DOWNWARD NOMINAL WAGE RIGIDITY: A DYNAMIC MODEL AND MICROECONOMIC EVIDENCE

by

Liudmyla Hvozdyk

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Arts in Economics

National University "Kyiv-Mohyla Academy"
Economics Education and Research Consortium
Master's Program in Economics

2004

Approved by ____
Ms.Svitlana Budagovska (Head of the State Examination Committee)

____

____

____

Program Authorized
to Offer Degree Master's Program in Economics, NaUKMA

Date ____

National University "Kyiv-Mohyla Academy"

Abstract

DOWNWARD NOMINAL WAGE RIGIDITY: A DYNAMIC MODEL AND MICROECONOMIC EVIDENCE

by Liudmyla Hvozdyk

Head of the State Examination Committee: Ms.Svitlana Budagovska,
Economist, World Bank of Ukraine

In the thesis, I evaluate whether downward nominal wage rigidity is affected by changes in the money supply. The issue is firstly addressed in the context of the dynamic general equilibrium business cycle model. This model predicts that unexpected shocks to money supply tend to reduce wage rigidity, while expected shocks are shown to have no effect on wage rigidity. I test the model's predictions by applying the histogram-location approach to two microeconomic dataset, Ukrainian (ULMS) and American (PSID). I find that the predictions of the theoretical model are in agreement with the evidence from both datasets.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to Professor Lilia Maliar and Professor Serguei Maliar, my teachers and supervisors, for their insightful guidance, encouragement and valuable advice during my thesis writing. I am also grateful to Professor Tom Coupé for his help in finding appropriate literature, thorough reviewing all my drafts and giving many helpful comments. I thank Olga Kupets, EERC alumnus, for her support in collecting Ukrainian data for the thesis.

Chapter 1

INTRODUCTION

Downward nominal wage rigidity means that wages do not move downward as much as they should. Empirical evidence shows that in many countries wages are downwardly rigid to some extent. Wages and prices are argued to be less flexible downward than upward because labor mobility is imperfect and workers resist fall in nominal wages. Economic factors such as public sector pay scales which are fixed by law for a certain period, and wage contracts which are usually not renegotiated immediately after nominal shocks, contribute to wage rigidity. Alternatively, wage stickiness may be optimal in the presence of uncertainty, that is, risk averse workers require insurance in the form of a stable income.

As macroeconomic theory predicates, nominal wage rigidity is one of the possible reasons for the existence of an upward sloping aggregate supply, and the resulting short-run trade-off between unemployment and inflation – known as the Phillips curve – at the root of Keynesian stabilization policies. As Tobin (1972) argues, if wages are rigid downwards, negative demand shocks leave real wages higher than marginal product, resulting in unemployment. Thus, the cost of downward nominal rigidity is unemployment.

The purpose of this paper is as follows. First, the issue of the downwardly rigid wages is addressed in the context of a dynamic general equilibrium business cycle model developed by Lilia Maliar and Serguei Maliar (2003). The model predicts that wage rigidities are negatively affected by unexpected shocks to money supply but do not depend on the expected money supply changes. Second, the predictions of the theoretical model are tested using two large datasets, the Ukrainian Longitudinal Monitoring Survey and Panel Study of Income Dynamics.

As for Ukraine, there has been very little exploration of the wage rigidity behavior, in spite of its importance. Certainly, until recently there has been a general lack of sufficient data series with which to examine the relationship of wage changes and money supply dynamics. New sources of data on individual wages suggest that investigating the said issue will be more fruitful. As for PSID dataset, it was used previously in Kahn's paper (1997) for identifying the downward nominal wage rigidity. In the thesis, PSID is used as an alternative dataset for testing the theoretical prediction concerning the impact of expected and unexpected money supply shocks.

The rest of the paper is organized in the following way. Chapter II presents a literature review of the relevant theoretic and empirical literature on downward nominal wage rigidity. In Chapter III the theoretical model is presented. The data used for empirical investigation is discussed in the Chapter IV, and the empirical testing is provided in the Chapter V. Finally, Chapter VI summarizes the results.

Chapter 2

LITERATURE REVIEW

This chapter consists of two parts. The first one discusses the theoretical papers devoted to the investigation of the wage rigidity as a propagation mechanism for shocks in the economy, and its role in business cycle fluctuations. The second part describes empirical literature the wage rigidity phenomenon.

Two predominant modern theories which explain the importance of money in business cycle fluctuations can be identified. The first one, developed by Lucas (1972), shows that shocks originating in monetary policy could have real consequences by creating information problems for economic agents. Lucas argues that information confusion makes it difficult for economic agents to find out whether observed changes in prices are the result of the relative price changes or changes in the aggregate price level.

The second theory explains the role of monetary shocks which influence the economy through the price rigidity channel. That is, nominal rigidities in prices and wages, not information problems, have been regarded as an important propagation mechanism for shocks in the real economy. This approach assumes that workers and firms set up the contracts which fix the wages in advance. Theoretical justification of the latter approach is discussed in more details below.

In a recent contribution, Shimer (2003) proves that rigid wages contribute to the economic fluctuations. He develops his paper with the simplest possible model of rigid wages introducing a constant wage. Although he incorporates productivity shocks instead of monetary shocks into his model, it is worth noting that fluctuations in such aggregate variables as unemployment and vacancies due to the said shocks can be substantial if the wage for new hires is independent of the current state of aggregate productivity, that is, rigid.

On the contrary, in the case of flexible wage model, Shimer illustrates that when positive productivity shock occurs, firms respond by creating more vacancies. This reduces the duration of unemployment putting upward pressure on wages. Since the wages are flexible, the wage movements absorb virtually whole shock, and so the shock has little effect on unemployment and vacancies.

Heer (2002) studied monetary economies by means of the dynamic general equilibrium methods. To introduce money into the neoclassical growth framework, the approach that money is required for purchase of consumption goods or some subset of consumption goods was employed. The economy in which money is held for this reason is called cash-in-advance economy. That is, in order to purchase units of goods agents require previously accumulated cash balances.

The goal of Heer's study is similar to that of Shimer (2003) – both papers study consequences of shocks which get propagated through price rigidity channels. The difference between the two is that Heer introduces monetary shocks while Shimer deals with productivity shocks. Additionally, Heer uses cash-in–advance constraint. This means that purchases of the cash goods is possible only with the sum consisting of currency carried over from the previous period, principal and lump sum transfer. Employment effects of the monetary policy, as demonstrated by the Heers's paper, is positive, that is, low rates of inflation are demonstrated to reduce employment and output in the benchmark calibration.

To see how predetermined wages improve the fit of the business cycle models, Benassy (1995) presents an explicitly computable business cycle model with optimizing agents in an economy with wage contracts and money. Considering a one-sector economy he introduces money into the model. He proves that consideration of rigid prices in a monetary economy subject to a monetary shock improves substantially the fit of such models in terms of matching a number of stylized facts in actual economies.

Apart from a theoretical foundation and justification of the importance of considering wage rigidity in monetary economies there are empirical works on investigating nominal wage and inflation dynamics. In a very important work, Card and Hyslop (1996) attempted to test the claim that nominal flexibility of wages occurs more readily in higher inflation economies using the US data. Focusing on two types of evidence (wages on individual and market levels), they found that about 6-10 percent of workers experience nominally rigid wages in a 10-percent inflation environment; this proportion rises to over 15 percent at a 5 percent inflation environment leading to the conclusion that nominal wage changes exhibit some degree of asymmetry. To measure the fraction of negative wage changes "prevented" by nominal wage rigidities on individual level, authors constructed a "counterfactual" distribution of wage changes using an assumption of symmetry – known as a symmetry approach. Although counterfactual distributions suggests that a 1 percent increase in the inflation rate reduces the fraction of workers with downwardly rigid wages by about 0.8 percent, a market level analysis is less conclusive – due to wage aggregation and loss of heterogeneity, the statistical relationship between inflation and wage adjustments becomes weaker.

