited for working a shift in Table 1.3 support one hypothesis of the current analysis by indicating that some shift workers are motivated to select shift work in order to receive compensating wages. Overall, the information in the CPS supplements provides evidence that the current research is relevant and that much can be learned by analyzing labor market outcomes in light of work hours preferences of individuals.

### 1.4 The Inconvenience of Shift Work

The current analysis is motivated by a desire to better model a unique workplace disamenity: working non-standard hours. The theory of equalizing differences as applied to night shift work relies on the premise that night shift work is an inconvenience for at least some workers. This section seeks to briefly explain why night shift work is inconvenient. An understanding of the hazards and side effects associated with night shifts aids in understanding why night shift workers may receive compensating differentials. The inconvenience of night shift work is well-documented in the health and sociology literature. A majority of these studies on shift work concern the physical and psychological responses of workers to shift work. The focused nature of the current research does not permit a thorough review of the vast number of shift work studies. For detailed accounts of shift worker responses to shift work, see Dunham (1977), Finn (1981), Costa (1996), Pati, *et al.* (2001), Buxton (2003), and Saksvik, *et al.* (2011). The main side effects or problems associated with shift work are difficulty sleeping and sleepiness during work, increased health problems, adverse effects on family and social life, and increased risk of injury and accidents on the job.

### 1.4.1 Difficulty Sleeping and Sleepiness during Work

Akerstedt (2003) notes that, although there are many health-related side effects of shift work, "disturbed sleep is the most common." Much of the literature on sleep effects of night shift work is based upon an understanding of circadian rhythms. Circadian rhythms are 24 hour biological body rhythms that rise and fall throughout the course of a day. These bodily patterns are synchronized with light and dark and are designed to slow down bodily function during the night and allow for increased activity during the day. For night shift workers, work occurs when circadian rhythms are low and sleep occurs when circadian rhythms are high (Rosa and Colligan, 1997). In addition to negative sleep effects of interrupted circadian rhythms, shift workers' daytime sleep is often interrupted by their environment or family life schedule. Akerstedt (1985) estimates that shift workers receive an hour less sleep on average than day workers. Drake, *et al.* (2004) analyze a medical condition called "shift work sleep disorder," a disorder in which shift workers experience periods of extreme sleepiness and insomnia as a result of the altered quantity and quality of their sleep.

### 1.4.2 Increased Health Problems

In addition to the harmful side effects caused by a lack of sleep, night shift work impacts workers' health in other ways. Rosa and Colligan (1997) note that some health consequences of shift work occur immediately while others take time to develop. Immediate consequences include sleep disorders, depressed mood, and digestive problems. Costa (1996) finds that 20 - 75% of night workers experience gastrointestinal problems. Shift workers also experience more heart problems than day workers. Studies by Akerstedt, *et al*. (1984), Michel-Briand, *et al*. (1981), and Knuttson, *et al*. (1999) indicate that shift workers are more likely to develop cardiovascular disease, myocardial infarction, heart attacks, and high blood pressure than day workers. Scott and Ladou (1990) note that shift work can be an added stressor during pregnancy. Davis, *et al.* (2001) find that exposure to light at night, particularly by night shift workers, may be associated with the risk of developing breast cancer. Scott (2000) finds that some individuals may develop moderate to severe depression while working shifts. Additional studies indicate that there may be linkages between shift work and obesity and diabetes, whether due to poor diet, irregular mealtimes, or lack of exercise often associated with shift schedules.

### 1.4.3 Adverse Effects on Family and Social Life

Presser (2003) notes that dual-earner spouses are "the predominant family type among married couples" and that "employment at nonstandard hours and on weekends undoubtedly challenges such families." Shift workers often have reduced quality and quantity of time with family and others. Work or sleep often conflicts with social activities and child care arrangements. Additionally, the negative effects of shift work are often shared with one's family. Grosswald (2003) finds significant negative spillover effects of shift work to family, indicating that shift work negatively impacts one's mood, energy, and time for family life. Pati, *et al.* (2001) find higher anxiety levels and lower mental health levels in spouses and children of shift workers when compared with spouses and children of day workers.

### 1.4.4 Increased Risk of Injury and Accidents on the Job

Smith, *et al.* (1994) find that the risk of sustaining injuries is higher for night shift workers than for those working during the day. Shift workers' ability to remain alert is negatively impacted by circadian rhythm disruptions, making it more likely that they make mistakes or are injured on the job (Rosa and Colligan 1997). Dula, *et al.* (2001) find that night shift workers' performance declines after they have worked five consecutive night shifts. Akerstedt, *et al.* (2002) find that night workers are more likely to fall asleep at work than day workers. Folkard (1997) finds that most worker mistakes and accidents occur between the hours of 2:00 a.m. and 7:00 a.m. In an interesting report, Mitler, *et al.* (1988) observe that disasters at nuclear power plants Three Mile Island and Chernobyl, the Exxon Valdez oil spill, and the Challenger space shuttle accident all occurred during the early morning hours of night shifts.

**1.5 Shift Differentials**

This paper seeks to determine an empirical measure of the wage differential for night shift work. The U.S. Office of Personnel Management defines a night shift differential as "the differential paid for work performed when the majority of a prevailing rate employee's regularly scheduled non-overtime hours fall between 3 p.m. and 8 a.m." Shift differentials are considered supplemental pay and may be paid for evening, night, split, rotating, or irregular shifts. Shift differentials are commonly awarded as a percentage of the employee's rate of regular pay or as a fixed cents-per-hour increase over day wages. The Fair Labor Standards Act does not require extra pay for night work. According to the U.S. Department of Labor, shift differentials are a matter of agreement between employers and employees.

Data on shift differentials are limited. Using estimates from BLS surveys from 1959-1968, O'Connor (1970) determines that 95% of workers on late shifts received compensating wages. Although the incidence and amount vary depending upon industry and occupation, the average shift differential for night shift workers was under 10%. Foss (1984) summarizes O'Connor's findings, stating that late shift differentials are small relative to straight-time wages.

King and Williams (1985) offer a rare account of shift differentials for manufacturing workers using Area Wage Survey data from the BLS from 1959-1984. King and Williams note that "in 1984, more than 90 percent of the workers on second and third shifts in urban manufacturing plants received premium pay for such schedules." Average shift differentials in cents per hour for night shifts were 11.1 cents above day workers in 1959 and 29.9 cents above day workers in 1984. Average shift differentials in percentages for night shifts were approximately 10 percent of day rates in both 1959 and 1984. In a 1979 BLS report on CPS data, Hedges and Sekskenski find that the median night shift wage was $5.62 compared to $4.62 for day workers. They also indicate that 80% of late shift union workers had collective bargaining agreements that specified payment of either a money or time differential for shift work. O'Connor, Hedges and Sekskenski, and King and Williams find that shift differentials have tended to rise slower than general wage rates. Foss (1981) commented on the apparent long run decline in night shift differentials, speculating that the supply curve of labor willing to work nights may have shifted to the right. Foss (1984) also surmises that the increased prevalence of shift work may result from the failure of shift differentials to rise as much as straight-time wages, making employers more inclined to offer shift work.

In a BLS report, Bishow (2009) briefly examines three forms of supplemental cash compensation for employees: overtime, bonuses, and shift differentials. Bishow analyzes data from seven quarters of Employer Cost for Employee Compensation surveys from 2001-2007 finding that shift differentials are the least common form of supplemental pay. 20% of workers receive shift differentials. When analyzing supplemental pay by wage quartiles, Bishow also finds that shift differentials are a larger proportion of cash compensation for low-paid workers. When analyzing workers by occupation, Bishow finds that shift differentials as a percentage of cash compensation are highest for healthcare practitioner and technical occupations at approximately 3%.

Most published estimates of shift differentials referenced above are negligible. These estimates are computed from average earnings or, in the case of Bishow, from reports of firm costs; thus they fail to control for individual worker characteristics or self-selection into shift work. An empirical measure of shift differentials, such as the one estimated in this paper, would be more informative.

### 1.6 Contribution to the Literature

Shift work is an important and still partly undiscovered area of research for labor economists. The organization of work and the sorting of workers among firms are fundamental economic questions. This dissertation contributes to the literature by providing a recent test of the theory of equalizing differences, by adding to a small economic literature on shift differentials, by being the first to provide maximum likelihood estimates of an endogenous switching regression model of shift work, by employing an improved econometric model that includes indicators of labor market strength, by developing a new method of analyzing interaction effects in the endogenous switching regression model, and by modeling shift differentials and shift selection using a larger, more diverse dataset.

This paper provides a recent test of the theory of equalizing differences. Although this classical labor economics theory predicts substantial wage differentials for jobs with undesirable characteristics, there is mixed empirical support. Section 2.3.1 provides a survey of studies on compensating differentials. This paper also helps to fill a gap in the existing literature estimating wage differentials for shift work. Labor economics literature focused specifically on shift differentials is limited to five published studies. Section 2.3.1.2 outlines the shift studies of Kostiuk (1990), Lanfranchi, *et al.* (2002), Schumacher and Hirsch (1997), Agnarsson (1998), DeBeaumont and Nsiah (2010), and Scheffel (2011). Kostiuk and Lanfranchi, *et al.* provide the most widely cited findings of shift differentials.

This dissertation is the first shift work analysis to employ maximum likelihood estimation of an endogenous switching regression model. Previous labor studies by Kostiuk and Lanfranchi, *et al.,* have estimated shift differentials and shift choice by estimating the endogenous switching regression model using a two-step estimator. In addition to using the two-step estimator, the current analysis provides maximum likelihood estimates of the switching regression as applied to shift work. The estimates obtained through maximum likelihood are more asymptotically efficient than those obtained using the two-step method, and provide an interesting point of comparison for the two-step results.

The models used in this paper further improve upon the research of Kostiuk and Lanfranchi, *et al.* by including measures of local economic conditions in the analysis. An individual's decision to work a night shift may be related to local economic conditions; thus we estimate the impact of the local unemployment rate and the state leading index on both the incidence of shift work and upon the size of compensating wages for shift work. Kostiuk and Lanfranchi, *et al.* only consider worker, firm, and industry characteristics when estimating wages of day and shift workers, thus failing to consider a relationship between shift differentials and the strength of the labor market. Section 2.3.3 reviews existing theory and literature on the link between local economic conditions and compensating differentials.

This paper is also an improvement on research by DeBeaumont and Nsiah. DeBeaumont and Nsiah include the local unemployment rate in their estimation of day and night wages;

however, they employ a treatment effects model. The current analysis uses a less restricted, more general model, a switching regression model with endogenous switching. This model allows for the estimation of the effect of wage differentials on the decision to work a night shift and allows the returns to individual characteristics of day and night workers to differ. Additionally the model is analyzed using the state leading index as an alternate measure of local economic conditions. Analyzing the interaction effect between shift differentials and local economic conditions on shift choice is complicated in the endogenous switching regression model. This paper offers a method of investigating interaction effects by estimating lower and upper bounds on the probability of selecting night shift work for different values of the shift differential and the local economic conditions.

This dissertation applies these improved econometric models to a larger, more diverse dataset of workers than previous literature. This paper uses data from the National Longitudinal Survey of Youth 1979, which allows for the estimation of shift premiums for full-time workers in various industries and occupations. Additionally, this paper includes both male and female workers from across the United States. Kostiuk employs CPS data on shift workers from 1979 and 1985, but limits the analysis to full-time male manufacturing workers. Lanfranchi, *et al.* use French data on male blue collar private sector workers from 1992. Schumacher and Hirsch restrict their analysis to 1985 and 1991 data on nurses employed in hospitals. Anargsson considers only Swedish male workers. Scheffel employs German Time Use data on male workers from 2001-2002. DeBeaumont and Nsiah (2010) estimate their model using the same cross-sectional dataset from 1990 as used in this paper; however, as previously discussed, this paper improves upon their analysis by estimating shift choice and shift differentials using an endogenous switching regression model.

# CHAPTER II

# LITERATURE REVIEW

This chapter first briefly reviews existing literature on sample selection models and switching regression models. Then, attention is focused on existing estimation methods for the type of sample selection model used in the current analysis, a switching regression model with endogenous switching. An overview of research on unfavorable working conditions is next included with attention devoted to shift work literature focusing on hedonic wage models. A brief discussion of demand side shift work issues follows, and the literature review concludes with analysis of research motivating the use of local economic conditions in the current analysis.

## 2.1 Sample Selection Models

### 2.1.1 Sample Selection Problem and Related Studies

Selection bias is common in analyzing labor economics issues since workers self-select into jobs that best suit their abilities and preferences. Participation in shift work is not randomly determined; workers self-select into shift work. A sample selection model is necessary to estimate the shift premium and the choice to work a shift.

Gronau (1974), Lewis (1974), and Heckman (1974) provide the first major discussions of the problem of self-selection. Gronau (1974) examined self-selection issues by modeling the labor force participation decisions of women. Lewis (1974) expands Gronau's work. The Gronau/Lewis model describes the decision to accept employment as a function of an individual's reservation wage. If the market wage is greater than the reservation wage, individuals choose to work, and wages are observed. Otherwise, wages are unobserved. A simple regression of observed wages on individual characteristics of workers leads to sample selection bias and inconsistent estimates, and returns to individual characteristics will be estimated on workers alone, not the population as a whole. To address this selection bias, Heckman developed a two-stage estimation method in a series of papers (1974, 1976, 1978, 1979, 1990). Heckman (1979) provides a well-known correction for sample selection by approaching selectivity bias as an omitted variables problem. A survey of the many extensions of the general sample selection model is provided by Maddala (1983).

**2.2 Switching Regression Models**

The sample selection model employed in the current analysis is a switching regression model. The basic switching regression model is provided by Goldfeld and Quandt (1973) and is useful when the behavior of individuals is best described by two regression equations or regimes. An additional criterion function determines which regime applies to particular individuals, i.e. the criteria provide the motivation for a "switch" in the regression equation used. For example:

Regime 1: $Y_i = X_{1i}\beta_1 + \varepsilon_{1i}$ iff $Z\delta \geq \varepsilon_i$

Regime 2: $Y_i = X_{2i}\beta_2 + \varepsilon_{2i}$ iff $Z\delta \leq \varepsilon_i$

where $\varepsilon_i$ is assumed to be uncorrelated with $\varepsilon_{1i}$ and $\varepsilon_{2i}$. The criterion function $Z\delta \geq \varepsilon_i$ or $Z\delta \leq \varepsilon_i$ determines which regression equation applies. This model is more formally called a switching regression model with exogenous switching. Maddala and Nelson (1975) consider a switching regression model with endogenous switching. In their model, it is assumed that $\varepsilon_i$ is correlated with $\varepsilon_{1i}$ and $\varepsilon_{2i}$.

### 2.2.1 Switching Regression Model with Endogenous Switching

The sample selection model most applicable to the current research is a switching regression model with endogenous switching. Individuals self-select into either day work or night work, and wages of day workers and wages of night workers are observed dependent upon a selection equation modeling the decision to work at night. Factors influencing the decision to work at night which are included in the error term of the selection equation are likely correlated with factors in the error term of the individual's wage equation. The switching regression model with endogenous switching may be estimated by a two step procedure employed by Lee (1978) or by maximum likelihood.

#### 2.2.1.2 Estimation Methods: Lee Model

Following previous research on shift work, the model provided by Lee (1978) is first employed in the analysis. The Lee model is a variation of the switching regression model with endogenous switching which involves estimating endogenous variables and then substituting these variables into the selection equation prior to final estimation of the selection equation. This method, known as the structural probit method, is similar to Heckman's two-step method. Lee's endogenous switching regression model analyzes union and non-union wages, and allows for two hedonic wage equations, one for log wages of union workers and one for log wages of non-union workers. A simplified version of the regression equations presented in Lee (1978) allow for the returns to union and non-union membership to vary and take the form

$$w_{ui} = \theta_{u0} + X_{ui}\theta_{u1} + Z_{ui}\theta_{u2} + \varepsilon_{ui} \qquad (1)$$

$$w_{ni} = \theta_{n0} + X_{ni}\theta_{n1} + Z_{ni}\theta_{n2} + \varepsilon_{ni} \qquad (2)$$

(1) and (2) are the log wage equations for union and non-union workers respectively. The vector

$X$ includes worker characteristics and the vector $Z$ includes firm characteristics. Since workers self-select into union status, a selection equation, or structural probit, is needed to model an individual's decision to join a union. The structural probit takes the form

$$I_i^* = \delta_0 + \delta_1 \left( w_{ui} - w_{ni} \right) + \delta_2 X_i + \delta_3 Z_i + v_i \tag{3}$$

Additionally, $\varepsilon_u \sim N\left(0, \sigma_u^2\right)$, $\varepsilon_n \sim N\left(0, \sigma_n^2\right)$, and $v \sim N(0, \sigma_v^2)$. In (3), $X$ and $Z$ include a majority of the individual and firm variables from the individual wage equations as well as an additional $Z$ variable, an indicator of the industrial-concentration ratio that serves as an exclusion restriction to improve model identification. The variable $\left( w_{ui} - w_{ni} \right)$ indicates the wage differential for union workers. When $I_i^* \geq 0$ the individual joins the union, otherwise, the individual does not join the union.

The individual wage equations (1) and (2) may be substituted into the selection equation (3) to compute the reduced form (4).

$$I_i^* = \gamma_0 + \gamma_1 X_i + \gamma_2 Z_i + \eta_i \tag{4}$$

This equation is estimated by probit, and the results are used to calculate the inverse Mills ratios for each observation. The conditional expected wages for union and non-union workers are calculated as

$$E(w_{ui} \mid X_{ui}, Z_{ui}) = \theta_{u0} + X_{ui}\theta_{u1} + Z_{ui}\theta_{u2} + \sigma_{\varepsilon^u, \eta} \frac{\phi(\psi)}{\Phi(\psi)} \tag{5}$$

$$E(w_{ni} \mid X_{ni}, Z_{ni}) = \theta_{n0} + X_{ni}\theta_{n1} + Z_{ni}\theta_{n2} - \sigma_{\varepsilon^n, \eta} \frac{\phi(\psi)}{1\text{-}\Phi(\psi)} \tag{6}$$

where $\psi = \gamma_0 + \gamma_1 X_i + \gamma_2 Z_i$. $\phi\left(\psi\right)$ and $\Phi(\psi)$ are the density function and cumulative distribution function evaluated at $\psi$. Including the Mills ratios in the expected wage equations provides an estimate of the sample selection bias and controls for selectivity. The coefficients on

$\frac{\phi(\psi)}{\Phi(\psi)}$ and $\frac{\phi(\psi)}{1-\Phi(\psi)}$ yield estimates of the covariance between the error term in the individual wage equations and the selection equation.

Lee's estimation method for endogenous switching regression models may be summarized as follows:

1) Estimate the reduced form of the selection equation (4) using probit. Compute $\phi(\psi)$ and $\Phi(\psi)$ for each observation.
2) Apply OLS to the conditional expected wage equations (5) and (6). The coefficients of the selection terms, $\sigma_{\varepsilon^u,\eta}$ and $\sigma_{\varepsilon^n,\eta}$, serve as an estimate of the covariance between the error in the individual wage equations and the error in the selection equation. These coefficients also serve as an indicator of selection bias.
3) The estimated wage gain, $(w_{ui} - w_{ni})$, is next computed and included in probit estimation of the structural equation (3) to obtain an estimate of $\delta_1$.

In his application of the above model to union data, Lee finds that $\delta_1$ is a significant predictor of union choice, indicating that workers consider expected wage gains of union membership when deciding whether or not to join a union. Lee (1976) proves the consistency of the estimate of $\delta_1$ and provides a formal presentation of his two-step estimator.

Maddala (1983) notes that the model described above can be modified to evaluate the benefit of selection. This creates the treatment effects model, which is a restricted version of the expected wage equations. Using the Lee model above as an example, the treatment effects model describes the total gross benefit of participation in union work for all workers in the sample by comparing the expected potential outcome from union work, $log W_{ui}$ (participation in the program) to the expected potential outcome without union work, $log W_{ni}$ (not participating in the program). The treatment effects model assumes that all coefficients for union and non-union workers are identical except for the intercept term. For the union model, the treatment effects model is

$$E(w_i \mid X_i, Z_i) = \theta_0 + X_i\theta_1 + Z_i\theta_2 + \alpha\Phi(\psi) + (\sigma_{\varepsilon^u,\eta} - \sigma_{\varepsilon^n,\eta})\phi(\psi) \qquad (7)$$

where $\alpha$ is the difference in the intercepts for union and non-union workers and indicates the effect of union employment on wages. $(\sigma_{\varepsilon^u,\eta} - \sigma_{\varepsilon^n,\eta})$ indicates the direction of selection into union work and provides a test for the presence of selection bias.

For other examples of the use of endogenous switching regression models, see Willis and Rosen (1979), Lee and Trost (1978), and Adamchik and Bedi (2000). Willis and Rosen estimate expected lifetime earnings of high school versus college graduates. The model includes a wage equation for high school graduates, a wage equation for college graduates, and a selection equation modeling an individual's decision to attend college. The wage differential for college graduates is determined to be a significant predictor of the individual's decision to attend college. Another well-known example of a switching regression model with endogenous switching is Lee and Trost's (1978) model of expenditures on owned housing and rental housing. Adamchik and Bedi (2000) use an endogenous switching regression model to examine wage differentials for public versus private sector work. The estimation of the Lee model for shift work is outlined in Section 4.3.2.

#### 2.2.1.2.1 Roy/Borjas Interpretation of Selection Term Coefficients

The Lee model provides a test for the presence of selectivity bias. A test for selectivity bias is a test of $\sigma_{\varepsilon^u,\eta} = 0$ and $\sigma_{\varepsilon^n,\eta} = 0$ in equations (5) and (6). Additionally, the sign of these coefficients can be used to indicate positive or negative selection. Roy (1951) offers an early treatment of the problem of self-selection in analyzing the optimizing behavior of individuals selecting between two occupations: hunting and fishing. Roy indicates that workers are endowed with skills and abilities in each occupation, but they will choose their occupation based upon expected wages. Roy's main contribution to the literature involved using the signs of the covariances (the coefficients on the selection terms in the individual wage equations of hunters and fishermen) as an indication of positive or negative selection based on comparative advantage. For example, positive selection into hunting implies that those who choose to hunt have above average earnings in hunting. Negative selection into hunting implies that those who choose to hunt have below average earnings in hunting. Maddala (1983) provides a summary of the Roy model. Borjas (1987) develops Roy's framework into a well-known model through analysis of migration selection between a source and host country.

Because the Roy/Borjas model deals with how individuals sort themselves into different regimes, it is commonly used in evaluating the selection term coefficients in switching regression models with endogenous switching. Using the Roy method, Lee (1978) finds positive selection into both union and non-union work. As an example of how positive versus negative selection is determined for the version of the Lee model presented above, let the sign of the coefficients obtained from regressions (5) and (6) be $\sigma_{\varepsilon^u,\eta} = \text{positive}$ and $\sigma_{\varepsilon^n,\eta} = \text{negative}$. Positive or negative selection into union or non-union status is determined by interpreting these coefficients in light of equations (5) and (6), shown below.

$$E(w_{ui} \mid X_{ui}, Z_{ui}) = \theta_{u0} + X_{ui}\theta_{u1} + Z_{ui}\theta_{u2} + \sigma_{\varepsilon^u,\eta} \frac{\phi(\psi)}{\Phi(\psi)} \tag{5}$$

$$E(w_{ni} \mid X_{ni}, Z_{ni}) = \theta_{n0} + X_{ni}\theta_{n1} + Z_{ni}\theta_{n2} - \sigma_{\varepsilon^n,\eta} \frac{\phi(\psi)}{1\text{-}\Phi(\psi)} \tag{6}$$

$\sigma_{\varepsilon^u,\eta}$ positive indicates a positive correlation between variables in the error term in the union equation and the variables in the error term in the selection equation. For example, if a worker has abilities not captured by the union wage equation that lead to higher wages, the union error term is positive. If, additionally, this higher union wage makes the individual more likely to choose union work than is indicated by the selection equation, the selection equation error term will also be positive. The covariance $\sigma_{\varepsilon^u,\eta}$ will be positive, implying positive selection into union work. Likewise, if an individual has abilities not captured by the non-union wage equation that lead to higher wages, the non-union error term is positive. This higher non-union wage makes the individual less likely to choose union work, and the selection equation error term is negative. The covariance $\sigma_{\varepsilon^n,\eta}$ will be negative, which indicates positive selection into non-union work.

Another way to understand the interpretation of the selection term coefficients is to realize that the conditional expected wage equations provide the mean income of union and non-union workers. Equation (5) evaluated for $\sigma_{\varepsilon^u,\eta}$ positive indicates that the mean income of union workers is greater than $\theta_{u0} + X_{ui}\theta_{u1} + Z_{ui}\theta_{u2}$ and those who choose union membership have higher expected wages from union work than the average union worker. Thus, a positive selection coefficient is evidence of positive selection into union work. Likewise, equation (6) evaluated at $\sigma_{\varepsilon^n,\eta}$ negative indicates that the mean income of non-union workers is greater than

$\theta_{u0} + X_{ui}\theta_{u1} + Z_{ui}\theta_{u2}$. This result indicates positive selection into non-union work since those who choose non-union work have higher expected wages from non-union work than the average non-union worker.

### 2.2.1.3 Estimation Methods: Maximum Likelihood

The switching regression model with endogenous switching may also be estimated using maximum likelihood. Full Information Maximum Likelihood is preferred over the two-step method prescribed by Lee above. As noted by Maddala (1983), maximum likelihood produces consistent and asymptotically efficient estimates. Full information maximum likelihood involves forming the joint distribution of the endogenous variables and then maximizing the likelihood function. Maximum likelihood estimates the individual wage equations and structural equation from the switching regression model simultaneously. Following Maddala (1983), the likelihood function for the current analysis is derived in Section 4.3.3. The interpretation of the coefficients and selection terms is the same as explained for the Lee model above.

## 2.3 Review of Shift Work-Related Studies

### 2.3.1 Tests of the Theory of Compensating Differentials

The focus of the current research is to analyze compensating differentials and labor supply decisions for shift work. The basis of this research is the theory of compensating differentials, the belief that workers receive compensating wage differentials for unfavorable work conditions. The literature review that follows first considers research on unfavorable working conditions, then specifically examines shift work literature focusing on hedonic wage models.

#### 2.3.1.1 Unfavorable Work Conditions

Previous labor research has attempted to find support for the theory of equalizing differences by estimating the wage premiums received by workers who face undesirable working conditions. These work conditions range from risk of death or injury on the job to stress, physical work, fast-paced work, supervisory responsibilities, work with machinery, job repetitiveness, and job insecurity.

Thaler and Rosen (1976) provide the first major study of death or injury on the job, finding positive and significant wage differentials, which is consistent with the theory of compensating differentials. A majority of the economic literature since has concluded that risk of death or possibility of injury on the job lead to compensating wages. Hersch (1998) finds strong evidence of compensating differentials for women facing risk of injury on the job. Viscusi and Aldy (2003) provide a comprehensive review of economic studies that evaluate compensating differentials for on-the-job mortality risk. These studies form the basis for economic literature calculating the value of a statistical life.

Economic literature has not seen as much success in consistent estimation of compensating differentials for other unpleasant work characteristics. For example, Lucas (1977) finds that jobs requiring physical strength, repetitive work, and supervisory responsibilities induce statistically significant compensating wage differentials. According to the theory of equalizing differences, jobs requiring physical strength are less pleasant and thus should pay higher wages. Lucas, however, finds that the sign on the physical strength coefficient is negative, suggesting that jobs demanding physical strength actually pay less. Counterintuitive signs such as this are common in research on equalizing differences.

Smith (1979) offers a review of previous hedonic research on compensating differentials by Bluestone (1974), Duncan (1976), Hamermesh (1978), Thaler and Rosen (1976), and many others. Smith concludes that "tests of the theory of compensating wage differentials are inconclusive with respect to every job characteristic except the risk of death." Brown (1980) also offers a review of previous literature on equalizing differences stating the there was "some clear support for the theory, but an uncomfortable number of exceptions." Brown believed that many of the previous studies failed because they did not accurately control for worker characteristics, but in his empirical analysis of longitudinal data from the United States, Brown was still unsuccessful in finding significant effects of most working conditions on wages. He does find significant wage differentials for repetitive work, but notes that the wage differential is negative, not positive as the theory of equalizing differences would predict.

There are however, several studies that find compensating differentials of the expected sign. Antos and Rosen (1975) apply the theory of equalizing differences to unpleasant job characteristics faced by teachers, particularly examining factors that could induce white teachers to seek employment at predominantly black schools. They determine that differences in teacher wages could be the result of equalizing differences for difficult work conditions such as high dropout rates, lack of student motivation, job location, or teaching students of the opposite race. Duncan and Stafford (1980) find that a portion of the compensating wage differentials for union workers could be explained by job conditions such as working with machinery or work effort. Duncan and Holmlund (1983) find statistically significant compensating wages for stressful and dangerous work, but do not find statistically significant compensating wages for difficult physical work or hours constraints.

Eberts and Stone (1985) find that failure to include firm-specific information such as financial status and bargaining strength can lead to small or incorrectly-signed compensating differentials. Roback (1982, 1988) determines that compensating wages for differences in regional amenities can explain regional wage differentials. Garen (1988) emphasizes the importance of correcting for selection bias in estimates of compensating differentials for working conditions. Hwang, et.al. (1992) examine whether unobserved productivity heterogeneity in workers could account for inconclusive or wrong-signed estimates of compensating differentials. Applications of panel data, however, do not correct for the problem (see Duncan and Holmlund, 1983). Gronberg and Reed (1994) use a job search model to analyze the theory of equalizing differences through estimation of workers' marginal willingness to pay for job amenities. Bonhomme and Jolivet (2009) develop a model of wages and amenities, emphasizing the importance of modeling job mobility in order to find significant compensating differentials for work conditions. They argue that the theory of compensating differentials is unlikely to hold unless worker mobility is perfectly free.

#### 2.3.1.2 Compensating Wage Differentials for Shift Work

Following previous research on the theory of equalizing differences, economists realized that shift work qualified as an unfavorable work condition that might result in compensating wages. Research by Kostiuk (1990) provides the first estimates of shift-based wage premiums. Prior to his attempts, most research fails to find shift differentials, likely due to failure to correct for self-selection. Kostiuk applies a switching regression model with endogenous switching to CPS data on United States male manufacturing workers from 1979 and 1985. He estimates a positive shift differential of 4.6% in 1979 and 8.2% in 1985. Kostiuk finds evidence of positive selection into daytime work, but no evidence of selection into night work. His results also indicate that shift differentials have a positive and significant impact on the decision to work a shift.

Lanfranchi, Ohlsson, and Skalli (2002) follow Kostiuk's model, also estimating a switching regression model with endogenous switching. Lanfranchi *et al.* analyze a matched employer-employee French dataset from 1992. They estimate that shift workers receive wages that are 16% higher than daytime workers. Like Kostiuk, they determine that the shift premium is significant for shift choice and find evidence of positive selection into daytime work. A significant difference between Kostiuk and Lanfranchi *et al*. is that Lanfranchi *et al.* find evidence of negative selection into shift work, indicating that the choice to work a shift is the result of compensating wage differentials, not shift preferences. They also find that data for shift and day workers should not be pooled, providing support for the use of the switching regression model.

Schumacher and Hirsch (1997) explore the sources of the large wage premiums realized by nurses employed in hospitals relative to nurses employed elsewhere. Using CPS data from 1985 and 1991, they find that the shift premium of evening shift nurses is approximately 4%, while the shift premium of night shift nurses is approximately 11.6%. Additionally, they estimate that shift work accounts for 10% of the premium hospital nurses receive over nurses employed in health practitioner offices. Schumacher and Hirsch fail to find significant premiums for working rotating or split shifts.

DeBeaumont and Nsiah (2010) employ a treatment effects model to estimate the night shift differential for respondents of the National Longitudinal Survey of Youth 1979. They additionally examine the impact of the local unemployment rate on the night shift differential and an individual's choice to work a night shift. They confirm the presence of a wage premium for night shift work, with the size of the wage differential dependent upon the local unemployment rate. In areas of high unemployment (approximately 15%), the night shift differential was 5%, while areas of low unemployment (approximately 3%) experienced a night shift differential of 15%. Thus, areas experiencing high unemployment offered lower compensating differentials for night shift work.

Agnarsson (1998) estimates shift differentials for Swedish male employees, finding a 5% shift premium. Scheffel (2011) builds upon the work of Kostiuk and Lanfranchi *et al.*, employing a treatment effects model as well as a switching regression model with endogenous switching to estimate shift differentials. Analyzing German Time Use Data on male workers from 2001-2002, Scheffel finds evidence of significant negative selection into shift work. The treatment effects model reveals a shift premium of 10.3% for shift workers.

The above referenced research provides evidence that compensating wage differentials exist for shiftwork. The size of the wage differential as estimated by these researchers ranges from 4% to 16%. The above research also indicates that it is necessary to control for self-selection into shift work. Although Kostiuk, Lanfranchi *et al.*, Scheffel, and DeBeaumont and Nsiah all find evidence of positive selection into day work, Kostiuk finds no evidence of selection into shift work, while Lanfranchi *et al.*, and Scheffel find evidence of negative selection into shift work. Thus, the previous research is inconclusive as to the direction of selection into shift work.

### 2.3.2 Shift Work Demand-Side Issues

A growing economics literature considers the firm's motivation to use shift work. The analysis of shift work is often used synonymously with the terms "duration" and "capital utilization." Karl Marx (1867) and economist Alfred Marshall (1873) both studied the length of the working day, with Marshall advocating the adoption of multiple shifts as early as 1873. In 1964, Robin Marris published *The Economics of Capital Utilization* which has been called the "seminal analysis of shift work". He suggests that economies could prosper by more intensive utilization of capital stock through employing multiple shifts. Marris develops some of the first theoretical models of shiftwork, and using British data, looks at the impact of various factors upon the planned utilization rate of capital. For a review of literature and advances in the theory of capital utilization (use of shift work) since the work of Marris, see Betancourt (2008). A fundamental finding of these studies that is relevant to the current analysis is a reduction in the rate of capital utilization in the presence of large wage differentials for shift workers. Betancourt (1986) provides a model of the theory of the firm which allows for choice of duration.

Shapiro (1993) and (1996) find that much of the cyclical nature of production can be accounted for by variations in the workweek of capital or variations in the number of operative shifts. Thus, when adjustments for the workweek of capital are made, the Solow residual is no longer pro-cyclical. Following Marris's work, Mayshar and Solon (1993) find that shiftwork is procyclical. Mayshar and Solon estimate elasticity of late shift employment versus elasticity of overall employment to changes in real GNP. The elasticity of late shift employment in both manufacturing sectors and in all nonfarm employment is approximately double the elasticity of overall employment. They find that "although late shifts account for only about one-sixth of full-time nonfarm wage and salary employment, they account for almost one-third of cyclical variation." These results indicate that one-third of the declines in employment during a recession occur through declines in employment of late shift workers. Mayshar and Solon's research indicates that the procyclical nature of capital utilization can aid in explaining procyclical productivity. Halevy and Nason (2002) find that shift work explains business cycle fluctuations and concur with the findings of Mayshar and Solon, that employment during the late shift is very procyclical. The procyclical nature of shift work as determined by the above literature has interesting implications for the current analysis. These implications are discussed in Section 3.1.1.

### 2.3.3 Wages, Compensating Differentials, and Local Labor Market Conditions

In addition to estimating compensating differentials for shift workers, this paper also seeks to determine the effect of local economic conditions on compensating wages for shift workers and on the incidence of shift work. A closer examination of the literature relating local economic conditions to wages is warranted.

One way that local economic conditions affects wages is through compensating differentials offered for risk of job loss. Adam Smith (1776) believed that one unpleasant work characteristic that might generate a compensating wage differential was “constancy or inconstancy of employment.” In order to persuade workers to accept a job with low job security, firms will need to offer a compensating differential. Abowd and Ashenfelter (1984) provide support to this theory, concluding that industries where workers experience little anticipated unemployment receive small compensating differentials. Industries where workers experience substantial anticipated unemployment receive large compensating differentials. Hatton and Williamson (1991) author a historical study of workers in 1890’s, finding that who faced a higher risk of layoff commanded wage premiums. Winter-Ebmer (2001) finds that layoff risk can explain a portion of the firm size wage differential. Assad and Tunali (2002) find that employers offer substantial compensation for turnover risk. Using data from the 1880’s

Averette, Bodenhorn, and Staisiunas (2005) find that compensating differentials were awarded for workers facing a higher probability of predictable unemployment and that low-skill workers received larger compensating differentials than more skilled workers when facing unanticipated unemployment. Moretti (2000) and Magnani (2002) also find a positive compensating differential for risk of unemployment. For additional discussion of the compensating wage differentials for risk of layoff see Harris and Todaro (1970), Hutchens (1983), and Hamermesh and Wolfe (1990).

A second channel through which local economic conditions affect wages is through changes in compensating differentials for work characteristics during economic downturns. In terms of labor supply, when the economy slows and unemployment rises, workers are more likely to take jobs that would otherwise be undesirable. Section 1.1.1.1 discussed the economic theory for compensating differentials for night shift work. When unemployment is high and the local economy is weak, the worker's indifference curves in Figure 1.1 may become flatter. Thus the compensating differential required to induce workers to accept night shift work may be lower in weak economies. On the demand side, when the economy weakens and unemployment rises, employers have the advantage of a larger number of potential employees. For these employers, the need to offer compensating wages for undesirable work conditions is reduced. Thus, compensating wages for undesirable work characteristics should fall during recessions.

Section 1.2.2 offers an overview of the research of Bender and Mridha (2011) who provide a basic model for the effect of the local unemployment rate on compensating wages. Bender and Mridha emphasize that one of the major assumptions of the theory of equalizing differences is that labor markets are working efficiently. Firms must pay compensating differentials in order to induce workers to accept inconvenient or undesirable work conditions.

However, when labor markets do not clear and unemployment exists, the theory of equalizing differences is weakened. Thus, compensating wages for work characteristics may change. Bender and Mridha attempt to estimate the impact of the local unemployment rate on compensating differentials for injury on the job. Their basic model is

$$w_i = \alpha + \beta_1 X_i + \beta_2 I_i + \beta_3 UE_i + \theta I_i UEi + \varepsilon_i$$

where they estimate the log wages of workers dependent upon a vector of individual characteristics, *X*, a measure of risk, *I*, the local unemployment rate, *UE*, and the interaction of the risk measure and the local unemployment rate, *IUE*. $\theta$ indicates how the compensating differential for risk changes as the unemployment rate rises. Bender and Mridha compare estimates obtained from this model with estimates obtained from a simple model that includes no information on the local unemployment rate. They determine that estimated compensating wage differentials for injury risk are lower in areas of high unemployment, suggesting a downward bias in estimates of compensating wage differentials for injury in typical cross-sectional research that does not consider local labor market conditions.

There is limited research on the effect of the local unemployment rate on the size of compensating differentials for work characteristics. This paper follows DeBeaumont and Nsiah (2010) in applying an analysis of the local unemployment rate to estimates of the compensating differential for night shift work. We develop a method of analyzing the impact of changing local economic conditions on shift differentials in an endogenous switching regression model. In order to further investigate the impact of macroeconomic phenomenon on worker wages and shift selection, we use both the local unemployment rate and the state leading index in the wage and selection regressions.

# CHAPTER III

# DATA

## 3.1 Dataset

This paper uses cross-sectional data from the National Longitudinal Survey of Youth 1979 (NLSY79). The survey is sponsored and directed by the Bureau of Labor Statistics. The NLSY79 provides a sample of 12,686 men and women who were surveyed annually from 1979 to 1994 and are currently interviewed on a biennial basis. The NLSY79 provides a nationally representative sample and includes information on earnings, demographic characteristics, and shift work. Two major portions of the NLSY79 data are analyzed in this paper. First, a cross-section of data from 1990 is analyzed. Additionally, a pooled cross-section of data from 1990, 1992, 1994, 1996, 1998, and 2000 is evaluated.

