OPPORTUNITY COSTS OF THE MINIMUM WAGE

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I. INTRODUCTION

Over a period of several decades, legislators have repeatedly voted for legislation that expands the coverage and increases the rates of legal minimum wages.[1] The passage of this legislation can be explained by the political economic analysis in Cox and Oaxaca (1981a, 1982). Those papers include a general equilibrium theoretical model that identifies possible gainers and losers under the wage floor policy. The present paper is concerned with an econometric study of the effects of minimum wages in a multisector model. Specifically, we here present a simulation of the effects of abolishing wage floors during the period 1975–1978. The simulation results provide estimates of the opportunity costs of minimum wage rates during that period.

The econometric model consists of nine one-digit SIC (Standard Industrial Classification) industries (including government) and is estimated

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with data from the *National Income and Product Accounts of the United States* and other sources. The simulation results indicate that abolition of minimum wage rates would have increased the employment of low-wage labor while lowering employment among high-wage workers. Gross domestic product (GDP) in constant 1972 dollars would have been less and labor's share of GDP would also have been reduced. Real average hourly compensation would have fallen for low-wage workers and risen among high-wage workers; however, total real labor compensation would have been reduced for both low-wage and high-wage labor. The inflation rate and overall price level (as measured by the GDP implicit price deflator) would have been lower in the absence of minimum wages. Quantitative estimates of these aggregate effects are presented in the following sections, as are quantitative estimates of the effects for each of nine sectors of the economy.

Before we present a detailed explanation of our simulation, we will review some related research. Many of the papers that we will discuss