Further, Dwyer and Liong (2000) found that the distribution of wage changes in Australia is more dispersed during the high-inflation episode than when inflation is either falling or low. Authors explored the presence of wage stickiness by employing a number of statistical approaches to measuring the skewness of wage changes, skewness coefficient, mean-median difference, LSW statistic (firstly introduced by Lebow, Stockton and Wascher (1995) to identify asymmetry due to a shortage of observations below zero, also known as the skewness-location approach). Then, breaking up the sample into three periods (high, falling and low inflation), researchers showed that the skewness of annual wage changes was negatively correlated with inflation.

Beissinger and Knoppik (2000) analyzed extensively the wage rigidity phenomenon in Western Germany, presenting a common analytical framework for three approaches to the analysis of downward nominal rigidity, the symmetry approach, the skewness-location approach, and the histogram-location approach. The third method, firstly used by Kahn(1997), explains bin sizes of the actual median-centered histograms in different years by two determinants, the counterfactual median-centered histogram and the rigidity coefficient which measures the proportion of earning cuts. Using German microdata on wages, authors also presented evidence that earnings of job stayers are characterized by substantial downward nominal rigidity. Researchers concluded that real wage adjustments can be damaged by zero inflation targets.

In Britain, the recent study by Brown and Wadsworth (2002) explores the evolution of nominal wage settlements in UK and offer some evidence of the influence of inflation on settlement outcomes using group-level wage contract data. Authors show that there is very little suggestion from the data that British firms will cut nominal settlements when in trouble. They argue that up to 10 percent but typically around 1-2 percent of employees appear to settle be affected by nominal wage stickiness each year. Further, authors show that zero wage changes are more likely when inflation is low. On the macro-level, however, their results are shown to be more ambiguous.

A great deal of research about wage rigidity was done by other economists: Smith, United Kingdom (2000); Devicienty, Italy (2002); Puhani (2000) enriches the analysis by considering labor markets with wage rigidities in Poland.

Chapter 3

THE MODEL

3.1 The description of the model.

The model was developed by Lilia Maliar and Serguei Mailar (2003).

A Sidrovski type of model with money in the utility function is considered. Time is discrete and the horizon is infinite, $t \in T$, where $T = \{0,1,2,...\}$. The consumer side of the economy consists of a representative consumer. The production side of the economy consists of one representative firm. The firm is owned by the consumer who receives the profits from the capital in the form of dividends. The firm also rents labor in exchange for wages. Finally, there is government that issues money each period, so that the stock of money grows over time.

The government prints money at rate μ_t , so that the monetary stock evolves according to

$$M_t = M_{t-1}\mu_t \tag{1}$$

The newly printed money are distributed among the households in proportion to the amount of the monetary stock they currently own. Thus, a household that carries out M_{t-1} units of money from the previous period *t-1* will start a new period t with $M_{t-1}\mu_t$ units of money.

An infinitely-lived representative consumer solves the intertemporal utility maximization problem:

$$\max \max_{\{c_t, n_t, M_t, k_t\}_{t \in T}} E_0 \sum_{t=0}^{\infty} \delta^t u\left(c_t, 1-n_t, \frac{M_t}{p_t}\right),$$

subject to

$$\frac{M_t}{p_t} + k_t + c_t = k_{t-1}(1-d+r_t) + \frac{M_{t-1}\mu_t}{p_t} + \frac{w_t n_t}{p_t}, \tag{3}$$

where $c_t, n_t, M_t, k_t \geq 0$, and initial condition (M_{-1}, k_{-1}) is given. Here, c_t is consumption; l_t and n_t represent leisure and working hours, respectively, with the total time endowment being normalized to 1, $l_t+n_t=1$; M_t and k_t are, respectively, the stock of money and capital chosen at t; p_t is the nominal price for one unit of the output good at t; r_t and w_t are the real interest rate and the nominal wage paid by the firm respectively; $\delta \in (0,1)$ is the standard discount factor; d is the depreciation rate of capital; and E_0 is the operator of the conditional expectation. The utility function u is continuously differentiable, strictly increasing in each argument and concave.

The production firm maximizes period-by-period profit choosing the demand for capital and labor given the prices r_t and w_t

$$\max_{\{k_{t-1}, n_t\}} \{p_t z_t f(k_{t-1}, n_t) - r_t k_{t-1} - w_t n_t\}, \tag{4}$$

where $y_t = z_t f(k_{t-1}, n_t)$ is the real output which depends o capital, labor and real technology shocks z_t. When solving the profit maximization problem the firm may fact nominal rigidities, for example, the nominal wage must be above certain level $\overline{w}_t$,

$$w_t \geq \overline{w}_{t.} \tag{5}$$

The objective will be to establish hoe the probability of having the rigidities (5) depends on the stochastic properties of real and nominal shocks.

3.2 Equilibrium Conditions

Definition: Equilibrium in the economy (1)-(5) is defined as a sequence for consumer allocation $\{c_t, n_t, M_t, k_t\}_{t\in T}$, for the prices $\{r_t, w_t, p_t\}_{t\in T}$, and for production inputs $\{n_t, k_{t-1}\}_{t\in T}$ such that

(i) $\{c_t, n_t, M_t, k_t\}_{t\in T}$ solves the utility maximization problem (2), (3);

(ii) $\{n_t, k_{t-1}\}_{t\in T}$ solves the profit maximization problem (4), (5);

(iii) all markets clear and the economy's resource constraint is satisfied.

We use notations of type $h_j(x_1,..., x_K)$ to denote partial derivative of a function $h(x_1,..., x_K)$ with respect to variable x_j, $j \in \{1,..., K\}$.

We shall now write down the conditions that describe the equilibrium in our economy. We write the Lagrangian for the individual problem (2), (3)

$$L = E_0 \sum_{t=0}^{\infty} \delta^t u\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) +$$
$$+ E_0 \sum_{t=0}^{\infty} \delta^t \lambda_t \left[\frac{M_t}{p_t} + k_t + c_t - k_{t-1}(1-d+r_t) - \frac{M_{t-1}\mu_t}{p_t} - \frac{w_t n_t}{p_t}\right],$$

where λ_t is the Lagrange multiplier. Finding the derivatives with respect to c_t, n_t, M_t, k_t, we get

$$u_1\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) + \lambda_t = 0, \tag{6}$$

$$-u_2\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) - \lambda_t \frac{w_t}{p_t} = 0, \tag{7}$$

$$\frac{u_3\left(c_t, 1-n_t, \frac{M_t}{p_t}\right)}{p_t} + \frac{\lambda_t}{p_t} - \delta E_t\left[\frac{\lambda_{t+1}\mu_{t+1}}{p_{t+1}}\right] = 0. \tag{9}$$

By combining the above conditions to eliminate the Lagrange multipliers, we get the following conditions

$$u_2\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) = u_1\left(c_t, 1-n_t, \frac{M_t}{p_t}\right)\frac{w_t}{p_t}, \tag{10}$$

$$u_1\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) = \delta E_t\left[u_1\left(c_{t+1}, 1-n_{t+1}, \frac{M_{t+1}}{p_{t+1}}\right)(1-d+r_{t+1})\right], \tag{11}$$

$$\frac{u_3\left(c_t, 1-n_t, \frac{M_t}{p_t}\right)}{p_t} + \frac{u_1\left(c_t, 1-n_t, \frac{M_t}{p_t}\right)}{p_t} = \delta E_t\left[\frac{u_1\left(c_{t+1}, 1-n_{t+1}, \frac{M_{t+1}}{p_{t+1}}\right)\mu_{t+1}}{p_{t+1}}\right]. \tag{12}$$

We next consider the problem of the profit maximization for the firm (4). Maximizing (4) with respect to demand for capital and labor, we obtain the conditions that determine the prices for capital and labor in the absence of borrowing restrictions

$$r_t = p_t z_t f_1(k_{t-1}, n_t), \tag{13}$$

$$w_t = p_t z_t f_2(k_{t-1}, n_t). \tag{14}$$

Finally, we can write the economy resource constraint in the following form

$$k_t + c_t = k_{t-1}(1-d) + z_t f(k_{t-1}, n_t). \tag{15}$$

The conditions (10)-(15) are both necessary and sufficient for equilibrium.