### 3.1.1 1990 Cross-Section

Following the previous literature, a cross-sectional dataset of shift workers is used to analyze shift wages. This paper seeks to analyze the response of shift wages to local economic conditions, so the choice of cross-section used is important. Data from 1990 are employed in the current analysis for a few major reasons. First, 1990 marked the end of an economic expansion. From July 1990 through March 1991, the United States suffered a recession. Thus, 1990 provides an opportunity to analyze shift wages and shift choice during a weak economy. 1990 data was also chosen to take advantage of a larger sample of night shift workers. Additionally,

**Table 3.1 Summary Statistics, Sample Mean and Standard Deviation, 1990 Cross-Section**

| Variable | Description | All | Day | Night |
|---|---|---|---|---|
| *Wage* | hourly wage in dollars and cents | 9.79 | 9.84 | 9.23 |
| | | (5.065) | (5.012) | (5.700) |
| *Log Wage* | logarithm of hourly wage | 6.773 | 6.780 | 6.697 |
| | | (0.474) | (0.471) | (0.503) |
| *Night Shift* | =1 if night shift worker | 0.070 | | |
| | | (0.255) | | |
| *Age* | age as of 1990 | 29.058 | 29.170 | 29.050 |
| | | (2.269) | (2.274) | (2.268) |
| *Years of School* | years of completed schooling | 12.923 | 12.981 | 12.153 |
| | | (2.409) | (2.431) | (1.939) |
| *Experience* | age - hgc - 5 | 11.135 | 11.069 | 12.017 |
| | | (3.226) | (3.231) | (3.031) |
| *Tenure* | number of years worked at current job | 3.456 | 3.496 | 2.932 |
| | | (3.365) | (3.380) | (3.114) |
| *Union* | =1 if wages are set by collective bargaining | 0.181 | 0.174 | 0.304 |
| | | (0.385) | (0.377) | (0.461) |
| *Non-white* | =1 if nonwhite | 0.304 | 0.295 | 0.423 |
| | | (0.460) | (0.456) | (0.495) |
| *Female* | =1 if female | 0.448 | 0.455 | 0.349 |
| | | (0.497) | (0.498) | (0.477) |
| *Married* | =1 if married | 0.533 | 0.540 | 0.406 |
| | | (0.499) | (0.542) | (0.406) |
| *North East* | =1 if resident of northeast | 0.147 | 0.150 | 0.111 |
| | | (0.355) | (0.357) | (0.314) |
| *North Central* | =1 if resident of north central | 0.237 | 0.234 | 0.281 |
| | | (0.426) | (0.423) | (0.450) |
| *South* | =1 if resident of South | 0.419 | 0.419 | 0.420 |
| | | (0.493) | (0.493) | (0.494) |
| *MSA Resident* | =1 if resident of MSA | 0.476 | 0.475 | 0.491 |
| | | (0.499) | (0.499) | (0.501) |
| *Professional Occupation* | =1 if professional and/or management occupation | 0.255 | 0.264 | 0.131 |
| | | (0.436) | (0.441) | (0.338) |
| *Sales Occupation* | =1 if sales and/or clerical occupation | 0.270 | 0.279 | 0.151 |
| | | (0.444) | (0.449) | (0.358) |
| *Craft Occupation* | =1 if production, craft, repair, or operator occupation | 0.352 | 0.351 | 0.369 |
| | | (0.478) | (0.477) | (0.483) |
| *Unemployment Rate* | unemployment rate at labor market of current residence | 5.554 | 5.546 | 5.671 |
| | (in percent) | (1.819) | (1.835) | (1.587) |
| *Leading Index* | state leading index, prediction of the six-month growth rate | 1.200 | 1.195 | 1.275 |
| | in the state coincident index | (0.864) | (0.869) | (0.790) |
| *Number of Children* | number of children | 1.075 | 1.056 | 1.324 |
| | | (1.169) | (1.154) | (1.322) |
| *Industry Shift Rate* | shift rate within the industry, calculated as the proportion | 0.591 | 0.579 | 0.757 |
| | of night shift workers in 11 industry categories | (0.387) | (0.386) | (0.367) |
| *Firm Size 1* | =1 if employed at a firm with 25-99 employees | 0.248 | 0.252 | 0.199 |
| | | (0.432) | (0.434) | (0.400) |
| *Firm Size 2* | =1 if employed at a firm with 100 to 499 employees | 0.211 | 0.205 | 0.290 |
| | | (0.408) | (0.404) | (0.454) |
| *Firm Size 3* | =1 if employed at a firm with 500 to 999 employees | 0.058 | 0.052 | 0.136 |
| | | (0.233) | (0.221) | (0.344) |
| *Firm Size 4* | =1 if employed at a firm with over 1000 employees | 0.147 | 0.143 | 0.207 |
| | | (0.354) | (0.350) | (0.406) |
| *Observations* | | 5026 | 4674 | 352 |

Note: Standard Deviations are in parentheses.

**Table 3.2 Summary Statistics, Sample Mean and Standard Deviation, 1990 Cross-Section**

| Variable | Description | All | Day | Night |
|---|---|---|---|---|
| *Ag/Construct Industry* | =1 if agric, forestry, mining, & construction industry | 0.117 | 0.124 | 0.028 |
| | | (0.321) | (0.329) | (0.166) |
| *Manufacturing Industry* | =1 if manufacturing industry | 0.231 | 0.227 | 0.278 |
| | | (0.422) | (0.419) | (0.449) |
| *Transportation Industry* | =1 if transportation industry | 0.075 | 0.074 | 0.088 |
| | | (0.264) | (0.262) | (0.284) |
| *Wholesale Trade Industry* | =1if wholesale trade industry | 0.046 | 0.047 | 0.023 |
| | | (0.209) | (0.023) | (0.149) |
| *Retail Trade Industry* | =1 if retail trade industry | 0.119 | 0.111 | 0.227 |
| | | (0.324) | (0.314) | (0.420) |
| *Finance Industry* | =1 if finance industry | 0.076 | 0.081 | 0.011 |
| | | (0.265) | (0.272) | (0.106) |
| *Prof. & Related Industry* | =1 if professional or related industry | 0.183 | 0.185 | 0.156 |
| | | (0.386) | (0.388) | (0.364) |
| *Public Administration Industry* | =1 if public administration industry | 0.047 | 0.046 | 0.057 |

Note: Standard Deviations are in parentheses.

during the 1990 survey round, the survey respondents were between the ages of 25 and 33 and were likely participants in the labor force.

For 1990, the dataset of 12,686 workers was first modified to only include full-time workers, defined as those working more than thirty-five hours per week. To remove outliers from the NLSY79 wage data, only individuals with wages between $1 and $150 per hour were included. Observations on 5026 workers are included in the final analysis. Tables 3.1 and 3.2 provide summary statistics for the variables included in the 1990 cross-section regressions.

### 3.1.2 1990-2000 Pooled Cross-Section

In order to analyze changes in shift differentials and shift choice over time, cross-sections of data from 1990, 1992, 1994, 1996, 1998, and 2000 are pooled. Analyzing additional years of data allows for a larger number of observations on night shift workers. From 1990 to 2000, the 1980 Census/CPS codes were used to categorize workers by occupation and industry in the NSLY79. Thus, using cross-sections of data from these years permits consistent comparison of

**Table 3.3 Summary Statistics, Sample Mean and Standard Deviation, 1990-2000 Pooled Cross-Section**

| Variable | Description | All | Day | Night |
|---|---|---|---|---|
| *Wage* | hourly wage in dollars and cents | 13.04 | 13.16 | 11.14 |
| | | (8.67) | (8.79) | (6.14) |
| *Log Wage* | logarithm of hourly wage | 7.017 | 7.025 | 6.893 |
| | | (0.543) | (0.545) | (0.492) |
| *Night Shift* | =1 if night shift worker | 0.060 | | |
| | | (0.237) | | |
| *Age* | age for years 1990-2000 | 33.860 | 33.870 | 33.709 |
| | | (4.180) | (4.179) | (4.218) |
| *Years of School* | years of completed schooling | 13.110 | 13.164 | 12.260 |
| | | (2.416) | (2.439) | (1.806) |
| *Experience* | age - hgc - 5 | 15.750 | 15.706 | 16.450 |
| | | (4.748) | (4.756) | (4.569) |
| *Tenure* | number of years worked at current job | 5.039 | 5.074 | 4.474 |
| | | (4.875) | (4.880) | (4.758) |
| *Union* | =1 if wages are set by collective bargaining | 0.169 | 0.160 | 0.302 |
| | | (0.374) | (0.367) | (0.459) |
| *Non-white* | =1 if nonwhite | 0.337 | 0.330 | 0.455 |
| | | (0.473) | (0.470) | (0.498) |
| *Female* | =1 if female | 0.453 | 0.459 | 0.371 |
| | | (0.498) | (0.498) | (0.483) |
| *Married* | =1 if married | 0.571 | 0.578 | 0.458 |
| | | (0.495) | (0.494) | (0.498) |
| *North East* | =1 if resident of northeast | 0.146 | 0.148 | 0.125 |
| | | (0.353) | (0.355) | (0.331) |
| *North Central* | =1 if resident of north central | 0.233 | 0.230 | 0.276 |
| | | (0.423) | (0.421) | (0.447) |
| *South* | =1 if resident of South | 0.425 | 0.424 | 0.435 |
| | | (0.494) | (0.494) | (0.496) |
| *MSA Resident* | =1 if resident of MSA | 0.524 | 0.522 | 0.556 |
| | | (0.521) | (0.521) | (0.513) |
| *Unemployment Rate* | unemployment rate at labor market of | 6.028 | 6.027 | 6.036 |
| | current residence (in percent) | (2.804) | (2.817) | (2.598) |
| *Leading Index* | state leading index (prediction of the six month | 1.706 | 1.707 | 1.688 |
| | growth rate in the state coincident index) | (0.904) | (0.905) | (0.893) |
| *Number of Children* | number of children | 1.468 | 1.453 | 1.702 |
| | | (1.305) | (1.293) | (1.462) |
| *Industry Shift Rate* | shift rate within the industry, calculated | 0.525 | 0.517 | 0.639 |
| | as the proportion of night shift workers | (0.326) | (0.327) | (0.286) |
| | in 11 industry categories | | | |
| *Firm Size 1* | =1 if employed at a firm with 25-99 employees | 0.253 | 0.256 | 0.200 |
| | | (0.435) | (0.437) | (0.400) |
| *Firm Size 2* | =1 if employed at a firm with 100 to 499 employees | 0.227 | 0.221 | 0.311 |
| | | (0.419) | (0.415) | (0.463) |
| *Firm Size 3* | =1 if employed at a firm with 500 to 999 employees | 0.061 | 0.058 | 0.114 |
| | | (0.239) | (0.233) | (0.318) |
| *Firm Size 4* | =1 if employed at a firm with over 1000 employees | 0.124 | 0.119 | 0.211 |
| | | (0.330) | (0.324) | (0.408) |
| *Observations* | | 24732 | 23260 | 1472 |

Standard Deviations are in parentheses.

**Table 3.4 Summary Statistics, Sample Mean and Standard Deviation, 1990-2000 Pooled Cross-Section**

| Variable | Description | All | Day | Night |
|---|---|---|---|---|
| *Professional Occupation* | =1 if professional and/or management occupation | 0.310 | 0.321 | 0.137 |
| | | (0.462) | (0.467) | (0.343) |
| *Sales Occupation* | =1 if sales and/or clerical occupation | 0.245 | 0.251 | 0.144 |
| | | (0.430) | (0.434) | (0.351) |
| *Craft Occupation* | =1 if production, craft, repair, or operator occupation | 0.326 | 0.320 | 0.431 |
| | | (0.469) | (0.466) | (0.495) |
| *Ag/Farm/Fish Industry* | =1 if agriculture, farming, or fishing industry | 0.022 | 0.023 | 0.003 |
| | | (0.146) | (0.150) | (0.058) |
| *Mining Industry* | =1 if mining industry | 0.006 | 0.005 | 0.015 |
| | | (0.076) | (0.072) | (0.121) |
| *Construction Industry* | =1 if construction industry | 0.083 | 0.088 | 0.013 |
| | | (0.276) | (0.283) | (0.113) |
| *Non-Durable Manufacturing Industry* | =1 if non-durable manufacturing industry | 0.088 | 0.082 | 0.181 |
| | | (0.283) | (0.274) | (0.385) |
| *Durable Manufacturing Industry* | =1 if durable manufacturing industry | 0.128 | 0.127 | 0.145 |
| | | (0.334) | (0.333) | (0.353) |
| *Transportation Industry* | =1 if transportation industry | 0.085 | 0.084 | 0.094 |
| | | (0.278) | (0.277) | (0.292) |
| *Wholesale Trade Industry* | =1if wholesale trade industry | 0.035 | 0.036 | 0.026 |
| | | (0.184) | (0.185) | (0.159) |
| *Retail Trade Industry* | =1 if retail trade industry | 0.103 | 0.100 | 0.162 |
| | | (0.305) | (0.300) | (0.368) |
| *Finance Industry* | =1 if finance industry | 0.072 | 0.076 | 0.007 |
| | | (0.259) | (0.265) | (0.086) |
| *Prof. & Related Industry* | =1 if professional or related industry | 0.207 | 0.209 | 0.165 |
| | | (0.405) | (0.407) | (0.371) |
| *Public Administration Industry* | =1 if public administration industry | 0.062 | 0.062 | 0.063 |
| | | (0.242) | (0.242) | (0.243) |

Note: Standard Deviations are in parentheses.

individuals by occupation and industry. Again, only full-time workers with wages between $1 and $150 an hour were included in the analysis. Observations on 24,732 individuals were analyzed. In 1990, the minimum age of respondents was 25 and by 2000, the oldest respondent was 44. Tables 3.3 and 3.4 provide summary statistics for the variables included in 1990-2000 pooled cross-section regressions.

## 3.2 Variable Description

A description of the main variables of interest, the shift variable, the unemployment rate, the leading index, the wage variable, and other demographic variables is next provided in addition to a discussion of occupation and industry characteristics.

### 3.2.1 Shift Variable

The variable of primary interest is the shift variable. Respondents to the NLSY79 are asked to select one of the following categories to describe the hours or shift they normally work: regular day, regular evening, regular night, rotating shift, split shift, irregular shift, or other. The BLS defines a regular day shift as one that takes place between the hours of 6 a.m. and 6 p.m. Regular evening shifts usually occur between the hours of 2 p.m. and midnight. A regular night shift is defined as a shift schedule taking place between the hours of 9 p.m. and 8 a.m. Rotating shifts require that workers rotate through a cycle of shifts; i.e. working first day shifts, then evening shifts, then night shifts. Individuals working irregular shifts do not have a predetermined regular shift schedule. For example, they may work night shifts one week, day shifts the next week, then possibly night shifts again the next week. Irregular schedules may be employer-arranged, allowing employers to vary the time of the shift to meet the needs of the business (McMenamin 2004). The final samples only include day and night shift workers. In the original sample of 12,686 individuals in the 1990 cross-section, 9,170 respondents indicated the hours or shift that they normally worked. 72% of the respondents work a regular day shift. Approximately 6% work a regular evening shift, while 5.2% work a regular night shift. 6.4% of respondents report working a rotating shift, 1% report working a split shift, and 8.4% report working an irregular shift. 1% of respondents report a shift that does not fall into the above categories. In the original sample of 76,116 observations from the 1990-2000 pooled cross-sections, 46,970 observations on shift status were available. 74% of observations were regular day shift workers. Approximately 6% of the observations were regular evening shift workers, while 4.5% of observations were regular night shift workers. 5.5% of observations were rotating shift workers, 1% were split shift workers, and 8.4% were irregular shift workers. 0.85% of observations did not fall within these categories.

Following the research of DeBeaumont and Nsiah, the two categories considered for the current analysis are regular day shift and regular night shift. The rationale for choosing to compare day workers to night workers rather than comparing day workers to all workers who are employed during non-standard hours follows the research of Schumacher and Hirsch (1997), Shapiro (1993) , Mayshar and Solon (1993), and Halevy and Nason (2002). Schumacher and Hirsch (1997) indicate larger wage premiums for night shift workers relative to evening shift, split shift, rotating shift, or other shifts. This finding is consistent with the theory of compensating differentials. Night shift work is an unfavorable work condition that a majority of workers may find inconvenient, and substantial wage premiums may be necessary to induce workers to accept night work. Thus, compensating wages are likely to be more prevalent in night shifts.

The current analysis also seeks to determine the impact of local economic conditions on the size of the compensating wage differential for shift work and on the incidence of shift work. This further justifies the use of day versus night shifts. Shapiro (1993) and Mayshar and Solon (1993) provide evidence of the cyclical nature of shiftwork. Mayshar and Solon indicate that night shift employment is more responsive to changes in real GNP than overall employment. Halevy and Nason (2002) also find that night shift employment is extremely procyclical. The current analysis is restricted to a comparison of day and night shift work since differences in compensating wages and the effect of changes in local economic conditions will be more pronounced. Table 3.5 indicates that 7.1% of respondents in the 1990 cross-section were night shift workers, while 6% of the respondents in the 1990-2000 pooled cross-sections worked at night. Night shift work was most prevalent in 1990, with the lowest incidence of night shift

**Table 3.5 Observations, All Years**

| Year | All | Night | Day |
|---|---|---|---|
| *1990* | 5026 | 352 | 4674 |
| *(%)* | | 7.1 | 92.9 |
| *1992* | 4157 | 254 | 3903 |
| *(%)* | | 6.1 | 93.9 |
| *1994* | 2523 | 117 | 2406 |
| *(%)* | | 4.6 | 95.4 |
| *1996* | 4339 | 251 | 4088 |
| *(%)* | | 5.8 | 94.2 |
| *1998* | 4371 | 240 | 4131 |
| *(%)* | | 5.5 | 94.5 |
| *2000* | 4312 | 258 | 4054 |
| *(%)* | | 6.0 | 94.0 |
| *Pooled* | 24732 | 1472 | 23260 |
| *(%)* | | 6.0 | 94.0 |

work occurring in 1994 with 4.6% of the sample working at night. After 1994, night shift work became more prevalent.

Evaluating the respondents of the NLSY from 1979 to 2004, Presser and Ward (2011) find that shift participation varies over an individual's lifetime, with higher participation rates in non-standard shift work more prevalent early in one's life, from ages 18-24. They find relatively stable rates of shift work after the age of 25. Similar results are obtained when conducting this analysis for night shift workers using the current dataset. In 1990, the youngest workers were 25, and the data indicate that night shift work participation rates remain relatively stable, averaging 6% and ranging from approximately 4.7 – 7.13% of workers at each age in the sample.

### 3.2.2 Local Unemployment Rate

The unemployment rate used in the analysis is defined as the local unemployment rate at the labor market of current residence. The unemployment rate variable is part of the NLSY confidential geocode information, and was obtained through a license agreement with the BLS.

To construct the unemployment rate variable, the BLS uses data from the March publication of *Employment and Earnings,* a report of the Department of Labor. Unemployment rates are available for each state and for selected metropolitan areas. Respondents are determined to live in a specific metropolitan area based on their state, county, and zip code information. For respondents living in those selected metropolitan areas listed in the *Employment and Earnings* report, the unemployment rate is the unemployment rate for that area. For respondents living in a metropolitan area that is not listed in the report, the BLS uses the state unemployment rate and the unemployment rates from the metropolitan areas to compute an unemployment rate. The average unemployment rate for 1990 respondents was 5.6%, while the average unemployment rate for respondents from 1990-2000 was 6.0%.

Table 3.6 indicates the percentiles for the unemployment rate for the years used in this analysis. Blanchard (1993) remarks that the recession of 1990-1991 featured a "slow and weak" recovery. Schweitzer (2003) summarizes that the "expansion of the 1990's began with such unexpectedly slow employment growth that commentators called it the jobless recovery." This slow recovery is reflected in the NLSY79 data, since the respondents still experience high unemployment for years after the 1990 recession. The average unemployment rate in the sample was 5.6% in March of 1990 and reached a peak in 1992 at 7.9%. Unemployment slowly tapered off through 1994 and 1996. By 1998, the average unemployment rate in the sample was below the average unemployment rate in 1990. The lowest average unemployment rate occurred in 2000, at 4.5% unemployment. Table 3.5 indicates declines in the incidence of night shift work from 1990 through 1994, reflecting the slow recovery and the high unemployment rates experienced in these years.

**Table 3.6 Percentiles for Unemployment Rate, All Years**

| Percentile *(for model with Unemployment Rate)* | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | Pooled |
|---|---|---|---|---|---|---|---|
| *10th* | 3.6 | 5.3 | 4.4 | 3.6 | 2.8 | 2.4 | 3.1 |
| *25th* | 4.4 | 6.2 | 5.2 | 4.5 | 3.3 | 2.9 | 4.1 |
| *mean* | 5.6 | 7.9 | 7.0 | 6.8 | 5.1 | 4.5 | 6 |
| *50th* | 5.3 | 7.4 | 6.3 | 6.1 | 4.5 | 3.9 | 5.5 |
| *75th* | 6.2 | 9.0 | 8.3 | 7.6 | 5.8 | 5.3 | 7.3 |
| *90th* | 8.0 | 10.4 | 10.3 | 13.3 | 7.9 | 6.4 | 9.6 |

### 3.2.3 Leading Index

This paper also uses the state leading index as another indicator of local economic conditions. The leading index used in the analysis is produced for each of the 50 states by the Federal Reserve Bank of Philadelphia. The indexes are calculated monthly. The state leading index predicts the six month growth rate of the state's coincident index. The state coincident index provides information about the current state of the economy and includes four state-level indicators, nonfarm payroll employment, average hours worked in manufacturing, the unemployment rate, and wage and salary disbursements deflated by the consumer price index. The Philadelphia Fed uses vector autoregression models to construct the state leading index, which includes the state coincident index, state level housing permits, state initial unemployment insurance claims, delivery times from the Institute for Supply Management manufacturing survey, and the interest rate spread between the 10-year Treasury bond and the 3 month Treasury bill. Prior and current values of these variables are used to determine the future values of the state coincident index.

To remain consistent with the local unemployment rate variable, the leading index values used in this paper are from March of the survey year. Respondents were interviewed from June through December, with a majority of the respondents completing the survey in July, August, and September. Thus, the leading index from March of the survey years predicts growth in the coincident index that coincides with the time period of the interviews. Table 3.7 provides percentiles of the leading index. In 1990, the average leading index value was 1.2, indicating that the coincident index was predicted to grow 1.2% in the next six months. Predicted growth continued to be relatively low in 1992, reflective of the slow recovery from the recession of 1990. As the economy rebounded in 1994, the average predicted growth increased to 2.6%. Predicted growth tapered off in the remaining years in the sample, reaching smaller values in 2000, foreshadowing the recession that would plague the 2000's.

**Table 3.7 Percentiles for Leading Index, All Years**

| Percentile *(for model with Leading Index)* | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | Pooled |
|---|---|---|---|---|---|---|---|
| *10th* | 0.2 | 0.2 | 1.6 | 1.2 | 1.2 | 0.2 | 0.5 |
| *25th* | 0.9 | 0.4 | 1.9 | 1.4 | 1.4 | 1.1 | 1.2 |
| *mean* | 1.2 | 1.6 | 2.6 | 1.8 | 1.9 | 1.5 | 1.7 |
| *50th* | 1.3 | 1.7 | 2.4 | 1.7 | 2.0 | 1.9 | 1.7 |
| *75th* | 1.7 | 2.5 | 3.2 | 2.3 | 2.5 | 2.1 | 2.3 |
| *90th* | 2.4 | 3.0 | 3.9 | 2.6 | 2.6 | 2.3 | 2.7 |

### 3.2.4 Other Variables

#### 3.2.4.1 Wage

The dependent variable in this paper is the log of the individual's hourly wage. The NLSY79 survey collects information on each respondent's rate of pay as well as information on the applicable unit of time an individual worked. For those respondents who did not report an hourly unit of pay, the time measure and reported wage are used to calculate an hourly rate of pay. The wage is reported in dollars and cents. As reported in Table 3.1, the average hourly wage is approximately $9.84 for day workers compared to approximately $9.23 for night shift workers in the 1990 cross-section. Table 3.3 indicates that the average hourly wage is

**Table 3.8 Average Wage, All Years**

| Year | All | Day | Night |
|---|---|---|---|
| *1990* | 9.79 | 9.84 | 9.23 |
| | (5.07) | (5.01) | (5.70) |
| *1992* | 10.95 | 11.04 | 9.39 |
| | (6.52) | (6.63) | (4.34) |
| *1994* | 12.41 | 12.49 | 10.65 |
| | (8.01) | (8.14) | (4.41) |
| *1996* | 13.55 | 13.62 | 12.40 |
| | (8.55) | (8.57) | (8.11) |
| *1998* | 14.91 | 15.09 | 11.94 |
| | (9.27) | (9.42) | (5.30) |
| *2000* | 16.79 | 17.01 | 13.41 |
| | (11.28) | (11.50) | (6.26) |
| *Pooled* | 13.04 | 13.16 | 11.14 |
| | (8.67) | (8.79) | (6.14) |

Standard deviations in parentheses.

$13.16 for day workers compared to $11.14 for night workers in the pooled cross-sections from 1990-2000. Table 3.8 details the mean wage for all of the years of data included in the analysis. Both day and night wages increased over time, however, night wages did not rise as much on average as day wages. The largest difference in the average wages of day and night workers occurred in 1998 and 2000. Overall, day wages are consistently higher than night wages.

### 3.2.4.2 Exclusion Restrictions

To improve model identification, two exclusion restrictions, number of children and industry shift rate are included in the analysis. In both the cross-section and pooled cross-section analysis, night shift workers have more children on average than day workers. Following Kostiuk (1990) and Lanfranchi *et. al* (2002), the industry shift rate is included in the analysis. The shift rate variable is calculated as the proportion of night shift workers in the full NLSY79 cross-sections in each of 11 industry categories: agriculture/forestry/fishing, mining, construction, non-durable manufacturing, durable manufacturing, transportation, wholesale trade, retail trade, finance, business/repair/personal services, entertainment/recreation, professional, and public administration industries.  The shift rate variable provides a way of incorporating industry differences in the frequency of night shift work and reflects worker preferences since workers may avoid industries where night shift work is common if they are averse to working at night.

### 3.2.4.3 Demographic Variables

The wage equation also includes several standard demographic variables, such as education, job tenure and experience, union status, marital status, race, and region of residence. Tables 3.1 and 3.3 provide summary statistics for these variables.  Highest grade completed, *hgc*, is used as a measure of the educational attainment of respondents.  In the 1990 cross-section and in the pooled cross-sections, on average, day workers had one year of additional schooling when compared to night shift workers.  A variable indicating job experience, *exp*, is calculated as a respondent's age minus the highest grade completed minus five (age-hgc-5).  On average, night shift workers had an additional year of experience when compared to day shift workers.  When comparing job tenure, *teny,* night shift workers have worked at their current job half of a year less, on average, than day workers.

Night shift workers are almost twice as likely as day workers to be members of a union. 30% of night shift workers are union members in both the 1990 cross-section and in the pooled cross-section.  Approximately 42% of night shift workers were non-white in 1990 compared to 45% in the pooled cross-section.  Night shift workers are less likely to be female, with female night shift participation at 35% in 1990 and 37% in the pooled cross-section.  Night shift workers are approximately 12-13% less likely to be married than day workers.

Respondents are also classified as living in one of four regions of the United States:

northeast, north central, south, and west. Table B1 in Appendix B details how states are classified according to region in the NLSY79. The South is the most densely populated region, with 43% of the final sample in residence in the pooled cross-section. The regional distribution of night shift workers and day workers is relatively similar. When compared to day workers, a higher percentage of night shift workers live in the north central region, while a lower percentage of night shift workers live in the northeast region. A variable is also included to model whether or not a respondent lives in a metropolitan statistical area, or msa. Metropolitan statistical areas are cities and counties that are grouped into a common region by the Office of Management and Budget. Metropolitan areas contain an urban area with a population of 50,000 or more. In both the cross-section and pooled cross-section, night shift workers are more likely to live in a metropolitan area.

#### 3.2.4.3 Industry and Occupation

The prevalence of night shift work varies by industry and occupation. An industry is a group of firms that produce similar products and services. An occupation is the set of tasks that a worker performs. For the years 1990 through 2000, the NLSY79 categorizes a worker's industry and occupation according to the 1980 Census Bureau classifications. In cross-sectional analysis, each worker is assigned a dummy variable for each of thirteen major industrial categories and eight major occupational categories.

The major industry classifications included in the NLSY79 are detailed in Tables 3.9 and 3.10. The tables indicate the percentage of the entire sample and the percentage of both day and night workers employed in each industry category for the 1990 cross-section and for the pooled cross-sections. The third column of Table 3.9 indicates the percentage of night shift workers

**Table 3.9 Percentage Distribution of Total, Day, & Night Workers by Industry Category, 1990 Cross-Section**

| Industry Category | % of All Workers | % of Day Workers | % of Night Workers |
|---|---|---|---|
| Agriculture, Forestry, and Fishing | 2.0* | 2.2** | 0.3^ |
| Mining | 0.6 | 0.6 | 1.4 |
| Construction | 9.0 | 9.6 | 1.1 |
| Non-Durable Manufacturing | 9.4 | 9.1 | 14.2 |
| Durable manufacturing | 13.7 | 13.7 | 13.6 |
| Transportation, Communications, and Other Public Utilities | 7.5 | 7.4 | 8.8 |
| Wholesale Trade | 4.6 | 4.7 | 2.3 |
| Retail Trade | 11.9 | 11.1 | 22.7 |
| Finance, Insurance, and Real Estate | 7.6 | 8.1 | 1.1 |
| Business, Repair, and Personal Services | 10.0 | 9.9 | 11.9 |
| Entertainment and Recreation Services | 0.7 | 0.6 | 1.1 |
| Professional and Related Services | 18.3 | 18.5 | 15.6 |
| Public Administration | 4.7 | 4.6 | 5.7 |
| | 100.0 | 100.0 | 100.0 |

*For example, calculated as total# of workers in agriculture, farming, and fishing industries / total # of workers
**For example, calculated as total# of day workers in agriculture, farming, and fishing industries / total # of day workers
^For example, calculated as total# of night workers in agriculture, farming, and fishing industries / total # of night workers

employed in each industry category in 1990. In the sample, approximately 28% of night shift workers are employed in the manufacturing industry (both durable and non-durable). Approximately 25% of night shift workers are employed in trade (both wholesale and retail). 16% of night shift workers are employed in professional and related services, while 12% are employed in business, repair, and personal services. The industries least populated by night shift work are agriculture, forestry, and fishing; mining; construction; finance, insurance, and real estate; and entertainment and recreation services. Approximately 1% of night shift workers were employed in these industries. The categories which differ the most between night and day workers are construction, retail trade, and finance, insurance, and real estate. Table 3.10 indicates the percentage distribution by industry for the pooled cross-sections. The percentage distribution of night shift workers is similar to the distribution in 1990, with higher percentages of night shift workers employed in non-durable manufacturing compared to the 1990 sample. 16% of night workers are employed in retail trade from 1990-2000 compared to 22.7% in 1990.

**Table 3.10 Percentage Distribution of Total, Day, & Night Workers by Industry Category, 1990-2000 Pooled Cross-Sections**

| Industry Category | % of All Workers | % of Day Workers | % of Night Workers |
|---|---|---|---|
| Agriculture, Forestry, and Fishing | 2.2* | 2.3** | 0.3^ |
| Mining | 0.6 | 0.5 | 1.5 |
| Construction | 8.3 | 8.8 | 1.3 |
| Non-Durable Manufacturing | 8.8 | 8.2 | 18.1 |
| Durable manufacturing | 12.8 | 12.7 | 14.5 |
| Transportation, Communications, and Other Public Utilities | 8.4 | 8.4 | 9.4 |
| Wholesale Trade | 3.5 | 3.6 | 2.6 |
| Retail Trade | 10.3 | 10.0 | 16.2 |
| Finance, Insurance, and Real Estate | 7.2 | 7.6 | 0.7 |
| Business, Repair, and Personal Services | 10.1 | 10.0 | 11.0 |
| Entertainment and Recreation Services | 0.8 | 0.8 | 1.6 |
| Professional and Related Services | 20.7 | 20.9 | 16.5 |
| Public Administration | 6.2 | 6.2 | 6.2 |
| | 100.0 | 100.0 | 100.0 |

*For example, calculated as total# of workers in agriculture, farming, and fishing industries / total # of workers
**For example, calculated as total# of day workers in agriculture, farming, and fishing industries / total # of day workers
^For example, calculated as total# of night workers in agriculture, farming, and fishing industries / total # of night workers

The major occupational categories included in the NLSY79 are detailed in Tables 3.11 and 3.12. The tables indicate the percentage of the entire sample and the percentage of both day and night workers employed in each occupation category for the 1990 cross-section and for the pooled cross-sections. The third column of Table 3.11 indicates the percentage of night shift workers employed in each occupation category. In the sample, approximately 34% of night shift workers are employed in the service industry, with night workers three times more likely to be employed in service occupations than day workers. 30% of night workers are employed as operators, fabricators, and laborers, compared to only 20% of day workers. 11.6% of night shift workers are employed in administrative/clerical positions and 11.1% are employed in managerial and professional specialties. The occupations least populated by night shift work are farming, forestry, and fishing, technical, and sales workers.

Table 3.12 provides a similar analysis for the 1990-2000 pooled cross-sections. When data on night shift workers is averaged from 1990-2000, higher percentages of night shift

**Table 3.11 Percentage Distribution of Total, Day, &Night Workers by Occupation, 1990 Cross-Section**

| Occupation | % of All Workers | % of Day Workers | % of Night Workers |
|---|---|---|---|
| Managerial and Professional Specialties | 22.0* | 22.8** | 11.1^ |
| Technical | 3.5 | 3.6 | 2.0 |
| Sales | 7.4 | 7.7 | 3.4 |
| Administrative Support/Clerical | 19.6 | 20.2 | 11.6 |
| Service | 10.4 | 8.6 | 34.4 |
| Farming, Forestry, and Fishing | 1.9 | 2.0 | 0.6 |
| Precision Production, Craft, and Repair | 14.6 | 15.1 | 6.8 |
| Operators, Fabricators, and Laborers | 20.7 | 20.0 | 30.1 |
| | 100.0 | 100.0 | 100.0 |

*For example, calculated as total# of workers in managerial occupations / total # of workers
**For example, calculated as total# of day workers in managerial occupations / total # of day workers
^For example, calculated as total# of night workers in managerial occupations / total # of night workers

workers are employed in precision production, craft, and repair and operator, fabricator, and laborer occupations relative to 1990. Only 28% of night shift workers were employed as service workers, compared to 34% in 1990.

Following DeBeaumont and Nsiah, broad occupation and industry categories are defined for the regression analysis. Definitions and summary statistics for the industry and occupation variables used in the 1990 cross-section regressions are outlined in Table 3.2, with definitions

**Table 3.12 Percentage Distribution of Total, Day, & Night Workers by Occupation, 1990-2000 Cross-Section**

| Occupation | % of All Workers | % of Day Workers | % of Night Workers |
|---|---|---|---|
| Managerial and Professional Specialties | 27.0* | 28.0** | 10.3^ |
| Technical | 4.0 | 4.0 | 3.4 |
| Sales | 6.7 | 6.9 | 3.4 |
| Administrative Support/Clerical | 17.8 | 18.2 | 11.0 |
| Service | 10.0 | 8.8 | 28.6 |
| Farming, Forestry, and Fishing | 2.0 | 2.1 | 0.2 |
| Precision Production, Craft, and Repair | 13.7 | 14.0 | 9.6 |
| Operators, Fabricators, and Laborers | 18.9 | 18.0 | 33.6 |
| | 100.0 | 100.0 | 100.0 |

*For example, calculated as total# of workers in managerial occupations / total # of workers
**For example, calculated as total# of day workers in managerial occupations / total # of day workers
^For example, calculated as total# of night workers in managerial occupations / total # of night workers

and summary statistics for the industry and occupation variables used in the pooled cross-section analysis outlined in Table 3.4. Business, personal, and entertainment services are controlled as the base industry group in the regressions. Three major occupation variables included in the regression analysis are professional workers, which includes workers in the managerial and professional specialty occupations as well as those in technical occupations, sales workers, which includes both sales and administrative support/clerical workers, and craft workers, which includes those workers in the precision production, craft and repair occupations as well as those in the operators, fabricators, and laborers category. Service, farming, forestry, and fishing workers are controlled as the base occupations in the regressions.

# CHAPTER IV

# MODEL SPECIFICATION AND ESTIMATION STRATEGY

## 4.1 Introduction

This chapter describes econometric estimation techniques employed to analyze the following questions:

- What is the impact of local economic conditions on shift choice?
- What is the impact of the shift differential on shift choice?
- How does the impact of the shift differential on shift selection depend on local economic conditions?

First, a basic OLS model is described. The proper model to analyze the current data is the switching regression model with endogenous switching. Both cross-sectional and pooled panel datasets are estimated using both a two-step procedure provided by Lee (1978) and by maximum likelihood. The endogenous switching regression model is also estimated using two measures of local economic conditions, the local unemployment rate and the state-level leading index. Wage differentials are estimated for all variations of the models.

## 4.2 OLS Estimation

An analysis of shift differentials begins with a simple hedonic log wage equation with the form

$$w_i = \alpha + \beta_1 X_i + \beta_2 nshift_i + \varepsilon_i \quad (1)$$

where the dependent variable is the log of the individual's wage, $X$ is a vector of personal characteristics, $nshift$ is a dummy variable indicating whether or not an individual works a night shift, and $\varepsilon$ is an i.i.d. error term. In this model, $\beta_2$ is an estimate of the compensating differential for night shift work. If individuals are located in labor markets with varying local economic conditions, $\beta_2$ may be estimated incorrectly. To correct for this, the hedonic wage equation is estimated as

$$w_i = \alpha + \beta_1 X_i + \beta_2 nshift_i + \beta_3 LEC_i + \theta nshift_i LEC_i + \varepsilon_i \tag{2}$$

where $LEC$ is the measure of local economic conditions (either the local unemployment rate or the state leading index) and $nshiftLEC$ is the interaction between $nshift$ and $LEC$. In model (2), $\beta_2$ indicates the compensating differential for night shift work when the local unemployment rate or the state leading index is zero. $\theta$ indicates how the compensating differential for night shift work changes when local economic conditions change. If compensating differentials for night shift work are lower in areas with weak economic conditions, $\theta$ will be negative in models using the local unemployment rate as the indicator of local labor market conditions and $\theta$ will be positive in models using the leading index as the indicator of local labor market conditions.[1]

Simple OLS estimates of the above equations are biased and inconsistent due to the failure to correct for the endogeneity of the night shift variable. An individual's status as a night shift worker is likely correlated with some unidentified variable in the error term of the individual's wage equation. Worker characteristics included in $X$ such as ability, schedule constraints, preferences, and family obligations are unmeasured components of an individual's

[1] Models (1) and (2) are estimated with the data from the current analysis, and the results are included in Table A33. All of the models fail to find significant impacts of the interaction between the local economic condition and status as a night shift worker.

wage that are likely correlated with the decision to work a night shift. Additionally, participation in night shift work is not randomly determined; workers self-select into night work. As detailed in Section 1.3.1, workers may choose to work a night shift for various reasons including higher wages, nature of the job, or personal preference. Following Kostiuk (1990) and Lanfranchi, *et al.* (2002), model (2) is best estimated by using a selection model.

### 4.3 Switching Regression Model with Endogenous Switching

One goal of this paper is to determine the impact of shift differentials and local labor market conditions on the decision to work a night shift. The appropriate model to estimate shift premiums and the choice to work a shift is a switching regression model with endogenous switching. Individuals self-select into either day work or night work, and wages of day and night workers are observed dependent upon a selection equation modeling the decision to work a shift. Factors influencing the decision to work a shift which are included in the error term of the selection equation are likely correlated with factors in the error term of the individual's wage equation. A switching regression model with endogenous switching is estimated using both a two-step procedure provided by Lee (1978) and maximum likelihood.

#### 4.3.1. Basic Equations Used in the Switching Regression Model

In the switching regression model, separate log wage equations for night and day workers are specified and are assumed to take the form

$$w_i^s = X_i\beta^s + LEC_i\theta^s + \varepsilon_i^s \tag{3}$$

$$w_i^d = X_i\beta^d + LEC_i\theta^d + \varepsilon_i^d \tag{4}$$

where the dependent variable is the log hourly wage rate for individuals and $X$ is a vector of personal, demographic, occupational, and industrial variables. $LEC$ denotes the local economic conditions, either the local unemployment rate or the state leading index. Equation (3) models wages for night shift work (denoted by the superscript *s*), and equation (4) models wages for day workers (denoted by the superscript *d*). These equations allow the returns to each work characteristic to be different for night and day workers. Since workers choose which shift to work, a structural selection equation specifying shift choice is also included in the model. Shift choice is determined by

$$S_i^* = Z_i\gamma_1 + LEC_i\gamma_2 + \delta\left(w_i^{\,s} - w_i^{\,d}\right) + v_i \tag{5}$$

where $S_i^*$ is a latent variable indicating the net benefit of working a night shift. Only the decision $s_i$, to work a night shift or not, is observed, where

$$s_i = I(s_i^* \geq 0) \tag{6}$$

where $s_i$ indicates if the net benefit is non-negative and shift work is selected. $s_i = 1$ if $s_i^* \geq 0$ and $s_i = 0$ otherwise. The observed log wage is thus defined as

$$w_i = s_i w_i^s + (1 - s_i) w_i^d \tag{7}$$

and is equal to $w_i^s$ for those who choose to work the night shift and is equal to $w_i^d$ for those who choose to work the day shift.

In (5) above, $Z$ is a vector of variables that influence shift choice. It includes some of the variables in $X$ and exclusion restrictions, exogenous variables expected to influence the decision to work a shift that are not included in the individual wage equations, which improve model identification. The variable $(w_i^{\,s} - w_i^{\,d})$ indicates the premium obtained for night shift work. The unobserved errors $(\varepsilon_i^s, \varepsilon_i^d, v_i)$ are assumed to be independent of $(X, Z, LEC)$ and are normally distributed:

$$\begin{pmatrix} \varepsilon_i^s \\ \varepsilon_i^d \\ v_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_s^2 & \sigma_{sd} & \sigma_{sv} \\ \sigma_{sd} & \sigma_d^2 & \sigma_{dv} \\ \sigma_{sv} & \sigma_{dv} & 1 \end{pmatrix}\right] \tag{8}$$

The wage equations (3) and (4) and the selection equation (5) form the switching regression model with endogenous switching. The error terms in the individual's wage equations, $\varepsilon_i^s$ and $\varepsilon_i^d$, are likely correlated with the error term in the selection equation, $v_i$. This correlation gives rise to selectivity bias. Thus, it is useful to substitute the wage equations into the selection equation to find the following reduced form:

$$S_i^* = Z_i\gamma_1 + LEC_i\gamma_2 + \delta X_i\left(\beta^s - \beta^d\right) + \delta LEC_i\left(\theta^s - \theta^d\right) + \delta\left(\varepsilon_i^s - \varepsilon_i^d\right) + v_i \tag{9}$$

which can be given new parameters to become

$$S_i^* = Z_i\gamma + X_i\gamma_1 + LEC_i\gamma_2 + \eta_i \tag{10}$$

where $\left(\eta_i | X_i, LEC_i, Z_i\right) \sim N$ (0,1).