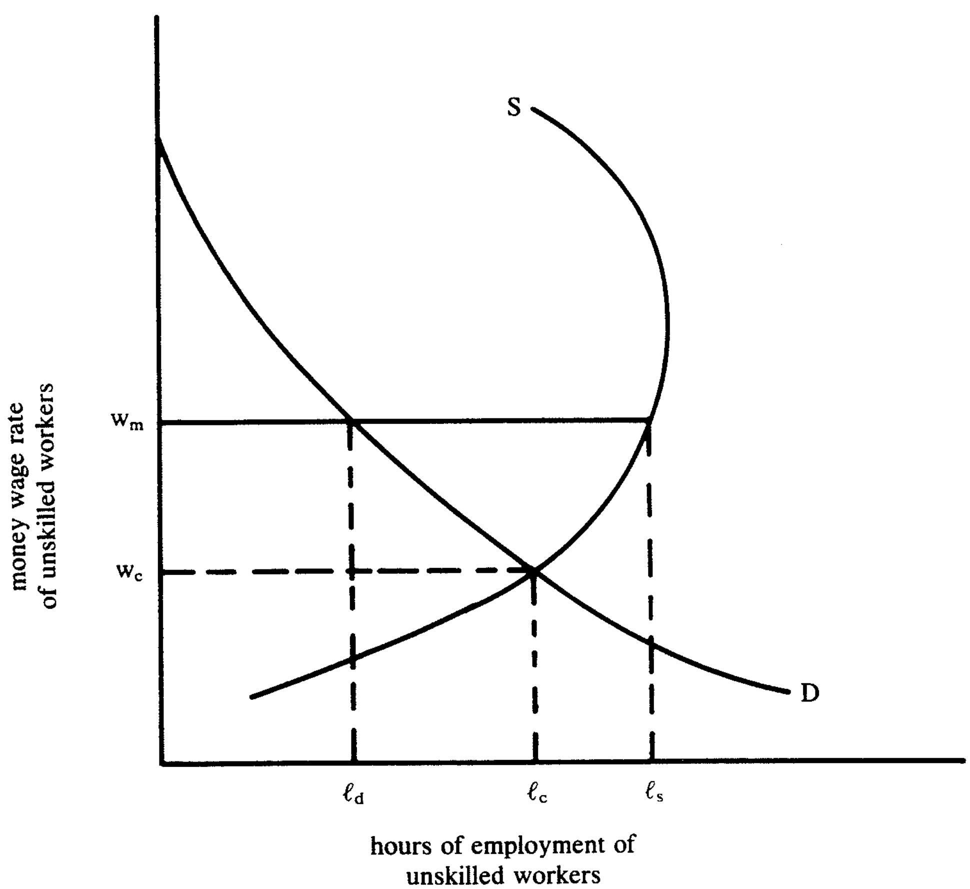

Figure 1

use a single market, partial equilibrium approach to analysis of the effects of a legal minimum wage. There is a basic methodological problem with that approach which can be explained using a standard textbook partial equilibrium model. Consider Figure 1, which contains demand and supply curves for low-wage labor, D and S. In the absence of a wage floor, the equilibrium money wage rate is w_c and the equilibrium number of hours of employment is ℓ_c. Now assume that a perfectly enforced legal minimum wage rate is introduced at the rate w_m. At the nominal wage floor w_m, with demand and supply curves D and S, the number of hours demanded is ℓ_d and the number of hours supplied is ℓ_s. Hence the minimum wage causes disemployment in the amount $\ell_c - \ell_d$ and unemployment, in the sense of excess supply, in the amount $\ell_s - \ell_d$.

The notable feature of the preceding partial equilibrium analysis is that it begs or ignores most of the interesting questions. It obviously ignores the question of the effect of a (nominal) minimum wage on the real wage of low-wage workers. Furthermore, it begs the question of the disemployment effect of a minimum wage since that effect depends on shifts of the low-wage labor demand and supply curves which result from feedback from other markets.[2] Finally, the partial equilibrium approach ignores the effects of a minimum wage on other factor prices, including the wage rates of higher paid workers.[3]

II. RELATED WORK

Research on the economic effects of legislated wage floors has assumed the dimensions of a growth industry. Studies in this area span the effects of minimum wages on employment, unemployment, output, wage rates, price levels, inflation, and the distribution of income. With some notable exceptions, the bulk of this research employs static, partial equilibrium, single-equation methods. A favored topic is the effects of minimum wages on employment, especially teenage employment. It is reasoned that if minimum wages have any employment effects at all they are going to be concentrated among low wage workers, e.g., teenagers.

A good summary of the employment studies is provided by Brown et al. (1982). While some of these studies estimate employment functions that are interpreted as reduced form equations (e.g., Boschen and Grossman, 1981; Brown et al., 1982, 1983), others identify labor demand functions (e.g., Zucker, 1973; Gramlich, 1976; Hamermesh, 1982). Taken as a whole, time series studies of the effects of minimum wages on teenage employment indicate a 1–3% employment reduction per 10% rise in the minimum wage. When teenagers are disaggregated into demographic subgroups categorized by race and sex, there are instances of estimated positive employment effects of minimum wages for some of these groups.

In the case of adults, the estimated employment effects of minimum wages are small and sometimes statistically insignificant. There is some ambiguity about the direction of the employment effect of minimum wages for adult labor. Both positive and negative estimated employment effects for adults can be found in the literature.

A relatively recent development in the study of the effects of legislated wage floors is the systems approach. A broad range of minimum wage phenomena are considered within a single analytical model. Linkages across equations provide for feedback effects of a more general equilibrium nature. Built-in lags add a dynamic element to the analysis, i.e., the system has a "memory." Such a model can be used to simulate the effects of minimum wage policies by comparison of a control solution with a policy change solution. The control solution tracks history by setting the minimum wage policy variables and the exogenous variables equal to their historical values when solving for the endogenous variables. Next, a hypothetical policy change is adopted by making the desired changes in the minimum wage policy instruments and solving for the new values of the endogenous variables. An approach of this type was followed in Cox and Oaxaca (1981b). In that study the effects of a temporary minimum wage freeze were investigated with a more restrictive model than the one we use in the present study. Other studies that employ some form of a systems approach are discussed below.

Boschen and Grossman (1981) developed a rational expectations model of the labor market. They used annual time series data to estimate reduced form equations for the aggregate wage rate, aggregate employment, female employment, teenage employment, and employment in selected industries with high concentrations of minimum wage labor. In this system structural linkages are implicit. Minimum wage effects were obtained directly from parameter estimates rather than from a simulation. Boschen and Grossman found that minimum wages had no statistically significant effects on the aggregate wage rate and aggregate employment. Although minimum wages did reduce teenage employment, this was offset by the positive effects of minimum wages on adult female employment. In most of the industries with high concentrations of minimum wage labor, minimum wages tended to depress employment. Since there was no aggregate employment effect, this last result implies offsetting employment increases in the unconstrained sector.