3.3 A Closed-Form Solution

In general, the model presented in Section 3.2 does not admit a closed-form solution and has to be studied by numerical methods. However, we can obtain a closed-form solution under some additional simplifying restrictions. One set of assumption that lead to a closed-form solution is described in Benassy (1995). Specifically, we shall assume, first, that the utility function has the form

$$u_2\left(c_t, 1-n_t, \frac{M_t}{p_t}\right) = \left\{\log(c_t) + \theta \log\left(\frac{M_t}{p_t}\right) + V(1-n_t)\right\}, \tag{16}$$

where $\theta>0$ and V is a strictly increasing and concave function, second, that the production function is of the Cobb-Douglas type

$$y_t = z_t f(k_{t-1}, n_t) = z_t k_{t-1}^{\alpha} n_t^{1-\alpha}, \tag{17}$$

where $\alpha \in (0,1)$ and finally, capital fully depreciates in each period, d=1. Under the above assumptions, we can rewrite the conditions (10)-(12) and the budget constraint (15) as

$$V'(1-n_t) = \frac{w_t}{c_t p_t}, \tag{18}$$

$$\frac{1}{c_t} = \delta E_t\left[\frac{r_{t+1}}{c_{t+1}}\right], \tag{19}$$

$$\frac{\theta}{M_t} + \frac{1}{p_t c_t} = \delta E_t\left[\frac{\mu_{t+1}}{p_{t+1}c_{t+1}}\right], \tag{20}$$

$$k_t + c_t = z_t k_{t-1}^{\alpha} n_t^{1-\alpha} \tag{21}$$

and the prices of the capital and labor are, respectively,

$$r_t = \alpha p_t z_t k_{t-1}^{\alpha-1} n_t^{1-\alpha} \quad \text{and} \quad w_t = (1-\alpha) p_t z_t k_{t-1}^{\alpha} n_t^{-\alpha} \tag{22}$$

It is easy to check by guess and verify (of show by using forward recursion that the solution to the equation (19) is

$$c_t = (1-\alpha\delta) y_t = (1-\alpha\delta) z_t k_{t-1}^{\alpha} n_t^{1-\alpha}, \tag{23}$$

$$k_t = \alpha\delta y_t = \alpha\delta z_t k_{t-1}^{\alpha} n_t^{1-\alpha},$$

i.e., the agent always splits the output onto consumption and capital in the proportion $(1-\alpha\delta)$ and $\alpha\delta$, respectively. The equation (20) yields

$$\theta + \frac{M_t}{p_t c_t} = \delta E_t\left[\frac{M_{t+1}}{p_{t+1}c_{t+1}}\right]. \tag{24}$$

Again, either by forward recursion or by 'guess and verify' method, we can show that the solution to this equation is

$$\frac{M_t}{p_t c_t} = \frac{\theta}{1-\delta} \qquad \Rightarrow \qquad \frac{M_t}{p_t} = \frac{\theta(1-\alpha\delta)}{1-\delta} y_t \tag{25}$$

Finally, substituting c_t and w_t into (18), we obtain

$$V'(1-n_t) = \frac{(1-\alpha) p_t z_t k_{t-1}^{\alpha} n_t^{-\alpha}}{(1-\alpha\delta) p_t z_t k_{t-1}^{\alpha} n_t^{1-\alpha}} = \frac{(1-\alpha)}{(1-\alpha\delta) n_t} \qquad \Rightarrow \qquad n_t = n, \tag{26}$$

where n is defined as a solution to $V'(1-n_t)n_t = \frac{(1-\alpha)}{(1-\alpha\delta)}$. That is, in the absence of nominal rigidities, working hours in this economy are always constant and do not respond to either real or nominal shocks.

3.4 Introducing Nominal Rigidities

We shall now study the relation between the wage rigidities of type (5) and the real and nominal shocks in the economy in the context of the model with a closed form solution. Under the assumption of the Cobb-Douglas production function, we can rewrite (5) as follows

$$w_t = (1-\alpha) p_t z_t k_{t-1}^{\alpha} n_t^{-\alpha} \geq \overline{w}_t. \tag{27}$$

In fact, the nominal prices in our model can be expressed from (25) in the following way of

$\frac{M_t (1-\alpha)}{y_t \theta (1-\alpha\delta)} = p_t$. By substituting this result into (27) and taking into account that $M_t = M_{t-1}\mu_t$, we can rewrite the probability of having rigidities in a simple form

$$\Pr(w_t < \overline{w}_t) = \Pr(\mu_t < \overline{\mu}_t), \tag{28}$$

where $\bar{\mu}_t \equiv \frac{\bar{w}_t \theta (1-\alpha\delta) n}{M_{t-1}(1-\delta)(1-\alpha)}$.With some additional assumption about the distribution of the random variable μ_t , we can compute the probability of having rigidities. For example, assume that $\mu_t = \mu \exp(\varepsilon_t^{\mu})$, where ε_t^{μ} has Normal distribution, ε_t^{μ} ~N(0, σ_μ^2). Then the probability of having nominal rigidities can be written as

$$\Pr(w_t < \bar{w}_t) = \Pr(\varepsilon_t^{\mu} < \log(\bar{\mu}_t) - \log(\mu)) \equiv$$
$$\Omega(\mu, \sigma_\mu, \bar{\mu}_t) = \frac{1}{\sigma_\mu \sqrt{2\pi}} \int_{-\infty}^{\log(\bar{\mu}_t) - \log(\mu)} \exp\left(-\frac{(\varepsilon_t^{\mu})^2}{\sigma_\mu^2} \right) d\varepsilon_t^{\mu} \qquad (29)$$

where μ determines the long-run growth of money supply. If the value of μ>1, the stock of money grows over time. We can now determine how the probability of having nominal rigidities depends on the rate of money growth μ

$$\frac{d\Omega(\mu, \sigma_\mu, \bar{\mu}_t)}{d\mu} = \frac{\frac{d\log(\bar{\mu}_t)}{\log(\mu)} - 1}{\mu\sqrt{2\pi\sigma_\mu^2}} \exp\left(-\frac{[\log(\bar{\mu}_t) - \log(\mu)]^2}{\sigma_\mu^2} \right). \qquad (30)$$

In a similar manner, we can compute how the probability of having nominal rigidities depends on the volatility of money supply, σ_μ

$$\frac{d\Omega(\mu, \sigma_\mu, \bar{\mu}_t)}{d\sigma_\mu} = \frac{\frac{d\log(\bar{\mu}_t)}{\log(\mu)} - (\log(\bar{\mu}_t) - \log(\mu))}{\sigma_\mu^2 \sqrt{2\pi}} \exp\left(-\frac{[\log(\bar{\mu}_t) - \log(\mu)]^2}{\sigma_\mu^2} \right).$$

To compute the above integral, we use integration by parts (Appendix A).