### 4.3.2 Two-Step Estimation Strategy

Lee (1978) provides the two-step method for estimating the endogenous switching regression model. Lee's estimator for the switching regression model is summarized as follows:

1) Estimate the reduced form of the selection equation, (9) using probit. Compute $\phi(\psi)$, the probability density function and $\Phi(\psi)$, the distribution function evaluated at $\psi = Z_i\gamma + X_i\gamma_1 + LEC_i\gamma_2$. The density and distribution functions may be used to calculate the inverse Mills ratios $\frac{\phi(\psi)}{\Phi(\psi)}$ and $\frac{\phi(\psi)}{(1-\Phi(\psi))}$ for each observation.

2) The inverse Mills ratios are next included in OLS estimation of the expected wage equations

$$E\left(w_i^s \mid X_i, LEC_i, Z_i, S_i^* \geq 0\right) = X_i\beta^s + LEC_i\theta^s + \sigma_{\varepsilon^s,\eta}\frac{\phi(\psi)}{\Phi(\psi)} \tag{11}$$

$$E\left(w_i^d \mid X_i, LEC_i, Z_i, S_i^* < 0\right) = X_i\beta^d + LEC_i\theta^d - \sigma_{\varepsilon^d,\eta}\frac{\phi(\psi)}{(1-\Phi(\psi))} \tag{12}$$

to estimate $\widehat{\beta^s}$, $\widehat{\beta^d}$, $\widehat{\theta^s}$, $\widehat{\theta^d}$, $\widehat{\sigma_{\varepsilon^s,\eta}}$, and $\widehat{\sigma_{\varepsilon^d,\eta}}$. Here, $\widehat{\sigma_{\varepsilon^s,\eta}}$, and $\widehat{\sigma_{\varepsilon^d,\eta}}$ are estimates of the covariance between the error in the individual wage equations and the error in the selection equation.

3) The results of the individual wage equations are next used to calculate

$$E\left(w_i^s - w_i^d \mid X_i, LEC_i\right) = X_i(\beta^s - \beta^d) + LEC_i(\theta^s - \theta^d) \tag{13}$$

the wage differential for night shift work. This wage differential is then included as a regressor in probit estimation of the structural form of the selection equation (5).

A comparison of the results of the reduced and structural estimation allows us to determine the impact of local economic conditions on shift choice and the impact of the shift differential on shift choice. The estimation of the conditional expected wage equations (11) and (12) provides a test for the presence of selection bias by estimating the covariances $\widehat{\sigma_{\varepsilon^s,\eta}}$, and $\widehat{\sigma_{\varepsilon^d,\eta}}$, the coefficients on the inverse Mills ratios. If $\widehat{\sigma_{\varepsilon^s,\eta}}$, and $\widehat{\sigma_{\varepsilon^d,\eta}}$ are significant in the individual wage equations, the correction for sample selection was necessary. The sign of these coefficients indicates the presence of positive or negative selection into day or night work and should be interpreted as follows:

- $\widehat{\sigma_{\varepsilon^s,\eta}}$ positive indicates positive selection into night shifts, and that workers choosing night shift work earn above average wages at night. $\widehat{\sigma_{\varepsilon^s,\eta}}$ negative indicates negative selection into night shifts and that workers choosing night shift work earn below average wages at night.

- $\widehat{\sigma_{\varepsilon^d,\eta}}$ negative indicates positive selection into day shifts, and that workers choosing day work earn above average wages during the day. $\widehat{\sigma_{\varepsilon^d,\eta}}$ positive indicates negative selection into day work and that workers choosing day work earn below average wages during the day.

### 4.3.3 Maximum Likelihood Estimation

The switching regression model with endogenous switching may also be estimated using maximum likelihood, which leads to consistent and asymptotically efficient estimates. To derive the likelihood function for the switching regression model, the individual wage equations (3) and (4) from above are needed as well as the structural equation (5) and the reparameterized version of the reduced form (10). Full information maximum likelihood involves forming the joint distribution of the endogenous variables and then maximizing the likelihood function.

The likelihood function for this model is

$$L = \prod_{i=1}^{n} f(W_i, S_i \mid X_i, LEC_i, Z_i)$$

$$L = \prod_{i=1}^{n} \left[ S \int_{-\psi}^{\infty} f_{\varepsilon^s,\eta}(W_i - X_i\beta^s - LEC_i\theta^s,\ \eta)\mathrm{d}\eta + (1-S) \int_{-\infty}^{-\psi} f_{\varepsilon^d,\eta}(W_i - X_i\beta^d - LEC_i\theta^d,\ \eta)\mathrm{d}\eta \right]$$

where $\psi = Z_i\gamma + X_i\gamma_1 + LEC_i\gamma_2$. $f_{\varepsilon^s,\eta}$ and $f_{\varepsilon^d,\eta}$ are the bivariate normal density functions of $(\varepsilon^s, \eta)$ and $(\varepsilon^d, \eta)$.

Selection into night shift work is endogenous to wages; thus, simultaneous maximum likelihood estimation of equations (3), (4), and the selection equation (5) corrects for this selection bias by taking $f\left(W_i, S_i\right)$ into account. Estimates of the individual wage equations (3) and (4) are used to calculate the estimated wage differential for night shift work (13). This wage differential is then included in probit estimation of the structural form of the selection equation (5). The coefficients on the inverse Mills ratios in equations (11) and (12) are also estimated in the maximum likelihood model. These coefficients provide a test for the presence of selection bias and indicate positive or negative selection into day and night work[2].

### 4.3.4 Interaction Effects

In the simpler models proposed by Bender and Mridha (2011) and DeBeaumont and Nsiah (2010), determining the impact of local labor market conditions on the size of the wage differential was accomplished by interacting a shift indicator variable with the local unemployment rate and including this interaction term in OLS wage regressions. The coefficient on the interaction effect in the wage regressions in Section 4.2, $\theta$, indicates how the compensating differential for night shift work changes when local economic conditions change. The use and interpretation of interaction terms is more complicated in the endogenous switching regression model. Analyzing the impact of local labor market conditions on shift differentials is accomplished in this model by analyzing the impact of an interaction effect between the shift differential and local economic conditions on shift selection in the structural selection equation. This analysis will help to answer the third major question addressed by this paper: how does the impact of the shift differential on shift selection depend on local economic conditions? In areas with weak economic conditions, we might expect shift selection to depend less on the night shift

[2] Lokshin and Sajaia (2004) provide a Stata program, movestay, for maximum likelihood estimation of the endogenous switching regression model. The movestay results include estimates of the inverse Mills ratios, estimates of the correlation coefficient between the error term in each wage equation and the selection equation ($\rho_{\varepsilon^s,\eta}$ and $\rho_{\varepsilon^d,\eta}$), and the standard deviation of the errors in the wage equations ($\sigma_{\varepsilon^s}$ and $\sigma_{\varepsilon^d}$). The selection term coefficients, estimates of the covariance between the errors, are obtained by multiplying the correlation coefficients by the standard deviations from each individual wage equation. Using the night shift selection term as an example, since $\sigma_{\varepsilon^s,\eta} = \sigma_{\varepsilon^s}\rho_{\varepsilon^s,\eta}\sigma_\eta$ where $\sigma_\eta$ is normalized to 1, multiplying $\sigma_{\varepsilon^s}$ by $\rho_{\varepsilon^s,\eta}$ provides an estimate of the covariance. Since $\sigma_{\varepsilon^s}$ is a scale factor, the significance of $\rho_{\varepsilon^s,\eta}$ and $\rho_{\varepsilon^d\eta}$ determine the significance of the selection terms.

differential since workers would likely have fewer alternatives to night shift work and there would be more unemployed workers competing for shift positions. Night shift work is also less likely to be profitable in weak economies when production levels are down and thus fewer shift positions are likely to be available. Consequently, a greater supply of shift workers coupled with lower demand for them means that firms can pay a smaller shift differential.

To investigate this possible interaction, we consider the probability of selecting shift work conditional on the shift differential, local business conditions and the observed exogenous covariates. It follows from equations (3) though (7) and well-known properties of the multivariate normal distribution that

$$P(s_i = 1 \mid w_i^s - w_i^d, LEC_i, X_i, Z_i) = \\ 1 - \Phi[-\mu(w_i^s - w_i^d, LEC_i, X_i, Z_i) / \sqrt{\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i)(1-\rho^2)}] \tag{14}$$

where $\Phi$ denotes the standard normal distribution function and

$$\mu(w_i^s - w_i^d, LEC_i, X_i, Z_i) = E(s_i^* \mid LEC_i, X_i, Z_i) + \\ \rho\sqrt{\frac{\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i)}{\mathrm{var}(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)}}(w_i^s - w_i^d - E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i))$$

where

$$E(s_i^* \mid LEC_i, X_i, Z_i) = Z_i\gamma_1 + LEC_i\gamma_2 + \delta E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)$$

$$E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i) = X_i(\beta^s - \beta^d) + LEC_i(\theta^s - \theta^d)$$

$$\rho = \frac{\mathrm{cov}(s_i^*, w_i^s - w_i^d \mid LEC_i, X_i, Z_i)}{\sqrt{\mathrm{var}(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)\,\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i)}}$$

$$\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i) = \delta^2\,\mathrm{var}(w_i^s - w_i^d \mid LEC_i, X_i, Z_i) + 1 + 2(\sigma_{sv} - \sigma_{dv})$$

$$\mathrm{cov}(s_i^*, w_i^s - w_i^d \mid LEC_i, X_i, Z_i) = \delta\,\mathrm{var}(w_i^s - w_i^d \mid LEC_i, X_i, Z_i) + \sigma_{sv} - \sigma_{dv}$$

$$\mathrm{var}(w_i^s - w_i^d \mid LEC_i, X_i, Z_i) = \sigma_s^2 + \sigma_d^2 - 2\sigma_{sd}$$

Of interest is the effect of changes in the shift differential on the probability of selecting night shift work (14) under different local economic conditions. One obstacle is that (14) depends on $\sigma_{sd}$ which is not point identified and, therefore, neither is (14). Both quantities are only partially identified. Vijverberg (1993) provides informative bounds for $\sigma_{sd}$ that can be consistently estimated, but deriving informative bounds for (14) from these is complicated by the fact that (14) is not a monotonic function of $\sigma_{sd}$ for all values of the shift differential. However, (14) is a monotonic function of $\sigma_{sd}$ when conditioned on the expected differential, that is, $w_i^s - w_i^d = E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)$, and, thus, deriving informative bounds in this case is a straightforward exercise.[3] A focus on the expected differential can also be justified by being the "average" shift differential for the subset of the population characterized by the given values of *X, Z,* and *LEC.* Hence, we will investigate how the effect of the shift differential on the distribution of shift selection depends on local economic conditions by analyzing changes in the *expected* differential for various local economic conditions. The lower and upper bounds of the selection probability are calculated according to Theorem 1.

**Theorem 1**

If $w_i^s - w_i^d = E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)$ then $B_L \leq P(s_i = 1 \mid w_i^s - w_i^d, LEC_i, X_i, Z_i) \leq B_U$

where $B_L = 1 - \Phi\left(\dfrac{-E(s_i^* \mid LEC_i, X_i, Z_i)}{\sqrt{\Lambda_L}}\right)$ and $B_U = 1 - \Phi\left(\dfrac{-E(s_i^* \mid LEC_i, X_i, Z_i)}{\sqrt{\Lambda_U}}\right)$.

(continued)

[3] For the other cases, it would be necessary to apply constrained minimization and maximization techniques to (14) over the bounds interval for $\sigma_{sd}$ to derive the bounds.

Let

$$\Lambda_L = \Lambda_2 I[E(s_i^* \mid LEC_i, X_i, Z_i) \geq 0] + \Lambda_1 I[E(s_i^* \mid LEC_i, X_i, Z_i) < 0]$$

$$\Lambda_U = \Lambda_2 I[E(s_i^* \mid LEC_i, X_i, Z_i) < 0] + \Lambda_1 I[E(s_i^* \mid LEC_i, X_i, Z_i) \geq 0]$$

where

$$\Lambda_1 = 1 + 2(1-\delta)(\sigma_{sv} - \sigma_{dv}) - \frac{(\sigma_{sv} - \sigma_{dv})^2}{\sigma_s^2 + \sigma_d^2 - 2(\sigma_{sv}\sigma_{dv} + c)}$$

$$\Lambda_2 = 1 + 2(1-\delta)(\sigma_{sv} - \sigma_{dv}) - \frac{(\sigma_{sv} - \sigma_{dv})^2}{\sigma_s^2 + \sigma_d^2 - 2(\sigma_{sv}\sigma_{dv} - c)}$$

$$c = \sigma_s \sigma_v \sqrt{\left(1 - \left(\frac{\sigma_{sv}}{\sigma_s}\right)^2\right)\left(1 - \left(\frac{\sigma_{dv}}{\sigma_v}\right)^2\right)}.$$

Proof: See Appendix B

The lower and upper bounds of the selection probability in Theorem 1 are functions of only the identified parameters and thus can be consistently estimated for any specified setting of $LEC_i, X_i, Z_i, E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)$. The estimated bounds are reported in Section 5.4 for the local unemployment rate and the state leading index for both the cross-section and pooled cross-section models.

### 4.3.5 Tests for Pooling

Lanfranchi, *et al.* (2002) point out that a potential problem of estimating wages of day and night shift workers is model misspecification. The estimation of separate wage equations in the switching regression model allows for the wages of day and night workers to be determined in different ways. If day and night wages are determined differently, the data should not be pooled, and the switching regression model is appropriate. If, however, the returns to each worker characteristic are the same for all workers, the data can instead be pooled and a single wage equation, a treatment effects model, may be estimated. Following Lanfranchi, *et al.* pooling may be tested by estimating the conditional expected wage equation and a treatment effects model. The conditional expected wage equation is derived as

$$\mathrm{E}\left(w_i|X_i, LEC_i, Z_i\right) = X_i\beta^d + UE_i\theta^d + X_i\left(\beta^s - \beta^d\right)\Phi(\psi) + LEC_i\left(\theta^s - \theta^d\right)\Phi(\psi) + (\sigma_{\varepsilon^s,\eta} - \sigma_{\varepsilon^d,\eta})\phi(\psi) \qquad (15)$$

which is estimated using a similar two-step procedure as employed in the estimation of the individual wage equations. The coefficients $(\beta^s - \beta^d)$ and $(\theta^s - \theta^d)$ indicate the difference in the returns to day and night workers. A Wald test of the hypothesis $(\beta^s - \beta^d)$=$(\theta^s - \theta^d)$=0 determines the joint significance of the variables representing the difference in the returns to day and night workers. If significant, the test results indicate that data on day and night workers should not be pooled. If insignificant, however, the treatment effects model is preferred. A restricted version of the expected wage equation (10), the treatment effects model assumes $\beta^s = \beta^d$ and $\theta^s = \theta^d$, that the coefficients for day and night workers are identical except for the intercept term. The treatment effects model is estimated as

$$E\left(w_i|X_i, LEC_i, Z_i\right) = X_i\beta + LEC_i\theta + \alpha\Phi(\psi) + (\sigma_{\varepsilon^s,\eta} - \sigma_{\varepsilon^d,\eta})\phi(\psi) \qquad (16)$$

where α is the difference in the intercepts for day and night workers. The coefficient α indicates the effect of night shift work on wages and its significance indicates whether a significant difference exists between the wages of day and night workers.

Analogous to the tests for pooling provided by Lanfranchi, *et al.* for the two-step estimator, pooling may also be tested for the maximum likelihood estimates. This is accomplished by comparing the results obtained from the switching regression estimates of the individual wage equations (3) and (4) to the results obtained from maximum likelihood estimates of a treatment effects model of the form

$$log W_i = \alpha + \beta_1 X_i + \beta_2 nshift_i + \beta_3 LEC_i + \varepsilon_i \qquad (17)$$

The reduced form of the selection equation for night shift work is provided by (9) above. The log-likelihoods from the switching regression and treatment effects models are compared through a likelihood ratio test, which, if significant, indicates that data on day and night workers should not be pooled.

### 4.3.6 Shift Differentials

As mentioned in Section 4.3.2, the log wage differential (13) is calculated for each individual in the sample. This paper seeks to estimate the expected value of the wage, not the expected value of the log wage. The expected wage differential can be derived using the properties of the bivariate log-normal distribution as follows

$$\mathrm{E}\left(w_i^s - w_i^d \,|\, X_i, UE_i\right) = exp(X_i\beta^s + UE_i\theta^s + \frac{\sigma^2{}_{\varepsilon^s}}{2}) - exp(X_i\beta^d + UE_i\theta^d + \frac{\sigma^2{}_{\varepsilon^d}}{2}) \qquad (18)$$

where $\widehat{\sigma^2}_{\varepsilon^s}$ and $\widehat{\sigma^2}_{\varepsilon^d}$ are estimated as the intercepts in the following OLS regressions

$$(ln(w_i^s) - (X_i\beta^s + UE_i\theta^s))^2 = \sigma^2{}_{\varepsilon^s} + \alpha\frac{\phi(\psi)}{\Phi(\psi)}\psi + u_i \qquad (19)$$

$$(ln(w_i^d) - (X_i\beta^d + UE_i\theta^d))^2 = \sigma^2{}_{\varepsilon^d} + \alpha\frac{\phi(\psi)}{(1-\Phi(\psi))}\psi + u_i \qquad (20)$$

where $\psi = Z_i\gamma + X_i\gamma_1 + UE_i\gamma_2$. These estimates can be used to compute the average shift premium in dollars. Following Lee (1978) the percentage difference in the wage rate for night workers when compared to day workers, $\mathrm{E}\left(w_i^s - w_i^d \,|\, X_i, UE_i\right)$, is computed as

$$\{exp(X_i\beta^s + UE_i\theta^s)exp(1/2(\sigma^2{}_{\varepsilon^s} - \sigma^2{}_{\varepsilon^d})) - exp(X_i\beta^d + UE_i\theta^d)\} / exp(X_i\beta^d + UE_i\theta^d) \qquad (21)$$

This equation indicates the average percentage increment of the wage rate for night workers.

# CHAPTER V

# RESULTS AND ANALYSES

## 5.1 Organization of Results

The results from the estimation of shift choice and shift differentials using the endogenous switching regression model are divided into two major sections; results for a cross-section of data from 1990 and results for a pooled cross-section of data from 1990-2000. Both datasets are estimated using two-step (Section 4.3.2) and maximum likelihood (Section 4.3.3) methods. Results will be evaluated using two measures of local economic conditions, the local unemployment rate and the state leading index. Interaction effects are also estimated as discussed in Section 4.3.4. The models are tested for pooling. Major results for other cross-sections from 1992-2000 are presented, as well as major results for the pooled cross-section regressions for different industries. Wage differentials are estimated for the cross-section and pooled cross-section models as outlined in Section 4.3.7. Tables highlighting the main results are presented throughout the chapter, with supporting results presented in tables in the Appendix.

## 5.2 1990 Cross-Section Switching Regression Results

The endogenous switching regression model is first evaluated for the 1990 cross-section as outlined in Section 4.3.1. Results are first presented using the local unemployment rate as an indicator of local economic conditions, followed by model results using the leading index. Results for pooled cross-section analysis are reported in Section 5.3.

### 5.2.1. 1990 Cross-Section Switching Regression with Unemployment Rate

#### 5.2.1.1 Reduced Form Selection Equation

Selected coefficients from the two-step and maximum likelihood estimation of the reduced form of the selection equation (9) are reported in columns 1 and 3 of Table 5.1. Columns 2 and 4 report the results from estimation of the structural equation (5), which will be discussed in Section 5.2.1.3. Tables A1_1 and A1_2 in the Appendix reports coefficients and standard errors for all variables, offering a more complete version of the information provided in Table 5.1. Regressors in the reduced form selection equation include a measure of local economic conditions (either the local unemployment rate or the leading index), the explanatory variables used in the individual wage equations, and two exclusion restrictions, *number of children* and *industry shift rate*.

The results for most of the variables in estimation of the reduced form equation are largely similar between two-step and maximum likelihood methods. The unemployment rate is insignificant for shift selection and the coefficient is negligible. Both two-step and maximum likelihood results indicate that having more children significantly impacts the likelihood of working at night. Two-step and maximum likelihood results also indicate that those working for larger firms are significantly more likely to work a night shift, with firm size having the largest impact for workers at firms with 500-999 employees, denoted by *firm size 3*. Education, denoted by *years of school*, is a significant predictor of shift choice, however, experience and tenure fail to have a significant impact on the likelihood of selecting night shift work. Union status positively and significantly influences shift choice in both the two-step and maximum likelihood results. Female and married individuals are significantly less likely to choose night shift work. Those employed in professional, sales, and craft occupations are significantly less

**Table 5.1 Two-Step and ML Selection Equations, 1990 Cross-Section with Unemployment Rate**

| | Two-Step | | Maximum Likelihood | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Variable | Reduced Form Coefficient | Structural Form Coefficient | Reduced Form Coefficient | Structural Form Coefficient |
| *Wage Differential* | | 0.933** | | 0.831** |
| *Unemployment Rate* | 0.001 | -0.000 | 0.001 | 0.000 |
| *Number of Children* | 0.045* | 0.051* | 0.048** | 0.052* |
| *Industry Shift Rate* | 0.456 | 0.430 | 0.756 | 0.421 |
| *Firm Size 1* | 0.194** | 0.185** | 0.203** | 0.189** |
| *Firm Size 2* | 0.610*** | 0.280 | 0.627*** | 0.352** |
| *Firm Size 3* | 1.057*** | 0.549** | 1.059*** | 0.668*** |
| *Firm Size 4* | 0.706*** | 0.274 | 0.726*** | 0.364** |
| *Years of School* | 0.390*** | -0.019 | 0.412*** | -0.021 |
| *Experience* | 0.234 | 0.014 | 0.241 | 0.016 |
| *Tenure* | -0.042 | -0.038*** | -0.040 | -0.041*** |
| *Union* | 0.259*** | 0.055 | 0.256*** | 0.103 |
| *Non-white* | 0.022 | 0.027 | 0.012 | 0.013 |
| *Female* | -0.317*** | -0.227*** | -0.314*** | -0.206*** |
| *Married* | -0.278*** | -0.162** | -0.283*** | -0.254*** |
| *Professional Occupation* | -0.742*** | -0.451** | -0.714*** | -0.538*** |
| *Sales Occupation* | -0.855*** | -0.404** | -0.832*** | -0.523*** |
| *Craft Occupation* | -0.729*** | -0.494*** | -0.721*** | -0.566*** |
| *Ag/Construction Industry* | -0.528 | -0.432 | -0.413 | -0.038 |
| *Manufacturing Industry* | -0.053 | -0.026 | -0.076 | -0.518 |
| *Transportation Industry* | 0.130 | 0.082 | 0.139 | 0.073 |
| *Wholesale Trade Industry* | 0.006 | 0.108 | 0.162 | 0.079 |
| *Retail Trade Industry* | 0.025 | -0.202 | -0.238 | -0.147 |
| *Constant* | -4.337*** | -0.256 | -4.602*** | -0.487 |
| *Log-likelihood* | -1036.46 | -1044.9792 | -2894.75 | -1045.85 |
| *Observations* | 5026 | 5026 | 5026 | 5026 |

Levels of significance: ***1%, **5%, *10%. Table A1 in the Appendix reports additional variables and standard errors.

likely to work at night than those in the base group, service occupations. There are not significant differences in shift choice as defined by broad industry categories.

### 5.2.1.2. Individual Wage Equations

The reduced form probit results are next used to control for self-selection into shift work in the estimation of the individual expected wage equations (11) and (12). The coefficients from two-step and maximum likelihood estimation results for night and day workers are included in Table 5.2. Tables A2_1 and A2_2 in the Appendix provide full results and standard errors. The

**Table 5.2 Two-Step and ML Wage Equations, 1990 Cross-Section with Unemployment Rate**

| | Two-Step Coefficients | | Maximum Likelihood Coefficients | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Variable | Night Worker | Day Worker | Night Worker | Day Worker |
| *Unemployment Rate* | -0.001 | -0.003*** | -0.002 | -0.003*** |
| *Selection Term* | 0.518* | -0.142 | 0.401*** | 0.120*** |
| *Firm Size 1* | 0.036 | 0.031** | 0.031 | 0.031*** |
| *Firm Size 2* | 0.390*** | 0.054*** | 0.342*** | 0.052*** |
| *Firm Size 3* | 0.647*** | 0.129*** | 0.561*** | 0.123*** |
| *Firm Size 4* | 0.570*** | 0.130*** | 0.511*** | 0.127*** |
| *Years of School* | 0.120 | 0.050** | 0.080 | 0.049*** |
| *Experience* | -0.126 | 0.014 | -0.086 | 0.013 |
| *Tenure* | 0.100*** | 0.060*** | 0.101*** | 0.060*** |
| *Union* | 0.332*** | 0.112*** | 0.298*** | 0.111*** |
| *Non-white* | -0.093** | -0.092*** | -0.079* | -0.093*** |
| *Female* | -0.288*** | -0.206*** | -0.262*** | -0.205*** |
| *Married* | -0.089 | 0.039*** | -0.052 | 0.039*** |
| *Professional Occupation* | -0.053 | 0.329*** | 0.002 | 0.333*** |
| *Sales Occupation* | -0.286 | 0.202*** | -0.199** | 0.207*** |
| *Craft Occupation* | -0.112 | 0.136*** | -0.050 | 0.140*** |
| *Ag/Construction Industry* | 0.016 | 0.146*** | 0.099 | 0.148*** |
| *Manufacturing Industry* | -0.012 | 0.014 | 0.003 | 0.013 |
| *Transportation Industry* | 0.151 | 0.122*** | 0.164* | 0.121*** |
| *Wholesale Trade Industry* | -0.101 | 0.016*** | -0.083 | 0.016 |
| *Retail Trade Industry* | 0.150 | -0.116 | 0.122 | -0.118*** |
| *Constant* | 4.980*** | 5.936*** | 5.187*** | 5.938*** |
| *R squared* | 0.60 | 0.44 | | |
| *Log-Likelihood* | | | -2894.75 | |
| *Observations* | 352 | 4674 | 5026 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable:Log Wage

unemployment rate has a negative and significant impact on the wages of day workers but does not have a significant impact on the wages of night workers. The selection term coefficients are estimates of the covariance between the error terms in the individual wage equations and the error term in reduced form of the selection equation. In both two-step and maximum likelihood estimation, the coefficient on the selection term for night workers is positive, indicating a positive correlation between the error term of the night shift equation and the error term in the reduced form of the selection equation. This coefficient is also significant indicating the presence of selection bias. This paper is the first study to find significant *positive* selection into shift work, indicating that those who choose night shift work have a comparative advantage in working at night, earning above average wages at night. Kostiuk finds no evidence of significant selection into shift work, while Lanfranchi, *et al*., find negative and significant selection into shift work. In the two-step estimation, the coefficient on the selection term for day workers is insignificant, indicating no evidence of selection into day work. Maximum likelihood results, however, indicate negative selection into day work and those choosing to work during the day earn below average wages in the day. Both two-step and maximum likelihood results seem to suggest that those choosing to work at night earn above average wages at night. Two-step and maximum likelihood results are inconclusive as to the direction of selection into day work.

The returns to education are significant for day workers but are not significant for night workers. *Union*, *non-white, female,* and *tenure* variables are statistically significant for both day and night workers. The returns to union membership are twice as high for night workers. Additionally, returns to tenure are higher for night shift workers. The results also indicate a larger wage penalty for female night shift workers. In maximum likelihood estimation, non-white night workers are not penalized as much their daytime counterparts. A majority of the occupation and industry variables are significant predictors of wages for day workers, while significant differences in wages are not prevalent for night workers based on occupation and industry. Maximum likelihood results indicate that those employed in sales occupations earn significantly less at night than those employed in the base group of service occupations, while those working in the transportation industry earn significantly more than those employed in the base group of business and personal services industries.

#### 5.2.1.3. Structural Equation

The final step in the estimation of the Lee model is the estimation of the structural equation (5). The parameter of interest to be estimated is $\widehat{\delta_1}$, the coefficient on the wage differential in the structural form of the selection equation. First, the results of the wage regressions for day and night workers, which are provided in Table 5.2, are used to compute the unconditional expected night shift premium (13) for each individual. Shift differentials calculated from this model are discussed in Section 5.8. The expected wage differential is then used in the estimation of the structural probit (5). These results are displayed in Table 5.1, columns 2 and 4 for ease of comparison with the reduced form results in columns 1 and 2. Tables A1_1 and A1_2 in the Appendix provides the full results including standard errors.

Two goals of the current analysis are to determine the impact of the local unemployment rate on the decision to work a night shift and on the size of the compensating differential for night shift work. The coefficients on the unemployment rate continue to be negligible and insignificant in the structural form estimation. The wage differential, however, is a statistically significant predictor of shift choice in both two-step and maximum likelihood estimation. These coefficients indicate that rising wage differentials for night shift work make individuals more likely to choose night shift work. Additionally, these coefficients are also practically significant and provide evidence that individuals consider the size of the shift premium when deciding whether to work at night.

The results for other variables included in the structural equation provide evidence of the factors influencing workers as they make choices regarding work hours after controlling for the wage differential. In Table 5.1, the variables affecting shift choice not included in the wage equations, *number of children* and *shift rate*, are similar in both the reduced and structural probits, which is expected if the model is correctly specified. The inclusion of the wage differential causes the coefficient on education to change from positive to negative and to become statistically insignificant. This result indicates that, after controlling for the wage differential, higher educated individuals are less likely to choose to work at night. Thus, much of education's impact on shift choice occurs through its impact on wages. A similar effect is seen with union status. After the wage differential for night shift work is accounted for, union status is not a significant predictor of shift choice. Another personal characteristic variable, *tenure*, becomes statistically significant, indicating that those workers with seniority are less likely to work at night. The firm size variables, *female*, *married*, and the occupational variables remain significant for shift choice. These variables thus impact shift selection separately from their impact on the individual's wage. In maximum likelihood estimation, all of the firm size variables remain statistically significant for shift choice, while in the two-step results, those employed at firms with 25-99 employees, *firm size 1,* and those employed at firms with 500-999 employees, *firm size 3*, are significantly more likely to select night shift work, probably due to the fact that larger firms are more likely to employ night shift work in order to better utilize capacity. In both two-step and maximum likelihood results, the magnitude of the firm size variables is reduced, suggesting that firm size partially affects shift selection by impacting shift wages. Gender and marital status highly influence one's schedule and monetary needs, thus impacting one's work schedule preferences. Additionally, one's occupation continues to significantly impact shift choice, most likely because individual's work schedules are often dictated by their employer or job responsibilities.

### 5.2.2. 1990 Cross-Section Switching Regression with Leading Index

The local unemployment rate is only one indicator of labor market strength. This section recomputes the above regressions, replacing the local unemployment rate with the leading index. Tables A3_1, A3_2, A4_1, and A4_2 in the Appendix contain the complete results from these regressions. When compared with the estimation of the model using the local unemployment rate, a majority of the results are similar. Condensed versions of the results will be presented in the following pages to facilitate comparison between the two versions of the model.

The main variables of interest from the two-step and maximum likelihood estimation of the reduced form of the selection equation (9) are reported in Table 5.3. The top rows report the reduced and structural coefficients for the model using the local unemployment rate, which was discussed thoroughly in Section 5.2.1.1. The bottom rows report the reduced and structural coefficients for the model using the leading index. The structural equation coefficients are compared on the following page. Table 5.3 indicates that the leading index has a larger impact on shift selection than the unemployment rate in the both the two-step and ML estimation of the reduced form. The unemployment rate is a small and insignificant predictor of shift selection,

**Table 5.3 Unemployment Rate vs. Leading Index Selection Equations, 1990 Cross-Section**

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Reduced | Structural | Reduced | Structural |
| *Wage Differential* | | 0.933 | | 0.831 |
| | | (0.374**) | | (0.412**) |
| *Unemployment Rate* | 0.001 | 0.001 | 0.001 | 0.001 |
| | (0.002) | 0.002 | (0.002) | (0.002) |

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Reduced | Structural | Reduced | Structural |
| *Wage Differential* | | 0.864 | | 0.743 |
| | | (0.352**) | | 0.404* |
| *Leading Index* | 0.079 | 0.069 | 0.092 | 0.096 |
| | (0.048) | (0.040*) | (0.047*) | (0.038**) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Complete results for all variables for unemployment rate model reported in Table A1.
Complete results for all variables for leading index model reported in Table A3.
Standard errors in parentheses.

however, maximum likelihood estimates of the reduced form indicate that the leading index has a statistically significant impact on shift selection. The coefficient on the leading index is positive, suggesting that individuals in areas with higher projected growth are more likely to select night shift work, likely because of an increased availability of night shift jobs.

The reduced form probit results are next used to control for self-selection into night work in the estimation of the individual expected wage equations (11) and (12). Complete results for night and day wage regressions using the leading index are reported in Tables A4_1 and A4_2. The results for the two main variables of interest, the unemployment rate/leading index and the selection term, are provided in Table 5.4. The top rows report the night and day coefficients for the model using the local unemployment rate, which was discussed in Section 5.2.1.2. The bottom rows report the night and day coefficients for the model using the leading index. Again, when compared to the magnitude of the coefficient on the unemployment rate, the leading index has a larger effect on the wages of night and day workers. Like the unemployment rate, the leading index has a negative and significant impact on the wages of day workers, but not on the

**Table 5.4 Unemployment Rate vs. Leading Index Wage Equations, 1990 Cross-Section**

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Night | Day | Night | Day |
| *Unemployment Rate* | -0.001 | -0.003 | -0.002 | -0.003 |
| | (0.001) | (0.000***) | (0.001) | (0.000***) |
| *Selection Term* | 0.518 | -0.142 | 0.401*** | 0.120*** |
| | (0.275*) | (0.096) | | |

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Night | Day | Night | Day |
| *Leading Index* | -0.014 | -0.052 | -0.041 | -0.052 |
| | (0.036) | (0.008***) | (0.032) | (0.008***) |
| *Selection Term* | 0.619 | -0.127 | 0.431*** | 0.121*** |
| | (0.270**) | (0.097) | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage
Complete results for all variables for unemployment rate model reported in Table A2.
Complete results for all variables for leading index model reported in Table A4.
Standard errors in parentheses.

wages of night workers. The leading index coefficients are negative, which indicates that those individuals living in states with larger projected growth have lower wages. The selection term coefficients exhibit similar signs, magnitudes, and significance as the model using the unemployment rate. The results indicate positive and significant selection into night shifts. The two-step results find no significant selection into day shifts, while the maximum likelihood results indicate negative and significant selection into day shifts. In the estimation of both models, night shift workers choose to work at night because they have a comparative advantage in working at night, earning higher than average wages at night. Again, the two-step and maximum likelihood results disagree as to the direction of selection into day work. The models consistently find significant selection effects, indicating that it is important to control for self-selection into shifts.

The results of the wage regressions for day and night workers are next used to compute the unconditional expected night shift premium for each individual. Shift differentials calculated from this model are discussed in Section 5.8. The expected wage differential is then used in the estimation of the structural probit (5). These results are displayed in Table 5.3 for ease of comparison with the reduced form results. Tables A3_1 and A3_2 in the Appendix provide the full results including standard errors. For both the two-step and maximum likelihood results, the model including the unemployment rate finds that the shift differential is a positive and significant predictor of shift choice. The unemployment rate continues to be insignificant. The wage differential for night shift work is also a significant predictor of shift choice in the model including the leading index. The leading index coefficient is positive and significant, indicating that individuals living in states with higher projected growth are significantly more likely to select night shift work. This result could be due to increased plant activity and greater availability of night shift work in high growth regions. These results provide evidence that individuals take both the size of the wage premium offered for night shift work and local economic conditions into account when determining whether to work at night.

### 5.3 1990-2000 Pooled Cross-Section Switching Regression Results

The model outlined in Section 4.3 is next estimated using a pooled cross-section of data from 1990-2000. Results are first presented using the local unemployment rate as an indicator of local economic conditions, followed by model results using the leading index.

#### 5.3.1. 1990-2000 Pooled Cross-Section Switching Regression with Unemployment Rate

##### 5.3.1.1 Reduced Form Selection Equation

Selected coefficients from the two-step and maximum likelihood estimation of the reduced form of the selection equation (9) for the pooled cross-section are reported in columns 1 and 3 of Table 5.5. Columns 2 and 4 report the results from estimation of the structural equation (5), which will be discussed in Section 5.3.1.3. Tables A5 and A6 in the Appendix report coefficients and standard errors for all variables, offering a more complete version of the information provided in Table 5.5.

Most of the coefficients for the variables in the reduced form estimation are similar between two-step and maximum likelihood methods. The unemployment rate is insignificant for shift selection and the coefficient continues to be negligible. *Number of children* and *industry shift rate* positively and significantly impact shift selection. *Firm size*, *years of school*, and *union* status positively and significantly impact shift selection while *tenure*, *female*, and *married* are significant negative predictors of shift choice. The pooled cross-section results permit a more detailed analysis of shift selection by industry. Significant differences in shift selection exist among the various industries. Those employed in business, entertainment, and other service industries serve as the base group for comparison in the regression analysis. Agriculture, farming, fishing, construction, durable manufacturing, finance, and professional industries are

**Table 5.5 Two-Step and ML Selection Equations, 1990-2000 Pooled Cross-Section with Unemployment Rate**

| | Two-Step | | Maximum Likelihood | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Reduced Form | Structural Form | Reduced Form | Structural Form |
| Variable | Coefficient | Coefficient | Coefficient | Coefficient |
| *Wage Differential* | | 0.231 | | 0.275 |
| *Unemployment Rate* | 0.001 | -0.000 | 0.000 | -0.000 |
| *Number of Children* | 0.026** | 0.031*** | 0.028** | 0.031*** |
| *Industry Shift Rate* | 0.309** | 0.312*** | 0.270** | 0.312*** |
| *Firm Size 1* | 0.219*** | 0.201*** | 0.233*** | 0.198*** |
| *Firm Size 2* | 0.535*** | 0.512*** | 0.558*** | 0.508*** |
| *Firm Size 3* | 0.738*** | 0.719*** | 0.754*** | 0.714*** |
| *Firm Size 4* | 0.780*** | 0.744*** | 0.809*** | 0.738*** |
| *Years of School* | 0.244*** | -0.041*** | 0.284*** | -0.040*** |
| *Experience* | -0.005 | 0.011 | -0.021 | 0.011* |
| *Tenure* | -0.050*** | -0.027*** | -0.054*** | -0.027*** |
| *Union* | 0.330*** | 0.313*** | 0.312*** | 0.309*** |
| *Non-white* | 0.035*** | 0.037 | 0.043 | 0.035 |
| *Female* | -0.229*** | -0.240*** | -0.220*** | -0.243*** |
| *Married* | -0.183*** | -0.195*** | -0.184*** | -0.195*** |
| *Professional Occupation* | -0.692*** | -0.764*** | -0.703*** | -0.761*** |
| *Sales Occupation* | -0.718*** | -0.708*** | -0.713*** | -0.700*** |
| *Craft Occupation* | -0.505*** | -0.509*** | -0.507*** | -0.507*** |
| *Agriculture/Farm/Fish Industry* | -0.999*** | -1.122*** | -1.010*** | -1.132*** |
| *Mining Industry* | 0.749*** | 0.672*** | 0.754*** | 0.654*** |
| *Construction Industry* | -0.750*** | -0.790*** | -0.820*** | -0.797*** |
| *Non-Durable Manufacturing Industry* | 0.190*** | 0.173*** | 0.212*** | 0.170** |
| *Durable Manufacturing Industry* | -0.103* | -0.107* | -0.079 | -0.111* |
| *Transportation Industry* | -0.003 | -0.036 | 0.003 | -0.041 |
| *Wholesale Trade Industry* | 0.005 | -0.020 | -0.002 | -0.027 |
| *Retail Trade Industry* | 0.147** | 0.136* | 0.142** | 0.132* |
| *Finance Industry* | -0.667*** | -0.695*** | -0.668*** | -0.701*** |
| *Prof. & Related Industry* | -0.208*** | -0.233*** | -0.198*** | -0.238*** |
| *Public Administration Industry* | -0.046 | -0.131 | -0.080 | -0.145 |
| *1992* | -0.041 | -0.006 | -0.042 | -0.004 |
| *1994* | -0.106 | -0.087 | -0.114 | -0.087 |
| *1996* | -0.050 | -0.031 | -0.058 | -0.031 |
| *1998* | -0.068 | -0.052 | -0.077 | -0.050 |
| *2000* | -0.057 | -0.030 | -0.071 | -0.029 |
| *Constant* | -2.655*** | -0.888*** | -2.722 | -0.911*** |
| *Log-likelihood* | -4649.43 | -4688.97 | -15756.94^ | -4688.87 |
| *Observations* | 24732 | 24732 | 24732 | 24732 |

Levels of significance: ***1%, **5%, *10%. Tables A6 and A7 in the Appendix report additional variables and standard errors.
^ denotes the log-likelihood from the simultaneous estimation of the wage equations and the reduced form of the selection equation.

less likely to select night shift work than the base group. Those in mining, non-durable manufacturing, and retail trade industries are significantly more likely to select night shift work than those in the base group. These results are consistent with industries known for high prevalence of night shift work. When analyzing shift selection using the year dummy variables, there are not significant differences in shift selection from the base year of 1990. Shift selection was not as prevalent in the years 1992-2000 as in 1990, with 1994 showing the largest difference in shift prevalence when compared to 1990.