Using quarterly time-series data, Hamermesh (1982) estimated a two-equation model of conditional demand functions for teenage employment and adult employment. The elasticity of teenage employment with respect to the effective minimum wage was estimated to be -0.08. Because of a lack of statistical significance, no minimum wage variable appears in the adult employment function. In order to directly investigate the effects of minimum wages on factor substitution, Hamermesh estimated factor share equations for teenagers, adults, and capital. The factor share equations were derived from a translog cost function and were estimated with annual time series data. This model was used to simulate the effects of establishing a youth subminimum wage equal to 75% of the adult minimum wage. Depending upon the assumptions about truncation in the teenage wage distribution, the respective effects on teenage employment and adult employment ranged from 4.08% and −0.05% to 4.6% and −0.12%.

Pettengill (1981) constructed a mathematical model of the economy for the purpose of simulating various effects of minimum wages. A distribution of labor quality across workers was incorporated into the model. The lowest quality worker was assumed to receive 29% of the median wage in the absence of a legislated wage floor. Pettengill simulated the effects of imposing minimum wages slightly in excess of 50% of the pre-wage-floor median wage. Several simulations were run with varying assumed values of the key parameters. A set of simulations treated labor quality as endogenous in that workers could upgrade their quality in response to the raised hiring standards, greater required on-the-job effort, and reduction in on-the-job amenities occasioned by the imposition of a legislated wage floor. It was shown that with complete coverage and endogenous labor quality, increased labor productivity could actually raise output. The reported percentage employment and output effects of minimum wages, respectively, ranged from −0.73% and 0.27% to −4.57% and −0.59%.

In an ambitious undertaking, Wolff and Nadiri (1981) constructed an input–output based model of the U.S. economy in order to simulate the effects of raising the minimum wage above its 1972 value of $1.60/hour. The model was disaggregated over 85 industry sectors, 12 income classes, and 441 occupational categories. Complete coverage and full compliance with minimum wage provisions were assumed. It was also assumed that increases in the legal wage floor have no effect on the wages of high-wage workers. Minimum wage effects were measured as the ratio of simulated effects to the actual 1972 values of the model's endogenous variables. When technology and consumption patterns by income class were held fixed, increasing the wage floor was shown to raise employment, real gross national product (GNP), and the price level. Wolff and Nadiri also conducted simulations in which they allowed for substitution in consumption in response to relative price changes and for technical substitution between intermediate inputs and labor. In these simulations increases in the wage floor lowered employment but still increased real GNP and the price level. However, wage increases in excess of 25% started to raise employment again.

Sellekaerts (1982) modified the 1978 version of the quarterly MIT–

Penn–Social Science Research Council model in order to simulate the inflationary effects of minimum wages. One of the runs simulated a sustained 10% rise in minimum wages over the period 1974(1)–1979(2). Wage inflation and producer price inflation were increased by 0.76 and 0.30 percentage points, respectively. The implied increase in the growth rate of real labor costs was attributed to the fact that labor costs are only a fraction of total costs and rises in average productivity attenuate price inflation while increasing wage inflation. Although real personal income was largely unchanged, a redistribution of income did occur.

There have been some recent studies of the effects of minimum wages on income distribution. Johnson and Browning (1983) developed a simplified framework for examining the distributional and efficiency implications of legislated wage floors. Their model admits only two factors of production: low-wage labor and a composite of all remaining factors. The composite input was assumed to be in perfectly inelastic supply. An infinite elasticity of substitution was assumed between all grades of low-wage labor. In order to abstract from the general equilibrium effects of changes in relative product prices on the distribution of income, a one-product economy was assumed. Appealing to the fact that the uncovered sector has become quite small, Johnson and Browning assume complete coverage.

Current Population Survey (CPS) data on individual households were used in simulating an increase in the 1976 minimum wage from $2.30/hour to $2.80/hour. The percentage increase in wages for those earning less than $2.30/hour was assumed to equal the percentage increase in the minimum wage (22%). Those who were earning less than or equal to $2.80/hour prior to the increase were defined to be low-wage labor. Consistent with Gramlich's findings (1976), low-wage workers were observed to be evenly distributed across households grouped by deciles of the income distribution. Johnson and Browning apportioned the costs of increased minimum wages in accordance with assumed losses in the purchasing power of each household's disposable income. Prior to the minimum wage increase the Gini concentration ratio for income was estimated to be 0.3925. The larger the assumed elasticity of demand for low-wage labor, the greater the simulated reduction in national income and the smaller the reduction in the Gini concentration ratio. Johnson and Browning conclude that the efficiency losses from minimum wages outweigh any benefits derived from their negligible effects on the income distribution.