3.5 How the Wage Rigidity is Set?

In fact, the implications of the result of the previous section depend significantly on how the wage rigidities are set. Following Benassy (1995), we assume that the contractual nominal wage is set in period t-1 equals to the expected nominal wage in period *t* in logarithmic terms where the expectation is computed conditional on the information set in *t-1*. In this case, neither the average money supply μ nor its volatility σ_μ has any effect on the probability of having wage rigidities. Indeed, we have

$$\begin{aligned}\log(\overline{w}_t) &= E_{t-1}\left[\log\left((1-\alpha)p_t z_t k_{t-1}^{\alpha} n_t^{-\alpha}\right)\right]= \\ &= E_{t-1}\left[\log\left(\frac{M_t(1-\delta)}{y_t\theta(1-\alpha\delta)}(1-\alpha)z_t k_{t-1}^{\alpha} n_t^{-\alpha}\right)\right]= \\ &= E_{t-1}\left[\log\left(\frac{(1-\alpha)(1-\delta)}{\overline{n}\,\theta(1-\alpha\delta)}M_{t-1}\mu\exp(\varepsilon_t^{\mu})\right)\right]= \\ &= \log\left(\frac{(1-\alpha)(1-\delta)}{\overline{n}\,\theta(1-\alpha\delta)}M_{t-1}\mu\right).\end{aligned}$$

Hence, we have $\overline{\mu}_t = \mu$ and the probability $\Omega(\mu,\sigma_\mu,\mu) = 1/2$ for any μ,σ_μ.

Consider the economy that in period *t-1* had a process for money supply characterized by some (μ,σ_μ) and suppose that in period *t*, these parameters change to $(\mu',\sigma_\mu') \equiv (\mu + d\mu, \sigma_\mu + d\sigma_\mu)$. The effect of such a change on the probability of having the wage rigidities will depend on whether it was expected or not in period *t-1*.

If this change was expected, than $\overline{\mu}_t = \mu'$ and the probability of having nominal rigidities is not affected since

$$\frac{\partial \Omega(\mu', \sigma'_{\mu}, \mu')}{\partial \mu} = 0 \quad \text{and} \quad \frac{\partial \Omega(\mu', \sigma'_{\mu}, \mu')}{\partial \sigma_{\mu}} = 0.$$

However, if this change is not expected then

$$\frac{\partial \log(\overline{\mu}_t)}{\partial \log(\mu)} = 0 \quad \text{and} \quad \frac{\partial \log(\overline{\mu}_t)}{\partial \log(\sigma_{\mu})} = 0,$$

and evaluating the derivatives in the point $\mu' = \mu$, we obtain the derivatives of probability of having nominal rigidities with

$$\frac{d\Omega(\mu, \sigma_{\mu}, \mu)}{d\mu} = -\frac{1}{\mu\sqrt{2\pi\sigma_{\mu}^2}} \quad \text{and} \quad \frac{d\Omega(\mu, \sigma_{\mu}, \mu)}{d\sigma_{\mu}} = 0.$$

The model predicts that under small unexpected changes $(\mu + d\mu, \sigma_{\mu} + d\sigma_{\mu})$ the probability of having nominal rigidities should be affected by money supply shocks but only when such shocks are unexpected.

Chapter 4

DATA DESCRIPTION

1. Data Sources

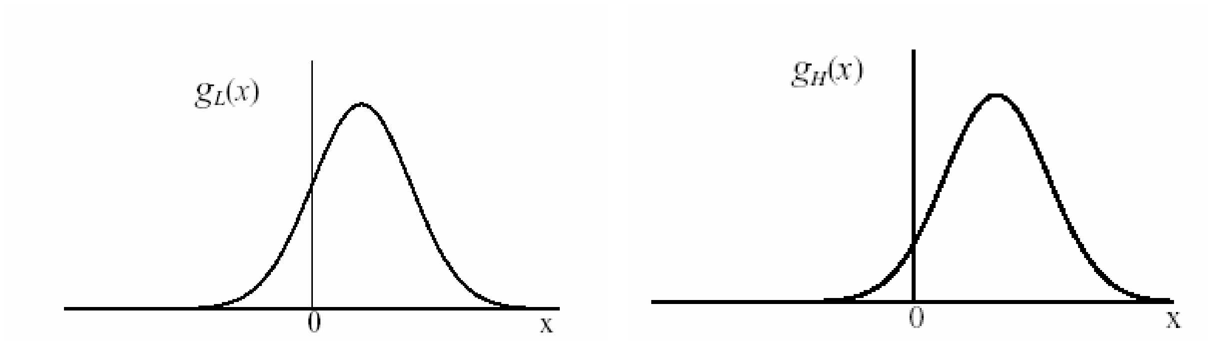
The issue of downward nominal wage rigidity and its relationship with money supply is addressed using two datasets. One is the Ukrainian Longitudinal Monitoring Survey, ULMS, which covers the years 1997-2003 and contains the results of interviews with about 8,000 individuals. The second is the Panel Study of Income Dynamics, PSID, which covers the years 1968 to 1993 providing a continuous series on income outcomes of about 53,000 individuals.

Concerning Ukrainian dataset, the year 1997 was chosen as a starting year because Hryvnia, current Ukrainian currency, was introduced in the fall 1996. As most studies of nominal wage rigidity deal with individuals who do not change their place of work, attention is then restricted to the sample of 'job stayers', that is, the employees who remained at the same place of work for two contiguous years, resulting in a sub sample of about 1,500 employees for each year, on average. It is an advantage of the ULMS dataset that it contains information on job-specific tenure, which make it possible to distinguish between job movers and job stayers.

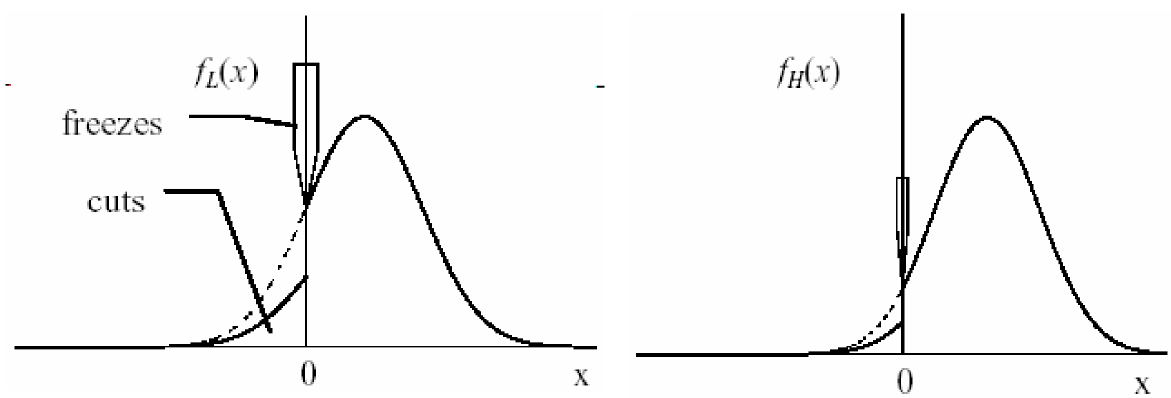
American dataset was also processed. First, the number of individuals was reduced to the sub-sample of those receiving only labor income. Then, people with missing values of total labor income or hours worked were also excluded from the sample. The initial sample thus was reduced to 5,000 individuals per year, on average. Next, each individual's wage was calculated as a labor income divided by total hours worked. Finally, since job stayers and job movers are not distinguished in PSID, one would expect greater variability of wage changes than in the ULMS dataset.

2. Descriptive Evidence.

A helpful starting point for investigating behavior of wage changes is to distinguish the actual distribution of wage changes from the counterfactual one, that is, distribution in the absence of rigidity. It is assumed that the counterfactual distribution is symmetric around its median (Card and Hyslop, 1996).



I. Counterfactual distribution, low median   II. Counterfactual distribution, high median



III. Actual distribution, low median   IV. Actual distribution, high median

Figure 1. Distributions of Wage Changes with Low and High Median - Theoretical Illustration.

Panels I and II of Figure 1 illustrate probability density functions of counterfactual distributions for low and high medians, t=L, H. Panels III and IV show an example of downward rigidity. Downward nominal rigidity causes censoring in the distribution of wage changes at zero. Observations are missing from the distribution below zero, having been piled up into a zero spike. Consequently, the distributions are asymmetric. One can also see from panels III and IV that as the location of the distribution changes over time, varying portions of the left part of the distribution are affected by rigidity in the form of thinning and piling-up.