#### 5.3.1.2. Individual Wage Equations

The individual expected wage equations are next computed. The coefficients from two-step and maximum likelihood estimation results for night and day workers are included in Table 5.6. Tables A7 and A8 in the Appendix provide the full results including standard errors. Unlike the results for the 1990 cross-section, the unemployment rate has a statistically significant impact on the wages of both night and day workers. In both two-step and maximum likelihood estimation, the coefficient on the selection term for night workers is negative, but insignificant. Thus, when the data are pooled over multiple years, there is no evidence of significant selection into night shifts and no evidence that night workers have a comparative advantage in working at night. The two-step results indicate significant positive selection into day shifts while the maximum likelihood results indicate significant negative selection into day shifts. In the two-step model, individuals choosing to work during the day earn higher than average wages in the daytime. In the maximum likelihood results, individuals choosing to work during the day earn lower than average wages. This difference in the findings of two-step and maximum likelihood estimation is consistent from the 1990 cross-section to the pooled cross-section.

Other variables included in the wage equations provide evidence of differences between night and day workers. The firm size variables continue to have a positive and significant impact on wages. Experience significantly impacts day wages, while tenure significantly impacts the wages of both night and day workers. Night shift workers belonging to unions earn approximately five percent higher than day workers belonging to unions. Wage penalties for

**Table 5.6 Two-Step and ML Wage Equations, 1990-2000 Pooled Cross-Section with Unemployment Rate**

| | Two-Step Coefficients | | Maximum Likelihood Coefficients | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Variable | Night Worker | Day Worker | Night Worker | Day Worker |
| *Unemployment Rate* | -0.001*** | -0.001*** | -0.001*** | -0.001*** |
| *Selection Term* | -0.014 | -0.300*** | -0.029 | 0.156*** |
| *Firm Size 1* | 0.097* | 0.049*** | 0.094** | 0.045*** |
| *Firm Size 2* | 0.150 | 0.096*** | 0.143** | 0.084*** |
| *Firm Size 3* | 0.208 | 0.153*** | 0.199** | 0.135*** |
| *Firm Size 4* | 0.289** | 0.199*** | 0.279*** | 0.180 |
| *Years of School* | 0.053 | 0.007 | 0.049 | 0.003 |
| *Experience* | 0.012 | 0.039*** | 0.012 | 0.039*** |
| *Tenure* | 0.056*** | 0.032*** | 0.057*** | 0.033*** |
| *Union* | 0.172*** | 0.121*** | 0.168*** | 0.111*** |
| *Non-white* | -0.064*** | -0.107*** | -0.064*** | -0.108*** |
| *Female* | -0.127*** | -0.218*** | -0.125*** | -0.213*** |
| *Married* | 0.062* | 0.053*** | 0.064*** | 0.057*** |
| *Professional Occupation* | 0.314*** | 0.299*** | 0.323*** | 0.322*** |
| *Sales Occupation* | 0.075 | 0.144*** | 0.083 | 0.168*** |
| *Craft Occupation* | 0.088 | 0.046*** | 0.094* | 0.064*** |
| *Agriculture/Farm/Fish Industry* | 0.124 | -0.177*** | 0.138 | -0.153*** |
| *Mining Industry* | 0.393*** | 0.094*** | 0.385*** | 0.074** |
| *Construction Industry* | 0.346* | 0.153*** | 0.358*** | 0.169*** |
| *Non-Durable Manufacturing Industry* | 0.027 | -0.004 | 0.024 | -0.015 |
| *Durable Manufacturing Industry* | 0.128*** | 0.032*** | 0.128*** | 0.034*** |
| *Transportation Industry* | 0.230*** | 0.114*** | 0.230*** | 0.115*** |
| *Wholesale Trade Industry* | 0.150** | 0.003 | 0.151** | 0.005 |
| *Retail Trade Industry* | -0.054 | -0.122*** | -0.057 | -0.129*** |
| *Finance Industry* | 0.204 | 0.077*** | 0.213* | 0.086*** |
| *Prof. & Related Industry* | 0.000 | -0.092*** | 0.001 | -0.090*** |
| *Public Administration Industry* | 0.345*** | 0.035*** | 0.347*** | 0.038*** |
| *1992* | 0.035 | 0.088*** | 0.036 | 0.090*** |
| *1994* | 0.173*** | 0.154*** | 0.175*** | 0.158*** |
| *1996* | 0.239*** | 0.214*** | 0.240*** | 0.216*** |
| *1998* | 0.246*** | 0.265*** | 0.248*** | 0.267*** |
| *2000* | 0.327*** | 0.345*** | 0.328*** | 0.347*** |
| *Constant* | 5.893*** | 6.055*** | 5.936*** | 6.039*** |
| *R-Squared* | 0.55 | 0.51 | | |
| *Log-Likelihood* | | | -15756.94^ | |
| *Observations* | 1472 | 23260 | 24732 | |

Levels of significance: ***1%, **5%, *10%. Tables A7 and A8 in the Appendix report additional variables and standard errors.

^ denotes the log-likelihood from the simultaneous estimation of the wage equations and the reduced form of the selection equation.

non-white and female workers are lower for night workers. Only night workers in professional occupations earn significantly higher than those in service occupations, while there are significant differences between wages for all occupations for day workers. Mining, construction, manufacturing, transportation, and public administration workers earn significantly higher wages on night shifts than night workers in business, personal, and entertainment services. When analyzing the time variables, night shift workers earned significantly higher wages in years 1994, 1996, 1998, and 2000 when compared to the base year of 1990. Relative to day workers, night workers experienced higher wage increases in 1994 and 1996. Day workers experienced higher wage increases in 1992, 1998, and 2000.

#### 5.3.1.3. Structural Equation

Two-step and maximum likelihood estimation of the structural equation (5) are shown in Table 5.5, columns 2 and 4 for ease of comparison with the reduced form results in columns 1 and 2. Tables A5 and A6 in the Appendix provide the full results including standard errors. Shift differentials computed from this model are discussed in Section 5.8. The coefficients on the unemployment rate continue to be negligible and insignificant in the structural form estimation. The wage differential is an insignificant predictor of shift choice in both estimation methods. The coefficients are, however, positive and are similar in magnitude. These coefficients provide evidence that rising wage differentials for night shift work make individuals more likely to choose night shift work.

After controlling for the wage differential, the firm size variables remain significant for shift choice, again indicating that larger firms are more likely to operate night shifts. The magnitudes of the coefficients are slightly lower, which is expected since firm size also impacts shift selection through worker wages. Similar to the cross-section results, prior to the inclusion of the wage differential, education was a positive and significant predictor of shift choice. When the wage differential is included in probit estimation, however, education is a negative and significant predictor of shift choice. Thus, once wage differences are accounted for, those individuals with higher education are less likely to choose to work at night. Tenure and union status remain significant although the coefficient magnitudes are slightly diminished, which is to be expected since these variables also influence worker wages. Number of children, female, and married variables remain significant, but actually increase slightly in magnitude, which provides evidence that these variables have impacts on shift selection through another channel than through their impact on wages. These variables impact shift selection likely because they are related to schedule preferences. The occupation and industry variables that significantly influenced shift choice in the reduced form estimation continue to significantly impact shift selection even with the inclusion of the wage differential, most likely because the presence of shift work is largely dictated by one's job responsibilities.

### 5.3.2. 1990-2000 Pooled Cross-Section Switching Regression with Leading Index

This section recomputes the above pooled cross-section regressions, replacing the local unemployment rate with the leading index. When compared with the estimation of the model using the local unemployment rate, a majority of the results are similar. Condensed versions of the results will be presented in the following pages to facilitate comparison between the two versions of the model. Tables A9, A10, A11 and A12 in the Appendix contain the complete results from these regressions.

The main variables of interest from the two-step and maximum likelihood estimation of the reduced form of the selection equation (9) are reported in Table 5.7. The top rows report the reduced and structural coefficients for the pooled cross-section using the local unemployment rate. The bottom rows report the reduced and structural coefficients for the pooled cross-section using the leading index. The structural equation coefficients are compared on the following page. The leading index continues to have a larger impact on shift selection than the unemployment rate in the both the two-step and ML estimation of the reduced form. Both the unemployment rate and the leading index are insignificant predictors of shift choice. The coefficients on the leading index variables are positive, suggesting that individuals in areas with higher projected growth are more likely to select night shift work.

**Table 5.7 Unemployment Rate vs. Leading Index Selection Equations, 1990-2000 Pooled Cross-Section**

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Reduced | Structural | Reduced | Structural |
| *Wage Differential* | | 0.231 | | 0.275 |
| | | (0.314) | | (0.317) |
| *Unemployment Rate* | 0.001 | -0.000 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Reduced | Structural | Reduced | Structural |
| *Wage Differential* | | 0.292 | | 0.240 |
| | | (0.320) | | (0.326) |
| *Leading Index* | 0.019 | 0.014 | 0.019 | 0.015 |
| | (0.018) | (0.020) | (0.018) | (0.020) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Complete results for all variables for unemployment rate model reported in Tables A5 and A6.
Complete results for all variables for leading index model reported in Tables A9 and A10.
Standard errors in parentheses.

The complete results of the night and day wage regressions using the leading index are reported in Tables A11 and A12. The results for the two main variables of interest, the unemployment rate/leading index and the selection term, are provided in Table 5.8. The top rows report the night and day coefficients for the model using the local unemployment rate. The bottom rows report the night and day coefficients for the model using the leading index. The unemployment rate has a small negative significant impact on the wages of both day and night workers. The leading index, however, only has a significant impact on the wages of day workers. Interestingly, the signs of the coefficients on the leading index are different for night and day workers. For night workers, although insignificant, the coefficient is positive, which

**Table 5.8 Unemployment Rate vs. Leading Index Wage Equations, 1990-2000 Pooled Cross-Section**

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Night | Day | Night | Day |
| *Unemployment Rate* | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.000***) | (0.000***) | (0.000***) | (0.000***) |
| *Selection Term* | -0.014 | -0.300 | -0.029 | 0.156*** |
| | (0.208) | (0.054***) | | |

| | Two-Step Coefficients | | ML Coefficients | |
|---|---|---|---|---|
| Variable | Night | Day | Night | Day |
| *Leading Index* | 0.016 | -0.014 | 0.016 | -0.014 |
| | (0.012) | (0.003***) | (0.011) | (0.003***) |
| *Selection Term* | 0.008 | -0.302 | -0.020 | 0.159*** |
| | (0.206) | (0.054***) | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage
Complete results for all variables for unemployment rate model reported in Table A7 and A8.
Complete results for all variables for leading index model reported in Tables A11 and A12.
Standard errors in parentheses.

seems to indicate that individuals in areas with higher projected economic growth have slightly higher wages. For day workers, the coefficient is negative, which indicates that those day workers living in states with larger projected growth have lower wages. The selection term coefficients exhibit similar magnitudes and significance as the model using the unemployment rate. The results indicate insignificant selection into night shifts in both specifications of the model.  When both the unemployment rate and the leading indicator are used, the two-step results indicate positive selection into day shifts, while the maximum likelihood results indicate negative selection into day shifts.

Structural probit results are displayed in Table 5.7 for ease of comparison with the reduced form results.  Shift differentials computed from this model are discussed in Section 5.8. The unemployment rate and the leading index continue to be insignificant predictors of shift choice.  For both the two-step and maximum likelihood results, the models find that the shift differential is a positive but insignificant predictor of shift choice.  The results of the pooled cross-section analysis do not provide evidence that shift differentials and local economic conditions significantly impact shift choice.

### 5.4 Interaction Effects

The results of the cross-section and pooled cross-section were also used to estimate interaction effects between the shift differential and the two measures of local economic conditions.  To investigate possible interaction effects, we consider the probability of selecting shift work conditional on the shift differential, local economic conditions, and the observed exogenous covariates, as outlined in Section 4.3.4.  We estimate the effect of changes in the shift differential on the selection probability (14) under different local economic conditions.   The estimated bounds of the selection probability are reported for different values of the local unemployment rate and the state leading index in the following four tables, all of which are formatted and interpreted in the same manner.

#### 5.4.1 1990 Cross-Section with Unemployment Rate

Table 5.9 presents the results for the 1990 cross-section using the local unemployment rate as the measure of local economic conditions. The table presents the lower and upper bounds of the selection probability for different combinations of percentile values of the log wage differential and the local unemployment rate. As a method of interpreting the bounds, the midpoint of the lower and upper bounds is presented below each interval. The intervals in each row, represented by letters A-E, indicate how changes in the shift differential affect the selection probability for a given level of the unemployment rate. For example, one can compare interval A2 to interval A3 to see how a rise in the shift differential from -1.097 to -0.88 impacts shift selection given an unemployment rate of 3.6%. The intervals in each column, represented by numbers 1-5, indicate how changes in the unemployment rate affect the selection probability for a given shift differential. For example, one can compare interval A2 to interval B2 to see how a rise in the unemployment rate from 3.6% to 4.4% impacts shift selection given a shift differential of -1.097. Consequently, comparing intervals across two columns for two different rows reveals

**Table 5.9 Interaction Effects, 1990 Cross-Section using Unemployment Rate**

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.577154 | | -1.097199 | | -0.8826764 | | -0.6764674 | | -0.4742174 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.6% | A | 5.640E-07 | 0.009599 | 0.000054 | 0.025714 | 0.000267 | 0.038217 | 0.000986 | 0.054535 | 0.002945 | 0.075474 |
| Avg.* | | 0.004800 | | 0.012884 | | 0.019242 | | 0.027761 | | 0.039209 | |
| 4.4% | B | 5.760E-07 | 0.009640 | 0.000055 | 0.025810 | 0.000270 | 0.038351 | 0.000997 | 0.054713 | 0.002974 | 0.075702 |
| Avg. | | 0.004820 | | 0.012933 | | 0.019310 | | 0.027855 | | 0.039338 | |
| 5.5% | C | 5.940E-07 | 0.009697 | 0.000056 | 0.025943 | 0.000275 | 0.038535 | 0.001013 | 0.054958 | 0.003014 | 0.076017 |
| Avg. | | 0.004849 | | 0.013000 | | 0.019405 | | 0.027985 | | 0.039516 | |
| 6.2% | D | 6.050E-07 | 0.009733 | 0.000057 | 0.026028 | 0.000279 | 0.038652 | 0.001023 | 0.055114 | 0.003040 | 0.076219 |
| Avg. | | 0.004867 | | 0.013042 | | 0.019465 | | 0.028069 | | 0.039629 | |
| 8.0% | E | 6.360E-07 | 0.009828 | 0.000059 | 0.026246 | 0.000287 | 0.038956 | 0.001049 | 0.055518 | 0.003107 | 0.076738 |
| Avg. | | 0.004914 | | 0.013153 | | 0.019621 | | 0.028283 | | 0.039922 | |

This table presents lower and upper bounds on the probability of working the night shift. The bounds on the probability are computed for each combination of the log wage differential and the unemployment rate. For example, the lower bound for the log wage differential and unemployment rate combination A1 is 5.640E-07 while the upper bound is 0.009599. *The average of the lower and upper bounds is reported below each combination. For example, the average probability for combination A1 is 0.004800. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentil, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1990. This corresponds to approximate wage differentials of -$8.39, -$6.57, -$5.31, -$3.72, and -$2.66. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1990.

how the impact of changing shift differentials varies for two different unemployment rates, while comparing intervals across two rows for two different columns reveals how the impact of changing unemployment rates varies for two different shift differentials. This method will be used to analyze possible interaction effects with examples provided in the following pages.

First, reading the rows in Table 5.9 from left to right indicates that, for a given unemployment rate, increases in the wage differential for night shift work lead to a higher average probability of selecting night shift work. Reading the columns from top to bottom indicates that, for a given wage differential, increases in the unemployment rate lead to a higher average probability of selecting night shift work. Thus, both the wage differential and the local unemployment rate have a positive impact on shift selection. These positive impacts on selection probability follow from the results of maximum likelihood estimation of the structural probit, provided above in Table 5.1, in which the coefficients on the wage differential and the unemployment rate were both positive.

Intervals are next compared across two rows for two columns to determine interaction effects, which can be considered for many different combinations of changes in the wage differential and changes in the unemployment rate. For example, comparing the interval in A2, which has an average value of approximately 1.29%, to the interval in A3, which has an average value of approximately 1.92%, indicates that, for an unemployment rate of 3.6%, increasing the wage differential from approximately -1.097 to -0.883 leads to an increase in the average selection probability of approximately 0.636%. Comparing the interval in E2, which has an average value of 1.32%, to the interval in E3, which has an average value of 1.96%, indicates that, for an unemployment rate of 8%, increasing the wage differential from approximately -1.097 to -0.883 leads to an increase in the average selection probability of approximately

0.647%. When comparing the effect of increasing the wage differential from -1.097 to -0.883 at 3.6% unemployment to the effect of increasing the wage differential from -1.097 to -0.883 at 8% unemployment, the probability of night shift selection is 0.011% higher. In a similar fashion, comparing the intervals in A3 and A4 to those in E3 and E4 indicates that the average probability of night shift selection is 0.014% higher for an unemployment rate of 8% compared to an unemployment rate of 3.6%. Comparing the intervals in A4 and A5 to those in E4 and E5 indicates that the average probability of night shift selection is 0.019% higher for an unemployment rate of 8% compared to an unemployment rate of 3.6%. These interaction effects, although small, indicate that at higher levels of the unemployment rate, an increase in the wage differential has a larger impact on shift selection. This result would seem to suggest that individuals value shift differentials when determining whether to work at night even in weak economies. This result lies counter to the hypothesis that employers can offer lower compensating differentials in times of high unemployment.

Similar results are obtained when intervals are compared across two columns. For example, comparing the interval in A2, which has an average value of approximately 1.288%, to the interval in B2, which has an average value of approximately 1.29%, indicates that, for a wage differential of approximately -1.097, increasing the unemployment rate from 3.6% to 4.4% leads to an increase in the average selection probability of approximately 0.005%. Comparing the interval in A5, which has an average value of 3.92%, to the interval in B5, which has an average value of 3.93%, indicates that, for a wage differential of approximately -0.474, increasing the unemployment rate from 3% to 6% leads to an increase in the average selection probability of approximately 0.012%. When comparing the effect of increasing the unemployment rate from 3.6% to 4.4% at a wage differential of -1.097 to the effect of increasing the unemployment rate from 3.6% to 4.4% at a wage differential of -0.474, the probability of night shift selection is 0.008% higher. Thus, at higher values of the wage differential, increases in the unemployment rate have a larger impact on shift selection.

### 5.4.2 1990 Cross-Section with Leading Index

Next, interaction effects are analyzed for the 1990 cross-section with the leading index serving as the indicator of local labor market conditions. Table 5.10 provides the average interaction effect for each combination of the wage differential and the leading index. Like the results for the model using the unemployment rate, examining the rows in Table 5.10 indicates that, for a given value of the leading index, increases in the wage differential for night shift work lead to a higher probability of selecting night shift work. Examining the columns indicates that, for a given wage differential, increases in the leading index lead to a higher average probability of night shift selection. Thus, both the wage differential and the leading index have a positive

**Table 5.10 Interaction Effects, 1990 Cross-Section using Leading Index**

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.339548 | | -1.157821 | | -0.9419208 | | -0.7285666 | | -0.51542 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.22 | A | 1.640E-05 | 0.014375 | 0.000061 | 0.020069 | 0.000238 | 0.029222 | 0.000773 | 0.041445 | 0.002141 | 0.057512 |
| Avg.* | | 0.007196 | | 0.010065 | | 0.014730 | | 0.021109 | | 0.029826 | |
| 0.9 | B | 3.130E-05 | 0.016915 | 0.000108 | 0.023435 | 0.000394 | 0.033816 | 0.001195 | 0.047537 | 0.003125 | 0.065390 |
| Avg. | | 0.008473 | | 0.011772 | | 0.017105 | | 0.024366 | | 0.034258 | |
| 1.2 | C | 4.120E-05 | 0.018153 | 0.000138 | 0.025065 | 0.000487 | 0.036024 | 0.001437 | 0.050444 | 0.003667 | 0.069123 |
| Avg. | | 0.009097 | | 0.012601 | | 0.018256 | | 0.025941 | | 0.036395 | |
| 1.65 | D | 6.150E-05 | 0.020154 | 0.000197 | 0.027687 | 0.000664 | 0.039556 | 0.001879 | 0.055069 | 0.004627 | 0.075027 |
| Avg. | | 0.010108 | | 0.013942 | | 0.020110 | | 0.028474 | | 0.039827 | |
| 2.42 | E | 1.180E-04 | 0.024013 | 0.000352 | 0.032705 | 0.001097 | 0.046252 | 0.002903 | 0.063755 | 0.006756 | 0.086014 |
| Avg. | | 0.012066 | | 0.016528 | | 0.023675 | | 0.033329 | | 0.046385 | |

This table presents lower and upper bounds on the probability of working the night shift. The bounds on the probability are computed for each combination of the log wage differential and the unemployment rate. For example, the lower bound for the log wage differential and unemployment rate combination A1 is 1.640E-05 while the upper bound is 0.014375. *The average of the lower and upper bounds is reported below each combination. For example, the average probability for combination A1 is 0.007196. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1990. This corresponds to approximate wage differentials of -$8.58, -$6.79, -$5.52, -$3.92, and -$2.86. From top to bottom, the values of the leading indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the leading index in 1990.

impact on shift selection. These positive impacts on the selection probability follow from the results of the structural probit, provided above in Table 5.3, in which the coefficients on the wage differential and the leading index were both positive.

Intervals are next compared across two rows. For example, comparing the interval in A2, which has an average value of approximately 1.01%, to the interval in A3, which has an average value of approximately 1.47%, indicates that, for a leading index value of 0.22, increasing the wage differential from approximately -1.158 to -0.942 leads to an increase in the average selection probability of approximately 0.47%. Comparing the interval in E2, which has an average value of 1.65%, to the interval in E3, which has an average value of 2.37 %, indicates that, for a leading index value of 2.42, increasing the wage differential from approximately -1.158 to -0.942 leads to an increase in the average selection probability of approximately 0.71%. When comparing the effect of increasing the wage differential at a leading index value of 0.22 to the effect of increasing the wage differential at a leading index value of 2.42, the probability of night shift selection is 0.25% higher. This interaction effect implies that, at higher levels of the leading index, an increase in the wage differential has a larger impact on shift selection. In other words, in areas projected to have higher growth and, therefore, stronger economies, individuals are more likely to consider the size of the shift premium when determining whether to work at night. Conversely, in regions with weaker economies, individuals are less likely to consider the size of the shift differential when determining whether to work at night. This result provides evidence that compensating differentials for night shift work may be lower in weak economies.

### 5.4.3 1990-2000 Pooled Cross-Section with Unemployment Rate

Interaction effects are next considered for the 1990-2000 pooled cross-section with the local unemployment rate serving as the indicator of local labor market conditions. Table 5.11 provides the average interaction effect for each combination of the wage differential and the unemployment rate. Like the cross-section results, examining the rows in Table 5.10 indicates that, for a given unemployment rate, increases in the wage differential for night shift work lead to a higher probability of selecting night shift work. Examining the columns, however, indicates that, for a given wage differential, increases in the unemployment rate lead to a lower probability

**Table 5.11 Interaction Effects, 1990-2000 Pooled Cross-Section using Unemployment Rate**

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.1675968 | | -0.0813582 | | 0.0070029 | | 0.096875 | | 0.1796389 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.1% | A | 0.000281 | 0.044254 | 0.0003351 | 0.0462621 | 0.000398 | 0.048395 | 0.000471 | 0.050643 | 0.000547 | 0.052786 |
| Avg.* | | 0.022267 | | 0.022167 | | 0.024396 | | 0.025557 | | 0.026667 | |
| 4.1% | B | 0.000276 | 0.044059 | 0.000330 | 0.046060 | 0.000392 | 0.048185 | 0.000464 | 0.050426 | 0.000539 | 0.052562 |
| Avg. | | 0.022167 | | 0.023195 | | 0.024288 | | 0.025445 | | 0.026550 | |
| 6.0% | C | 0.000267 | 0.043691 | 0.000319 | 0.045678 | 0.000380 | 0.047790 | 0.000450 | 0.050016 | 0.000524 | 0.052138 |
| Avg. | | 0.021979 | | 0.022999 | | 0.024085 | | 0.025233 | | 0.026331 | |
| 7.3% | D | 0.000261 | 0.043440 | 0.000312 | 0.045419 | 0.000372 | 0.047520 | 0.000441 | 0.049736 | 0.000513 | 0.051849 |
| Avg. | | 0.021850 | | 0.022865 | | 0.023946 | | 0.025089 | | 0.026181 | |
| 9.6% | E | 0.000250 | 0.042999 | 0.000300 | 0.044962 | 0.000358 | 0.047047 | 0.000425 | 0.049246 | 0.000495 | 0.051342 |
| Avg. | | 0.021624 | | 0.022631 | | 0.023702 | | 0.024835 | | 0.025919 | |

This table presents lower and upper bounds on the probability of working the night shift. The bounds on the probability are computed for each combination of the log wage differential and the unemployment rate. For example, the lower bound for the log wage differential and unemployment rate combination A1 is 0.000281 while the upper bound is 0.044254. *The average of the lower and upper bounds is reported below each combination. For example, the average probability for combination A1 is 0.022267. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled dataset. This corresponds to approximate wage differentials of -$2.10, -$0.84, $0.05, $1.07, and $2.22. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled dataset.

of selecting night shift work. Thus, the wage differential continues to have a positive impact on shift selection, while the unemployment rate has a negative impact on shift selection. These results follow from the results of the structural probit, provided above in Table 5.5.

Intervals are next compared across two rows. For example, comparing the interval in A2, which has an average value of approximately 2.22%, to the interval in A3, which has an average value of approximately 2.44%, indicates that, for an unemployment rate of 3.1%, increasing the wage differential from approximately -0.081 to 0.007 leads to an increase in the average selection probability of approximately 0.22%. Comparing the interval in E2, which has an average value of 2.26%, to the interval in E3, which has an average value of 2.37%, indicates that, for an unemployment rate of 9.6%, increasing the wage differential from approximately -0.081 to 0.007 leads to an increase in the average selection probability of approximately 0.11%. When comparing the effect of increasing the wage differential from -0.081 to 0.007 at 3.1% unemployment to the effect of the same size increase in the wage differential at 9.6% unemployment, the probability of night shift selection is 0.12% lower. This interaction effect implies that, at higher levels of the unemployment rate, an increase in the wage differential has a smaller impact on shift selection; thus, individuals are less likely to consider shift differentials when determining whether to work at night in weak economies. This result is consistent with the hypothesis that compensating differentials for night shift work may be lower when the local unemployment rate rises. As mentioned previously, this is only one combination of interaction effects that may be compared. For instance, comparing the intervals in A3 and A4 to those in E3 and E4 indicates that the probability of night shift selection is 0.0028% lower for an unemployment rate of 9.6% compared to an unemployment rate of 3.1%. Comparing the intervals in A4 and A5 to those in E4 and E5 indicates that the probability of night shift selection is 0.0026% lower for an unemployment rate of 9.6% compared to an unemployment rate of 3.1%. In each case, at higher levels of the unemployment rate, an increase in the wage differential has a smaller impact on shift selection.

### 5.4.4 1990-2000 Pooled Cross-Section with Leading Index

Table 5.12 provides the interaction effects for the pooled cross-section using the leading index as an indicator of local economic conditions. While the wage differential continues to have a positive impact on shift selection for a given leading index value, unlike the results for the pooled cross-section model using the unemployment rate, examining the columns of Table 5.12 indicates that, for a given wage differential, increases in the leading index lead to a higher probability of selecting night shift work. For the pooled cross-section using the leading index, both the wage differential and the leading index have a positive impact on shift selection. Comparing the interval in A2, which has an average value of approximately 2.24%, to the interval in A3, which has an average value of approximately 2.33%, indicates that, for a leading index value of 0.46, increasing the wage differential from approximately -0.104 to -0.015 leads to an increase in the average selection probability of approximately 0.093%. Comparing the

**Table 5.12 Interaction Effects, 1990-2000 Pooled Cross-Section using Leading Index**

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.1921215 | | -0.1041496 | | -0.0150659 | | 0.0764587 | | 0.159587 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.46 | A | 0.000244 | 0.042764 | 0.000286 | 0.044500 | 0.000335 | 0.046315 | 0.000391 | 0.04824 | 0.000448 | 0.050044 |
| Avg.* | | 0.021504 | | 0.022393 | | 0.023325 | | 0.023810 | | 0.025246 | |
| 1.18 | B | 0.000265 | 0.043649 | 0.000310 | 0.045414 | 0.000362 | 0.047258 | 0.000421 | 0.049215 | 0.000481 | 0.051047 |
| Avg. | | 0.021957 | | 0.022862 | | 0.023810 | | 0.024818 | | 0.025764 | |
| 1.71 | C | 0.000282 | 0.044310 | 0.000329 | 0.046096 | 0.000383 | 0.047962 | 0.000444 | 0.049942 | 0.000507 | 0.051796 |
| Avg. | | 0.022296 | | 0.023212 | | 0.024172 | | 0.025193 | | 0.026152 | |
| 2.27 | D | 0.000300 | 0.045017 | 0.000349 | 0.046825 | 0.000405 | 0.048715 | 0.000470 | 0.050720 | 0.000536 | 0.052596 |
| Avg. | | 0.022658 | | 0.023587 | | 0.024560 | | 0.025595 | | 0.026566 | |
| 2.67 | E | 0.000313 | 0.045527 | 0.000365 | 0.047352 | 0.000422 | 0.049259 | 0.000489 | 0.051281 | 0.000557 | 0.053174 |
| Avg. | | 0.022920 | | 0.023858 | | 0.024841 | | 0.025885 | | 0.026865 | |

This table presents lower and upper bounds on the probability of working the night shift. The bounds on the probability are computed for each combination of the log wage differential and the unemployment rate. For example, the lower bound for the log wage differential and unemployment rate combination A1 is 0.000244 while the upper bound is 0.042764. *The average of the lower and upper bounds is reported below each combination. For example, the average probability for combination A1 is 0.021504. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1990. This corresponds to approximate wage differentials of -$2.43, -$1.10, -$0.22, $0.82, and $1.90. From top to bottom, the values of the leading indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the leading index in 1990.

interval in E2, which has an average value of 2.39%, to the interval in E3, which has an average value of 2.48 %, indicates that, for a leading index value of 2.67, increasing the wage differential from approximately -0.104 to -0.015 leads to an increase in the average selection probability of approximately 0.098%. When comparing the effect of increasing the wage differential from -0.104 to -0.014 at a leading index value of 0.46 to the effect of increasing the wage differential from -0.104 to -0.015 at a leading index value of 2.67, the probability of night shift selection is 0.005% higher. This interaction effect implies that, at higher levels of the leading index, an increase in the wage differential has a larger impact on shift selection. Similar to the results of the 1990 cross-section using the leading index, these results indicate that individuals are less likely to consider shift differentials in weak economic conditions.

In all of the models analyzed, the interaction effects were small. At average probabilities for both models in the 1990 cross-section, the interaction effects were positive. In the pooled cross-section model with the unemployment rate, the interaction effects were negative, while in the pooled cross-section model with the leading index, the interaction effects were positive. Of the four sets of interaction effects estimated, three lend support to the hypothesis established in this paper: shift differentials have a smaller impact on shift choice as local economic conditions weaken. Thus, individual's choices regarding work hours are impacted by local economic conditions.

**5.5 Tests for Pooling**

Estimating the individual wage equations separately for day and night workers in the endogenous switching regression model allows for the possibility that the returns to individual characteristics of workers are different. As a way to test whether data on day and night workers should instead be pooled, the expected wage equation (15) and the treatment effects model (17) are estimated for the both the two-step and maximum likelihood estimation of the cross-section and pooled cross-section models discussed above.

### 5.5.1 1990 Cross-Section

For the two-step model, estimates of the expected wage equation (15) may be used to test pooling in two ways: 1) variable by variable or 2) by determining the joint significance of the variables that indicate the difference between the returns to day and night work. If these variables are jointly insignificant, the data on day and night workers may be pooled, and the treatment effects model (16) may be more appropriate.

First, pooling may be tested variable by variable by using the results of the two-step switching regression expected wage equation (15), which is reported for the model using the unemployment rate in Table 5.13. The left columns indicate the coefficients for day workers and the right columns indicate the difference in coefficients between day and night workers. The impact of a variable differs between day and night workers if the estimated coefficients of the variables in the right column of Table 5.13 are significant. Variables that are significantly different between day and night workers include the tenure variables, as well as union status, sales occupation, retail trade, finance, and public administration industries. These results indicate that night workers in sales occupations and finance industries have significantly lower wages than day workers in the same professions. Those night workers in retail trade and public administration industries earn significantly higher wages than their daytime counterparts. Preliminary evaluation of the expected wage equation results indicate that several variables are significantly different between night and day workers, suggesting that the data should not be pooled.

**Table 5.13 Expected Wage Equation (Test for Pooling), 1990 Cross-Section with Unemployment Rate**

| | Day Workers | | Difference Between Night and Day Workers | | |
|---|---|---|---|---|---|
| Variable | Coefficient | Robust Std. Error | Interaction between Φ(¥) and | Coefficient | Robust Std. Error |
| *Firm Size 1* | 0.030 | 0.018* | *Firm Size 1* | 0.011 | 0.262 |
| *Firm Size 2* | 0.052 | 0.027** | *Firm Size 2* | 0.594 | 0.479 |
| *Firm Size 3* | 0.117 | 0.054** | *Firm Size 3* | 1.077 | 0.838 |
| *Firm Size 4* | 0.145 | 0.029*** | *Firm Size 4* | 0.542 | 0.529 |
| *Years of School* | 0.046 | 0.026* | *Years of School* | 0.015 | 0.383 |
| *Years of School* $^2$ | 0.001 | 0.001 | *Years of School* $^2$ | -0.001 | 0.016 |
| *Experience* | 0.031 | 0.027 | *Experience* | -0.481 | 0.391 |
| *Experience* $^2$ | -0.003 | 0.002 | *Experience* $^2$ | 0.040 | 0.030 |
| *Experience* $^3$ | 0.000 | 0.000 | *Experience* $^3$ | -0.001 | 0.001 |
| *Tenure* | 0.051 | 0.007*** | *Tenure* | 0.138 | 0.071* |
| *Tenure* $^2$ | -0.002 | 0.001*** | *Tenure* $^2$ | -0.013 | 0.006** |
| *Union* | 0.117 | 0.023*** | *Union* | 0.355 | 0.207* |
| *Non-white* | -0.085 | 0.016*** | *Non-white* | -0.022 | 0.144 |
| *North East* | 0.029 | 0.023 | *North East* | -0.314 | 0.258 |
| *North Central* | -0.095 | 0.021*** | *North Central* | -0.239 | 0.251 |
| *South* | -0.165 | 0.019*** | *South* | -0.190 | 0.211 |
| *Female* | -0.206 | 0.018*** | *Female* | -0.195 | 0.226 |
| *Married* | 0.046 | 0.016*** | *Married* | -0.338 | 0.210 |
| *MSA Resident* | 0.020 | 0.013 | *MSA Resident* | -0.097 | 0.109 |
| *Professional Occ.* | 0.363 | 0.049*** | *Professional Occ.* | -0.736 | 0.614 |
| *Sales Occ.* | 0.274 | 0.051*** | *Sales Occ.* | -1.764 | 0.691** |
| *Craft Occ.* | 0.177 | 0.047*** | *Craft Occ.* | -0.847 | 0.553 |
| *Ag/Construct Ind.* | 0.176 | 0.037*** | *Ag/Construct Ind.* | -1.328 | 0.902 |
| *Manufacturing Ind.* | 0.039 | 0.028 | *Manufacturing Ind.* | -0.324 | 0.238 |
| *Transportation Industry* | 0.108 | 0.034*** | *Transportation Industry* | 0.245 | 0.271 |
| *Wholesale Trade Industry* | 0.033 | 0.037 | *Wholesale Trade Industry* | -0.762 | 0.575 |
| *Retail Trade Industry* | -0.160 | 0.037*** | *Retail Trade Industry* | 0.777 | 0.326** |
| *Finance Industry* | 0.078 | 0.035** | *Finance Industry* | -2.090 | 1.247* |
| *Prof. & Related Industry* | -0.040 | 0.029 | *Prof. & Related Industry* | -0.047 | 0.254 |
| *Public Administration Industry* | 0.012 | 0.033 | *Public Administration Industry* | 0.817 | 0.273*** |
| *Unemployment Rate* | -0.003 | 0.000*** | *Unemployment Rate* | 0.001 | 0.003 |
| *Constant* | 5.828 | 0.187*** | *Constant* | 1.602 | 1.213 |
| Ø(¥) | -0.543 | 4.411 | | | |
| *R squared* | 0.450 | | | | |
| *Observations* | 5026 | | *Chi-Square(31)* | 87.11 | |

Levels of significance: ***1%, **5%, *10% Dependent Variable: Log Wage

The results of the expected wage equation for the two-step model using the leading index as an indicator of local economic conditions are presented in Table 5.14. Again, the impact on wages of the tenure, union status, sales occupations, retail trade, finance, and public administration occupation variables differ significantly between day and night workers. Additionally, married night shift workers earn significantly less than married day workers.

Those working in craft occupations and agriculture/construction industries earn significantly lower wages than their daytime counterparts. Also, the impact of the leading index on worker wages is significantly different for night workers. Those living in regions with higher projected

**Table 5.14 Expected Wage Equation (Test for Pooling), 1990 Cross-Section with Leading Index**

| | Day Workers | | Difference Between Night and Day Workers | | |
|---|---|---|---|---|---|
| Variable | Coefficient | Robust Std. Error | Interaction between Φ(¥) and | Coefficient | Robust Std. Error |
| *Firm Size 1* | 0.031 | 0.018* | *Firm Size 1* | 0.083 | 0.265 |
| *Firm Size 2* | 0.059 | 0.027** | *Firm Size 2* | 0.672 | 0.483 |
| *Firm Size 3* | 0.125 | 0.054** | *Firm Size 3* | 1.277 | 0.841 |
| *Firm Size 4* | 0.152 | 0.029*** | *Firm Size 4* | 0.655 | 0.532 |
| *Years of School* | 0.035 | 0.026 | *Years of School* | 0.182 | 0.385 |
| *Years of School* $^2$ | 0.001 | 0.001 | *Years of School* $^2$ | -0.008 | 0.016 |
| *Experience* | 0.030 | 0.027 | *Experience* | -0.447 | 0.401 |
| *Experience* $^2$ | -0.002 | 0.002 | *Experience* $^2$ | 0.036 | 0.031 |
| *Experience* $^3$ | 0.000 | 0.000 | *Experience* $^3$ | -0.001 | 0.001 |
| *Tenure* | 0.050 | 0.007*** | *Tenure* | 0.144 | 0.071** |
| *Tenure* $^2$ | -0.002 | 0.001*** | *Tenure* $^2$ | -0.014 | 0.005*** |
| *Union* | 0.117 | 0.023*** | *Union* | 0.409 | 0.211* |
| *Non-white* | -0.090 | 0.016*** | *Non-white* | 0.041 | 0.147 |
| *North East* | -0.058 | 0.027** | *North East* | 0.052 | 0.264 |
| *North Central* | -0.100 | 0.022*** | *North Central* | -0.170 | 0.255 |
| *South* | -0.173 | 0.020*** | *South* | -0.038 | 0.218 |
| *Female* | -0.206 | 0.018*** | *Female* | -0.259 | 0.226 |
| *Married* | 0.044 | 0.016*** | *Married* | -0.374 | 0.213* |
| *MSA Resident* | 0.046 | 0.013*** | *MSA Resident* | -0.177 | 0.111 |
| *Professional Occ.* | 0.378 | 0.049*** | *Professional Occ.* | -0.907 | 0.612 |
| *Sales Occ.* | 0.288 | 0.051*** | *Sales Occ.* | -1.986 | 0.696*** |
| *Craft Occ.* | 0.181 | 0.048*** | *Craft Occ.* | -0.953 | 0.561* |
| *Ag/Construct Ind.* | 0.174 | 0.037*** | *Ag/Construct Ind.* | -1.549 | 0.907* |
| *Manufacturing Ind.* | 0.036 | 0.028 | *Manufacturing Ind.* | -0.378 | 0.237 |
| *Transportation Industry* | 0.099 | 0.035*** | *Transportation Industry* | 0.283 | 0.273 |
| *Wholesale Trade Industry* | 0.029 | 0.038 | *Wholesale Trade Industry* | -0.977 | 0.619 |
| *Retail Trade Industry* | -0.170 | 0.037*** | *Retail Trade Industry* | 0.875 | 0.330*** |
| *Finance Industry* | 0.077 | 0.035** | *Finance Industry* | -2.038 | 1.205* |
| *Prof. & Related Industry* | -0.049 | 0.029* | *Prof. & Related Industry* | -0.053 | 0.255 |
| *Public Administration Industry* | 0.004 | 0.033 | *Public Administration Industry* | 0.806 | 0.268*** |
| *Leading Index* | -0.061 | 0.010*** | *Leading Index* | 0.252 | 0.103** |
| *Constant* | 1.841 | 1.212 | *Constant* | -2.423 | 4.444 |
| Ø(¥) | 5.803 | 0.190*** | | | |
| *R squared* | 0.440 | | | | |
| *Observations* | 5026 | | *Chi-Square(31)* | 93.62 | |

Levels of significance: ***1%, **5%, *10% Dependent Variable: Log Wage. The chi-square test statistic refers to the statistic computed by the Wald of the above estimates with the hypothesis that the variables indicating a difference between day and night workers equal zero.

growth, as indicated by the leading index, earn significantly higher wages as night workers than they earn as day workers.