Behrman et al. (1981) investigated the effects of minimum wage policy on earnings dispersion by estimating the effects of minimum wage levels and coverage on the variance of the logarithm of earnings. The working population was divided into 12 mutually exclusive demographic groups. Weighted time series regressions were run for each group with data from the CPS–SSA–IRS exact match sample covering about 90,000 individuals from 1951–1976. This study turned up evidence of interactions between minimum wages and schooling and between minimum wage coverage and schooling in the determination of earnings dispersion. Because of the mixed results across demographic groups, there is no simple way to summarize the overall impact of minimum wage policy on earnings dispersion. An attempt was made to determine long-run effects of minimum wages from impact multipliers derived from estimated dynamic equations. The long-run effects tended to follow the same patterns as the short-run effects but were somewhat larger.

We next turn our attention to our simulation model, beginning with a discussion that outlines the structure of the model.

III. MODEL SPECIFICATION

The model consists of the following six parts:

a. Product demand functions
b. Factor supply price functions
c. Factor share equations
d. Product supply price functions
e. Factor employment equations
f. Accounting identities

Parameters for parts a–c are estimated from the data, and those estimated parameters are used to construct parts d–f.

There is a product demand function for each industry. The dependent variable for the product demand function for industry j is the log of real output per capita in that industry. The explanatory variables are subsets of the logs of industry product price ratios (with the manufacturing product price in the denominators) and the ratio of nominal GNP per capita to the manufacturing product price.[4] Some of the demand functions also include a time trend variable.

The supply side of the factor markets is represented by factor supply price equations for low-wage and high-wage labor by industry. Because of data limitations, nonlabor inputs are assumed to be in perfectly elastic supply to each industry. The dependent variable for the low-wage (or, respectively, high-wage) labor supply price equation for industry j is the log of the ratio of the average hourly compensation of low-wage (or, respectively, high-wage) labor to the previous year's GDP price deflator. In general, the independent variables include: (a) the log of the previous year's real hourly compensation rate in a different industry (the opportunity cost wage rate); (b) the log of the previous year's real nonemployee income per capita; (c) the log of the previous year's ratio of low-wage (or, respectively, high-wage) employment in the industry to total adult population; and (d) a time trend. In addition, the low-wage labor supply price equation includes a real minimum wage independent variable, defined as the log of one plus the product of the basic adult minimum wage for the industry and the coverage rate for the industry divided by the previous year's GDP deflator. It is in the factor supply price equations for low-wage labor that the direct effects of minimum wages enter the model. Changes in minimum wages alter the labor supply schedules of low-wage workers by legally changing the reservation wages of those covered workers earning at or below the minimum wage. Since our low-wage labor input is an aggregate of workers with varying reservation wages, the direct effects of minimum wages are captured via their administered labor supply effects on the average hourly compensation of low-wage labor.

The functional form of the factor share equations is that implied by a linearly homogeneous translog cost function. Factor share equations for each industry are specified for low-wage labor, high-wage labor, and a nonlabor composite input. The dependent variables are the factor shares of low-wage labor, high-wage labor, and the nonemployee input. The independent variables are as follows: (a) the log of the ratio of the average hourly compensation of high-wage labor to the average hourly compensation of low-wage labor; (b) (except for the government sector) the log of the ratio of the price index for plant and equipment purchases to the average hourly compensation of low-wage labor; and (c) (in some equations) a time trend, to capture the effects of nonneutral technological change.

The supply side of the product markets is represented by the product supply price equations. These functions are derived from a profit maximization model which incorporates the linearly homogeneous translog cost function. The parameters of these functions are constructed from the estimated parameters from the factor share equations.

The factor employment equations are identities that relate factor employment to factor shares, product price and quantity, and factor price. Other identities in the model are definitional equations for aggregation and index numbers.

IV. DATA SOURCES

The primary data source was the *National Income and Product Accounts of the United States* (NIPA). The major advantage of using NIPA data is that all sectors, including government, are treated symmetrically. Annual data are available from 1947, for each sector, on output, output price, wages and salaries, fringe benefits, nonemployee compensation, employment, and man-hours.

Several other annual data sources were also used. Average farm and nonfarm federal minimum wage rates were obtained from the Employment Standards Administration, U.S. Department of Labor. This source was also used for data on coverage of federal minimum wages. Total population figures were obtained from the *Economic Report of the President*, and adult (16 or over) noninstitutional population figures were taken from the *Employment and Training Report of the President*. The Wholesale Price Index for finished producer goods was obtained from *Business Statistics, 1975*. Data series used in construction of the average hourly compensation and labor force proportion variables for low-wage and high-wage workers were taken from the CPS and the NIPA.