It is of interest to inspect the shape of the actual distributions of the year-to-year log wage changes for both samples. If nominal wage rigidity exists, one would expect a spike at zero which is created by shifting some probability mass to zero and thinning of the distributions below zero.

Figure 4 in Appendix B presents histograms of log wage changes for the ULMS dataset for years spanning 1997 to 2003. The initial examination of the data reveals a large spike at zero each period. Additionally, there is some thinning in the distributions below zero and a visible absence of pay changes in the bins above zero. It is necessary to stress that log wage changes of several job stayers take on very large values. In developed countries such changes can be regarded as misreporting. However, in the case of Ukraine it may reflect wage arrears. An individual could report the amount he received in December including previous wages which were also paid in December, thus generating huge difference with the previous year wage. The same logic applies to the wage decreases. But in any case, such outliers are not indicative of the wage rigidity and are trimmed from the sample. 2nd and 98th percentiles are thus cut excluding wage changes that involve cuts of greater than 22 % and increases of greater that 36%.

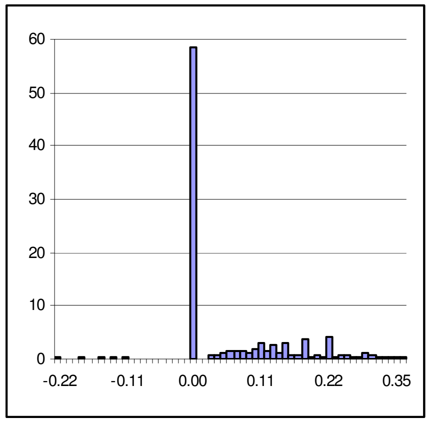


Figure 2. Distribution of Nominal Wage Changes,

ULMS dataset, 1997-2003

Figure 2 is an illustration of annual log wage changes for the whole period 1997-2003. Between 1997 and 2003, on average only 3.06 percent of workers received nominal pay cuts from their current employer, while for 58.64 percent of workers nominal wages remained unchanged over the same period.

If the distribution is symmetric, one would expect the skewness coefficient to be zero. For a distribution skewed to the right this coefficient should be significantly positive. One serious problem with the skewness statistics is that it is extremely sensitive to observations in the tails of the distribution (Lebow at al, 1999), and empirical wage-change distributions are quite disperse. In response to this problem, McLaughlin (1998) suggests replacing the skewness statistic with the difference between the mean and median of the wage-change distribution. This asymmetry measure is less sensitive to outliers because extreme observations affect it only by influencing the mean. So, the observations between mean and median constitute the sign-test statistic; the higher its value, the more likely is the distribution skewed to the right. Table 1 in Appendix B presents values for the skewness measures for Ukrainian data for year-to-year wage changes. All skewness coefficients generally suggest that distributions of nominal wage changes are skewed to the right.

Figure 5 in the Appendix B presents histograms of the nominal log wage changes for the PSID sub-sample from 1968 onward. The distributions are spread widely, as it was expected. This sample was trimmed at 5 and 95 percentiles. From visual examination of the data, one can conclude that spikes at zero are also present in American dataset, although they are of smaller extent than those of ULMS. At the same time, it is easy to notice that wage cuts are more pronounced here. The graphs show that wage distributions of the PSID dataset are more close to the symmetric distribution than those of Ukrainian wages. The following figure presents histogram of the annual log wage changes for the PSID for the period spanning 1968 to 1993.

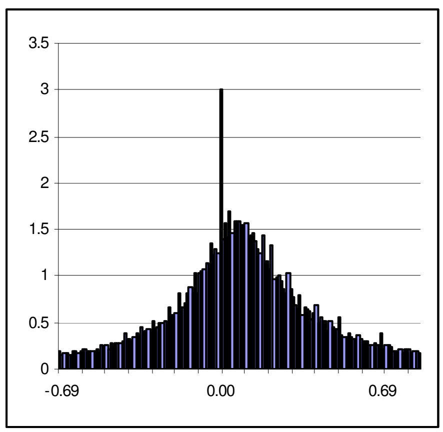


Figure 3. Distribution of Nominal Wage Changes,
PSID dataset, 1968-1993

Between 1968 and 1993, on average 33.94 percent of those workers receiving labor income experienced a nominal pay cut from their current employer. During this period, on average for 3.01 percent of workers the nominal wage was unchanged each year.

Skewness measures of the wage distributions for different years are presented in Table 2 in Appendix B. Note, that distributions are skewed both positively and negatively in different periods. This happens because skewness measure is sensitive to extreme values, as it was discussed earlier, and the PSID wage distributions are spread widely having many extreme values. Mean-median difference is of relatively low magnitude and counts on average to 0.0134.

The resulting histograms of log nominal wage changes for both datasets serve as an input into econometric estimation. The econometric estimation of the wage rigidity existence and its relationship with unexpected money supply is done in the following section.

C h a p t e r 5

ECONOMETRIC ESTIMATION:

HISTOGRAM-LOCATION APPROACH

The histogram-location approach, firstly introduced by Kahn (1997), allows to identify and estimate rigidity by exploring changes in location of the actual and counterfactual distributions. There are two basic assumptions for this method. First, nominal rigidity can have only direct effect, that is, probability mass of negative and small positive log wage changes is shifted to the probability of zero change. Second, only those bars which are located below mean of the counterfactual distribution are affected by the rigidity. Therefore, counterfactual and factual distributions coincide over ranges of changes that are not affected by rigidity (Beissinger, Knoppik, 2000) implying that the right tail of the factual distribution is identical to that of the counterfactual one, and left tail of the factual distribution can be inferred from that of the counterfactual.

Following Kahn (1997), the following specification is presented:

$$\begin{aligned} PA_{b,t} &= \alpha_b(1+\beta_1 DNEG_{b,t} + \beta_2 D1_{b,t} + \beta_3 D2_{b,t}) + \\ &\quad + [\gamma - \alpha_b(\beta_1 + \beta_2 + \beta_3)]D0_{b,t} + \mu_{b,t}, \end{aligned} \tag{31}$$

The notation of the equation (31) is as follows:

- $PA_{b,t}$, is the proportion of actual log nominal wage changes that in time t fall into b^{th} bin below median;
- $DNEG_{b,t}$, is the dummy for negative bin status which takes on the value of one if at time t log wage change falls into b^{th} bin in the negative range;

- $D1_{b,t}$ and $D2_{b,t}$ are dummy which take on the value of one if observation falls into two percentage ranges directly above or below zero, respectively.;
- $D0_{b,t}$ is a dummy for zero bin status, which takes on the value of one if observation falls into a zero bar.

In this notation, all bins below median are assigned indexes from right to left: $b = b^{\min} ... b^{\max}$, that is, from the closest to the median to the farthest from it. When the distribution shifts to the right, distance from the median to the zero bin increases, and less negative changes are affected by rigidity.

Equation (31) is the version of the so-called proportional model where β coefficients cut out a proportion of the density a_b that we would otherwise observe. According to the logic of the histogram-location approach, downward nominal wage rigidity exists if the estimated degree of downward nominal rigidity is significantly negative. So, β_1 is expected to be negative meaning that being negative decreases the number of workers observed within a category. Dummies $D1_{b,t}$ and $D2_{b,t}$ are also expected to be negative indicating that, ceteris paribus, we are less likely to observe pay changes when they entail small nominal changes.

There are two rigidity effects in the right-hand side of the equation (31), thinning (in round brackets) and piling-up (in square brackets). Thinning by $\sum_{i=1}^{3} \beta_i$ takes place in negative and first two positive bins. Pile-up at zero consists of the summation term which collects the non-enacted wage cuts in the range $b^{\min} \ldots b^{\max}$, and a constant γ which reflects freezes of those bins that are outside the range.