Pooling for both versions of the cross-section may also be tested by a Wald test of the expected wage equation (15), with the hypothesis that the coefficients on all of the variables indicating the difference between the returns to day and night work in the expected wage equation equal zero. For the 1990 cross-section using the unemployment rate as the indicator of local economic conditions, the $\mathcal{X}_{31}^2$ statistic is 87.11, providing evidence that the coefficients of day and night workers are significantly different. A test statistic of 93.62 is obtained for the 1990 cross-section with the leading index. Overall, the results of the pooled expected wage equation indicate that returns to characteristics of night and day workers are significantly different, providing evidence that data on night and day workers should not be pooled. The treatment effects model (16) is therefore an inappropriate model for estimating the current sample since it assumes that all of the wage equation coefficients are identical for night and day workers.

Pooling is also tested for the maximum likelihood estimates of the unemployment rate and leading index versions of the 1990 cross-section. This is accomplished by comparing the results obtained from the maximum likelihood estimates of the individual wage equations (3) and (4), which were provided in Tables A2 and A4, to the results obtained from maximum likelihood estimates of the treatment effects model (17). Using the fact that the maximum likelihood treatment effects model (17) is a restricted version of the maximum likelihood individual wage equations; a likelihood ratio test is computed. For the current analysis, a statistically significant likelihood ratio test statistic is obtained for both models. This test provides evidence that the data on day and night shift workers should not be pooled. The switching regression model is again appropriate in this case. The results of the treatment effects model, including both the selection equation and the wage equation for the cross-section using the unemployment rate and leading index and the LR test statistics, are provided in Tables A13 and A14 in the Appendix.

### 5.5.2 1990-2000 Pooled Cross-Section

The expected wage equation (15) is also estimated for the pooled cross-section results. Table 5.15 provides the results for the two-step model using the local unemployment rate. Interpreting the variables in the right column indicates that many of the variables that were significantly different between night and day workers in the cross-sectional analysis remain significant in the pooled cross-section, including the tenure variables, union status, sales occupation, retail trade, and public administration industries. None of the year indicator variables are significantly different for night workers. The pooled cross-section estimates results also indicate that more educated night shift workers earn significantly less than their daytime counterparts. The Wald test statistic for the pooled cross-section using the unemployment rate indicates that there are significant differences between night and day workers, and that the data should not be pooled.

The results of the expected wage equation for the two-step model using the leading index as an indicator of local economic conditions are presented in Table 5.16. Similar to the cross-section results, the leading index has a significantly higher impact on the wages of night workers relative to day workers. Those living in regions with higher project growth, as indicated by the leading index, earn significantly higher wages as night workers than they earn as day workers. The Wald test statistic for the pooled cross-section using the leading index indicates that there are significant differences between night and day workers, and that the data should not be

**Table 5.15 Expected Wage Equation (Test for Pooling), 1990-2000 Pooled Cross-Section, Unemployment Rate**

| | Day Workers | | Difference Between Night and Day Workers | | |
|---|---|---|---|---|---|
| Variable | Coefficient | Robust Std. Error | Interaction between Φ(¥) and | Coefficient | Robust Std. Error |
| *Firm Size 1* | 0.042 | 0.009*** | *Firm Size 1* | 0.148 | 0.171 |
| *Firm Size 2* | 0.093 | 0.013*** | *Firm Size 2* | -0.146 | 0.279 |
| *Firm Size 3* | 0.124 | 0.020*** | *Firm Size 3* | -0.057 | 0.378 |
| *Firm Size 4* | 0.195 | 0.018*** | *Firm Size 4* | -0.276 | 0.390 |
| *Years of School* | 0.015 | 0.010 | *Years of School* | -0.525 | 0.197*** |
| *Years of School* $^2$ | 0.002 | 0.000*** | *Years of School* $^2$ | 0.021 | 0.009** |
| *Experience* | 0.041 | 0.011*** | *Experience* | 0.025 | 0.180 |
| *Experience* $^2$ | -0.002 | 0.001*** | *Experience* $^2$ | -0.003 | 0.011 |
| *Experience* $^3$ | 0.000 | 0.000** | *Experience* $^3$ | 0.000 | 0.000 |
| *Tenure* | 0.025 | 0.002*** | *Tenure* | 0.172 | 0.031*** |
| *Tenure* $^2$ | -0.001 | 0.000*** | *Tenure* $^2$ | -0.008 | 0.001*** |
| *Union* | 0.073 | 0.012*** | *Union* | 0.287 | 0.172* |
| *Non-white* | -0.107 | 0.008*** | *Non-white* | 0.056 | 0.078 |
| *North East* | 0.017 | 0.012 | *North East* | -0.112 | 0.139 |
| *North Central* | -0.128 | 0.011*** | *North Central* | -0.051 | 0.143 |
| *South* | -0.181 | 0.010*** | *South* | 0.014 | 0.126 |
| *Female* | -0.213 | 0.009*** | *Female* | 0.213 | 0.126* |
| *Married* | 0.050 | 0.008*** | *Married* | 0.142 | 0.108 |
| *MSA Resident* | -0.005 | 0.007 | *MSA Resident* | 0.025 | 0.070 |
| *Professional Occ.* | 0.293 | 0.023*** | *Professional Occ.* | 0.784 | 0.376** |
| *Sales Occ.* | 0.163 | 0.024*** | *Sales Occ.* | -0.078 | 0.373 |
| *Craft Occ.* | 0.054 | 0.021*** | *Craft Occ.* | 0.293 | 0.251 |
| *Agriculture/Farm/Fish Industry* | -0.192 | 0.032*** | *Agriculture/Farm/Fish Industry* | 0.302 | 1.488 |
| *Mining Industry* | 0.074 | 0.062 | *Mining Industry* | 0.362 | 0.466 |
| *Construction Industry* | 0.095 | 0.021*** | *Construction Industry* | 4.251 | 0.988*** |
| *Non-Durable Manufacturing Ind.* | -0.005 | 0.019 | *Non-Durable Manufacturing Ind.* | 0.041 | 0.195 |
| *Durable Manufacturing Industry* | 0.003 | 0.016 | *Durable Manufacturing Industry* | 0.558 | 0.169*** |
| *Transportation Industry* | 0.085 | 0.018*** | *Transportation Industry* | 0.599 | 0.195*** |
| *Wholesale Trade Industry* | -0.181 | 0.018*** | *Wholesale Trade Industry* | 0.713 | 0.193*** |
| *Retail Trade Industry* | -0.033 | 0.021 | *Retail Trade Industry* | 0.774 | 0.272*** |
| *Finance Industry* | 0.052 | 0.019*** | *Finance Industry* | -0.876 | 1.188 |
| *Prof. & Related Industry* | -0.116 | 0.015*** | *Prof. & Related Industry* | 0.503 | 0.136*** |
| *Public Administration Industry* | -0.051 | 0.016*** | *Public Administration Industry* | 1.788 | 0.176*** |
| *1992* | 0.087 | 0.011*** | *1992* | 0.007 | 0.114 |
| *1994* | 0.161 | 0.014*** | *1994* | 0.003 | 0.175 |
| *1996* | 0.221 | 0.014*** | *1996* | -0.053 | 0.146 |
| *1998* | 0.264 | 0.016*** | *1998* | 0.044 | 0.168 |
| *2000* | 0.349 | 0.018*** | *2000* | -0.019 | 0.189 |
| *Unemployment Rate* | -0.001 | 0.000*** | *Unemployment Rate* | 0.001 | 0.001 |
| *Constant* | 6.030 | 0.094*** | *Constant* | 2.712 | 2.149 |
| Ø(¥) | -0.814 | 0.693 | | | |
| *R squared* | 0.51 | | | | |
| *Observations* | 34732 | | *Chi-Square(39)* | 374.79 | |

Levels of significance: ***1%, **5%, *10% Dependent Variable: Log Wage. The chi-square test statistic refers to the statistic computed by the Wald test of the above estimates with the hypothesis that the variables indicating a difference between day and night workers equal zero.

pooled. The treatment effects model (16) would be an inappropriate model for evaluating the current dataset.

A likelihood ratio test of the maximum likelihood wage equations from the pooled cross-section models with the unemployment rate and the leading index are compared to results from the estimation of a treatment effects model (17). The results again indicate that data on day and night shift workers should not be pooled. The results of the treatment effects model, including both the selection equation and the wage equation for the pooled cross-section using the

**Table 5.16 Expected Wage Equation (Test for Pooling), 1990-2000 Pooled Cross-Section, Leading Index**

| | Day Workers | | Difference Between Night and Day Workers | | |
|---|---|---|---|---|---|
| Variable | Coefficient | Robust Std. Error | Interaction between Φ(¥) and | Coefficient | Robust Std. Error |
| *Firm Size 1* | 0.043 | 0.009*** | *Firm Size 1* | 0.208 | 0.170 |
| *Firm Size 2* | 0.096 | 0.013*** | *Firm Size 2* | -0.057 | 0.278 |
| *Firm Size 3* | 0.130 | 0.020*** | *Firm Size 3* | 0.045 | 0.375 |
| *Firm Size 4* | 0.199 | 0.018*** | *Firm Size 4* | -0.164 | 0.387 |
| *Years of School* | 0.017 | 0.010 | *Years of School* | -0.482 | 0.194** |
| *Years of School* $^2$ | 0.002 | 0.000*** | *Years of School* $^2$ | 0.019 | 0.009** |
| *Experience* | 0.042 | 0.011*** | *Experience* | 0.023 | 0.182 |
| *Experience* $^2$ | -0.002 | 0.001*** | *Experience* $^2$ | -0.002 | 0.011 |
| *Experience* $^3$ | 0.000 | 0.000** | *Experience* $^3$ | 0.000 | 0.000 |
| *Tenure* | 0.024 | 0.002*** | *Tenure* | 0.170 | 0.031*** |
| *Tenure* $^2$ | -0.001 | 0.000*** | *Tenure* $^2$ | -0.008 | 0.001*** |
| *Union* | 0.070 | 0.012*** | *Union* | 0.319 | 0.172* |
| *Non-white* | -0.109 | 0.008*** | *Non-white* | 0.084 | 0.078 |
| *North East* | 0.028 | 0.012** | *North East* | -0.067 | 0.135 |
| *North Central* | -0.102 | 0.011*** | *North Central* | -0.029 | 0.132 |
| *South* | -0.149 | 0.009*** | *South* | 0.021 | 0.113 |
| *Female* | -0.214 | 0.009*** | *Female* | 0.194 | 0.125 |
| *Married* | 0.048 | 0.008*** | *Married* | 0.123 | 0.108 |
| *MSA Resident* | 0.000 | 0.007 | *MSA Resident* | 0.012 | 0.070 |
| *Professional Occ.* | 0.295 | 0.024*** | *Professional Occ.* | 0.721 | 0.375* |
| *Sales Occ.* | 0.163 | 0.024*** | *Sales Occ.* | -0.148 | 0.371 |
| *Craft Occ.* | 0.055 | 0.021*** | *Craft Occ.* | 0.235 | 0.250 |
| *Agriculture/Farm/Fish Industry* | -0.216 | 0.032*** | *Agriculture/Farm/Fish Industry* | -0.027 | 1.612 |
| *Mining Industry* | 0.080 | 0.062 | *Mining Industry* | 0.322 | 0.467 |
| *Construction Industry* | 0.090 | 0.021*** | *Construction Industry* | 4.297 | 0.984*** |
| *Non-Durable Manufacturing Ind.* | -0.008 | 0.019 | *Non-Durable Manufacturing Ind.* | 0.070 | 0.195 |
| *Durable Manufacturing Industry* | -0.001 | 0.016 | *Durable Manufacturing Industry* | 0.567 | 0.169*** |
| *Transportation Industry* | 0.079 | 0.018*** | *Transportation Industry* | 0.651 | 0.193*** |
| *Wholesale Trade Industry* | -0.187 | 0.018*** | *Wholesale Trade Industry* | 0.786 | 0.193*** |
| *Retail Trade Industry* | -0.039 | 0.021* | *Retail Trade Industry* | 0.778 | 0.275*** |
| *Finance Industry* | 0.051 | 0.019*** | *Finance Industry* | -1.055 | 1.152 |
| *Prof. & Related Industry* | -0.127 | 0.015*** | *Prof. & Related Industry* | 0.535 | 0.135*** |
| *Public Administration Industry* | -0.060 | 0.016*** | *Public Administration Industry* | 1.799 | 0.174*** |
| *1992* | 0.059 | 0.011*** | *1992* | 0.006 | 0.119 |
| *1994* | 0.163 | 0.016*** | *1994* | -0.108 | 0.195 |
| *1996* | 0.214 | 0.014*** | *1996* | -0.098 | 0.153 |
| *1998* | 0.286 | 0.016*** | *1998* | -0.053 | 0.176 |
| *2000* | 0.369 | 0.018*** | *2000* | -0.096 | 0.192 |
| *Leading Index* | -0.018 | 0.004*** | *Leading Index* | 0.088 | 0.045** |
| *Constant* | 5.942 | 0.094*** | *Constant* | 2.112 | 2.119 |
| Ø(¥) | -0.693 | 0.688 | | | |
| *R squared* | 0.51 | | | | |
| *Observations* | 24732 | | *Chi-Square(39)* | 381.81 | |

Levels of significance: ***1%, **5%, *10% Dependent Variable: Log Wage. The chi-square test statistic refers to the statistic computed by the Wald test of the above estimates with the hypothesis that the variables indicating a difference between day & night workers is zero.

unemployment rate and leading index and the LR test statistics, are provided in Tables A15 and A16 in the Appendix.

### 5.6 Additional Cross-Sectional Analysis

This paper focuses on an analysis of the 1990 cross-section for reasons highlighted in Section 3.2.4. The switching regression model is also applied to other cross-sectional datasets from 1992, 1994, 1996, 1998, and 2000. The same variable specifications that were employed in the 1990 analysis are used to model shift wages and shift selection in data from additional years. The focus of this dissertation is to analyze the impact of shift differentials and local economic conditions on shift choice and to determine the impact of interaction effects between the shift differential and local economic conditions on the selection probability. This section will thus focus on a discussion of the main variables of interest, the unemployment rate and the shift differential, and the interaction effects. Shift differentials calculated from these models are discussed in Section 5.8.

Table 5.17 displays the results of cross-sectional analysis for the local economic condition variables from the reduced and structural forms of the selection equation. The results for the unemployment rate indicate extremely small impacts on the selection probability, with similar results for all of the years. The unemployment rate does not have a significant impact on shift selection in any year. The results are much stronger when the leading index is included in the regression. In 1990, the impact of the leading index is positive and statistically significant. Additionally, comparing the results of the reduced form to those of the structural form indicate that the magnitude of the leading index variable is unchanged. This suggests that local economic conditions have an impact on shift selection apart from their impact on worker wages. The

**Table 5.17 Cross-Section Two-Step and ML, Selection Model Results, Local Economic Conditions**

| | Coefficient on Local Economic Condition Variable | | | |
|---|---|---|---|---|
| | Two-Step | | ML | |
| Model | Reduced | Structural | Reduced | Structural |
| *Using Unemployment Rate* | | | | |
| *1990* | 0.001 | 0.000 | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| *1992* | 0.002 | 0.000 | 0.002 | 0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) |
| *1994* | 0.002 | 0.002 | 0.001 | 0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| *1996* | -0.000 | -0.000 | --- | --- |
| | (0.002) | (0.001) | --- | --- |
| *1998* | 0.001 | 0.001 | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| *2000* | 0.002 | 0.002 | 0.002 | 0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| *Using Leading Index* | | | | |
| *1990* | 0.079 | 0.069 | 0.092 | 0.096 |
| | (0.048) | (0.400*) | (0.047**) | (0.038***) |
| *1992* | 0.015 | 0.016 | 0.006 | 0.030 |
| | (0.045) | (0.036) | (0.045) | (0.035) |
| *1994* | 0.078 | 0.013 | 0.100 | 0.049 |
| | (0.053) | (0.085) | 0.053* | (0.078) |
| *1996* | -0.016 | -0.115 | --- | --- |
| | (0.057) | (0.058**) | --- | --- |
| *1998* | -0.072 | -0.096 | --- | --- |
| | (0.072) | (0.060) | --- | --- |
| *2000* | -0.083 | -0.051 | -0.073 | -0.053 |
| | (0.054) | (0.037) | (0.055) | (0.037) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Standard errors in parentheses.

leading index remains a positive predictor of shift selection in 1992, but the magnitude of the effect is not as large. In 1994, a greater impact of the leading indicator is apparent, with the leading index statistically significant in the maximum likelihood reduced form of the selection equation. In both 1992 and 1994, the magnitude of the leading index coefficient is smaller in structural equation estimation, indicating that the leading index impacts shift choice largely through its impact on wages. In 1990-1994, the leading index positively predicts shift choice, indicating that individuals in regions with higher predicted growth were more likely to select night shift work. In 1996, the impact of the leading index becomes negative, and is larger in structural equation estimation. Thus, the leading index has a significant impact on shift choice apart from any impact that it has on the individual's wage. The leading index remains a negative predictor of shift choice in 1998 and 2000, indicating that those living in areas with higher projected growth were less likely to choose night shift work. One possible explanation for the reversal in sign of the leading index in the selection equations is that economic growth in the later years of the decade may have been more concentrated in industries that rely less on night shift work. The data reveal smaller percentages of workers employed on night shifts in 1996 and 1998 relative to 1990 and 1992. Hatch and Clinton (2000) summarize job growth during the 1990's, noting that the manufacturing industry suffered job losses that continued long after the recession of 1990-1991. They surmise that "technological improvements allowed fewer worker to generate more output than in the past, the Asian economic crisis reduced demand for goods manufacturing the United States, and the U.S. government reduced defense spending." Additionally, the retail sales industry, known for larger percentages of night shift workers, experienced slow job growth. In the 1990's job growth was driven by service producing industries relative to goods producing industries. However, service growth was most pronounced in business services such as personnel supply services and computer and data processing services. These industries are not known for a high prevalence of night shift work.

Table 5.18 displays the results of cross-sectional analysis for the wage differential variable in the structural equation estimation. In the model with the local unemployment rate, the wage differential has a positive and significant impact on shift selection in 1990, 1992, 1994, and 1996. The impact is large, with its largest impact occurring in 1996. These results indicate that rising wage differentials for night shift work make individuals more likely to select night shift work. Interestingly, in the 1998 and 2000 cross-sections, the impact of the wage differential is insignificant and negative in three of the four cases. This suggests that in later years of the dataset, individuals did not consider shift differentials when choosing whether to work at night. Similar results are found in the model when the leading index is used as the indicator of local economic conditions.

Interaction effects were also considered for the 1992, 1994, 1996, 1998, and 2000 cross-

**Table 5.18 Cross-Section Two-Step and ML, Structural Model Results, Wage Differential Coefficients**

| | Coefficient on Wage Differential Structural Selection Equation | |
|---|---|---|
| Model | Two-Step | ML |
| *with Unemployment Rate* | | |
| *1990* | 0.933 | 0.831 |
| | (0.374**) | (0.412**) |
| *1992* | 0.917 | 0.832 |
| | (0.285***) | (0.283***) |
| *1994* | 1.535 | 1.484 |
| | (0.621**) | (0.751**) |
| *1996* | 0.913 | --- |
| | (0.235***) | --- |
| *1998* | -0.036 | 0.014 |
| | (0.218) | (0.226) |
| *2000* | -0.322 | -0.238 |
| | (0.661) | (0.664) |
| *with Leading Index* | | |
| *1990* | 0.864 | 0.743 |
| | (0.352**) | (0.404*) |
| *1992* | 0.779 | 0.666 |
| | (0.283***) | (0.263**) |
| *1994* | 1.141 | 0.916 |
| | (0.702) | (0.782) |
| *1996* | 1.004 | --- |
| | (0.230**) | --- |
| *1998* | 0.027 | --- |
| | (0.214) | --- |
| *2000* | -0.353 | -0.257 |
| | (0.603) | (0.606) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Standard errors in parentheses.

sections. Interaction effects for the 1990 cross-section were discussed in Section 5.4. The interaction terms for each year are reported in Tables A17-A23.[4] Again, the computed interaction effects are negligible, but it is useful to interpret the sign of the interaction effects at average values of the probability. In the models including the leading index in 1990, 1992, and 1994 the interaction effect is positive, while in the model including the unemployment rate in 1996 the interaction effect is negative. These results suggest that shift differentials have a smaller impact on shift choice in areas experiencing high unemployment and less regional growth. Individuals in these regions may be more likely to work at night regardless of shift differentials in order to remain employed, leading to a decreased impact of shift differentials and local economic conditions on shift choice. For the models including the unemployment rate, the interaction effect was small and positive for years 1990, 1992, 1994, 1998, and 2000. In 2000, for the model including the leading index, the interaction effect is negative. These results suggest that shift differentials have a larger impact on shift choice in weak labor markets. Thus, the cross-sectional results do not agree as to the direction of the interaction effect between local economic conditions and shift differentials, and the interaction effects are small.

### 5.7 Additional Analysis by Industry

As discussed in Section 3.2.5.3 and demonstrated in the above regressions, industry plays a role in shift choice and shift wages. In order to further investigate shift choice and shift differentials, pooled cross-section datasets for four industries in which shift work is known to be prevalent are analyzed using the switching regression model outlined in Section 4.3. The industries analyzed are manufacturing, retail trade, professional and related, and service

---

[4] Maximum likelihood results were unavailable due to convergence issues for the leading index models in1996 and 1998.

industries. The same variable specifications that were employed in the cross-section and pooled cross-section regressions, including controls for occupation, were used in the analysis. The main variables of interest from the regression models are reported in Tables 5.19 and 5.20. Shift differentials calculated from these regressions are discussed in Section 5.8.

Table 5.19 displays the results of pooled cross-section analysis for the local economic condition variables from the two-step and maximum likelihood reduced and structural forms of the selection equation. The results for the unemployment rate indicate extremely small impacts on the selection probability, with similar results for all of the industries except for the manufacturing industry. For manufacturing workers, in the reduced form of the selection

**Table 5.19 Selection Equation Coefficients for Local Economic Condition Variables, Pooled Cross-Section Industry Regressions**

| | Coefficient on Local Economic Condition Variable | | | |
|---|---|---|---|---|
| | Two-Step | | ML | |
| Model | Reduced | Structural | Reduced | Structural |
| *Using Unemployment Rate* | | | | |
| *Manufacturing Industry* | 0.074 | -0.017 | 0.077 | -0.019 |
| | (0.033**) | (0.042) | (0.033**) | (0.041) |
| *Retail Trade Industry* | 0.002 | 0.002 | 0.002 | 0.001 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| *Prof. & Related Industry* | 0.001 | -0.002 | 0.001 | -0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| *Service Industry* | -0.000 | -0.002 | -0.000 | --0.001 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| *Using Leading Index* | | | | |
| *Manufacturing Industry* | 0.000 | 0.001 | 0.001 | 0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| *Retail Trade Industry* | -0.043 | 0.004 | -0.041 | 0.022 |
| | (0.046) | (0.044) | (0.047) | (0.044) |
| *Prof. & Related Industry* | 0.096 | 0.086 | 0.096 | 0.087 |
| | (0.041**) | (0.039**) | (0.045**) | (0.039**) |
| *Service Industry* | -0.022 | -0.001 | -0.014 | 0.011 |
| | (0.053) | (0.051) | (0.056) | (0.051) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Standard errors in parentheses.

equation, the unemployment rate has a positive and significant impact on shift selection. Thus, manufacturing workers are more likely to select night shift work in areas of high unemployment. In the structural equation estimation, however, the unemployment rate becomes negative and is no longer significant for shift choice for manufacturing workers, which suggests that the unemployment rate has an impact on shift choice, but this impact occurs mainly through changes in wages. After controlling for the shift differential, manufacturing workers are less likely to work at night as the unemployment rate rises. This result reflects the procyclical nature of the manufacturing industry. When the economy weakens and unemployment rises, night shifts in manufacturing are more likely to be cancelled and individuals are less likely to be able to choose night shift work. When the leading index is used in the analysis, it is only significant for shift choice for professional and related workers. The coefficient on the leading index maintains its significance in the structural equation estimation in both two step and maximum likelihood estimation. This indicates that the leading index is a strong positive predictor of shift choice even after controlling for shift differentials. The professional and related industry includes doctors, nurses, and other hospital staff, who are highly likely to work at night. Hatch and Clinton (2000) indicate that hospitals and doctor's offices were one of the top industries gaining the most jobs in the 1990's. The regression results indicate that the professional industry is highly impacted by projected growth, and that professional workers in areas with higher projected economic growth are likely to see a higher prevalence of night shift work.

Table 5.20 displays the results of pooled cross-sectional analysis for the wage differential variable in the structural equation estimation. In the two-step model both with the local unemployment rate and the model with the leading index, the wage differential has a positive and significant impact on shift selection in the manufacturing and retail trade industries. Rising wage differentials for night shift work make individuals more likely to select night shift work in these industries. Service industries are not significantly impacted by shift differentials. In the model with the unemployment rate, shift differentials have a negative and significant impact on shift choice for those in professional industries, while in the model with the leading index, the wage differential is insignificant for predicting shift choice. Thus, when controlling for projected growth in the professional industry, the shift differential is no longer significant for shift choice.

Interaction effects were also considered for the industries discussed in this section. The interaction effects for each year are reported in Tables A25-A32. Similar to the results outlined above, interaction effects computed at the average probabilities are small. Examining the sign

**Table 5.20 Structural Equation Estimation, Industry Pooled Cross-Section, Wage Differential Coefficients**

| | Coefficient on Wage Differential Structural Selection Equation | |
|---|---|---|
| Model | Two-Step | ML |
| *with Unemployment Rate* | | |
| *Manufacturing Industry* | 0.732 | 0.799 |
| | (0.327**) | (0.263***) |
| *Retail Trade Industry* | 0.502 | 1.087 |
| | (0.377**) | (0.316***) |
| *Prof. & Related Industry* | -0.937 | -0.839 |
| | (0.379**) | (0.393**) |
| *Service Industry* | -0.436 | -0.397 |
| | (0.288) | (0.295) |
| | | |
| *with Leading Index* | | |
| *Manufacturing Industry* | 0.980 | 0.925 |
| | (0.335***) | (0.276***) |
| *Retail Trade Industry* | 0.804 | 1.190 |
| | (0.354**) | (0.324***) |
| *Prof. & Related Industry* | -0.495 | -0.394 |
| | (0.422) | (0.425) |
| *Service Industry* | 0.264 | -0.248 |
| | (0.340) | (0.323) |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift
Standard errors in parentheses.

of the interaction effects provides some insight into the impact of shift differentials on shift choice when local economic conditions change. Interaction terms for the manufacturing industry were positive for the unemployment rate and negative for the leading index model. These results suggest that shift differentials remain important for shift choice in manufacturing industries even when the economy is weak. Interaction effects were positive for both the unemployment rate and leading index model for the retail trade industry, providing no conclusive direction for the interaction effects. These inconclusive results could be driven by differing impacts of economic conditions on the various sub-industries within the retail trade industry. Apparel and accessory stores experienced declining employment during the 1990's, while discount department stores and eating and drinking establishments experienced growth (Hatch and Clinton 2000). For the models including the unemployment rate, the interaction effects were negative for professional and related services industries and for service industries, while the interaction effects in the model with the leading index were positive. These results suggest that shift differentials have a smaller impact on shift choice in weak labor markets, and that compensating differentials offered for night shift work may be lower in these industries.

### 5.8 Shift Differentials

As noted above, the shift differential is calculated for each individual in the sample and is included in the estimation of the structural equation to determine the impact of shift differentials on shift choice. Wage differentials are calculated using equations (18) and (21) for the two-step and maximum likelihood estimation results with the results for both the cross-section and the pooled cross-section displayed in Table 5.21. The average shift differential for all of the models is negative indicating that night workers actually earn lower wages on average than day workers in the sample. The wage differentials for the 1990 cross-section are considerably larger when compared to the results for the pooled cross-section. The two-step results indicate that night workers earn approximately $6.50 less per hour than day workers, while maximum likelihood results indicate that night workers earn approximately $5.50 less per hour. Night shift workers earn approximately half of day wages in the 1990 sample. In pooled cross-section two-step estimation, night shift workers earn from an average of $1 to $1.67, or 7-11% lower wages than day workers. In pooled cross-section maximum likelihood estimation, night shift workers earn an average of -$0.38 to -$0.68, or 2-4% less than day workers. Maximum likelihood estimation provides smaller estimates of wage differentials than those obtained from the two-step model. The wage differentials in Table 5.21 indicate that shift differentials are higher in pooled cross-section analysis than in cross-sectional analysis. Possible explanations for the negative wage differentials include sample homogeneity and low demand for shift work. According to the theory of compensating differentials, the size and sign of the wage premium depends on the underlying distribution of worker tastes and on the demand for certain job characteristics. If worker preferences for night shift work are homogenous, and every worker agrees that night shift work is inconvenient and undesirable the compensating differential is expected to be positive. However, if some workers actually prefer night shift work, the compensating differential may be negative.

**Table 5.21 Shift Differentials, Cross-Section and Pooled Cross-Section**

| | Average Shift Differential | | % Difference* | |
|---|---|---|---|---|
| | Two-Step | ML | Two-Step | ML |
| 1990 Cross Section (Unemployment Rate) | -$6.28 | -$5.47 | -62.5 | -54.5 |
| 1990 Cross Section (Leading Index) | -$6.79 | -$5.65 | -67.8 | -56.5 |
| 1990-2000 Pooled Cross Section (Unemployment Rate) | -$1.03 | -$0.38 | -6.6 | -1.7 |
| 1990-2000 Pooled Cross Section (Leading Index) | -$1.67 | -$0.68 | -11.3 | -3.8 |

*Refers to the percent difference in night and day wages calculated using equation (21).

Section 1.2.2 provides evidence that preferences for shift work are not homogenous. As detailed in Table 1.3, voluntary reasons motivate approximately half of night shift workers to choose nighttime employment in the CPS sample. Table 1.3 also indicates that some workers actually prefer night shift work; personal preference was the primary reason for working a night shift for 10%-20% of night shift workers in the sample. As summarized in Borjas (2008) compensating differentials can “go the wrong way” in cases where workers actually prefer a certain type of work and where demand for certain types of workers is low. See Figure 1.1 in Section 1.1.1. In the current analysis, those choosing night shift work might prefer to work at night. Firms do not need to induce workers to work a shift; since night shift work is preferred, being able to work at night might actually be considered an amenity for some workers. The 1990 cross-section results indicate positive selection into night shifts. Thus, workers in the sample appear to have a comparative advantage in working at night and don’t require a compensating differential. In the 1990-2000 pooled cross-section results, selection into night shifts is insignificant and negative, which provides weak evidence that individuals’ preferences may have changed over time throughout the sample and that they may require higher wages to be induced to work at night in later years of the sample.

An additional factor that may contribute to the negative night shift differentials obtained in the current analysis is the breadth of the dataset. The NLSY79 sample includes both male and female workers from different regional labor markets in every occupation and industry. It is possible that worker preferences, earnings potential, and labor supply decisions are so diverse that estimated shift differentials for night shift work are negative. Additionally, the demand for night shift workers may be low. In other words, a small number of firms offer night shift work and those firms may be matched with individuals that prefer night shifts, making a compensating differential unnecessary.

As a supplement to the previous analysis, wage differentials for night shift workers are calculated for various worker characteristics from both the two-step and maximum likelihood estimates for the 1990 cross-section and the pooled cross-section results. These shift differentials are presented in Table 5.22. Even when shift differentials are analyzed by job classification and other personal worker characteristics, day workers earn consistently higher wages in the sample. Again, the shift differentials estimated for the 1990 cross-section are significantly larger than the premiums estimated for the pooled cross-sections. The shift

**Table 5.22 Shift Differentials by Worker Characteristics, 1990 Cross-Section and 1990-2000 Pooled Cross-Section**

| | Average Shift Differential, Unemployment Rate Model ($) | | | |
|---|---|---|---|---|
| | 1990 Cross-Section | | Pooled Cross-Sections | |
| **Category** | Two-Step | ML | Two-Step | ML |
| Union | -5.79 | -4.77 | 0.12 | 1.01 |
| Non-Union | -6.39 | -5.61 | -1.27 | -0.66 |
| Male | -6.60 | -5.72 | -1.44 | -0.73 |
| Female | -5.88 | -5.15 | -0.54 | 0.04 |
| Married | -6.82 | -5.94 | -1.14 | -0.45 |
| Non-Married | -5.66 | -4.93 | -0.90 | -0.29 |
| White | -6.74 | -4.43 | -1.38 | -0.70 |
| Non-White | -5.22 | -5.92 | -0.35 | 0.27 |
| Non-High School Graduate | -4.45 | -3.81 | -0.63 | 0.19 |
| High School Graduate | -5.75 | -4.98 | -1.12 | -0.09 |
| College Graduate | -9.30 | -8.24 | -3.80 | -2.28 |

| | Average Shift Differential, Leading Index Model ($) | | | |
|---|---|---|---|---|
| | 1990 Cross-Section | | Pooled Cross-Sections | |
| **Category** | Two-Step | ML | Two-Step | ML |
| Union | -6.42 | -5.00 | -0.62 | 0.66 |
| Non-Union | -6.88 | -5.80 | -1.90 | -0.95 |
| Male | -7.16 | -5.93 | -2.12 | -1.04 |
| Female | -6.35 | 5.32 | -1.15 | -0.24 |
| Married | -7.36 | -6.14 | -1.87 | -0.79 |
| Non-Married | -6.15 | -5.11 | -1.44 | -0.53 |
| White | -7.27 | -6.11 | -2.10 | -1.05 |
| Non-White | -5.71 | -4.63 | -0.87 | 0.05 |
| Non-High School Graduate | -4.88 | -4.00 | -0.67 | 0.08 |
| High School Graduate | -6.23 | -5.16 | -1.16 | -0.22 |
| College Graduate | -10.01 | -8.47 | -3.87 | -2.53 |

differentials presented in Table 5.22 offer interesting information on the distribution of shift premiums. On average, night shift workers belonging to unions earn higher premiums than non-union night shift workers. This result is consistent with the prevalence of collective bargaining agreements that ensure higher night wages for union workers. Female night shift workers are not penalized as much for working night shifts as male workers. Similar patterns are observed for non-married and non-white individuals, with non-married and non-white night shift workers receiving wages that are closer to those of their daytime counterparts. Workers who did not graduate high school earn larger shift premiums than those with higher education. Kostiuk (1990) finds a similar result, noting that estimates of shift differentials indicate that those who are paid less in the labor market, such as non-whites and those with less than a high school diploma, "earn consistently larger shift premiums." He posits that larger shift premiums occur for these workers because shift work jobs offer smaller pay changes for personal characteristics. This paper provides the first analysis of shift work that includes female workers, thus it is the first to find a similar result for female shift workers.

Table 5.23 presents wage differential estimates for the remaining cross-sections. Negative wage differentials are estimated for each year except for the 2000 cross-section. The gap between night and day wages seems to widen and then gradually begin to close by the year 1998. As a whole, the two-step shift differentials are larger than those obtained by maximum likelihood estimation. Shift differentials in 1990, 1992, and 1994 are relatively similar, with 1990 offering the smallest deficit below day wages. Estimated shift wages are far below those of day wages in 1996. According to the two-step results, night wages were only approximately 20% below day wages in 1998. By 2000, night wages were higher than day wages by 7.4-11%.

The shift differentials in Table 5.23 indicate a change over time in shift compensation.

The negative gap between night and day wages in the beginning of the decade widens through 1996, but by 2000, shift differentials become positive. The 1990's began in a recession with a relatively sluggish recovery. Real GDP grew at an average annual rate of 2.4% from 1990-1995 before averaging 4.3% from 1996-2000. By the end of the decade, non-supervisory workers in the services sector and production workers in the goods sector enjoyed higher earnings than at the beginning of the 1990's even after adjusting for inflation (Hatch and Clinton, 2000). The dataset indicates that wages for both day and night workers increased over time. Towards the end of the 1990's the wage differentials calculated in the sample begin to rise, eventually becoming positive. This could be the result of changing preferences for night shift work among the individuals in the sample. By 2000, the sample respondents are older and more experienced, thus those choosing to work at night may be able to command a higher shift premium. Additionally, the United States economy began to rely less on goods-producing industries during

**Table 5.23 Shift Differentials, Cross-Section Results**

| | Average Shift Differential | | % Difference* | |
|---|---|---|---|---|
| Cross Section (Unemployment Rate) | Two-Step | ML | Two-Step | ML |
| *1990* | -$6.28 | -$5.47 | -62.5 | -54.5 |
| *1992* | -$7.15 | -$4.56 | -62.6 | -39.5 |
| *1994* | -$7.91 | -$5.85 | -60.6 | -43.8 |
| *1996* | -$11.17 | -$10.50 | -78.5 | -74.9 |
| *1998* | -$3.16 | -$2.58 | -17.1 | -12.1 |
| *2000* | $1.80 | $1.44 | 11.1 | 9.1 |
| Cross Section (Leading Index) | Two-Step | ML | Two-Step | ML |
| *1990* | -$6.79 | -$5.65 | -67.8 | -56.5 |
| *1992* | -$7.16 | -$4.50 | -62.9 | -39.0 |
| *1994* | -$7.49 | -$4.36 | -57.4 | -32.2 |
| *1996* | -$11.21 | --- | -78.7 | --- |
| *1998* | -$3.71 | --- | -20.5 | --- |
| *2000* | $1.57 | $1.20 | 9.4 | 7.4 |

*Refers to the percent difference in night and day wages calculated using equation (21).
--- indicates that the maximum likelihood estimation did not converge.

this time and more on service-producing industries. Higher wage premiums for night shift work towards the end of the decade may reflect the need to attract individuals to night shift work as more opportunities for higher paid jobs in the services sector, particularly the technology sector, became available.

Table 5.24 presents wage differential estimates for pooled cross-sectional regressions for the four major industry groups outlined in Section 5.7. Negative wage differentials are estimated for each industry except for the professional industry. In both the model with the unemployment rate and the model with the leading index, night workers in the professional industry enjoy modest pay premiums. Two-step shift differentials are smaller than those estimated by maximum likelihood for the manufacturing and retail trade industries. Night shift service industry workers have the largest wage disadvantage of the four industry groups. Overall, the estimated shift differentials vary significantly by industry. Future studies could consider a more detailed treatment of shift differentials by industry.

**Table 5.24 Shift Differentials, Industry Regressions**

| | Average Shift Differential | | % Difference* | |
|---|---|---|---|---|
| Cross Section (Unemployment Rate) | Two-Step | ML | Two-Step | ML |
| *Manufacturing Industry* | -$2.55 | -$7.88 | -15.7 | -55.7 |
| *Retail Trade Industry* | -$3.19 | -$6.37 | -29.1 | -60.0 |
| *Prof. & Related Industry* | $2.66 | $0.57 | 17.0 | 2.3 |
| *Service Industry* | -$3.02 | -$4.27 | -17.3 | -27.3 |
| Cross Section (Leading Index) | Two-Step | ML | Two-Step | ML |
| *Manufacturing Industry* | -$3.48 | -$7.58 | -22.5 | -53.2 |
| *Retail Trade Industry* | -$4.58 | -$6.40 | -42.4 | -60.3 |
| *Prof. & Related Industry* | $0.67 | -$0.24 | 3.9 | -2.6 |
| *Service Industry* | -$9.29 | -$6.30 | -68.8 | -43.7 |

*Refers to the percent difference in night and day wages calculated using equation (21).

# CHAPTER VI

# CONCLUSION

## 6.1 Summary

Non-standard shift workers comprise nearly 20% of the United States work force, yet relatively little is known about this labor market phenomenon. It is important that economists continue to question the motivations for shift work, the wages paid for shift work, and the impact of labor market conditions upon work schedules. This dissertation seeks to provide a more comprehensive study of American shift workers using more recent data than previous studies to analyze shift choice and shift wages. We consider a variation of the theory of compensating differentials in which labor markets are weak. A switching regression model with endogenous switching is estimated using NLSY79 data. The main results of the analysis are as follows:

1) The results emphasize the importance of correcting for self-selection. All versions of the models estimated indicate the presence of selection bias. The endogenous switching regression model corrects for self-selection into shift work.
2) The models provide evidence that shift differentials significantly impact shift choice. In the 1990 cross-section model using both the unemployment rate and the leading index, both two-step and maximum likelihood estimation indicates positive and significant impacts of shift differentials on shift choice. Estimates of the 1990-2000 pooled cross-sections fail to find significant impacts of shift differentials on shift choice; however, the estimated coefficients are positive, suggesting that individuals are more likely to select

night shift work as wage differentials for night shift work rise. Thus, compensating differentials for night shift work motivate individuals to work at night. Shift differentials also positively and significantly influence shift choice for the 1992, 1994, and 1996 cross-sections. When the pooled cross-section is analyzed by industry, shift differentials positively and significantly predict shift choice for manufacturing and retail trade workers.

3) The models provide evidence that local economic conditions impact shift selection. Estimation of the 1990 cross-section finds a statistically significant impact of the leading index on shift selection, indicating that individuals in regions with higher projected growth are more likely to select night shift work. Estimation of the 1990-2000 pooled cross-sections indicates no significant impacts of local economic conditions on shift selection. The leading index has a larger impact on shift selection than the local unemployment rate in all of the models. This difference in magnitudes suggests that regional growth, which likely results in a greater number of shift positions offered, is a better predictor of shift selection than local unemployment rates.

4) The models provide weak evidence that compensating differentials for night shift work may be lower when local economies are weak. This paper offers a new estimation method for determining interaction effects in the endogenous switching regression model. To investigate possible interaction effects, we estimate the effect of changes in the shift differential on the probability of selecting night shift work under different local economic conditions. In all of the samples, the interaction effects are small. Examining the sign of the interaction effects at the average probabilities, however, provides some insight into the impact of shift differentials on shift choice when local economic conditions change.

In the 1990 cross-section, for both the model with the local unemployment rate and the model with the leading index, the interaction effects are positive. In the pooled cross-section model with the unemployment rate, the interaction effects are negative, while in the pooled cross-section model with the leading index, the interaction effects are positive. Of the four major samples studied in this paper, results from three lend support to the hypothesis established in this paper: shift differentials have a smaller impact on shift choice as local economic conditions weaken. Thus, compensating wages for night shift work may be lower in weak economies. When investigating interaction effects for the 1992, 1994, 1996, 1998, and 2000 cross-sections, results were inconclusive as to the direction of the interaction effect. When analyzing the pooled cross-sections by industry, interaction terms for professional and related services industries and service industries also provide evidence that shift differentials have a smaller impact on shift choice in weak economies. Interaction terms for the manufacturing industry, however, suggest that shift differentials remain an important predictor of shift choice even in weak economies.

5) Estimated wage premiums are negative for night shift workers. The wage differentials for the 1990 cross-section are considerably larger when compared to the results for the pooled cross-section. The two-step results using both the unemployment rate and the leading index indicate that night workers earn approximately $6.50 less per hour than day workers, while maximum likelihood results indicate that night workers earn approximately $5.50 less per hour. Night shift workers earn approximately half of day wages in the 1990 sample. In pooled cross-section two-step estimation, night shift workers earn from an average of $1 to $1.67, or 7-11% lower wages than day workers. In pooled cross-section maximum likelihood estimation, night shift workers earn an

average of -$0.38 to -$0.68, or 2-4% less than day workers. Maximum likelihood estimation provides smaller estimates of wage differentials than those obtained from the two-step model. Analyzing shift differentials for cross-sections from 1992, 1994, 1996, 1998, and 2000 indicate that shift differentials fall from 1990 to 1996, then rise through 2000. By 2000, shift differentials are positive and approximately 7.4-11% above day wages. Rising shift differentials over the years could be a product of the growing economy of the 1990's or the result of better job opportunities for the NLSY79 respondents as they age.

6) The 1990 cross-section models and the pooled cross-section model with the leading index indicate positive selection into night work, suggesting that night workers earn higher than average wages at night. These results also suggest that workers have preferences for shift work, and possibly do not require a compensating differential to work at night. In both cross-section and pooled cross-section models, selection into day work is positive in the two-step estimation and negative in the maximum likelihood estimation.

The current analysis is relevant, economically interesting, and improves upon existing research. Although many economic studies evaluate capacity utilization and demand-side issues associated with shift work, few studies attempt to analyze shift workers. Because shift work is widespread, this dissertation seeks to provide a better understanding of labor supply in response to shift work. This paper is differentiated from the shift work studies of Kostiuk (1990) and Lanfranchi, *et al*. (2002) by its focus on the sensitivity of the impact of shift differentials and local economic conditions on shift choice. Future studies could explore whether compensating differentials for other job characteristics are sensitive to local economic conditions.

# REFERENCES

Abowd, J., & Ashenfelter, O., (1984). Anticipated unemployment, temporary layoffs, and compensating wage differentials. In S. Rosen, (Ed.), *Studies in Labor Markets,* (pp. 141-186). University of Chicago Press.

Adamchik, V., & Bedi, A. (2000). Wage differentials between the public and the private sectors: evidence from an economy in transition. *Labour Economics*, *7*, 203-224.

Agnarsson, S., (1998) Who works shifts? An analysis of the characteristics of male shift workers in Sweden. In *Of Men and Machines: Essays in Applied Labour and Production Economics.* Department of Economics, Goteborg University, Goteborg, 1998.

Akerstedt, T., (2003). Shift work and disturbed sleep/wakefulness. *Occupational Medicine.* 53(2), 89-94.

Akerstedt, T. (1985). Adjustment of physiological circadian rhythms and the sleep-wake cycle to shift work. In S. Folkard & T.H. Monk, (Eds.), *Hours of Work: Temporal Factors in Work Scheduling.* New York: Wiley. 185-198.

Akerstedt, T., Knutsson, A., Alfredsson, L., & Theorell, T., (1984). Shift work and cardiovascular disease. *Scandinavian Journal of Work and Environmental Health, 10,* 409-414.

Akerstedt, T., Knutsson, A., Westerholm, P., Theorell, T., Alfredsson, L., & Kecklund, G., (2002). Work Organization and Involuntary Sleep at Work. *Occupational and Environmental Medicine. 59,* 595-600.

Antos, J. R., & Rosen, S., (1975). Discrimination in the market for public school teachers. *Journal of Econometrics,* 3(May) 123-150.

Assad, R., & Tunali, I., (2002). Wage formation and recurrent unemployment. *Labour Economics, 9,* 17-61.

Averette, S., Bodenhorn, H., and Staisiunas, J., (2005). Unemployment risk and compensating differentials in New Jersey manufacturing. *Economic Inquiry. 43*, 734-749.

Beers, T. M., (2000). Flexible schedules and shift work: Replacing the “9-to-5” workday? *Monthly Labor Review*, (June) 33-40.

Bender, K. A., & Mridha, H., (2011). The effect of local area unemployment on compensating wage differentials for injury risk. *Southern Economic Journal*, 78(2), 287-307.

Betancourt, R., (1986). A generalization of modern production theory. *Applied Economics, 18,* 915-928.

Betancourt, R., (2008). Capital utilization. In S. Durlauf & L. Blume (Eds.), *The New Palgrave: A Dictionary of Economics,* 2nd Edition, Palgrave Macmillan Ltd.

Bishow, J., (2009). A look at supplemental pay: Overtime pay, bonuses, and shift differentials. U.S. Department of Labor, Bureau of Labor Statistics. March 25, 2009.

Blanchard, O., (1993) Consumption and the Recession of 1990-1991. *American Economic Review.* 83(2), 270-274.

Bonhomme, S., and Jolivet, G., (2009). The pervasive absence of compensating differentials." *Journal of Applied Econometrics,* 24(5), 763–795.

Bluestone, B., (1974). "The personal earnings distribution: Individual and institutional determinants. Ph.D. Thesis, University of Michigan.

Borjas, G., (2008). *Labor Economics.* New York: McGraw-Hill.

Borjas, G., (1987). "Self-Selection and the earnings of immigrants." *The American Economic Review.* 77(4), 531-553.

Brown, C., (1980). Equalizing differences in the labor market. *Quarterly Journal of Economics*. *94*, 113-134.

Bureau of Labor Statistics, (1990). *Employment and Earnings.* (May). United States Department of Labor.

Bureau of Labor Statistics, (2002). U.S. Department of Labor. National Longitudinal Survey of Youth 1979 cohort, 1979-2002 (rounds 1-20) [computer file]. Produced and distributed by the Center for Human Resource Research, The Ohio State University. Columbus, OH.

Buxton, S., (2003). Shift work: An occupational health and safety hazard." Masters of Research thesis, Murdoch University.

Costa, G., (1996). The impact of shift and night work on health. *Applied Ergonomics, 27,* 9-16.

Davis, S., Mirick, D.K., & Stevens, R.G., (2001). Night shift work, light at night, and risk of breast cancer. *Journal of the National Cancer Institute, 93*, 1557-1562.

DeBeaumont, R., & Nsiah, C., (2010). Unemployment and compensating wages: An analysis of shift work. *Journal of Economics and Finance,* 34 (May) 142-149.

Drake, C., Roehrs, T., Richardson, M., Walsh, J., & Roth, T., (2004). Shift work sleep disorder: Prevalence and consequences beyond that of symptomatic day workers. *Sleep.* 27(8), 1453-1462.

Duncan, G., (1976). Earnings functions and non-pecuniary benefits. *Journal of Human Resources.* 11(Fall), 462-483.

Duncan, G., & Holmlund, B. (1983). Was Adam Smith right after all? Another test of the theory of compensating differentials. *Journal of Labor Economics*, 1(4), 366-379.

Duncan, G., & Stafford, F., (1980). Do union members receive compensating differentials? *American Economic Review,* 70 (June), 355-371.

Dula, D., Dula, N., Hamrick, C., & Wood, C., (2001). The effect of working serial night shifts on cognitive functioning of emergency physicians. *Annals of Emergency Medicine,* 38(2), 152-155.

Dunham, R.B., (1977). Shift Work: A Review and Theoretical Analysis. *Academy of Management Review,* (October), 624-634.

Eberts, R., & Stone, J., (1985) Wages, fringe benefits, and working conditions: An analysis of compensating differentials. *Southern Economic Journal*, 52(July), 274-280.

Federal Reserve Bank of Philadelphia. State Leading Indexes [computer file]. Produced and distributed by the Federal Reserve Bank of Philadelphia, Philadelphia, PA.

Folkard, S., (1997). Black times: temporal determinants of transport safety. *Accident Analyses and Prevention, 29,* 417-430.

Finn, P., (1981). The effects of shift work on the lives of employees. *Monthly Labor Review*, (October) 31-35.

Foss, M., (1981) Long run changes in the workweek of fixed capital. *AEA Papers and Proceedings.* 71(May), 58-63.

Foss, M., (1984). Changing utilization of fixed capital: An element in long-term growth. Washington: American Enterprise Institute.

Garen, J., (1988). Compensating wage differentials and the endogeneity of job riskiness. *Review of Economics and Statistics*. 70 (February) 9-16.

Goldfeld, S., & Quandt, R., (1973). The estimation of structural shifts by switching regressions. *Annals of Economic and Social Measurement.* 2(1973), 475-485.

Gronau, R., (1974). Wage comparisons-A selectivity bias. *Journal of Political Economy, 82,* 1119-1143.

Gronberg, T. & Reed, R., (1994). Estimating workers' marginal willingness to pay for job attributes using duration data. *Journal of Human Resources,* 29(3), 911-931.

Grosswald, B., (2003). Shift work and negative work-to-family spillover. *Journal of Sociology and Social Welfare, 30*, 31-58.

Halevy, Y. & Nason, J., (2002). Shiftwork and the real business cycle. Working Paper. University of British Columbia. http://econ.tau.ac.il/papers/faculty/shift04.pdf.

Hamermesh, D., (1978). Economic aspects of job satisfaction. In O. Ashenfelter & W. Oates, (Eds.) *Essays in Labor Market Analysis.* (pp. 53-72). John Wiley and Sons.

Hamermesh, D. S., & J. R. Wolfe., (1990). Compensating wage differentials and the duration of wage loss. *Journal of Labor Economics 8,* 175-97.

Harris, John R., and Todaro, Michael P., (1970). "Unemployment & development: A Two-Sector Analysis." *American Economic Review* 60:126-42.

Hatch, J., & Clinton A., (2000). Job growth in the 1990's: A retrospect. *Monthly Labor Review*, (December) 3-18.

Hatton, T. J., & Williamson J.G., (1991). Unemployment, employment contracts, and compensating wage differentials: Michigan in the 1890s. *Journal of Economic History. 51,*605-32.

Heckman, J., (1974). Shadow prices, market wages, and labor supply. *Econometrica*. *42*(4), 679-694.

Heckman, J., (1976). The common structure of statistical models of truncation, sample selection, and limited dependent variables and a simple estimator for such models. *Annals of Economic and Social Measurement*, 5, 475-492.

Heckman, J., (1978). Dummy endogenous variables in a simultaneous equations system. *Econometrica*. 46(4), 931-959.

Heckman, J., (1979). Sample selection bias as a specification error. *Econometrica,* 47(1), 153–61.

Heckman, J., (1990). Varieties of selection bias. *American Economic Review*, 80(2), 313-318.

Hedges, J., & Sekscenski, E., (1979). Workers on late shifts in a changing economy. *Monthly Labor Review*, (September) 14-22.

Hersch, J., (1998). Compensating wage differentials for gender-specific job injury risks. *American Economic Review,* 88(3), 598-607.

Hutchens, R. M., (1983). Layoffs and labor supply. *International Economic Review*. *47,* 37-55.

Hwang, H., Reed, R., & Hubbard, C., (1992). Compensating wage differentials and unobserved productivity. *Journal of Political Economy.* (August) 835-58.

King, S. L., & Williams, H.B., (1985). Shift work pay differentials and practices in management. *Monthly Labor Review*, (December) 26-33.

Knuttson, A., Hallquist, J., Reuterwall, C., Theorell, T., & Akerstedt, T., (1999). Shiftwork and myocardial infarction: A case control study. *Occupational Environmental Medicine.* (56), 46-50.

Kostiuk, P., (1990). Compensating differentials for shift work. *Journal of Political Economy*, 98(5), 1055-1075.

Lanfranchi, J., Ohlsson, H., & Skalli, A., (2002). Compensating wage differentials and shift work preferences. *Economics Letters, 74,* 393-398.

Lee, L., (1978). Unionism and wage rates: A simultaneous equations model with qualitative and limited dependent variables. *International Economic Review*. 19(June), 415-433.

Lee, L., (1976). Estimation of limited dependent variables models by two-stage methods. Ph.D. dissertation, University of Rochester.

Lee, L., & Trost, R., (1978). Estimation of some limited dependent variable models with applications to housing demand. *Journal of Econometrics. 8,* 357-382.

Lewis, H., (1969). Employer interests in employee hours of work. University of Chicago.

Lewis, H.G., (1974). Comments on Selectivity Biases in Wage Comparisons. *Journal of Political Economy*. 82(6), 1145-1155.

Lokshin, M., & Sajaia, Z., (2004). Maximum likelihood estimation of endogenous switching regression models. *The Stata Journal*. 4(3), 282-289.

Lucas, R.E.B., (1977). Hedonic wage equations and psychic returns to schooling. *American Economic Review*, 67(September) 549-558.

Maddala, G.S., (1983). *Limited Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, Cambridge.

Maddala G. S., & Nelson F.D., (1975). Switching regression models with endogenous and exogenous switching. *Proceedings of the American Statistical Association,* Business and Economics Section, 423-426.

Magnani, E., (2002). Product market variability and the adjustment of earnings to risk. *Industrial Relations.* 41(2), 304-328.

Marshall, A., (1873). The future of the working classes. In A.C. Pigou (Eds.), *Memorials of Alfred Marshall,* London: Macmillan.

Marris, R., (1964). *The Economics of Capital Utilization: A Report on Multiple-Shift Work.* Cambridge: Cambridge University Press.

Marx, K., (1867). *Capital.* Vol 1. New York: Vintage Books; Random House, 1979.

Mayshar, J., & Solon, G., (1993). Shiftwork and the business cycle. *American Economic Review,* 83(May) 224-228.

McMenamin, T. M., (2007). A time to work: Recent trends in shift work and flexible schedules. *Monthly Labor Review*, (December) 3-16.

Mellor, E. F., (1986). Shift work and flextime: How prevalent are they? *Monthly Labor Review*, (November) 14-21.

Michel-Briand, C., Chopard, J.L., & Guiot, A. (1981). The pathological consequences of shift work in retired workers. In A. Reinberg, N. Vieux, & P. Andlauer (Eds.), *Night and shift work: Biological and social aspects*, (pp.399-407). Oxford: Pergamon Press.

Mitler, M. M., Carskadon, M.A., Czeisler, C.A., Dement, W.C., Dinges, D.F., & Graeber, R.C. (1988). Catastrophes, sleep, and public policy: consensus report. *Sleep. 11,* 100-109.

Moretti, E., (2000). Do wages compensate for risk of unemployment? Parametrics and semiparametric evidence from seasonal jobs. *Journal of Risk and Uncertainty*, 20(1), 45-66.

O'Connor, C. M., (1970). Late-shift employment in manufacturing industries. *Monthly Labor Review.* (November), 37-42.

Pati, A.K., Chandrawanshi, A., & Reinberg, A., (2001). Shift work: Consequences and management. *Current Science*. 81(July), 32-52.

Presser, H., (2003) *Working in a 24/7 Economy: Challenges for American Families*. New York: Russell Sage Foundation.

Presser, H., & Ward, B.W., (2011). Nonstandard work schedules over the life course: A first look. *Monthly Labor Review*, (July) 3-16.

Roback, J., (1982). Wages, rents, and the quality of life. *Journal of Political Economy,* 90(December) 1257-1278.

Roback, J., (1988). Wages, rents, and amenities: Differences among workers and regions. *Economic Inquiry*. 26(January), 23-41.

Rosa, R. R. & Colligan, M.J., (1997). Plain Language about Shiftwork. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Institute for Occupational Health and Safety Report. Publication number 97-145. (July).

Rosen, S., (1986). The Theory of Equalizing Differences. In O. Ashenfelter & R. Layard (Eds.) *Handbook of Labor Economics,* (pp. 641-692). Vol.1 Amsterdam.

Roy, A., (1951). Some thoughts on the distribution of earnings. *Oxford Economic Papers*, 3(June), 135-146.

Saksvik, I.B., Bjorvatn, B., Hetland, H., Sandal, G.M., & Pallesen, S., (2011). Individual differences in tolerance to shift work – A systematic review." *Sleep Medicine Review.* (August), 221-35.

Scheffel, J., (2011). Compensation of unusual working schedules. Discussion Paper. Humboldt University, Berlin, Germany.

Schumacher, E. J., & Hirsch, B.T., (1997). Compensating differentials and unmeasured ability in the labor market for nurses: Why do hospitals pay more? *Industrial and Labor Relations Review*, 50(4), 557-579.

Schweitzer, M., (2003). Another Jobless Recovery. Federal Reserve Bank of Cleveland *Economic Commentary*, (March).

Scott, A.J., (2000). Shift work and health. *Primary Care, 27,* 1057-1078.

Scott, A.J., & LaDou, J., (1990). Shift work: Effects on sleep and health with recommendations for medical surveillance and screening. In A.J. Scott (Ed.), *Shiftwork: Occupational Medicine State of the Art Reviews.* Philadelphia: Hanley and Belfus, Inc.

Shapiro, M.D., (1993). Cyclical productivity and the workweek of capital. *The American Economic Review,* 83(May), 229-233.

Shapiro, M., (1996). Macroeconomic implications of variation in the workweek of capital. *Brookings Papers on Economic Activity*, *2,* 79-119.

Smith, A., (1776). *An inquiry into the nature and causes of the wealth of nations.*

Smith, L., Folkard, S., & Poole, C., (1994). Increased injuries on the night shift. *The Lancet. (334),* 1137-1139.

Smith, R., (1979). Compensating wage differentials and public policy: A review. *Industrial and Labor Relations Review.* 32(3), 339-352.

Thaler, R., & Rosen, S., (1976). The value of saving a life: Evidence from the labor market. In N. Terleckyj (Ed.) *Household Production and Consumption.* (pp. 265-298). New York: Columbia University Press.

U.S. Department of Labor, Night work and shift work. Retrieved April 12,2012. http://www.dol.gov/dol/topic/workhours/nightwork.htm.

U.S. Office of Personnel Management, Night Shift Differential for Federal Wage System Employees. Retrieved April 12, 2012. http://www.opm.gov/oca/pay/html/night_wg.asp#Night%20Work.

Vjiverberg, W., (1993) Measuring the unidentified parameter of the extended roy model of selectivity. *Journal of Econometrics*. *57,* 69-89.

Viscusi, W. K., & Aldy, J. E., (2003) The value of a statistical life: A critical review of market estimates throughout the world. *Journal of Risk and Uncertainty, 27,* 5-27.

Willis, R. and Rosen, S., (1979) Education and self-selection. *Journal of Political Economy.* 87(5, Part 2), 507-536.

Winter-Ebmer, R., (2001). Firm size, earnings, and displacement risk. *Economic Inquiry, 39,* 474-486.

## LIST OF APPENDICES

# APPENDIX A

**Table A1_1. Two-Step Reduced and Structural Equations, Unemployment Rate, 1990 Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Reduced Form Coefficient | Robust Std. Error | Structural Form Coefficient | Robust Std. Error |
| *Wage Differential* | | | 0.933 | 0.374** |
| *Unemployment Rate* | 0.001 | 0.002 | 0.000 | 0.002 |
| *Number of Children* | 0.045 | 0.027* | 0.051 | 0.027* |
| *Shift Rate* | 0.456 | 0.692 | 0.430 | 0.676 |
| *Firm Size 1* | 0.194 | 0.093** | 0.185 | 0.093** |
| *Firm Size 2* | 0.610 | 0.090*** | 0.280 | 0.158* |
| *Firm Size 3* | 1.057 | 0.122*** | 0.549 | 0.229** |
| *Firm Size 4* | 0.706 | 0.099*** | 0.274 | 0.188 |
| *Years of School* | 0.390 | 0.120*** | -0.019 | 0.020 |
| *Years of School*$^2$ | -0.017 | 0.005*** | | |
| *Experience* | 0.234 | 0.148 | 0.014 | 0.014 |
| *Experience*$^2$ | -0.022 | 0.012* | | |
| *Experience*$^3$ | 0.001 | 0.000** | | |
| *Tenure* | -0.042 | 0.029 | -0.038 | 0.010*** |
| *Tenure*$^2$ | 0.000 | 0.003 | | |
| *Union* | 0.259 | 0.074*** | 0.055 | 0.107 |
| *Non-white* | 0.022 | 0.069 | 0.027 | 0.066 |
| *North East* | -0.164 | 0.113 | | |
| *North Central* | 0.130 | 0.089 | | |
| *South* | 0.063 | 0.084 | | |
| *Female* | -0.317 | 0.071*** | -0.227 | 0.075*** |
| *Married* | -0.278 | 0.065*** | -0.162 | 0.083** |
| *MSA Resident* | -0.009 | 0.063 | | |
| *Professional Occupation* | -0.742 | 0.111*** | -0.451 | 0.180** |
| *Sales Occupation* | -0.855 | 0.099*** | -0.404 | 0.205** |
| *Craft Occupation* | -0.729 | 0.089*** | -0.494 | 0.122*** |
| *Ag/Construction Industry* | -0.528 | 0.394 | -0.432 | 0.390 |
| *Manufacturing Industry* | -0.053 | 0.125 | -0.026 | 0.125 |
| *Transportation Industry* | 0.130 | 0.155 | 0.082 | 0.153 |
| *Wholesale Trade Industry* | 0.006 | 0.379 | 0.108 | 0.375 |
| *Retail Trade Industry* | 0.025 | 0.528 | -0.202 | 0.530 |
| *Finance Industry* | -0.493 | 0.408 | -0.172 | 0.425 |
| *Prof. & Related Industry* | -0.237 | 0.214 | -0.268 | 0.211 |
| *Public Administration Industry* | 0.126 | 0.261 | -0.160 | 0.279 |
| *Constant* | -4.337 | 1.114*** | -0.256 | 0.651 |
| *Log-Likelihood* | -1036.46 | | -1044.9792 | |
| *Observations* | 5026 | | 5026 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift.

A summary of this information is provided in Table 5.1.

**Table A1_2. ML Reduced and Structural Equations, Unemployment Rate, 1990 Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Reduced Form | | Structural Form | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Wage Differential* | | | 0.831 | 0.412** |
| *Unemployment Rate* | 0.001 | 0.002 | 0.000 | 0.002 |
| *Number of Children* | 0.048 | 0.024** | 0.052 | 0.027* |
| *Shift Rate* | 0.756 | 0.466 | 0.421 | 0.675 |
| *Firm Size 1* | 0.203 | 0.094** | 0.189 | 0.093** |
| *Firm Size 2* | 0.627 | 0.092*** | 0.352 | 0.153** |
| *Firm Size 3* | 1.059 | 0.122*** | 0.668 | 0.218*** |
| *Firm Size 4* | 0.726 | 0.101*** | 0.364 | 0.184** |
| *Years of School* | 0.412 | 0.130*** | -0.021 | 0.020 |
| *Years of School*$^2$ | -0.018 | 0.005*** | | |
| *Experience* | 0.241 | 0.182 | 0.016 | 0.014 |
| *Experience*$^2$ | -0.023 | 0.015 | | |
| *Experience*$^3$ | 0.001 | 0.000* | | |
| *Tenure* | -0.040 | 0.030 | -0.041 | 0.010*** |
| *Tenure*$^2$ | 0.000 | 0.003 | | |
| *Union* | 0.256 | 0.076*** | 0.103 | 0.103 |
| *Non-white* | 0.012 | 0.069 | 0.013 | 0.067 |
| *North East* | -0.169 | 0.112 | | |
| *North Central* | 0.132 | 0.092 | | |
| *South* | 0.062 | 0.087 | | |
| *Female* | -0.314 | 0.070*** | -0.254 | 0.073*** |
| *Married* | -0.283 | 0.065*** | -0.206 | 0.077*** |
| *MSA Resident* | 0.001 | 0.064 | | |
| *Professional Occupation* | -0.714 | 0.108*** | -0.538 | 0.175*** |
| *Sales Occupation* | -0.832 | 0.100*** | -0.523 | 0.191*** |
| *Craft Occupation* | -0.721 | 0.095*** | -0.566 | 0.112*** |
| *Ag/Construction Industry* | -0.413 | 0.289 | -0.038 | 0.125 |
| *Manufacturing Industry* | -0.076 | 0.128 | -0.518 | 0.387 |
| *Transportation Industry* | 0.139 | 0.145 | 0.073 | 0.154 |
| *Wholesale Trade Industry* | 0.162 | 0.288 | 0.079 | 0.375 |
| *Retail Trade Industry* | -0.238 | 0.375 | -0.147 | 0.528 |
| *Finance Industry* | -0.347 | 0.325 | -0.286 | 0.417 |
| *Prof. & Related Industry* | -0.360 | 0.179** | -0.288 | 0.212 |
| *Public Administration Industry* | 0.182 | 0.206 | -0.142 | 0.287 |
| *Constant* | -4.602 | 1.166*** | -0.487 | 0.633 |
| *Log-Likelihood* | -2894.75 | | -1045.85 | |
| *Observations* | 5026 | | 5026 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift.

A summary of this information is provided in Table 5.1.

**Table A2_1. Two-Step Wage Equations, Unemployment Rate, 1990 Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Night Worker Coefficient | Robust Std. Error | Day Worker Coefficient | Robust Std. Error |
| *Unemployment Rate* | -0.001 | 0.001 | -0.003 | 0.000*** |
| *Selection Term* | 0.518 | 0.275* | -0.142 | 0.096 |
| *Firm Size 1* | 0.036 | 0.072 | 0.031 | 0.014** |
| *Firm Size 2* | 0.390 | 0.148*** | 0.054 | 0.018*** |
| *Firm Size 3* | 0.647 | 0.243*** | 0.129 | 0.031*** |
| *Firm Size 4* | 0.570 | 0.173*** | 0.130 | 0.021*** |
| *Years of School* | 0.120 | 0.114 | 0.050 | 0.021** |
| *Years of School*$^2$ | -0.003 | 0.005 | 0.001 | 0.001 |
| *Experience* | -0.126 | 0.153 | 0.014 | 0.022 |
| *Experience*$^2$ | 0.011 | 0.012 | -0.001 | 0.002 |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000 |
| *Tenure* | 0.100 | 0.023*** | 0.060 | 0.005*** |
| *Tenure*$^2$ | -0.007 | 0.002*** | -0.003 | 0.000*** |
| *Union* | 0.332 | 0.078*** | 0.112 | 0.016*** |
| *Non-white* | -0.093 | 0.040** | -0.092 | 0.012*** |
| *North East* | 0.017 | 0.083 | 0.016 | 0.019 |
| *North Central* | -0.012 | 0.072 | -0.121 | 0.016*** |
| *South* | -0.077 | 0.060 | -0.186 | 0.015*** |
| *Female* | -0.288 | 0.073*** | -0.206 | 0.013*** |
| *Married* | -0.089 | 0.069 | 0.039 | 0.012*** |
| *MSA Resident* | 0.018 | 0.039 | 0.014 | 0.011 |
| *Professional Occupation* | -0.053 | 0.188 | 0.329 | 0.030*** |
| *Sales Occupation* | -0.286 | 0.199 | 0.202 | 0.031*** |
| *Craft Occupation* | -0.112 | 0.165 | 0.136 | 0.029*** |
| *Ag/Construct Industry* | 0.016 | 0.223 | 0.146 | 0.027*** |
| *Manufacturing Industry* | -0.012 | 0.086 | 0.014 | 0.021 |
| *Transportation Industry* | 0.151 | 0.093 | 0.122 | 0.026*** |
| *Wholesale Trade Industry* | -0.101 | 0.184 | 0.016 | 0.029 |
| *Retail Trade Industry* | 0.150 | 0.111 | -0.116 | 0.026*** |
| *Finance Industry* | -0.298 | 0.196 | 0.063 | 0.027** |
| *Prof. & Related Industry* | -0.024 | 0.077 | -0.045 | 0.023** |
| *Public Administration Industry* | 0.347 | 0.089*** | 0.059 | 0.026** |
| *Constant* | 4.980 | 1.286*** | 5.936 | 0.159*** |
| *R-Squared* | 0.60 | | 0.44 | |
| *Log-Likelihood* | | | | |
| *Observations* | 352 | | 4674 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable:Log Wage.

A summary of this information is provided in Table 5.2.

**Table A2_2. ML Wage Equations, Unemployment Rate, 1990 Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Night Worker | | Day Worker | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Unemployment Rate* | -0.002 | 0.001 | -0.003 | 0.000*** |
| *Selection Term* | 0.401*** | | 0.120*** | |
| *Firm Size 1* | 0.031 | 0.066 | 0.031 | 0.014** |
| *Firm Size 2* | 0.342 | 0.072*** | 0.052 | 0.016*** |
| *Firm Size 3* | 0.561 | 0.096*** | 0.123 | 0.027*** |
| *Firm Size 4* | 0.511 | 0.079*** | 0.127 | 0.018*** |
| *Years of School* | 0.080 | 0.093 | 0.049 | 0.019*** |
| *Years of School*$^2$ | -0.001 | 0.004 | 0.001 | 0.001 |
| *Experience* | -0.086 | 0.150 | 0.013 | 0.023 |
| *Experience*$^2$ | 0.008 | 0.012 | -0.001 | 0.002 |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000 |
| *Tenure* | 0.101 | 0.021*** | 0.060 | 0.005*** |
| *Tenure*$^2$ | -0.007 | 0.002*** | -0.003 | 0.000*** |
| *Union* | 0.298 | 0.052*** | 0.111 | 0.015*** |
| *Non-white* | -0.079 | 0.047* | -0.093 | 0.012*** |
| *North East* | 0.052 | 0.076 | 0.016 | 0.018 |
| *North Central* | 0.001 | 0.063 | -0.122 | 0.016*** |
| *South* | -0.062 | 0.059 | -0.187 | 0.015*** |
| *Female* | -0.262 | 0.048*** | -0.205 | 0.012*** |
| *Married* | -0.052 | 0.043 | 0.039 | 0.011*** |
| *MSA Resident* | 0.020 | 0.043 | 0.014 | 0.011 |
| *Professional Occupation* | 0.002 | 0.083 | 0.333 | 0.022*** |
| *Sales Occupation* | -0.199 | 0.081** | 0.207 | 0.022*** |
| *Craft Occupation* | -0.050 | 0.077 | 0.140 | 0.021*** |
| *Ag/Construct Industry* | 0.099 | 0.139 | 0.148 | 0.023*** |
| *Manufacturing Industry* | 0.003 | 0.083 | 0.013 | 0.021 |
| *Transportation Industry* | 0.164 | 0.097* | 0.121 | 0.026*** |
| *Wholesale Trade Industry* | -0.083 | 0.148 | 0.016 | 0.029 |
| *Retail Trade Industry* | 0.122 | 0.076 | -0.118 | 0.023*** |
| *Finance Industry* | -0.207 | 0.185 | 0.064 | 0.025** |
| *Prof. & Related Industry* | 0.003 | 0.079 | -0.045 | 0.021** |
| *Public Administration Industry* | 0.362 | 0.105*** | 0.059 | 0.030** |
| *Constant* | 5.187 | 0.862*** | 5.938 | 0.158*** |
| *R-Squared* | | | | |
| *Log-Likelihood* | -2894.75 | | | |
| *Observations* | 5026 | | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable:Log Wage.

A summary of this information is provided in Table 5.2.

**Table A3_1. Two-Step Reduced and Structural Selection Equations, Leading Index, 1990 Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Reduced Form Coefficient | Robust Std. Error | Structural Form Coefficient | Robust Std. Error |
| *Wage Differential* | | | 0.864 | 0.352** |
| *Leading Index* | 0.079 | 0.048 | 0.069 | 0.040* |
| *Number of Children* | 0.045 | 0.027* | 0.049 | 0.027* |
| *Shift Rate* | 0.465 | 0.694 | 0.445 | 0.683 |
| *Firm Size 1* | 0.197 | 0.093** | 0.183 | 0.093* |
| *Firm Size 2* | 0.615 | 0.090*** | 0.278 | 0.163* |
| *Firm Size 3* | 1.062 | 0.122*** | 0.528 | 0.242** |
| *Firm Size 4* | 0.712 | 0.099*** | 0.267 | 0.195 |
| *Years of School* | 0.386 | 0.119*** | -0.020 | 0.020 |
| *Years of School*$^2$ | -0.017 | 0.005*** | | |
| *Experience* | 0.234 | 0.148 | 0.010 | 0.014 |
| *Experience*$^2$ | -0.022 | 0.012* | | |
| *Experience*$^3$ | 0.001 | 0.000** | | |
| *Tenure* | -0.042 | 0.029 | -0.035 | 0.010*** |
| *Tenure*$^2$ | 0.000 | 0.003 | | |
| *Union* | 0.261 | 0.074*** | 0.055 | 0.110 |
| *Non-white* | 0.034 | 0.069 | 0.046 | 0.065 |
| *North East* | -0.038 | 0.138 | | |
| *North Central* | 0.140 | 0.089 | | |
| *South* | -0.318 | 0.071*** | | |
| *Female* | 0.090 | 0.085 | -0.211 | 0.079*** |
| *Married* | -0.279 | 0.065*** | -0.150 | 0.087* |
| *MSA Resident* | -0.029 | 0.063 | | |
| *Professional Occupation* | -0.749 | 0.110*** | -0.425 | 0.195** |
| *Sales Occupation* | -0.858 | 0.099*** | -0.384 | 0.217* |
| *Craft Occupation* | -0.734 | 0.089*** | -0.471 | 0.133*** |
| *Ag/Construction Industry* | -0.521 | 0.396 | -0.341 | 0.398 |
| *Manufacturing Industry* | -0.053 | 0.125 | -0.031 | 0.125 |
| *Transportation Industry* | 0.135 | 0.155 | 0.090 | 0.154 |
| *Wholesale Trade Industry* | 0.013 | 0.380 | 0.114 | 0.378 |
| *Retail Trade Industry* | 0.024 | 0.529 | -0.209 | 0.532 |
| *Finance Industry* | -0.492 | 0.409 | -0.137 | 0.429 |
| *Prof. & Related Industry* | -0.240 | 0.214 | -0.269 | 0.212 |
| *Public Administration Industry* | 0.128 | 0.261 | -0.152 | 0.281 |
| *Constant* | -4.389 | 1.112*** | -0.259 | 0.673 |
| *Log-Likelihood* | -1035.15 | | -1041.4681 | |
| *Observations* | 5026 | | 5026 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift.

A summary of this information is provided in Table 5.3.

**Table A3_2. ML Reduced and Structural Selection Equations, Leading Index, 1990 Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Reduced Form | | Structural Form | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Wage Differential* | | | 0.743 | 0.404* |
| *Leading Index* | 0.092 | 0.047* | 0.096 | 0.038** |
| *Number of Children* | 0.049 | 0.024** | 0.050 | 0.027* |
| *Shift Rate* | 0.796 | 0.454* | 0.430 | 0.683 |
| *Firm Size 1* | 0.207 | 0.094** | 0.200 | 0.093** |
| *Firm Size 2* | 0.635 | 0.093*** | 0.390 | 0.148*** |
| *Firm Size 3* | 1.068 | 0.122*** | 0.712 | 0.218*** |
| *Firm Size 4* | 0.735 | 0.102*** | 0.399 | 0.183** |
| *Years of School* | 0.400 | 0.129*** | -0.025 | 0.020 |
| *Years of School*$^2$ | -0.017 | 0.005*** | | |
| *Experience* | 0.243 | 0.182 | 0.014 | 0.014 |
| *Experience*$^2$ | -0.023 | 0.015 | | |
| *Experience*$^3$ | 0.001 | 0.000* | | |
| *Tenure* | -0.038 | 0.030 | -0.040 | 0.010*** |
| *Tenure*$^2$ | 0.000 | 0.003 | | |
| *Union* | 0.259 | 0.076*** | 0.121 | 0.104 |
| *Non-white* | 0.022 | 0.069 | 0.040 | 0.065 |
| *North East* | -0.021 | 0.136 | | |
| *North Central* | 0.139 | 0.092 | | |
| *South* | 0.090 | 0.088 | | |
| *Female* | -0.314 | 0.070*** | -0.250 | 0.075*** |
| *Married* | -0.285 | 0.065*** | -0.207 | 0.079*** |
| *MSA Resident* | -0.021 | 0.064 | | |
| *Professional Occupation* | -0.721 | 0.108*** | -0.561 | 0.179*** |
| *Sales Occupation* | -0.835 | 0.100*** | -0.556 | 0.192*** |
| *Craft Occupation* | -0.728 | 0.095*** | -0.586 | 0.114*** |
| *Ag/Construction Industry* | -0.401 | 0.284 | -0.039 | 0.125 |
| *Manufacturing Industry* | -0.079 | 0.128 | -0.470 | 0.393 |
| *Transportation Industry* | 0.143 | 0.144 | 0.091 | 0.155 |
| *Wholesale Trade Industry* | 0.185 | 0.283 | 0.077 | 0.378 |
| *Retail Trade Industry* | -0.266 | 0.365 | -0.121 | 0.530 |
| *Finance Industry* | -0.341 | 0.321 | -0.286 | 0.420 |
| *Prof. & Related Industry* | -0.378 | 0.176** | -0.296 | 0.213 |
| *Public Administration Industry* | 0.183 | 0.204 | -0.134 | 0.294 |
| *Constant* | -4.662 | 1.161*** | -0.581 | 0.640 |
| *Log-Likelihood* | -2925.24 | | -1042.53 | |
| *Observations* | 5026 | | 5026 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift.

A summary of this information is provided in Table 5.3.

**Table A4_1. Two-Step Wage Equations, Leading Index, 1990 Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Night Worker Coefficient | Robust Std. Error | Day Worker Coefficient | Robust Std. Error |
| *Leading Index* | -0.014 | 0.036 | -0.052 | 0.008*** |
| *Selection Term* | 0.619 | 0.270** | -0.127 | 0.097 |
| *Firm Size 1* | 0.044 | 0.071 | 0.034 | 0.015** |
| *Firm Size 2* | 0.430 | 0.145*** | 0.055 | 0.018*** |
| *Firm Size 3* | 0.726 | 0.238*** | 0.131 | 0.031*** |
| *Firm Size 4* | 0.624 | 0.170*** | 0.130 | 0.021*** |
| *Years of School* | 0.149 | 0.114 | 0.043 | 0.021** |
| *Years of School*$^2$ | -0.004 | 0.005 | 0.001 | 0.001 |
| *Experience* | -0.123 | 0.156 | 0.011 | 0.023 |
| *Experience*$^2$ | 0.010 | 0.012 | -0.001 | 0.002 |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000 |
| *Tenure* | 0.099 | 0.023*** | 0.060 | 0.005*** |
| *Tenure*$^2$ | -0.007 | 0.002*** | -0.003 | 0.000*** |
| *Union* | 0.353 | 0.077*** | 0.109 | 0.016*** |
| *Non-white* | -0.098 | 0.040** | -0.094 | 0.012*** |
| *North East* | -0.013 | 0.075 | -0.055 | 0.022** |
| *North Central* | -0.013 | 0.071 | -0.123 | 0.017*** |
| *South* | -0.072 | 0.062 | -0.185 | 0.016*** |
| *Female* | -0.313 | 0.072*** | -0.205 | 0.013*** |
| *Married* | -0.114 | 0.068* | 0.039 | 0.012*** |
| *MSA Resident* | 0.024 | 0.041 | 0.038 | 0.011*** |
| *Professional Occupation* | -0.102 | 0.187 | 0.344 | 0.030*** |
| *Sales Occupation* | -0.342 | 0.197* | 0.214 | 0.031*** |
| *Craft Occupation* | -0.162 | 0.162 | 0.144 | 0.029*** |
| *Ag/Construct Industry* | -0.081 | 0.208 | 0.144 | 0.028*** |
| *Manufacturing Industry* | -0.014 | 0.085 | 0.008 | 0.021 |
| *Transportation Industry* | 0.150 | 0.091 | 0.114 | 0.026*** |
| *Wholesale Trade Industry* | -0.116 | 0.182 | 0.006 | 0.030 |
| *Retail Trade Industry* | 0.171 | 0.111 | -0.124 | 0.026*** |
| *Finance Industry* | -0.356 | 0.197* | 0.067 | 0.027** |
| *Prof. & Related Industry* | -0.033 | 0.077 | -0.053 | 0.023** |
| *Public Administration Industry* | 0.352 | 0.088*** | 0.049 | 0.027* |
| *Constant* | 4.575 | 1.274*** | 5.868 | 0.162*** |
| *R-Squared* | 0.60 | | 0.43 | |
| *Log-Likelihood* | | | | |
| *Observations* | 352 | | 4674 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage.

A summary of this information is provided in Table 5.4.