It is important to check whether there is a relationship between the total proportions of non-enacted wage cut and unexpected and expected shocks to money supply. Therefore, the equation (31) is modified and two new terms, interaction of dummy for negative bin status and unexpected and expected money supply, were introduced:

$$\begin{aligned} PA_{b,t} = {} & \alpha_b(1+\beta_1 DNEG_{b,t} + \beta_2 D1_{b,t} + \beta_3 D2_{b,t} + \\ & + \beta_4 DNEG_{b,t} * MS_t^{unexp} + \beta_5 DNEG_{b,t} * MS_t^{exp}) + \\ & + [\gamma - \alpha_b(\beta_1 + \beta_2 + \beta_3)]D0_{b,t} + \mu_{b,t}, \end{aligned} \qquad (32)$$

for all bins below or equal to the median.

In this specification, $MS_t^{un\exp}$ represents the unexpected money supply, while $MS_t^{\exp}$ stands for expected money supply. One would expect β_4 to be negative and significant indicating that nominal rigidity is relaxed after the economy experiences the unexpected change in money supply. In contrast, according to theoretical predictions, β_5 is expected to be zero.

Unexpected money supply was found as a difference between fitted and actual values of logs *MS* where fitted values represent expectations of money supply. Fitted values were estimated by regressing the log of actual money supply on its lagged value:

$$\log(MS_t) = \alpha + \beta \log(MS_{t-1}) + \mu_t$$

As the first step, specification (31) was estimated using data from ULMS and PSID datasets. Estimates were obtained by seemingly unrelated regressions

(SUR) which accounts for heteroskedasticity and contemporaneous correlation in the errors across equations[1].

Several key findings emerge. Concerning Ukrainian data, Table 3 (Appendix C) presents results of this estimation for complete sample period 1997-2003. All coefficients are statistically significant and have expected signs. The negative coefficients β_2 and β_3 show that one is less likely to observe pay changes when they entail small nominal changes, all else being equal, reflecting menu costs. The coefficient β_1 is negative indicating that pay changes are less likely if they require a pay cut. Judging from the obtained result, one can conclude that the downward nominal rigidity clearly exists in Ukrainian labor market and it is quite substantial: negative nominal observations occur 92 percent less often than they should. This estimation and average wage distributions which is represented by Figure 2 allows us to conclude that 35.19 percent of Ukrainian workers did not receive nominal wage cuts that they would have otherwise received, because of downwardly rigid wages.

The results of the estimation of the histogram-location approach applied to the PSID sample are shown in the first column of the Table 4. For PSID dataset for the complete period 1968-1993, all coefficients are also found to be highly significant. There is no ambiguity about downward nominal rigidity: the resulting wage rigidity coefficient is about 34 percent meaning that a substantial percentage of the reductions did not take place.

One interesting aspect of using the PSID dataset is that it is possible to compare our results with Kahn's who also used the PSID[2]. The results of the Kahn's

---

[1] Bin sizes at different distances from the median differ by up to more than a factor of ten which is likely that their error terms exhibit different standard errors, i.e. there is heteroskedasticity across equations.

estimation are shown in the fourth and fifth columns of Table 4. As one can notice, our coefficient on *DNEG* is lower than Kahn's coefficient for wage earners and higher for salary earners. This happens because Kahn distinguishes wage earners and salary earners, while our data does not differentiate these two groups of workers. We can suppose that if it would have been possible to split Kahn's sample, we would expect rigidity coefficient to be inside the range of estimated coefficients for wage and salary earners. Our menu cost coefficients β_2 and β_3 are of different signs implying that one is less likely to observe small pay increases, while small pay changes are more likely if they require a pay cut. In fact, we deal with distributions which are smoothed to a certain extent, since they contain both job movers and job stayers. In addition, the result conforms to the visual impression from Chapter IV where it is very hard to see the absence of pay decreases. In Kahn's case, coefficient on *D1* is negative and coefficient on *D2* is positive, and both of them are statistically significant.

It is of interest to compute how many people did not receive nominal wage cuts that they would have otherwise received in the absence of wage stickiness. Again, we take the estimated coefficient on *DNEG* and information on average wage distribution, and find that this figure equals to 17.48 percent. It is almost two times more than Kahn's figure (9.4 percent). They can not be equal because samples are not exactly the same and estimation coefficients are slightly different.

As a next step, the specification including two interaction terms, $MS_t^{un\exp}$ and $MS_t^{\exp}$, was estimated using two datasets. The results for the ULMS can be found in the third column of the Table 3, and the third column of the Table 4 provides estimates for PSID. Empirical evidence confirms the theoretical

[2] There are some differences between two samples, however. Kahn's sample contains observations for job stayers for smaller time range, 1980-1993. In addition, Kahn estimates equations separately for wage earners and salary earners. Therefore, certain differences in estimated coefficients are expected.

prediction that the unexpected changes in money supply lead to a decrease in the wage rigidity, while expected changes have no effect. In particular, for the Ukrainian dataset for the specification (32), estimate of the $MS_t^{\exp}$ term is indistinguishable from zero. $MS_t^{un\exp}$, on the other hand, is negative and statistically significant indicating that rigidity is relaxed after the economy observes unexpected increase in the money supply.

Empirical estimation of the specification (32) using PSID dataset reveals the following results. First, coefficient on interaction term with $MS_t^{un\exp}$ is negative and statistically significant at 5-percent level indicating that wage cuts are highly sensitive to unexpected changes in money supply. Second, the interaction term $MS_t^{\exp}$ is close to zero and statistically insignificant which again confirms the theoretical prediction that expected shocks to money supply do not change wage rigidity.

The analyses of this chapter can be briefly summarized. Downward nominal wage rigidity is present in ULMS and PSID data and it is quantitatively important. The extent of the wage rigidity is sensitive to unexpected changes in money supply and does not depend on the changes in the expected money supply.

Chapter 6

CONCLUSION

The phenomenon of downward nominal wage rigidity is present in wage change distributions of different countries. According to Lilia Maliar and Serguei Maliar's dynamic general equilibrium business cycle model, the extent of nominal wage rigidity is affected by changes in unexpected money supply, while expected changes in money supply have no effect on it.

The theoretical predictions are tested using the ULMS and PSID datasets. We build distributions of log wage changes and find spikes at zero each period and the thinning of the distributions below zero. Our method of econometric analysis is a version of the histogram-location approach which incorporates several improvements over the original version with respect to introducing two terms to capture the effects of expected and unexpected changes in the money supply. Our empirical findings suggest the existence of a considerable degree of wage rigidity in the distributions of wage changes in the ULMS and PSID datasets. We demonstrate that rigidity becomes less after the economy experiences the unexpected change in the money supply, while the wage rigidity is unaffected when changes are perceived by people. The estimates therefore provide evidence in support of the theoretical results.

BIBLIOGRAPHY

Akerlof, G.A., Dickens, W.T., Perry G.L. *The Macroeconomics of Low Inflation*. Brookings Papers of Economics Activity, January 1996.

Benassy, Jean-Pascal *Money and Wage Contracts in an Optimizing Model of the Business Cycle.* Journal of Monetary Economics,35, 1995.

Beissinger, T., Knoppik, C. *Downward Nominal Rigidity in West-German Earnings 1975-1995.* University of Regensburg Discussion Paper No 344, 2000.

Brown, D., Ingram, P., Wadsworth, J. *Pay Settlements and Nominal Wage Rigidity in Britain.* Centre For Economic Performance, December 2002.

Card, D., Hyslop, D. *Does Inflation 'Grease the Wheels of the Labor Market'?* NBER Working Paper 5538. Cambridge, United States: National Bureau of Economic Research, 1996.

Cooley, J.T., Hansen D.G. *Frontiers of Business Cycle Research.* Princeton University Press, 1995.

Devicienty, F. *Downward Nominal Wage Rigidity in Italy: Evidence and Consequences.* Working Paper Series, No.20, 2002.

Dwyer, J., Leong, K.*Nominal Wage Rigidity in Australia*. Research Discussion Paper, 2000-08.

Heer, B. *Welfare Costs of Inlation in a Dynamic Economy with Search Unemployment.* Journal of Economic Dynamic & Control 28 , 2003, 255 –272.

Kahn, S. *Evidence of Nominal Wage Stickiness from Microdata.* The American Economic Review, Vol. 87, No.5 (Dec., 1997) 993-1008.

Lebow, D., Stockton, D., Washer, W. *Inflation, Nominal Wage rigidity, and the Efficiency of Labor Markets.* Finance and Economics Discussion Series 95-45, October 1995.

Lucas, R.E.Jr., *Expectations and the Neutrality of Money.* Journal of Economic Theory , 1972, 4, 103-23.

Puhani,P. *On the Identification of Relative Wage Rigidity Dynamics. A Proposed Methodology on Cross-. Section Data and Empirical Evidence for Poland in Transition.* Working Paper Number 343, 2000.

Smith, J.C. *Nominal Wage Rigidity in the United Kingdom.* The Economic Journal, 110 (March), C176-C195, 2000.

Shimer, R. *The Cyclical Behavior of Labor Markets.* University of Chicago and NBER, September 2003.

Tobin, J. *Inflation and Unemployment.* American Economic Review, 1972 vol.62, no.1, pp.1-18.

APPENDIX A

$$\frac{d\Omega(\mu,\sigma_\mu,\overline{\mu}_t)}{d\sigma_\mu} = -\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\int_{-\infty}^{\log(\overline{\mu}_t)-\log(\mu)} \exp\left(-\frac{(\varepsilon_t^\mu)^2}{\sigma_\mu^2}\right)d\varepsilon_t^\mu +$$

$$+\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\exp\left(-\frac{[\log(\overline{\mu}_t)-\log(\mu)]^2}{\sigma_\mu^2}\right)\frac{\partial\log(\overline{\mu}_t)}{\partial\log(\sigma_\mu)}+$$

$$+\frac{1}{\sigma_\mu\sqrt{2\pi}}\int_{-\infty}^{\log(\overline{\mu}_t)-\log(\mu)} \exp\left(-\frac{(\varepsilon_t^\mu)^2}{\sigma_\mu^2}\right)\frac{2(\varepsilon_t^\mu)^2}{\sigma_\mu^3}d\varepsilon_t^\mu =$$

$$=\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\int_{-\infty}^{\log(\overline{\mu}_t)-\log(\mu)} \exp\left(-\frac{(\varepsilon_t^\mu)^2}{\sigma_\mu^2}\right)d\varepsilon_t^\mu +$$

$$+\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\exp\left(-\frac{[\log(\overline{\mu}_t)-\log(\mu)]^2}{\sigma_\mu^2}\right)\frac{\partial\log(\overline{\mu}_t)}{\partial\log(\sigma_\mu)}-$$

$$-\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\int_{-\infty}^{\log(\overline{\mu}_t)-\log(\mu)} \varepsilon_t^\mu\, d\exp\left(-\frac{(\varepsilon_t^\mu)^2}{\sigma_\mu^2}\right)=$$

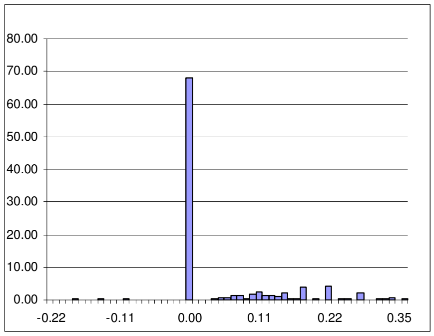
$$=\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\exp\left(-\frac{[\log(\overline{\mu}_t)-\log(\mu)]^2}{\sigma_\mu^2}\right)\frac{\partial\log(\overline{\mu}_t)}{\partial\log(\sigma_\mu)}-$$

$$-\frac{1}{\sigma_\mu^2\sqrt{2\pi}}\exp\left(-\frac{(\varepsilon_t^\mu)^2}{\sigma_\mu^2}\right)\Big|_{-\infty}^{\log(\overline{\mu}_t)-\log(\mu)}=$$

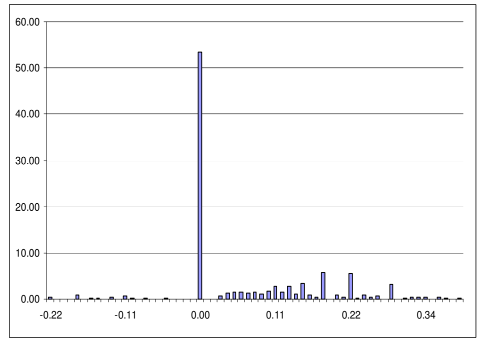
$$=\frac{\frac{d\log(\overline{\mu}_t)}{\log(\mu)}-(\log(\overline{\mu}_t)-\log(\mu))}{\sigma_\mu^2\sqrt{2\pi}}\exp\left(-\frac{[\log(\overline{\mu}_t)-\log(\mu)]^2}{\sigma_\mu^2}\right).$$

APPENDIX B

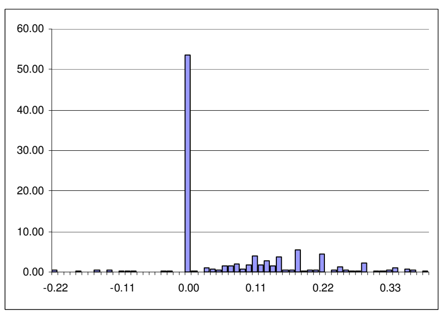
1997/98



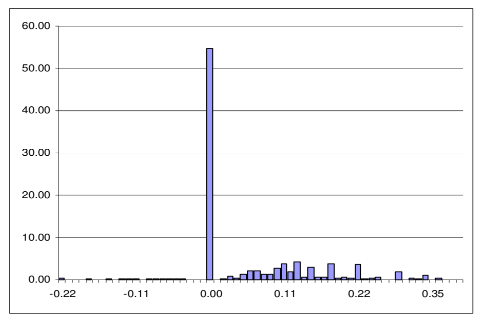
1998/99



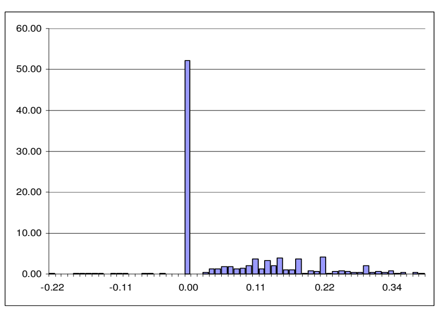
1999/00



2000/01



2001/02



2002/03

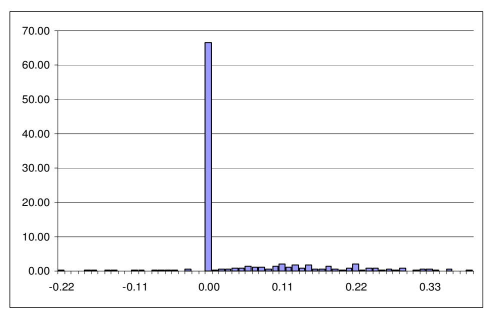


Figure 4. Histograms of the Distribution of Log Nominal Wage Changes, ULMS Dataset, 1997 - 2003*.

Observations below 2nd and above 98th percentile are trimmed from the sample.