**Table A4_2. ML Wage Equations, Leading Index, 1990 Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Night Worker | | Day Worker | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Leading Index* | -0.041 | 0.032 | -0.052 | 0.008*** |
| *Selection Term* | 0.431*** | | 0.121*** | |
| *Firm Size 1* | 0.020 | 0.067 | 0.034 | 0.014** |
| *Firm Size 2* | 0.339 | 0.072*** | 0.054 | 0.016*** |
| *Firm Size 3* | 0.572 | 0.095*** | 0.129 | 0.027*** |
| *Firm Size 4* | 0.521 | 0.079*** | 0.130 | 0.018*** |
| *Years of School* | 0.086 | 0.094 | 0.042 | 0.019** |
| *Years of School*$^2$ | -0.001 | 0.004 | 0.001 | 0.001 |
| *Experience* | -0.097 | 0.151 | 0.010 | 0.024 |
| *Experience*$^2$ | 0.009 | 0.012 | -0.001 | 0.002 |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000 |
| *Tenure* | 0.102 | 0.021*** | 0.060 | 0.005*** |
| *Tenure*$^2$ | -0.007 | 0.002*** | -0.003 | 0.000*** |
| *Union* | 0.303 | 0.053*** | 0.109 | 0.015*** |
| *Non-white* | -0.090 | 0.048* | -0.095 | 0.012*** |
| *North East* | 0.001 | 0.090 | -0.055 | 0.023** |
| *North Central* | -0.008 | 0.063 | -0.124 | 0.016*** |
| *South* | -0.064 | 0.061 | -0.186 | 0.015*** |
| *Female* | -0.273 | 0.049*** | -0.204 | 0.013*** |
| *Married* | -0.062 | 0.044 | 0.039 | 0.011*** |
| *MSA Resident* | 0.033 | 0.044 | 0.038 | 0.011*** |
| *Professional Occupation* | -0.001 | 0.083 | 0.346 | 0.023*** |
| *Sales Occupation* | -0.200 | 0.080** | 0.216 | 0.022*** |
| *Craft Occupation* | -0.054 | 0.076 | 0.145 | 0.021*** |
| *Ag/Construct Industry* | 0.045 | 0.138 | 0.144 | 0.023*** |
| *Manufacturing Industry* | 0.000 | 0.084 | 0.008 | 0.021 |
| *Transportation Industry* | 0.154 | 0.098 | 0.114 | 0.026*** |
| *Wholesale Trade Industry* | -0.091 | 0.150 | 0.006 | 0.030 |
| *Retail Trade Industry* | 0.116 | 0.077 | -0.125 | 0.023*** |
| *Finance Industry* | -0.229 | 0.185 | 0.067 | 0.026*** |
| *Prof. & Related Industry* | 0.009 | 0.080 | -0.054 | 0.021** |
| *Public Administration Industry* | 0.376 | 0.106*** | 0.048 | 0.030 |
| *Constant* | 5.082 | 0.860*** | 5.868 | 0.159*** |
| *R-Squared* | | | | |
| *Log-Likelihood* | -2925.24 | | | |
| *Observations* | 5026 | | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage.

A summary of this information is provided in Table 5.4.

**Table A5. Two-Step Reduced & Structural Equations, Unemployment Rate, 1990-2000 Pooled Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Reduced Form Coefficient | Robust Std. Error | Structural Form Coefficient | Robust Std. Error |
| *Wage Differential* | | | 0.231 | 0.314 |
| *Unemployment Rate* | 0.001 | 0.001 | -0.000 | 0.001 |
| *Number of Children* | 0.026 | 0.012** | 0.031 | 0.012*** |
| *Shift Rate* | 0.309 | 0.121** | 0.312 | 0.121*** |
| *Firm Size 1* | 0.219 | 0.044*** | 0.201 | 0.046*** |
| *Firm Size 2* | 0.535 | 0.042*** | 0.512 | 0.046*** |
| *Firm Size 3* | 0.738 | 0.058*** | 0.719 | 0.060*** |
| *Firm Size 4* | 0.780 | 0.049*** | 0.744 | 0.056*** |
| *Years of School* | 0.244 | 0.052*** | -0.041 | 0.012*** |
| *Years of School*$^2$ | -0.012 | 0.002*** | | |
| *Experience* | -0.005 | 0.063 | 0.011 | 0.007 |
| *Experience*$^2$ | 0.001 | 0.004 | | |
| *Experience*$^3$ | 0.000 | 0.000 | | |
| *Tenure* | -0.050 | 0.009*** | -0.027 | 0.004*** |
| *Tenure*$^2$ | 0.002 | 0.001*** | | |
| *Union* | 0.330 | 0.036*** | 0.313 | 0.038*** |
| *Non-white* | 0.035 | 0.032 | 0.037 | 0.034 |
| *North East* | 0.003 | 0.053 | | |
| *North Central* | 0.180 | 0.046*** | | |
| *South* | 0.106 | 0.044** | | |
| *Female* | -0.229 | 0.033*** | -0.240 | 0.044*** |
| *Married* | -0.183 | 0.031*** | -0.195 | 0.031*** |
| *MSA Resident* | 0.021 | 0.030 | | |
| *Professional Occupation* | -0.692 | 0.054*** | -0.764 | 0.053*** |
| *Sales Occupation* | -0.718 | 0.049*** | -0.708 | 0.053*** |
| *Craft Occupation* | -0.505 | 0.044*** | -0.509 | 0.046*** |
| *Agriculture/Farm/Fish Industry* | -0.999 | 0.198*** | -1.122 | 0.220*** |
| *Mining Industry* | 0.749 | 0.144*** | 0.672 | 0.175*** |
| *Construction Industry* | -0.750 | 0.115*** | -0.790 | 0.129*** |
| *Non-Durable Manufacturing Industry* | 0.190 | 0.066*** | 0.173 | 0.066*** |
| *Durable Manufacturing Industry* | -0.103 | 0.057* | -0.107 | 0.064* |
| *Transportation Industry* | -0.003 | 0.063 | -0.036 | 0.074 |
| *Wholesale Trade Industry* | 0.005 | 0.102 | -0.020 | 0.112 |
| *Retail Trade Industry* | 0.147 | 0.072** | 0.136 | 0.075* |
| *Finance Industry* | -0.667 | 0.133*** | -0.695 | 0.141*** |
| *Prof. & Related Industry* | -0.208 | 0.071*** | -0.233 | 0.076*** |
| *Public Administration Industry* | -0.046 | 0.076 | -0.131 | 0.125 |
| *1992* | -0.041 | 0.051 | -0.006 | 0.053 |
| *1994* | -0.106 | 0.069 | -0.087 | 0.068 |
| *1996* | -0.050 | 0.063 | -0.031 | 0.061 |
| *1998* | -0.068 | 0.070 | -0.052 | 0.068 |
| *2000* | -0.057 | 0.080 | -0.030 | 0.078 |
| *Constant* | -2.655 | 0.482*** | -0.888 | 0.205*** |
| *Log-Likelihood* | -4649.430 | | -4688.969 | |
| *Observations* | 24732 | | 24732 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift. A summary of this information is provided in Table 5.5.

**Table A6. ML Reduced & Structural Equations, Unemployment Rate, 1990-2000 Pooled Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Reduced Form | | Structural Form | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Wage Differential* | | | 0.275 | 0.317 |
| *Unemployment Rate* | 0.000 | 0.001 | -0.000 | 0.001 |
| *Number of Children* | 0.028 | 0.011** | 0.031 | 0.012*** |
| *Shift Rate* | 0.270 | 0.118** | 0.312 | 0.121*** |
| *Firm Size 1* | 0.233 | 0.044*** | 0.198 | 0.046*** |
| *Firm Size 2* | 0.558 | 0.043*** | 0.508 | 0.046*** |
| *Firm Size 3* | 0.754 | 0.058*** | 0.714 | 0.061*** |
| *Firm Size 4* | 0.809 | 0.049*** | 0.738 | 0.058*** |
| *Years of School* | 0.284 | 0.052*** | -0.040 | 0.012*** |
| *Years of School*$^2$ | -0.014 | 0.002*** | | |
| *Experience* | -0.021 | 0.065 | 0.011 | 0.007* |
| *Experience*$^2$ | 0.002 | 0.004 | | |
| *Experience*$^3$ | 0.000 | 0.000 | | |
| *Tenure* | -0.054 | 0.009*** | -0.027 | 0.004*** |
| *Tenure*$^2$ | 0.002 | 0.001*** | | |
| *Union* | 0.312 | 0.037*** | 0.309 | 0.039*** |
| *Non-white* | 0.043 | 0.032 | 0.035 | 0.035 |
| *North East* | 0.011 | 0.053 | | |
| *North Central* | 0.190 | 0.046*** | | |
| *South* | 0.114 | 0.044*** | | |
| *Female* | -0.220 | 0.032*** | -0.243 | 0.044*** |
| *Married* | -0.184 | 0.030*** | -0.195 | 0.031*** |
| *MSA Resident* | 0.011 | 0.030 | | |
| *Professional Occupation* | -0.703 | 0.050*** | -0.761 | 0.053*** |
| *Sales Occupation* | -0.713 | 0.048*** | -0.700 | 0.055*** |
| *Craft Occupation* | -0.507 | 0.046*** | -0.507 | 0.045*** |
| *Agriculture/Farm/Fish Industry* | -1.010 | 0.188*** | -1.132 | 0.219*** |
| *Mining Industry* | 0.754 | 0.154*** | 0.654 | 0.178*** |
| *Construction Industry* | -0.820 | 0.114*** | -0.797 | 0.129*** |
| *Non-Durable Manufacturing Industry* | 0.212 | 0.068*** | 0.170 | 0.067** |
| *Durable Manufacturing Industry* | -0.079 | 0.060 | -0.111 | 0.064* |
| *Transportation Industry* | 0.003 | 0.064 | -0.041 | 0.074 |
| *Wholesale Trade Industry* | -0.002 | 0.102 | -0.027 | 0.112 |
| *Retail Trade Industry* | 0.142 | 0.072** | 0.132 | 0.076* |
| *Finance Industry* | -0.668 | 0.136*** | -0.701 | 0.141*** |
| *Prof. & Related Industry* | -0.198 | 0.071*** | -0.238 | 0.076*** |
| *Public Administration Industry* | -0.080 | 0.078 | -0.145 | 0.126 |
| *1992* | -0.042 | 0.051 | -0.004 | 0.053 |
| *1994* | -0.114 | 0.069* | -0.087 | 0.068 |
| *1996* | -0.058 | 0.062 | -0.031 | 0.061 |
| *1998* | -0.077 | 0.069 | -0.050 | 0.068 |
| *2000* | -0.071 | 0.079 | -0.029 | 0.078 |
| *Constant* | -2.722 | 0.496*** | -0.911 | 0.210*** |
| *Log-Likelihood* | -15756.94^ | | -4688.87 | |
| *Observations* | 24732 | | 24732 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift. A summary of this information is provided in Table 5.5
^ denotes the log-likelihood from the simultaneous estimation of the wage equations and the reduced form of the selection equation.

**Table A7. Two-Step Wage Equations, Unemployment Rate, 1990-2000 Pooled Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Night Worker Coefficient | Robust Std. Error | Day Worker Coefficient | Robust Std. Error |
| *Unemployment Rate* | -0.001 | 0.000*** | -0.001 | 0.000*** |
| *Selection Term* | -0.014 | 0.208 | -0.300 | 0.054*** |
| *Firm Size 1* | 0.097 | 0.050* | 0.049 | 0.007*** |
| *Firm Size 2* | 0.150 | 0.095 | 0.096 | 0.009*** |
| *Firm Size 3* | 0.208 | 0.130 | 0.153 | 0.013*** |
| *Firm Size 4* | 0.289 | 0.139** | 0.199 | 0.011*** |
| *Years of School* | 0.053 | 0.061 | 0.007 | 0.008 |
| *Years of School*$^2$ | -0.001 | 0.003 | 0.002 | 0.000*** |
| *Experience* | 0.012 | 0.047 | 0.039 | 0.009*** |
| *Experience*$^2$ | -0.001 | 0.003 | -0.002 | 0.001*** |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000** |
| *Tenure* | 0.056 | 0.010*** | 0.032 | 0.002*** |
| *Tenure*$^2$ | -0.002 | 0.000*** | -0.001 | 0.000*** |
| *Union* | 0.172 | 0.059*** | 0.121 | 0.008*** |
| *Non-white* | -0.064 | 0.020*** | -0.107 | 0.006*** |
| *North East* | 0.013 | 0.033 | 0.011 | 0.009 |
| *North Central* | -0.124 | 0.043*** | -0.125 | 0.008*** |
| *South* | -0.144 | 0.033*** | -0.180 | 0.008*** |
| *Female* | -0.127 | 0.043*** | -0.218 | 0.006*** |
| *Married* | 0.062 | 0.035* | 0.053 | 0.006*** |
| *MSA Resident* | -0.017 | 0.020 | 0.000 | 0.005 |
| *Professional Occupation* | 0.314 | 0.120*** | 0.299 | 0.014*** |
| *Sales Occupation* | 0.075 | 0.129 | 0.144 | 0.014*** |
| *Craft Occupation* | 0.088 | 0.089 | 0.046 | 0.013*** |
| *Agriculture/Farm/Fish Industry* | 0.124 | 0.332 | -0.177 | 0.022*** |
| *Mining Industry* | 0.393 | 0.126*** | 0.094 | 0.036*** |
| *Construction Industry* | 0.346 | 0.190* | 0.153 | 0.015*** |
| *Non-Durable Manufacturing Industry* | 0.027 | 0.060 | -0.004 | 0.013 |
| *Durable Manufacturing Industry* | 0.128 | 0.044*** | 0.032 | 0.011*** |
| *Transportation Industry* | 0.230 | 0.044*** | 0.114 | 0.012*** |
| *Wholesale Trade Industry* | 0.150 | 0.072** | 0.003 | 0.015 |
| *Retail Trade Industry* | -0.054 | 0.059 | -0.122 | 0.013*** |
| *Finance Industry* | 0.204 | 0.185 | 0.077 | 0.014*** |
| *Prof. & Related Industry* | 0.000 | 0.042 | -0.092 | 0.011*** |
| *Public Administration Industry* | 0.345 | 0.050*** | 0.035 | 0.013*** |
| *1992* | 0.035 | 0.033 | 0.088 | 0.009*** |
| *1994* | 0.173 | 0.051*** | 0.154 | 0.011*** |
| *1996* | 0.239 | 0.043*** | 0.214 | 0.011*** |
| *1998* | 0.246 | 0.048*** | 0.265 | 0.012*** |
| *2000* | 0.327 | 0.053*** | 0.345 | 0.014*** |
| *Constant* | 5.893 | 0.711*** | 6.055 | 0.076*** |
| *R-Squared* | 0.55 | | 0.51 | |
| *Log-Likelihood* | | | | |
| *Observations* | 1472 | | 23260 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift. A summary of this information is provided in Table 5.6.

**Table A8. ML Wage Equations, Unemployment Rate, 1990-2000 Pooled Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Night Worker | | Day Worker | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Unemployment Rate* | -0.001 | 0.000*** | -0.001 | 0.000*** |
| *Selection Term* | -0.029 | | 0.156*** | |
| *Firm Size 1* | 0.094 | 0.037** | 0.045 | 0.007*** |
| *Firm Size 2* | 0.143 | 0.060** | 0.084 | 0.007*** |
| *Firm Size 3* | 0.199 | 0.079** | 0.135 | 0.012*** |
| *Firm Size 4* | 0.279 | 0.082*** | 0.180 | 0.009*** |
| *Years of School* | 0.049 | 0.043 | 0.003 | 0.008 |
| *Years of School* $^2$ | 0.000 | 0.002 | 0.002 | 0.000*** |
| *Experience* | 0.012 | 0.044 | 0.039 | 0.009*** |
| *Experience* $^2$ | -0.001 | 0.003 | -0.002 | 0.001*** |
| *Experience* $^3$ | 0.000 | 0.000 | 0.000 | 0.000** |
| *Tenure* | 0.057 | 0.008*** | 0.033 | 0.002*** |
| *Tenure* $^2$ | -0.002 | 0.000*** | -0.001 | 0.000*** |
| *Union* | 0.168 | 0.036*** | 0.111 | 0.008*** |
| *Non-white* | -0.064 | 0.020*** | -0.108 | 0.006*** |
| *North East* | 0.013 | 0.034 | 0.011 | 0.009 |
| *North Central* | -0.126 | 0.034*** | -0.129 | 0.008*** |
| *South* | -0.145 | 0.029*** | -0.183 | 0.008*** |
| *Female* | -0.125 | 0.028*** | -0.213 | 0.006*** |
| *Married* | 0.064 | 0.024*** | 0.057 | 0.005*** |
| *MSA Resident* | -0.017 | 0.020 | -0.001 | 0.005 |
| *Professional Occupation* | 0.323 | 0.073*** | 0.322 | 0.010*** |
| *Sales Occupation* | 0.083 | 0.075 | 0.168 | 0.010*** |
| *Craft Occupation* | 0.094 | 0.056* | 0.064 | 0.010*** |
| *Agriculture/Farm/Fish Industry* | 0.138 | 0.188 | -0.153 | 0.019*** |
| *Mining Industry* | 0.385 | 0.100*** | 0.074 | 0.036** |
| *Construction Industry* | 0.358 | 0.124*** | 0.169 | 0.012*** |
| *Non-Durable Manufacturing Industry* | 0.024 | 0.046 | -0.015 | 0.012 |
| *Durable Manufacturing Industry* | 0.128 | 0.040*** | 0.034 | 0.011*** |
| *Transportation Industry* | 0.230 | 0.042*** | 0.115 | 0.012*** |
| *Wholesale Trade Industry* | 0.151 | 0.063** | 0.005 | 0.016 |
| *Retail Trade Industry* | -0.057 | 0.041 | -0.129 | 0.011*** |
| *Finance Industry* | 0.213 | 0.128* | 0.086 | 0.012*** |
| *Prof. & Related Industry* | 0.001 | 0.036 | -0.090 | 0.010*** |
| *Public Administration Industry* | 0.347 | 0.047*** | 0.038 | 0.013*** |
| *1992* | 0.036 | 0.031 | 0.090 | 0.009*** |
| *1994* | 0.175 | 0.044*** | 0.158 | 0.011*** |
| *1996* | 0.240 | 0.038*** | 0.216 | 0.011*** |
| *1998* | 0.248 | 0.043*** | 0.267 | 0.012*** |
| *2000* | 0.328 | 0.049*** | 0.347 | 0.014*** |
| *Constant* | 5.936 | 0.454*** | 6.039 | 0.075*** |
| *Log-Likelihood* | -15756.94^ | | | |
| *Observations* | 24732 | | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage. ^ denotes the log-likelihood from simultaneous estimation of the wage equations and the reduced form selection equation. A summary of this information is provided in Table 5.6.

**Table A9. Two-Step Selection Equations, Leading Index, 1990-2000 Pooled Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Reduced Form Coefficient | Robust Std. Error | Structural Form Coefficient | Robust Std. Error |
| *Wage Differential* | | | 0.292 | 0.320 |
| *Leading Index* | 0.019 | 0.018 | 0.014 | 0.020 |
| *Number of Children* | 0.027 | 0.012** | 0.031 | 0.012*** |
| *Shift Rate* | 0.309 | 0.121** | 0.312 | 0.121*** |
| *Firm Size 1* | 0.219 | 0.044*** | 0.196 | 0.047*** |
| *Firm Size 2* | 0.533 | 0.042*** | 0.506 | 0.047*** |
| *Firm Size 3* | 0.736 | 0.058*** | 0.714 | 0.061*** |
| *Firm Size 4* | 0.779 | 0.049*** | 0.736 | 0.059*** |
| *Years of School* | 0.242 | 0.052*** | -0.039 | 0.012*** |
| *Years of School* $^2$ | -0.012 | 0.002*** | | |
| *Experience* | -0.006 | 0.063 | 0.011 | 0.007* |
| *Experience* $^2$ | 0.001 | 0.004 | | |
| *Experience* $^3$ | 0.000 | 0.000 | | |
| *Tenure* | -0.050 | 0.009*** | -0.027 | 0.004*** |
| *Tenure* $^2$ | 0.002 | 0.001*** | | |
| *Union* | 0.331 | 0.036*** | 0.309 | 0.039*** |
| *Non-white* | 0.035 | 0.032 | 0.034 | 0.035 |
| *North East* | 0.008 | 0.053 | | |
| *North Central* | 0.173 | 0.044*** | | |
| *South* | 0.094 | 0.041** | | |
| *Female* | -0.228 | 0.033*** | -0.244 | 0.044*** |
| *Married* | -0.183 | 0.031*** | -0.195 | 0.030*** |
| *MSA Resident* | 0.020 | 0.030 | | |
| *Professional Occupation* | -0.693 | 0.054*** | -0.759 | 0.053*** |
| *Sales Occupation* | -0.719 | 0.049*** | -0.700 | 0.055*** |
| *Craft Occupation* | -0.506 | 0.044*** | -0.509 | 0.045*** |
| *Agriculture/Farm/Fish Industry* | -0.989 | 0.197*** | -1.136 | 0.215*** |
| *Mining Industry* | 0.756 | 0.144*** | 0.651 | 0.173*** |
| *Construction Industry* | -0.749 | 0.115*** | -0.795 | 0.127*** |
| *Non-Durable Manufacturing Industry* | 0.192 | 0.066*** | 0.170 | 0.067** |
| *Durable Manufacturing Industry* | -0.102 | 0.057* | -0.113 | 0.065* |
| *Transportation Industry* | -0.002 | 0.063 | -0.044 | 0.075 |
| *Wholesale Trade Industry* | 0.006 | 0.102 | -0.031 | 0.113 |
| *Retail Trade Industry* | 0.149 | 0.072** | 0.131 | 0.076* |
| *Finance Industry* | -0.668 | 0.133*** | -0.695 | 0.139*** |
| *Prof. & Related Industry* | -0.206 | 0.071*** | -0.240 | 0.076*** |
| *Public Administration Industry* | -0.043 | 0.076 | -0.150 | 0.126 |
| *1992* | -0.038 | 0.051 | -0.014 | 0.055 |
| *1994* | -0.125 | 0.073* | -0.108 | 0.073 |
| *1996* | -0.055 | 0.064 | -0.043 | 0.062 |
| *1998* | -0.082 | 0.071 | -0.057 | 0.072 |
| *2000* | -0.064 | 0.080 | -0.027 | 0.079 |
| *Constant* | -2.622 | 0.480*** | -0.916 | 0.199*** |
| *Log-Likelihood* | -4649.25 | | -4688.07 | |
| *Observations* | 24732 | | 24732 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift. A summary of these results are provided in Table 5.7.

**Table A10. ML Selection Equations, Leading Index, 1990-2000 Pooled Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Reduced Form | | Structural Form | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Wage Differential* | | | 0.240 | 0.326 |
| *Leading Index* | 0.019 | 0.018 | 0.015 | 0.020 |
| *Number of Children* | 0.030 | 0.011*** | 0.031 | 0.012*** |
| *Shift Rate* | 0.268 | 0.119** | 0.311 | 0.121*** |
| *Firm Size 1* | 0.231 | 0.044*** | 0.199 | 0.047*** |
| *Firm Size 2* | 0.556 | 0.043*** | 0.510 | 0.047*** |
| *Firm Size 3* | 0.752 | 0.058*** | 0.717 | 0.061*** |
| *Firm Size 4* | 0.806 | 0.049*** | 0.742 | 0.059*** |
| *Years of School* | 0.282 | 0.052*** | -0.040 | 0.012*** |
| *Years of School*$^2$ | -0.014 | 0.002*** | | |
| *Experience* | -0.022 | 0.065 | 0.011 | 0.007 |
| *Experience*$^2$ | 0.002 | 0.004 | | |
| *Experience*$^3$ | 0.000 | 0.000 | | |
| *Tenure* | -0.054 | 0.009*** | -0.026 | 0.004*** |
| *Tenure*$^2$ | 0.002 | 0.001*** | | |
| *Union* | 0.313 | 0.037*** | 0.311 | 0.039*** |
| *Non-white* | 0.042 | 0.032 | 0.037 | 0.036 |
| *North East* | 0.017 | 0.054 | | |
| *North Central* | 0.184 | 0.044*** | | |
| *South* | 0.103 | 0.042** | | |
| *Female* | -0.219 | 0.032*** | -0.239 | 0.044*** |
| *Married* | -0.185 | 0.030*** | -0.195 | 0.030*** |
| *MSA Resident* | 0.011 | 0.030 | | |
| *Professional Occupation* | -0.705 | 0.050*** | -0.759 | 0.054*** |
| *Sales Occupation* | -0.713 | 0.048*** | -0.702 | 0.056*** |
| *Craft Occupation* | -0.507 | 0.046*** | -0.506 | 0.045*** |
| *Agriculture/Farm/Fish Industry* | -1.004 | 0.188*** | -1.124 | 0.217*** |
| *Mining Industry* | 0.761 | 0.153*** | 0.665 | 0.175*** |
| *Construction Industry* | -0.826 | 0.115*** | -0.788 | 0.129*** |
| *Non-Durable Manufacturing Industry* | 0.214 | 0.068*** | 0.171 | 0.067** |
| *Durable Manufacturing Industry* | -0.078 | 0.060 | -0.108 | 0.065* |
| *Transportation Industry* | 0.002 | 0.064 | -0.037 | 0.075 |
| *Wholesale Trade Industry* | -0.003 | 0.103 | -0.023 | 0.114 |
| *Retail Trade Industry* | 0.141 | 0.072** | 0.135 | 0.076* |
| *Finance Industry* | -0.668 | 0.136*** | -0.693 | 0.140*** |
| *Prof. & Related Industry* | -0.198 | 0.071*** | -0.236 | 0.076*** |
| *Public Administration Industry* | -0.079 | 0.077 | -0.134 | 0.127 |
| *1992* | -0.042 | 0.050 | -0.018 | 0.055 |
| *1994* | -0.134 | 0.073* | -0.110 | 0.073 |
| *1996* | -0.064 | 0.063 | -0.043 | 0.062 |
| *1998* | -0.091 | 0.070 | -0.059 | 0.072 |
| *2000* | -0.078 | 0.079 | -0.029 | 0.079 |
| *Constant* | -2.686 | 0.492*** | -0.931 | 0.202*** |
| *Log-Likelihood* | -15841.38^ | | -4688.21 | |
| *Observations* | 24732 | | 24732 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Night Shift. A summary of these results are provided in Table 5.7.
^ denotes the log-likelihood from simultaneous estimation of the wage equations and the reduced form selection equation.

**Table A11. Two-Step Wage Equations, Leading Index, 1990-2000 Pooled Cross-Section**

| | Two-Step | | | |
|---|---|---|---|---|
| Variable | Night Worker Coefficient | Robust Std. Error | Day Worker Coefficient | Robust Std. Error |
| *Leading Index* | 0.016 | 0.012 | -0.014 | 0.003*** |
| *Selection Term* | 0.008 | 0.206 | -0.302 | 0.054*** |
| *Firm Size 1* | 0.106 | 0.050** | 0.051 | 0.007*** |
| *Firm Size 2* | 0.164 | 0.094* | 0.100 | 0.009*** |
| *Firm Size 3* | 0.224 | 0.129* | 0.159 | 0.013*** |
| *Firm Size 4* | 0.305 | 0.137** | 0.203 | 0.011*** |
| *Years of School* | 0.058 | 0.061 | 0.008 | 0.008 |
| *Years of School*$^2$ | -0.001 | 0.003 | 0.002 | 0.000*** |
| *Experience* | 0.009 | 0.047 | 0.038 | 0.009*** |
| *Experience*$^2$ | -0.001 | 0.003 | -0.002 | 0.001*** |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000** |
| *Tenure* | 0.055 | 0.010*** | 0.031 | 0.002*** |
| *Tenure*$^2$ | -0.002 | 0.000*** | -0.001 | 0.000*** |
| *Union* | 0.172 | 0.058*** | 0.118 | 0.008*** |
| *Non-white* | -0.058 | 0.021*** | -0.107 | 0.006*** |
| *North East* | 0.044 | 0.034 | 0.024 | 0.010** |
| *North Central* | -0.093 | 0.041** | -0.097 | 0.008*** |
| *South* | -0.114 | 0.031*** | -0.147 | 0.007*** |
| *Female* | -0.131 | 0.043*** | -0.219 | 0.006*** |
| *Married* | 0.057 | 0.035 | 0.052 | 0.006*** |
| *MSA Resident* | -0.011 | 0.020 | 0.004 | 0.005 |
| *Professional Occupation* | 0.299 | 0.118** | 0.301 | 0.014*** |
| *Sales Occupation* | 0.062 | 0.128 | 0.144 | 0.014*** |
| *Craft Occupation* | 0.078 | 0.089 | 0.047 | 0.013*** |
| *Agriculture/Farm/Fish Industry* | 0.073 | 0.333 | -0.199 | 0.022*** |
| *Mining Industry* | 0.370 | 0.126*** | 0.083 | 0.036** |
| *Construction Industry* | 0.326 | 0.188* | 0.152 | 0.015*** |
| *Non-Durable Manufacturing Industry* | 0.027 | 0.060 | -0.008 | 0.013 |
| *Durable Manufacturing Industry* | 0.128 | 0.044*** | 0.029 | 0.011** |
| *Transportation Industry* | 0.233 | 0.044*** | 0.112 | 0.013*** |
| *Wholesale Trade Industry* | 0.152 | 0.072** | -0.001 | 0.016 |
| *Retail Trade Industry* | -0.051 | 0.059 | -0.124 | 0.013*** |
| *Finance Industry* | 0.183 | 0.182 | 0.078 | 0.014*** |
| *Prof. & Related Industry* | -0.008 | 0.042 | -0.099 | 0.011*** |
| *Public Administration Industry* | 0.335 | 0.049*** | 0.028 | 0.013** |
| *1992* | -0.004 | 0.033 | 0.061 | 0.008*** |
| *1994* | 0.127 | 0.057** | 0.152 | 0.012*** |
| *1996* | 0.212 | 0.044*** | 0.205 | 0.011*** |
| *1998* | 0.236 | 0.050*** | 0.282 | 0.012*** |
| *2000* | 0.325 | 0.054*** | 0.363 | 0.014*** |
| *Constant* | 5.705 | 0.705*** | 5.958 | 0.076*** |
| *R-Squared* | 0.54 | | 0.50 | |
| *Observations* | 1472 | | 23260 | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage. A summary of these results are provided in Table 5.8.

**Table A12. ML Wage Equations, Leading Index, 1990-2000 Pooled Cross-Section**

| | Maximum Likelihood | | | |
|---|---|---|---|---|
| | Night Worker | | Day Worker | |
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Leading Index* | 0.016 | 0.011 | -0.014 | 0.003*** |
| *Selection Term* | -0.020 | | 0.159*** | |
| *Firm Size 1* | 0.100 | 0.039*** | 0.047 | 0.007*** |
| *Firm Size 2* | 0.151 | 0.064** | 0.088 | 0.007*** |
| *Firm Size 3* | 0.207 | 0.085** | 0.141 | 0.012*** |
| *Firm Size 4* | 0.287 | 0.088*** | 0.185 | 0.009*** |
| *Years of School* | 0.051 | 0.044 | 0.005 | 0.008 |
| *Years of School*$^2$ | 0.000 | 0.002 | 0.002 | 0.000*** |
| *Experience* | 0.009 | 0.044 | 0.038 | 0.009*** |
| *Experience*$^2$ | -0.001 | 0.003 | -0.002 | 0.001*** |
| *Experience*$^3$ | 0.000 | 0.000 | 0.000 | 0.000** |
| *Tenure* | 0.056 | 0.008*** | 0.033 | 0.002*** |
| *Tenure*$^2$ | -0.002 | 0.000*** | -0.001 | 0.000*** |
| *Union* | 0.165 | 0.038*** | 0.108 | 0.008*** |
| *Non-white* | -0.059 | 0.020*** | -0.109 | 0.006*** |
| *North East* | 0.044 | 0.035 | 0.024 | 0.009*** |
| *North Central* | -0.098 | 0.034*** | -0.102 | 0.008*** |
| *South* | -0.116 | 0.028*** | -0.150 | 0.007*** |
| *Female* | -0.126 | 0.029*** | -0.214 | 0.006*** |
| *Married* | 0.060 | 0.025** | 0.056 | 0.005*** |
| *MSA Resident* | -0.011 | 0.020 | 0.003 | 0.005 |
| *Professional Occupation* | 0.315 | 0.078*** | 0.325 | 0.010*** |
| *Sales Occupation* | 0.078 | 0.080 | 0.169 | 0.010*** |
| *Craft Occupation* | 0.089 | 0.059 | 0.064 | 0.010*** |
| *Agriculture/Farm/Fish Industry* | 0.100 | 0.193 | -0.176 | 0.019*** |
| *Mining Industry* | 0.355 | 0.104*** | 0.063 | 0.036* |
| *Construction Industry* | 0.349 | 0.130*** | 0.168 | 0.012*** |
| *Non-Durable Manufacturing Industry* | 0.020 | 0.048 | -0.019 | 0.012 |
| *Durable Manufacturing Industry* | 0.129 | 0.040*** | 0.030 | 0.011*** |
| *Transportation Industry* | 0.233 | 0.042*** | 0.112 | 0.012*** |
| *Wholesale Trade Industry* | 0.154 | 0.063** | 0.001 | 0.016 |
| *Retail Trade Industry* | -0.057 | 0.043 | -0.132 | 0.011*** |
| *Finance Industry* | 0.202 | 0.132 | 0.086 | 0.012*** |
| *Prof. & Related Industry* | -0.006 | 0.036 | -0.098 | 0.010*** |
| *Public Administration Industry* | 0.338 | 0.047*** | 0.031 | 0.013** |
| *1992* | -0.002 | 0.030 | 0.063 | 0.009*** |
| *1994* | 0.131 | 0.047*** | 0.156 | 0.012*** |
| *1996* | 0.214 | 0.038*** | 0.207 | 0.011*** |
| *1998* | 0.239 | 0.044*** | 0.285 | 0.013*** |
| *2000* | 0.328 | 0.050*** | 0.365 | 0.014*** |
| *Constant* | 5.783 | 0.467*** | 5.941 | 0.075*** |
| *Log-Likelihood* | -15841.37^ | | | |
| *Observations* | 24732 | | | |

Levels of significance: ***1%, **5%, *10%. Dependent Variable: Log Wage. A summary of these results are provided in Table 5.8.

^ denotes log-likelihood from simultaneous estimation of the wage equations and the reduced form selection equation.

**Table A13. ML Treatment Effects Model, 1990 Cross-section, Unemployment Rate**

| | Wage Equation | | Selection Equation | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Number of Children* | | | 0.045 | 0.027* |
| *Shift Rate* | | | 0.214 | 0.535 |
| *Firm Size 1* | 0.018 | 0.014 | 0.182 | 0.094* |
| *Firm Size 2* | 0.036 | 0.015** | 0.605 | 0.092*** |
| *Firm Size 3* | 0.080 | 0.026*** | 1.041 | 0.121*** |
| *Firm Size 4* | 0.111 | 0.017*** | 0.693 | 0.100*** |
| *Years of School* | 0.042 | 0.018** | -0.034 | 0.021 |
| *Years of School* $^2$ | 0.001 | 0.001 | | |
| *Experience* | 0.002 | 0.023 | 0.019 | 0.014 |
| *Experience* $^2$ | 0.000 | 0.002 | | |
| *Experience* $^3$ | 0.000 | 0.000 | | |
| *Tenure* | 0.066 | 0.005*** | -0.033 | 0.010*** |
| *Tenure* $^2$ | -0.003 | 0.000*** | | |
| *Union* | 0.111 | 0.014*** | 0.260 | 0.073*** |
| *Non-white* | -0.099 | 0.012*** | 0.041 | 0.066 |
| *North East* | 0.023 | 0.017 | | |
| *North Central* | -0.124 | 0.015*** | | |
| *South* | -0.183 | 0.014*** | | |
| *Female* | -0.189 | 0.012*** | -0.266 | 0.069*** |
| *Married* | 0.051 | 0.011*** | -0.265 | 0.065*** |
| *MSA Resident* | 0.015 | 0.010 | | |
| *Professional Occupation* | 0.369 | 0.022*** | -0.820 | 0.106*** |
| *Sales Occupation* | 0.245 | 0.021*** | -0.893 | 0.101*** |
| *Craft Occupation* | 0.180 | 0.021*** | -0.713 | 0.094*** |
| *Ag/Construct Industry* | 0.182 | 0.023*** | -0.626 | 0.311** |
| *Manufacturing Industry* | 0.017 | 0.020 | 0.003 | 0.135 |
| *Transportation Industry* | 0.121 | 0.025*** | 0.130 | 0.144 |
| *Wholesale Trade Industry* | 0.027 | 0.029 | -0.084 | 0.309 |
| *Retail Trade Industry* | -0.132 | 0.022*** | 0.247 | 0.431 |
| *Finance Industry* | 0.085 | 0.025*** | -0.580 | 0.343* |
| *Prof. & Related Industry* | -0.035 | 0.020* | -0.154 | 0.199 |
| *Public Administration Industry* | 0.086 | 0.029*** | 0.139 | 0.211 |
| *Unemployment Rate* | -0.003 | 0.000*** | 0.002 | 0.002 |
| *Shift Worker* | 0.224 | 0.072*** | | |
| *Selection term* | -0.086 | 0.036** | | |
| *Constant* | 5.930 | 0.152*** | -1.018 | 0.503** |
| *Log Likelihood* | -2950.93 | | | |
| *LR Test Statistic* | 112.36*** | | | |
| *Observations* | 5026 | | | |

Levels of significance: ***1%, **5%, *10%. The LR Test Statistic refers to the statistic obtained by comparing the log-likelihood of the unrestricted model (the endogenous switching model, results shown in Table A2) to the log-likelihood of the restricted model (the treatment effects model, results shown above.)

**Table A14. ML Treatment Effects Model, 1990 Cross-section, Leading Index**

| | Wage Equation | | Selection Equation | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Number of Children* | | | 0.041 | 0.027 |
| *Shift Rate* | | | 0.192 | 0.537 |
| *Firm Size 1* | 0.020 | 0.014 | 0.182 | 0.094* |
| *Firm Size 2* | 0.038 | 0.015** | 0.611 | 0.092*** |
| *Firm Size 3* | 0.084 | 0.026*** | 1.048 | 0.121*** |
| *Firm Size 4* | 0.113 | 0.017*** | 0.699 | 0.100*** |
| *Years of School* | 0.036 | 0.018** | -0.034 | 0.021* |
| *Years of School* $^2$ | 0.001 | 0.001* | | |
| *Experience* | -0.001 | 0.023 | 0.019 | 0.014 |
| *Experience* $^2$ | 0.000 | 0.002 | | |
| *Experience* $^3$ | 0.000 | 0.000 | | |
| *Tenure* | 0.066 | 0.005*** | -0.033 | 0.010*** |
| *Tenure* $^2$ | -0.004 | 0.000*** | | |
| *Union* | 0.109 | 0.014*** | 0.268 | 0.073*** |
| *Non-white* | -0.103 | 0.012*** | 0.059 | 0.066 |
| *North East* | -0.050 | 0.022** | | |
| *North Central* | -0.128 | 0.015*** | | |
| *South* | -0.183 | 0.014*** | | |
| *Female* | -0.189 | 0.012*** | -0.266 | 0.070*** |
| *Married* | 0.050 | 0.011*** | -0.265 | 0.065*** |
| *MSA Resident* | 0.039 | 0.011*** | | |
| *Professional Occupation* | 0.383 | 0.022*** | -0.828 | 0.105*** |
| *Sales Occupation* | 0.255 | 0.022*** | -0.899 | 0.101*** |
| *Craft Occupation* | 0.186 | 0.021*** | -0.721 | 0.094*** |
| *Ag/Construct Industry* | 0.178 | 0.023*** | -0.635 | 0.312** |
| *Manufacturing Industry* | 0.011 | 0.020 | 0.008 | 0.136 |
| *Transportation Industry* | 0.114 | 0.025*** | 0.144 | 0.144 |
| *Wholesale Trade Industry* | 0.017 | 0.029 | -0.094 | 0.309 |
| *Retail Trade Industry* | -0.141 | 0.022*** | 0.279 | 0.433 |
| *Finance Industry* | 0.088 | 0.025*** | -0.587 | 0.344* |
| *Prof. & Related Industry* | -0.043 | 0.021** | -0.145 | 0.200 |
| *Public Administration Industry* | 0.077 | 0.029*** | 0.137 | 0.211 |
| *Leading Index* | -0.055 | 0.008*** | 0.103 | 0.037*** |
| *Shift Worker* | 0.234 | 0.073*** | | |
| *Selection term* | -0.091 | 0.037** | | |
| *Constant* | 5.858 | 0.153*** | -1.052 | 0.495** |
| *Log Likelihood* | -2981.36 | | | |
| *LR Test Statistic* | 112.24*** | | | |
| *Observations* | 5026 | | | |

Levels of significance: ***1%, **5%, *10%. The LR Test Statistic refers to the statistic obtained by comparing the log-likelihood of the unrestricted model (the endogenous switching model, results shown in Table A4) to the log-likelihood of the restricted model (the treatment effects model, results shown above.)