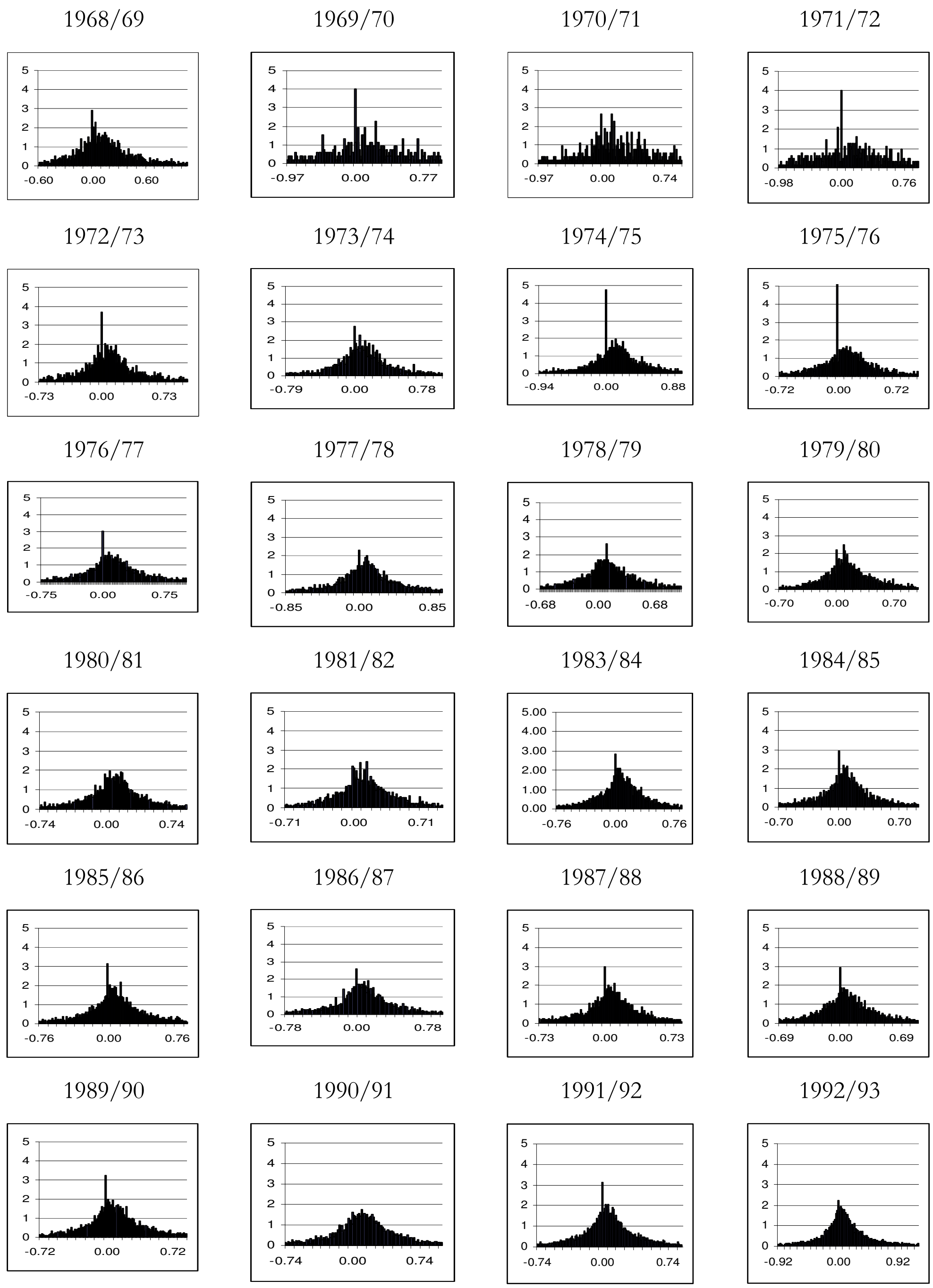


Figure 5. Histograms of the Distribution of Log Nominal Wage Changes, PSID Dataset, 1968-1993*

Observations below 5th and above 95th percentile are trimmed from the sample.

Table 1. Skewness Test Statistics of Log Wage Changes of the ULMS Dataset for Different Periods.

Period	Statistics	Value
1997-98	Skewness	1.39
	Mean-median dif.	0.05
1998-99	Skewness	0.72
	Mean-median dif.	0.07
1999-00	Skewness	0.88
	Mean-median dif.	0.07
2000-01	Skewness	0.90
	Mean-median dif.	0.06
2001-02	Skewness	0.88
	Mean-median dif.	0.07
2002-03	Skewness	1.31
	Mean-median dif.	0.04

Table 2. Skewness Test Statistics of Log Wage Changes of the PSID Dataset for Different Periods.

Period	Skewness	Mean-Median Difference
1968-69	0.4461	0.0344
1969-70	0.7267	0.0299
1970-71	0.6160	0.0722
0971-72	-0.5190	-0.0079
1972-73	0.2806	0.0230
1973-74	0.0662	0.0102
1974-75	-0.0515	0.0082
1975-76	0.1342	0.0093
1976-77	0.0713	0.0117
1977-78	-0.0276	0.0099
1978-79	0.1777	0.0150
1979-80	0.1258	0.0247
1980-81	-0.1012	-0.0042
1981-82	0.0451	0.0048
1982-83	-0.0887	-0.0021
1983-84	0.1029	0.0046
1984-85	-0.0040	0.0058
1985-86	0.0114	0.0060
1986-87	-0.0628	0.0035
1987-88	0.1048	0.0133
1988-89	0.0631	0.0104
1989-90	0.0329	0.0033
1990-91	0.0796	0.0053
1991-92	0.2927	0.0298

APPENDIX C

Table 3. Estimated Coefficients, Histogram-Location Approach, ULMS dataset, 1998-2003

Coefficient	(1)	(2)	(3)
DNEGb,t	-0.92*** (0.076)	-0.92*** (0.072)	-0.90*** (0.105)
D1b,t	-0.78*** (0.147)	-0.80*** (0.136)	-0.80*** (0.133)
D2b,t	-0.13*** (0.019)	-0.12*** (0.027)	-0.13*** (0.026)
$DNEG_{b,t}*MS_t^{exp}$	-	-0.45*** (0.119)	-0.48** (0.216)
$DNEG_{b,t}*MS_t^{unexp}$			-0.003 (0.016)
R^2	0.93	0.94	0.94

Note: Dependent variable is the proportion of wage cuts that fall into bin *b* at time *t*.
The equations were estimated by Seemingly Unrelated Regressions.
Total observations:162.
Bin width b= 0.01.Standard errors are reported in parentheses.
***, **, * indicate significance at the 1, 5, and 10-percent level, respectively.

Table 4. Estimated Coefficients, Histogram-Location Approach, PSID dataset, 1968-1993

Coefficient				Kahn's model	
	(1)	(2)	(3)	Wage earners	Salary earners
$DNEG_{b,t}$	-0.34*** (0.036)	-0.34*** (0.037)	-0.32*** (0.040)	-0.473** (0.042)	0.325** (0.074)
$D1_{b,t}$	-0.07** (0.038)	-0.06** (0.030)	-0.06** (0.030)	-0.150** (0.036)	-0.193*** (0.136)
$D2_{b,t}$	0.07** (0.034)	0.08** (0.039)	0.08** (0.039)	0.036*** (0.048)	-0.547** (0.158)
$DNEG_{b,t}*MS_t^{exp}$	-	-0.02** (0.007)	-0.03** (0.014)	-	-
$DNEG_{b,t}*MS_t^{unexp}$			0.02 (0.022)		
R^2	0.42	0.43	0.43	-	-

Note: Dependent variable is the proportion of wage cuts that fall into bin *b* at time *t*.
The equations were estimated by Seemingly Unrelated Regressions.
Total observations: 360.
Bin width b= 0.01.Standard errors are reported in parentheses.
***, **, * indicate significance at the 1, 5, and 10-percent level, respectively