**Table A15. ML Treatment Effects Model, 1990-2000 Pooled Cross-section, Unemployment Rate**

| | Wage Equation | | Selection Equation | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | Coefficient | Std. Error |
| *Number of Children* | | | 0.028 | 0.011*** |
| *Shift Rate* | | | 0.245 | 0.112** |
| *Firm Size 1* | 0.036 | 0.007*** | 0.239 | 0.043*** |
| *Firm Size 2* | 0.058 | 0.007*** | 0.532 | 0.042*** |
| *Firm Size 3* | 0.095 | 0.011*** | 0.751 | 0.057*** |
| *Firm Size 4* | 0.143 | 0.009*** | 0.779 | 0.048*** |
| *Years of School* | 0.004 | 0.007 | -0.058 | 0.010*** |
| *Years of School* $^2$ | 0.002 | 0.000*** | | |
| *Experience* | 0.036 | 0.009*** | 0.004 | 0.006 |
| *Experience* $^2$ | -0.002 | 0.001*** | | |
| *Experience* $^3$ | 0.000 | 0.000** | | |
| *Tenure* | 0.037 | 0.002*** | -0.020 | 0.003*** |
| *Tenure* $^2$ | -0.001 | 0.000*** | | |
| *Union* | 0.094 | 0.007*** | 0.326 | 0.035*** |
| *Non-white* | -0.112 | 0.006*** | 0.067 | 0.030** |
| *North East* | 0.013 | 0.009 | | |
| *North Central* | -0.132 | 0.008*** | | |
| *South* | -0.181 | 0.007*** | | |
| *Female* | 0.068 | 0.005*** | -0.173 | 0.031*** |
| *Married* | -0.195 | 0.006*** | -0.173 | 0.029*** |
| *MSA Resident* | -0.003 | 0.005 | | |
| *Professional Occupation* | 0.378 | 0.010*** | -0.743 | 0.048*** |
| *Sales Occupation* | 0.221 | 0.010*** | -0.733 | 0.048*** |
| *Craft Occupation* | 0.108 | 0.010*** | -0.475 | 0.045*** |
| *Agriculture/Farm/Fish Industry* | -0.086 | 0.019*** | -0.924 | 0.180*** |
| *Mining Industry* | 0.076 | 0.034** | 0.812 | 0.147*** |
| *Construction Industry* | 0.214 | 0.012*** | -0.646 | 0.110*** |
| *Non-Durable Manufacturing Industry* | -0.036 | 0.012*** | 0.240 | 0.068*** |
| *Durable Manufacturing Industry* | 0.046 | 0.011*** | 0.007 | 0.060 |
| *Transportation Industry* | 0.124 | 0.012*** | 0.076 | 0.064 |
| *Wholesale Trade Industry* | -0.145 | 0.011*** | 0.244 | 0.072*** |
| *Retail Trade Industry* | 0.021 | 0.015 | 0.089 | 0.100 |
| *Finance Industry* | 0.115 | 0.012*** | -0.601 | 0.132*** |
| *Prof. & Related Industry* | -0.080 | 0.010*** | -0.107 | 0.071 |
| *Public Administration Industry* | 0.063 | 0.013*** | 0.116 | 0.075 |
| *1992* | 0.090 | 0.009*** | -0.033 | 0.049 |
| *1994* | 0.168 | 0.011*** | -0.093 | 0.065 |
| *1996* | 0.222 | 0.011*** | -0.023 | 0.059 |
| *1998* | 0.272 | 0.012*** | -0.053 | 0.066 |
| *2000* | 0.351 | 0.014*** | -0.038 | 0.076 |
| *Unemployment Rate* | -0.001 | 0.000*** | 0.000 | 0.001 |
| *Shift Worker* | 0.346 | 0.025*** | | |
| *Selection term* | -0.168 | 0.012*** | | |
| *Constant* | 5.941 | 0.072*** | -0.752 | 0.199*** |
| *Log Likelihood* | -15911.96 | | | |
| *LR Test Statistic* | 310.04*** | | | |
| *Observations* | 24732 | | | |

Levels of significance: ***1%, **5%, *10%. The LR Test Statistic refers to the statistic obtained by comparing the log-likelihood of the unrestricted model (the endogenous switching model, results shown in Table A8) to the log-likelihood of the restricted model (the treatment effects model, results shown above.)

**Table A16. ML Treatment Effects Model, 1990-2000 Pooled Cross-section, Leading Index**

| Variable | Wage Equation Coefficient | Wage Equation Std. Error | Selection Equation Coefficient | Selection Equation Std. Error |
|---|---|---|---|---|
| *Number of Children* | | | 0.026 | 0.011** |
| *Shift Rate* | | | 0.246 | 0.112** |
| *Firm Size 1* | 0.038 | 0.007*** | 0.239 | 0.043*** |
| *Firm Size 2* | 0.062 | 0.007*** | 0.532 | 0.042*** |
| *Firm Size 3* | 0.100 | 0.012*** | 0.751 | 0.057*** |
| *Firm Size 4* | 0.146 | 0.009*** | 0.779 | 0.048*** |
| *Years of School* | 0.006 | 0.007 | -0.058 | 0.010*** |
| *Years of School*$^2$ | 0.002 | 0.000*** | | |
| *Experience* | 0.036 | 0.009*** | 0.005 | 0.006 |
| *Experience*$^2$ | -0.002 | 0.001*** | | |
| *Experience*$^3$ | 0.000 | 0.000** | | |
| *Tenure* | 0.036 | 0.002*** | -0.019 | 0.003*** |
| *Tenure*$^2$ | -0.001 | 0.000*** | | |
| *Union* | 0.090 | 0.007*** | 0.329 | 0.034*** |
| *Non-white* | -0.112 | 0.006*** | 0.072 | 0.030** |
| *North East* | 0.027 | 0.009*** | | |
| *North Central* | -0.105 | 0.008*** | | |
| *South* | -0.148 | 0.007*** | | |
| *Female* | -0.196 | 0.006*** | -0.171 | 0.031*** |
| *Married* | 0.067 | 0.005*** | -0.173 | 0.029*** |
| *MSA Resident* | 0.002 | 0.005 | | |
| *Professional Occupation* | 0.381 | 0.010*** | -0.744 | 0.048*** |
| *Sales Occupation* | 0.222 | 0.010*** | -0.733 | 0.048*** |
| *Craft Occupation* | 0.109 | 0.010*** | -0.476 | 0.045*** |
| *Agriculture/Farm/Fish Industry* | -0.108 | 0.019*** | -0.944 | 0.180*** |
| *Mining Industry* | 0.061 | 0.034* | 0.801 | 0.147*** |
| *Construction Industry* | 0.214 | 0.012*** | -0.645 | 0.110*** |
| *Non-Durable Manufacturing Industry* | -0.040 | 0.012*** | 0.239 | 0.067*** |
| *Durable Manufacturing Industry* | 0.044 | 0.011*** | 0.010 | 0.060 |
| *Transportation Industry* | 0.122 | 0.012*** | 0.080 | 0.064 |
| *Wholesale Trade Industry* | -0.149 | 0.011*** | 0.247 | 0.072*** |
| *Retail Trade Industry* | 0.017 | 0.015 | 0.089 | 0.100 |
| *Finance Industry* | 0.116 | 0.012*** | -0.596 | 0.132*** |
| *Prof. & Related Industry* | -0.087 | 0.010*** | -0.106 | 0.071 |
| *Public Administration Industry* | 0.056 | 0.013*** | 0.116 | 0.075 |
| *1992* | 0.063 | 0.009*** | -0.050 | 0.048 |
| *1994* | 0.166 | 0.012*** | -0.139 | 0.069** |
| *1996* | 0.213 | 0.011*** | -0.043 | 0.059 |
| *1998* | 0.288 | 0.012*** | -0.077 | 0.067 |
| *2000* | 0.367 | 0.014*** | -0.050 | 0.076 |
| *Leading Index* | -0.014 | 0.003*** | 0.033 | 0.017** |
| *Shift Worker* | 0.349 | 0.025*** | | |
| *Selection term* | -0.170 | 0.011*** | | |
| *Constant* | 5.841 | 0.072*** | -0.816 | 0.195*** |
| *Log Likelihood* | -15995.94 | | | |
| *LR Test Statistic* | 309.14*** | | | |
| *Observations* | 24732 | | | |

Levels of significance: ***1%, **5%, *10%. The LR Test Statistic refers to the statistic obtained by comparing the log-likelihood of the unrestricted model (the endogenous switching model, results shown in Table A12) to the log-likelihood of the restricted model (the treatment effects model, results shown above.)

## Table A17. Interaction Effects, 1992 Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.8279705 | | -0.6562409 | | -0.5004471 | | -0.3213925 | | -0.2003775 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 5.3% | A | 0.001682 | 0.025110 | 0.003144 | 0.033841 | 0.005364 | 0.043783 | 0.009532 | 0.057978 | 0.013738 | 0.069459 |
| Avg.* | | 0.013396 | | 0.018493 | | 0.024573 | | 0.033755 | | 0.041598 | |
| 6.2% | B | 0.001718 | 0.025367 | 0.003208 | 0.034170 | 0.005467 | 0.044188 | 0.009702 | 0.058484 | 0.013971 | 0.070041 |
| Avg. | | 0.013543 | | 0.018689 | | 0.024828 | | 0.034093 | | 0.042006 | |
| 7.9% | C | 0.001789 | 0.025858 | 0.003333 | 0.034798 | 0.005666 | 0.044962 | 0.010030 | 0.059450 | 0.014420 | 0.071152 |
| Avg. | | 0.013824 | | 0.019065 | | 0.025314 | | 0.034740 | | 0.042786 | |
| 9.0% | D | 0.001836 | 0.026180 | 0.003415 | 0.035209 | 0.005798 | 0.045469 | 0.010248 | 0.060082 | 0.014717 | 0.071877 |
| Avg. | | 0.014008 | | 0.019312 | | 0.025633 | | 0.035165 | | 0.043297 | |
| 10.4% | E | 0.001898 | 0.026595 | 0.003523 | 0.035739 | 0.005970 | 0.046120 | 0.010530 | 0.060893 | 0.015102 | 0.072809 |
| Avg. | | 0.014247 | | 0.019631 | | 0.026045 | | 0.035712 | | 0.043956 | |

This table presents lower and upper bounds on the probability of working the night shift. The bounds on the probability are computed for each combination of the log wage differential and the unemployment rate. For example, the lower bound for the log wage differential and unemployment rate combination A1 is 0.001682 while the upper bound is 0.025110. *The average of the lower and upper bounds is reported below each combination. For example, the average probability for combination A1 is 0.013396. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1992. This corresponds to approximate wage differentials of -$7.26, -$5.10, -$4.01, -$2.38, and -$1.48. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1992.

## Table A18. Interaction Effects, 1992 Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.8146973 | | -0.6465068 | | -0.4923245 | | -0.3098512 | | -0.1848998 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.23 | A | 0.001873 | 0.026984 | 0.003051 | 0.034015 | 0.004674 | 0.041720 | 0.007547 | 0.052599 | 0.010316 | 0.061265 |
| Avg.* | | 0.014429 | | 0.018533 | | 0.023197 | | 0.030073 | | 0.035790 | |
| 0.43 | B | 0.001924 | 0.027330 | 0.003131 | 0.034434 | 0.004790 | 0.042215 | 0.007724 | 0.053194 | 0.010547 | 0.061936 |
| Avg. | | 0.014627 | | 0.018782 | | 0.023502 | | 0.030459 | | 0.036241 | |
| 1.64 | C | 0.002262 | 0.029501 | 0.003651 | 0.037058 | 0.005546 | 0.045307 | 0.008871 | 0.056907 | 0.012047 | 0.066115 |
| Avg. | | 0.015882 | | 0.020355 | | 0.025427 | | 0.032889 | | 0.039081 | |
| 2.51 | D | 0.002536 | 0.031150 | 0.004071 | 0.039044 | 0.006154 | 0.047641 | 0.009785 | 0.059701 | 0.013236 | 0.069252 |
| Avg. | | 0.016843 | | 0.021558 | | 0.026897 | | 0.034743 | | 0.042535 | |
| 3.01 | E | 0.002707 | 0.032131 | 0.004332 | 0.040224 | 0.006529 | 0.049025 | 0.010347 | 0.061354 | 0.013964 | 0.071106 |
| Avg. | | 0.017419 | | 0.022278 | | 0.027777 | | 0.035850 | | 0.042535 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1992. This corresponds to approximate wage differentials of -$7.23, -$5.09, -$3.96, -$2.30, and -$1.42. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1992.

## Table A19. Interaction Effects, 1994 Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.9487352 | | -0.7812395 | | -0.5849081 | | -0.396421 | | -0.1961932 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 4.4% | A | 0.005686 | 0.007173 | 0.011066 | 0.013431 | 0.022565 | 0.026300 | 0.041791 | 0.047069 | 0.074906 | 0.081754 |
| Avg.* | | 0.006430 | | 0.012249 | | 0.024433 | | 0.044430 | | 0.078330 | |
| 5.2% | B | 0.005997 | 0.007542 | 0.011623 | 0.014067 | 0.023588 | 0.027423 | 0.043488 | 0.048873 | 0.077585 | 0.084521 |
| Avg. | | 0.006769 | | 0.012845 | | 0.025505 | | 0.046181 | | 0.081053 | |
| 7.0% | C | 0.006752 | 0.008432 | 0.012965 | 0.015593 | 0.026030 | 0.030096 | 0.047509 | 0.053136 | 0.083878 | 0.091003 |
| Avg. | | 0.007592 | | 0.014279 | | 0.028063 | | 0.050323 | | 0.087440 | |
| 8.3% | D | 0.007348 | 0.009132 | 0.014015 | 0.016782 | 0.027922 | 0.032158 | 0.050595 | 0.056393 | 0.088656 | 0.095909 |
| Avg. | | 0.008240 | | 0.015398 | | 0.030040 | | 0.053494 | | 0.092282 | |
| 10.3% | E | 0.008356 | 0.010308 | 0.015774 | 0.018761 | 0.031057 | 0.035556 | 0.055650 | 0.061710 | 0.096397 | 0.103831 |
| Avg. | | 0.009332 | | 0.017268 | | 0.033306 | | 0.058680 | | 0.100114 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1994. This corresponds to approximate wage differentials of -$9.12, -$6.78, -$5.07, -$2.96, and -$1.53. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1994.

## Table A20. Interaction Effects, 1994 Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.7668033 | | -0.5879579 | | -0.3794389 | | -0.1761456 | | 0.0170426 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 1.57 | A | 0.000000 | 0.005276 | 0.000000 | 0.008568 | 0.000000 | 0.014572 | 0.000000 | 0.023608 | 9.78E-09 | 0.036168 |
| Avg.* | | 0.002638 | | 0.004284 | | 0.007286 | | 0.011804 | | 0.018084 | |
| 1.87 | B | 0.000000 | 0.005276 | 0.000000 | 0.008938 | 0.000000 | 0.015158 | 0.000000 | 0.024490 | 2.32E-08 | 0.037423 |
| Avg. | | 0.002638 | | 0.004469 | | 0.007579 | | 0.012245 | | 0.018712 | |
| 2.58 | C | 0.000000 | 0.006127 | 0.000000 | 0.009869 | 0.000000 | 0.016625 | 0.000000 | 0.026687 | 1.56E-07 | 0.040535 |
| Avg. | | 0.003064 | | 0.004935 | | 0.008313 | | 0.013344 | | 0.020268 | |
| 3.16 | D | 0.000000 | 0.006669 | 0.000000 | 0.010692 | 0.000000 | 0.017913 | 0.000000 | 0.028603 | 6.30E-07 | 0.043231 |
| Avg. | | 0.003335 | | 0.005346 | | 0.008956 | | 0.014302 | | 0.023339 | |
| 3.86 | E | 0.000000 | 0.007380 | 0.000000 | 0.011764 | 0.000000 | 0.019579 | 1.42E-10 | 0.031066 | 2.84E-06 | 0.046675 |
| Avg. | | 0.003690 | | 0.005882 | | 0.009789 | | 0.015533 | | 0.023339 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1994. This corresponds to approximate wage differentials of -$7.67, -$5.27, -$3.52, -$1.35, and $0.13. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1994.

### Table A21. Interaction Effects, 1996 Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -2.24473 | | -1.951395 | | -1.670115 | | -1.335699 | | -1.072526 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.6% | A | 0.000000 | 0.000177 | 8.24E-11 | 0.000966 | 6.67E-08 | 0.004022 | 0.000016 | 0.017144 | 0.000493 | 0.044684 |
| Avg.* | | 0.000089 | | 0.000483 | | 0.002011 | | 0.008580 | | 0.022589 | |
| 4.5% | B | 0.000000 | 0.000174 | 5.49E-11 | 0.000950 | 6.29E-08 | 0.003965 | 0.000016 | 0.016942 | 0.000476 | 0.044238 |
| Avg. | | 0.000087 | | 0.000475 | | 0.001983 | | 0.008479 | | 0.022357 | |
| 6.8% | C | 0.000000 | 0.000166 | 5.49E-11 | 0.000911 | 5.43E-08 | 0.003823 | 0.000014 | 0.016435 | 0.000436 | 0.043113 |
| Avg. | | 0.000083 | | 0.000456 | | 0.001912 | | 0.008225 | | 0.021774 | |
| 7.6% | D | 0.000000 | 0.000163 | 5.49E-11 | 0.000911 | 5.16E-08 | 0.003775 | 0.000013 | 0.016262 | 0.000422 | 0.042727 |
| Avg. | | 0.000082 | | 0.000456 | | 0.001888 | | 0.008138 | | 0.021575 | |
| 13.3% | E | 0.000000 | 0.000145 | 4.12E-11 | 0.000809 | 3.60E-08 | 0.003447 | 0.000010 | 0.015072 | 0.000338 | 0.040057 |
| Avg. | | 0.000073 | | 0.000405 | | 0.001723 | | 0.007541 | | 0.020197 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1996. This corresponds to approximate wage differentials of -$16.20, -$12.18, -$10.10, -$6.92, and -$5.63. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1996.

### Table A22. Interaction Effects, 1998 Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.401019 | | -0.2483997 | | -0.1253796 | | 0.0209112 | | 0.1527381 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 2.8% | A | 0.000120 | 0.040518 | 0.000123 | 0.040694 | 0.000125 | 0.040836 | 0.000128 | 0.041006 | 0.000130 | 0.041159 |
| Avg.* | | 0.020319 | | 0.020408 | | 0.020480 | | 0.020567 | | 0.020645 | |
| 3.3% | B | 0.000121 | 0.040550 | 0.000123 | 0.040727 | 0.000125 | 0.040869 | 0.000128 | 0.041039 | 0.000131 | 0.041192 |
| Avg. | | 0.020335 | | 0.020425 | | 0.020497 | | 0.020583 | | 0.020661 | |
| 5.1% | C | 0.000122 | 0.040669 | 0.000125 | 0.040846 | 0.000127 | 0.040988 | 0.000130 | 0.041159 | 0.000133 | 0.041313 |
| Avg. | | 0.020396 | | 0.020485 | | 0.020558 | | 0.020644 | | 0.020723 | |
| 5.8% | D | 0.000123 | 0.040715 | 0.000126 | 0.040892 | 0.000128 | 0.041035 | 0.000131 | 0.041205 | 0.000133 | 0.041359 |
| Avg. | | 0.020419 | | 0.020509 | | 0.020581 | | 0.020668 | | 0.020746 | |
| 7.9% | E | 0.000125 | 0.040854 | 0.000128 | 0.041031 | 0.000130 | 0.041175 | 0.000133 | 0.041346 | 0.000136 | 0.041500 |
| Avg. | | 0.020490 | | 0.020580 | | 0.020652 | | 0.020739 | | 0.020818 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 1998. This corresponds to approximate wage differentials of -$6.02, -$3.07, -$1.67, $0.23, and $1.96. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 1998.

## Table A23. Interaction Effects, 2000 Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.2001662 | | -0.0716219 | | 0.119007 | | 0.2893047 | | 0.4987311 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 2.4% | A | 0.000236 | 0.044681 | 0.000175 | 0.042035 | 0.000110 | 0.038344 | 0.000071 | 0.035272 | 0.000040 | 0.031771 |
| Avg.* | | 0.022458 | | 0.021105 | | 0.019227 | | 0.017672 | | 0.015906 | |
| 2.9% | B | 0.000256 | 0.045451 | 0.000190 | 0.042769 | 0.000120 | 0.039026 | 0.000078 | 0.035910 | 0.000045 | 0.032357 |
| Avg. | | 0.022854 | | 0.021480 | | 0.019573 | | 0.017994 | | 0.016201 | |
| 4.5% | C | 0.000332 | 0.047988 | 0.000249 | 0.045186 | 0.000160 | 0.041274 | 0.000105 | 0.038012 | 0.000061 | 0.034289 |
| Avg. | | 0.024160 | | 0.022718 | | 0.020717 | | 0.019059 | | 0.017175 | |
| 5.3% | D | 0.000377 | 0.049297 | 0.000284 | 0.046435 | 0.000183 | 0.042435 | 0.000122 | 0.039100 | 0.000071 | 0.035291 |
| Avg. | | 0.024837 | | 0.023360 | | 0.021309 | | 0.019611 | | 0.017681 | |
| 6.4% | E | 0.000448 | 0.051143 | 0.000339 | 0.048197 | 0.000221 | 0.044076 | 0.000148 | 0.040636 | 0.000088 | 0.036705 |
| Avg. | | 0.025796 | | 0.024268 | | 0.022148 | | 0.020392 | | 0.018397 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 2000. This corresponds to approximate wage differentials of -$2.93, -$0.96, $2.48, $4.86, and $9.77. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 2000.

## Table A24. Interaction Effects, 2000 Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.2102375 | | -0.0815539 | | 0.1065317 | | 0.2671175 | | 0.4953103 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.15 | A | 0.000717 | 0.055476 | 0.000550 | 0.052283 | 0.000369 | 0.047879 | 0.000258 | 0.044356 | 0.000152 | 0.039708 |
| Avg.* | | 0.028096 | | 0.026417 | | 0.024124 | | 0.022307 | | 0.019930 | |
| 1.11 | B | 0.000462 | 0.050315 | 0.000351 | 0.047360 | 0.000230 | 0.043290 | 0.000159 | 0.040041 | 0.000091 | 0.035764 |
| Avg. | | 0.025389 | | 0.023855 | | 0.021760 | | 0.020100 | | 0.017927 | |
| 1.52 | C | 0.000381 | 0.048230 | 0.000287 | 0.045373 | 0.000187 | 0.041441 | 0.000128 | 0.038304 | 0.000072 | 0.034179 |
| Avg. | | 0.024305 | | 0.022830 | | 0.020814 | | 0.019216 | | 0.017126 | |
| 2.13 | D | 0.000284 | 0.045254 | 0.000212 | 0.042539 | 0.000136 | 0.038807 | 0.000092 | 0.035833 | 0.000051 | 0.031928 |
| Avg. | | 0.022769 | | 0.021376 | | 0.019472 | | 0.017962 | | 0.015738 | |
| 2.27 | E | 0.000265 | 0.044592 | 0.000198 | 0.041909 | 0.000126 | 0.038222 | 8.47E-05 | 0.035285 | 0.000047 | 0.031429 |
| Avg. | | 0.022429 | | 0.021053 | | 0.019174 | | 0.017685 | | 0.015738 | |

For explanation of how to interpret these results, see footnote on Table A18. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in 2000. This corresponds to approximate wage differentials of -$3.04, -$1.11, $2.24, $4.53, and $9.41. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in 2000.

## Table A25. Interaction Effects, Manufacturing Industry, Pooled Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.396927 | | -1.157729 | | -0.8751326 | | -0.6332769 | | -0.4982467 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.2% | A | 2.54E-08 | 0.019398 | 7.92E-07 | 0.030819 | 0.000023 | 0.050940 | 0.000250 | 0.075429 | 0.000772 | 0.092534 |
| Avg.* | | 0.009699 | | 0.015410 | | 0.025482 | | 0.037839 | | 0.046653 | |
| 4.2% | B | 3.05E-08 | 0.019873 | 9.28E-07 | 0.031520 | 0.000027 | 0.051992 | 0.000278 | 0.076854 | 0.000849 | 0.094194 |
| Avg. | | 0.009937 | | 0.015760 | | 0.026009 | | 0.038566 | | 0.047522 | |
| 6.0% | C | 4.27E-08 | 0.020755 | 1.23E-06 | 0.032814 | 0.000034 | 0.053928 | 0.000335 | 0.079472 | 0.001004 | 0.097238 |
| Avg. | | 0.010377 | | 0.016407 | | 0.026981 | | 0.039903 | | 0.049121 | |
| 7.2% | D | 5.31E-08 | 0.021360 | 1.49E-06 | 0.033700 | 0.000039 | 0.055250 | 0.000380 | 0.081253 | 0.001121 | 0.099307 |
| Avg. | | 0.010680 | | 0.016851 | | 0.027644 | | 0.040816 | | 0.050214 | |
| 9.3% | E | 7.77E-08 | 0.022456 | 2.05E-06 | 0.035299 | 0.000051 | 0.057624 | 0.000470 | 0.084443 | 0.001355 | 0.103004 |
| Avg. | | 0.011228 | | 0.017650 | | 0.028837 | | 0.042457 | | 0.052179 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -$14.22, -$9.21, -$7.57, -$4.23, and -$3.20. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

## Table A26. Interaction Effects, Manufacturing Industry, Pooled Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.323801 | | -1.084101 | | -0.8477175 | | -0.5775213 | | -0.4317508 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.43 | A | 2.47E-09 | 0.021263 | 2.50E-07 | 0.035562 | 1.02E-05 | 0.056564 | 0.000285 | 0.091340 | 0.001205 | 0.115690 |
| Avg.* | | 0.010632 | | 0.017781 | | 0.028287 | | 0.045812 | | 0.058448 | |
| 1.16 | B | 1.73E-09 | 0.020567 | 1.93E-07 | 0.034492 | 8.26E-06 | 0.055008 | 0.000243 | 0.089092 | 0.001051 | 0.113019 |
| Avg. | | 0.010283 | | 0.017246 | | 0.027508 | | 0.044667 | | 0.057035 | |
| 1.70 | C | 1.41E-09 | 0.020064 | 1.59E-07 | 0.033717 | 7.06E-06 | 0.053879 | 0.000215 | 0.087455 | 0.000949 | 0.111072 |
| Avg. | | 0.010032 | | 0.016859 | | 0.026943 | | 0.043835 | | 0.056011 | |
| 2.32 | D | 1.02E-09 | 0.019500 | 1.27E-07 | 0.032846 | 5.88E-06 | 0.052605 | 0.000187 | 0.085604 | 0.000842 | 0.108866 |
| Avg. | | 0.009750 | | 0.016423 | | 0.026305 | | 0.042896 | | 0.054854 | |
| 2.68 | E | 8.49E-10 | 0.019179 | 1.11E-07 | 0.032348 | 5.29E-06 | 0.051877 | 0.000173 | 0.084543 | 0.000786 | 0.107600 |
| Avg. | | 0.009589 | | 0.016174 | | 0.025941 | | 0.042358 | | 0.054193 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -$13.78, -$8.84, -$7.21, -$3.90, and -$2.88. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

## Table A27. Interaction Effects, Retail Trade Industry, Pooled Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.368292 | | -1.206698 | | -1.016966 | | -0.8193297 | | -0.6393297 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.2% | A | 1.67E-07 | 0.018676 | 2.18E-06 | 0.029548 | 0.000031 | 0.048539 | 0.000327 | 0.077603 | 0.002026 | 0.114144 |
| Avg.* | | 0.009338 | | 0.014775 | | 0.024285 | | 0.038965 | | 0.058085 | |
| 4.2% | B | 1.91E-07 | 0.019127 | 2.46E-06 | 0.030211 | 0.000034 | 0.049531 | 0.000357 | 0.079032 | 0.002184 | 0.116042 |
| Avg. | | 0.009563 | | 0.015107 | | 0.024783 | | 0.039695 | | 0.059113 | |
| 6.0% | C | 2.44E-07 | 0.019962 | 3.05E-06 | 0.031434 | 0.000041 | 0.051358 | 0.000418 | 0.081656 | 0.002498 | 0.119514 |
| Avg. | | 0.009981 | | 0.015719 | | 0.025699 | | 0.041037 | | 0.061006 | |
| 7.3% | D | 2.91E-07 | 0.020584 | 3.56E-06 | 0.032343 | 0.000047 | 0.052710 | 0.000469 | 0.083591 | 0.002748 | 0.122067 |
| Avg. | | 0.010292 | | 0.016173 | | 0.026378 | | 0.042030 | | 0.062408 | |
| 9.6% | E | 3.94E-07 | 0.021724 | 4.67E-06 | 0.034005 | 0.000059 | 0.055171 | 0.000571 | 0.087098 | 0.003247 | 0.126678 |
| Avg. | | 0.010862 | | 0.017005 | | 0.027615 | | 0.043834 | | 0.064963 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -\$9.49, -\$7.27, -\$5.97, -\$4.06, and -\$2.95. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

## Table A28. Interaction Effects, Retail Trade Industry, Pooled Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1.374762 | | -1.212662 | | -1.022833 | | -0.8315372 | | -0.6356616 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.41 | A | 8.05E-08 | 0.016311 | 1.42E-06 | 0.027305 | 2.66E-05 | 0.047413 | 0.000328 | 0.078236 | 0.002810 | 0.123528 |
| Avg.* | | 0.008155 | | 0.013653 | | 0.023720 | | 0.039282 | | 0.063169 | |
| 1.15 | B | 1.04E-07 | 0.017061 | 1.78E-06 | 0.028463 | 3.23E-05 | 0.049228 | 0.000387 | 0.080914 | 0.003214 | 0.127260 |
| Avg. | | 0.008531 | | 0.014233 | | 0.024630 | | 0.040650 | | 0.065237 | |
| 1.66 | C | 1.24E-07 | 0.017595 | 2.08E-06 | 0.029285 | 3.68E-05 | 0.050511 | 0.000432 | 0.082800 | 0.003522 | 0.129877 |
| Avg. | | 0.008798 | | 0.014644 | | 0.025274 | | 0.041616 | | 0.066699 | |
| 2.27 | D | 1.53E-07 | 0.018253 | 2.50E-06 | 0.030294 | 4.31E-05 | 0.052080 | 0.000493 | 0.085098 | 0.003924 | 0.133056 |
| Avg. | | 0.009127 | | 0.015148 | | 0.026062 | | 0.042796 | | 0.068490 | |
| 2.65 | E | 1.73E-07 | 0.018673 | 2.80E-06 | 0.030936 | 4.75E-05 | 0.053078 | 0.000535 | 0.086554 | 0.004195 | 0.135063 |
| Avg. | | 0.009337 | | 0.015470 | | 0.026563 | | 0.043545 | | 0.069629 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -\$9.54, -\$7.27, -\$5.98, -\$4.11, and -\$2.96. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

## Table A29. Interaction Effects, Professional and Related Industry, Pooled Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.1782866 | | -0.0771141 | | 0.0628313 | | 0.1883903 | | 0.3236609 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.1% | A | 0.0059974 | 0.057129 | 0.0041699 | 0.048961 | 0.002466 | 0.039229 | 0.001508 | 0.031893 | 0.000870 | 0.025295 |
| Avg.* | | 0.031563 | | 0.026565 | | 0.020847 | | 0.016700 | | 0.013083 | |
| 4.1% | B | 0.0055283 | 0.055182 | 0.0038314 | 0.047239 | 0.002257 | 0.037789 | 0.001375 | 0.030679 | 0.000791 | 0.024294 |
| Avg. | | 0.030355 | | 0.025535 | | 0.020023 | | 0.016027 | | 0.012543 | |
| 6.1% | C | 0.0046867 | 0.051445 | 0.0032277 | 0.043940 | 0.001886 | 0.035040 | 0.001142 | 0.028365 | 0.000653 | 0.022392 |
| Avg. | | 0.028066 | | 0.023584 | | 0.018463 | | 0.014754 | | 0.011522 | |
| 7.3% | D | 0.0042387 | 0.049301 | 0.0029084 | 0.042052 | 0.001691 | 0.033470 | 0.001020 | 0.027048 | 0.000581 | 0.021312 |
| Avg. | | 0.026770 | | 0.022480 | | 0.017581 | | 0.014034 | | 0.010947 | |
| 9.6% | E | 3.49E-03 | 0.045392 | 0.0023755 | 0.038616 | 0.001369 | 0.030623 | 0.000820 | 0.024666 | 0.000463 | 0.019365 |
| Avg. | | 0.024439 | | 0.020496 | | 0.015996 | | 0.012743 | | 0.009914 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -\$1.74, -\$0.75, \$1.30, \$2.58, and \$5.56. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

## Table A30. Interaction Effects, Professional and Related Industry, Pooled Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.191062 | | -0.1053805 | | 0.018251 | | 0.1296821 | | 0.2384944 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.51 | A | 0.0020927 | 0.036428 | 0.0017937 | 0.034122 | 0.0014320 | 0.031008 | 0.001166 | 0.028406 | 0.000952 | 0.026043 |
| Avg.* | | 0.019260 | | 0.017958 | | 0.016220 | | 0.014786 | | 0.013498 | |
| 1.26 | B | 0.0028033 | 0.041226 | 0.0024104 | 0.038674 | 0.0019327 | 0.035220 | 0.001579 | 0.032328 | 0.001294 | 0.029695 |
| Avg. | | 0.022015 | | 0.020542 | | 0.018576 | | 0.016954 | | 0.015494 | |
| 1.72 | C | 0.003343 | 0.044415 | 0.0028805 | 0.041703 | 0.0023163 | 0.038028 | 0.001898 | 0.034946 | 0.001558 | 0.032138 |
| Avg. | | 0.023879 | | 0.022292 | | 0.020172 | | 0.018422 | | 0.016848 | |
| 2.27 | D | 0.004112 | 0.048485 | 0.0035527 | 0.045574 | 0.0028674 | 0.041622 | 0.002356 | 0.038303 | 0.001940 | 0.035273 |
| Avg. | | 0.026298 | | 0.024563 | | 0.022245 | | 0.020330 | | 0.018606 | |
| 2.64 | E | 0.0047161 | 0.051387 | 0.0040824 | 0.048336 | 0.0033034 | 0.044192 | 0.002720 | 0.040706 | 0.002244 | 0.037521 |
| Avg. | | 0.028051 | | 0.026209 | | 0.023747 | | 0.021713 | | 0.019882 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentil, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -\$1.94, -\$1.02, \$0.51, \$1.69, and \$3.60. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

### Table A31. Interaction Effects, Services Industry, Pooled Cross-Section with Unemployment Rate

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.6528068 | | -0.4444704 | | -0.2708984 | | -0.0843472 | | 0.0691571 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Unemp. Rate | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 3.1% | A | 0.0426596 | 0.087289 | 0.0351066 | 0.076655 | 0.029660 | 0.068572 | 0.024584 | 0.060632 | 0.020956 | 0.054652 |
| Avg.* | | 0.064974 | | 0.055881 | | 0.049116 | | 0.042608 | | 0.037804 | |
| 4.0% | B | 0.0414188 | 0.085582 | 0.0340431 | 0.075107 | 0.028731 | 0.067150 | 0.023786 | 0.059340 | 0.020256 | 0.053461 |
| Avg. | | 0.063500 | | 0.054575 | | 0.047941 | | 0.041563 | | 0.036858 | |
| 5.8% | C | 0.0390223 | 0.082242 | 0.0319931 | 0.072083 | 0.026943 | 0.064376 | 0.022252 | 0.056821 | 0.018911 | 0.051142 |
| Avg. | | 0.060632 | | 0.052038 | | 0.045660 | | 0.039537 | | 0.035027 | |
| 7.0% | D | 0.0374862 | 0.080071 | 0.030682 | 0.070119 | 0.025801 | 0.062577 | 0.021275 | 0.055189 | 0.018057 | 0.049640 |
| Avg. | | 0.058778 | | 0.050401 | | 0.044189 | | 0.038232 | | 0.033848 | |
| 9.0% | E | 0.0350327 | 0.076548 | 0.0285926 | 0.066938 | 0.023986 | 0.059665 | 0.019725 | 0.052552 | 0.016703 | 0.047216 |
| Avg. | | 0.055790 | | 0.047765 | | 0.041825 | | 0.036138 | | 0.031959 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -$8.65, -$4.47, -$3.12, -$0.62, and $0.57. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

### Table A32. Interaction Effects, Services Industry, Pooled Cross-Section with Leading Index

| | | Log Wage Differential | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.9832497 | | -0.7466455 | | -0.5444499 | | -0.3264408 | | -0.1682181 | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| Leading Index | Cell | 1 | | 2 | | 3 | | 4 | | 5 | |
| 0.47 | A | 0.0752863 | 0.077636 | 0.0684688 | 0.070730 | 0.0630284 | 0.065210 | 0.057545 | 0.059639 | 0.053806 | 0.055834 |
| Avg.* | | 0.076461 | | 0.069599 | | 0.064119 | | 0.058592 | | 0.054820 | |
| 1.26 | B | 0.0763756 | 0.078738 | 0.0694818 | 0.071757 | 0.0639787 | 0.066175 | 0.058431 | 0.060539 | 0.054646 | 0.056689 |
| Avg. | | 0.077557 | | 0.070619 | | 0.065077 | | 0.059485 | | 0.055667 | |
| 1.75 | C | 0.0770572 | 0.079428 | 0.070116 | 0.072399 | 0.0645738 | 0.066779 | 0.058985 | 0.061103 | 0.055172 | 0.057225 |
| Avg. | | 0.078243 | | 0.071258 | | 0.065676 | | 0.060044 | | 0.056198 | |
| 2.31 | D | 0.0778419 | 0.080222 | 0.0708461 | 0.073139 | 0.065259 | 0.067474 | 0.059624 | 0.061752 | 0.055778 | 0.057841 |
| Avg. | | 0.079032 | | 0.071993 | | 0.066367 | | 0.060688 | | 0.056810 | |
| 2.68 | E | 0.0783636 | 0.080750 | 0.0713317 | 0.073631 | 0.0657149 | 0.067937 | 0.060049 | 0.062184 | 0.056181 | 0.058252 |
| Avg. | | 0.079557 | | 0.072481 | | 0.066826 | | 0.061116 | | 0.057216 | |

For explanation of how to interpret these results, see footnote on Table A17. From left to right, the values of the log wage differential indicate the 10th percentile, 25th percentil, mean, 75th percentile, and 90th percentile of the predicted log wage differential in the pooled cross-section. This corresponds to approximate wage differentials of -$1.94, -$1.02, $0.51, $1.69, and $3.60. From top to bottom, the values of the unemploymentrate indicate the 10th percentile, 25th percentile, mean, 75th percentile, and 90th percentile of the unemployment rate in the pooled cross-section.

**Table A33. OLS Regressions, Coefficients for Main Variables of Interest, 1990 Cross-Section and 1990-2000 Pooled Cross-Sections**

| | | Coefficient | | |
|---|---|---|---|---|
| Sample | Model | Nshift | LEC | Nshift*LEC |
| *Cross-Section (Unemployment Rate)* | (1) | 0.060*** | | |
| | (1a) | 0.061** | -0.003*** | |
| | (2) | -0.011 | -0.003*** | 0.001 |
| *Cross-Section (Leading Index)* | (1) | 0.060*** | | |
| | (1a) | 0.063** | -0.053*** | |
| | (2) | 0.137** | -0.053*** | -0.001 |
| *Pooled Cross-Section (Unemployment Rate)* | (1) | 0.018* | | |
| | (1a) | 0.019* | -0.001*** | |
| | (2) | -0.016 | -0.001*** | 0.001 |
| *Pooled Cross-Section (Leading Index)* | (1) | 0.018* | | |
| | (1a) | 0.018* | -0.013*** | |
| | (2) | 0.044* | -0.013*** | -0.001 |

Levels of significance: ***1%, **5%, *10%. CS denotes results from the 1990 cross-section. PCS denotes results from the 1990-2000 pooled cross-section. (1) indicates the simple model without the unemployment rate, (2) indicates the simple model with the unemployment rate, and (3) indicates the simple model with both the unemployment rate and the interaction between the unemployment rate and the night shift variable.

**APPENDIX B**

**Proof (Theorem 1, Section 4.3.4)**

Given $w_i^s - w_i^d = E(w_i^s - w_i^d \mid LEC_i, X_i, Z_i)$, it follows from (14) that

$$P(s_i = 1 \mid w_i^s - w_i^d, LEC_i, X_i, Z_i) = \\ 1 - \Phi[-E(s_i^* \mid LEC_i, X_i, Z_i) / \sqrt{\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i)(1-\rho^2)}] \tag{A1}$$

where:

$$\mathrm{var}(s_i^* \mid LEC_i, X_i, Z_i)(1-\rho^2) = 1 + 2(1-\delta)(\sigma_{sv} - \sigma_{dv}) - \frac{(\sigma_{sv} - \sigma_{dv})^2}{\sigma_s^2 + \sigma_d^2 - 2\sigma_{sd}} \tag{A2}$$

By Vijverberg (1993, p.71),

$$\sigma_{sv}\sigma_{dv} - c \le \sigma_{sd} \le \sigma_{sv}\sigma_{dv} + c$$

and, therefore,

$$-2(\sigma_{sv}\sigma_{dv} - c) \ge -2\sigma_{sd} \ge -2(\sigma_{sv}\sigma_{dv} + c) \tag{A3}$$

**Table B1. NSLY79 Geographic Regions**

| Northeast | North Central | South | West |
|---|---|---|---|
| Connecticut | Illinois | Alabama | Alaska |
| Maine | Indiana | Arkansas | Arizona |
| Massachusetts | Iowa | Delaware | California |
| New Hampshire | Kansas | District of Columbia | Colorado |
| New Jersey | Michigan | Florida | Hawaii |
| New York | Minnesota | Georgia | Idaho |
| Pennsylvania | Missouri | Kentucky | Montana |
| Rhode Island | Nebraska | Louisiana | Nevada |
| Vermont | North Dakota | Maryland | New Mexico |
| | Ohio | Mississippi | Oregon |
| | South Dakota | North Carolina | Utah |
| | Wisconsin | Oklahoma | Washington |
| | | South Carolina | Wyoming |
| | | Tennessee | |
| | | Texas | |
| | | Virginia | |
| | | West Virginia | |

## VITA

Colene Burns Trent, native of Hayden, Alabama, graduated from the University of North Alabama with a Bachelor of Business Administration degree in Finance and Economics in 2007. In 2009, she completed a Master of Business Administration degree from the University of North Alabama. Colene entered the economics Ph.D. program at the University of Mississippi in 2009. In 2013, she received the Outstanding Economics Graduate Student Fellowship.