The division of wage and salary employment into low-wage and high-wage categories is not one that occurs naturally in the data. Any attempt to define low-wage labor is inherently subjective. Ideally, the definition of low-wage labor should combine elements of both an absolute standard and a relative standard. The relative employment of low-wage labor should vary over time and across industries with ceteris paribus changes in the minimum wage rate. If the low-wage threshold were defined as a constant in real terms, e.g., proportional to the Consumer Price Index (CPI), then the proportion of workers earning less than the low-wage cutoff would diminish and eventually disappear with secular rises in productivity. As an alternative to this absolute standard, a relative standard could be used which defines low-wage labor as the bottom X% of the economywide wage distribution. This standard would imply a low-wage cutoff at any point in time. Although the proportion of low-wage workers would vary across industries at any point in time, by definition the low-wage proportion cannot vary over time for all industries combined. Consequently, changes in the minimum wage would by definition have no effect on the aggregate composition of employment in terms of low-wage and non-low-wage labor. At most only distributional changes between industries would be permitted under the relative standard.

An attractive alternative to both the absolute and relative standards, but one which incorporates features of both, is to define the low-wage threshold as some fixed percentage of the overall median wage rate. Workers who earn wage rates at or below this fixed percentage of the prevailing median wage are defined to be low-wage workers. Under this definition the overall proportion of low-wage employment can vary over time and can be influenced by changes in the minimum wage. The proportion of low-wage labor can vary across industries and over time within an industry and can also be influenced by changes in the minimum wage. A tendency for the low-wage employment proportion to disappear with secular growth in productivity or to remain constant are but special cases under this definition.

We define the low-wage cutoff to be 65% of the estimated median wage rate over all industries. This definition permits the inclusion as low-wage workers those earning somewhat above historical levels of the minimum wage as well as those earning below the minimum wage. The wage rates assigned to the low-wage category were calculated as the conditional mean wages for workers who earn less than the specified low-wage cutoff. These calculations were obtained from three-parameter log normal distributions estimated on the basis of special wage tabulations from the May CPS (1973–1978) and imposed on annual time-series industry data from the NIPA.[5] The details are discussed in Appendix A.

We adopted average hourly compensation as our measure of labor input prices. This measure adds the imputed hourly value of fringe benefits to average hourly wage rates. In determining the hourly compensation of low-wage labor it is necessary to make some assumption about the fringe benefit premium (the ratio of hourly compensation to hourly wages) that applies to this group of workers. It is reasonable to assume that the hourly value of fringe benefits received by low-wage workers is small in relative terms as well as in absolute terms. Accordingly, we assumed that the value of fringe benefits received by low-wage workers was equal to the sum of employer contributions to Social Security and Unemployment Insurance. Therefore, our measure of the hourly compensation of low-wage labor is given by

$$W_{\ell it} = w_{\ell it}\,(1 + s_t + u_t), \tag{4.1}$$

where $W_{\ell it}$ is the imputed average hourly compensation of low-wage labor in industry i in year t; $w_{\ell it}$ is the imputed average hourly wage rate obtained from the three-parameter log normal wage distributions described in Appendix A; s_t is the Social Security tax rate on the taxable wage base; and u_t is the average Employer Unemployment Insurance tax rate on the taxable wage base.

Since we were unable to obtain industry specific data on the tax rates, s_t and u_t, expression (4.1) was calculated with aggregate data for all industries combined. With the exceptions of Agriculture and Services, the hourly compensation rate calculated from (4.1) was assigned to low wage labor in each one digit industry. For both Agriculture and Services there were some early years in which the fringe benefit premiums for all workers in these industries were less than the value calculated from $1 + s_t + u_t$. Whenever this occurred, low-wage labor were assigned the fringe benefit premium corresponding to all workers in the given industry.

In order to obtain an estimate of the employment of low-wage labor in each industry, we merely apply the estimated proportion of low-wage workers in each industry to total employment in each industry:

$$E_{\ell it} = \hat{P}_{\ell it} E_{it}, \tag{4.2}$$

where $E_{\ell it}$ is the imputed employment of low-wage labor in industry i in year t; $\hat{P}_{\ell it}$ is the imputed proportion of low-wage labor obtained from the three-parameter log normal wage distributions described in Appendix A; and E_{it} is total employment in industry i.

Estimation of the aggregate hours of low-wage labor employed by each industry each year is not as straightforward as in the case of estimating the number of low-wage workers employed. This is because we have no direct evidence regarding the average annual hours worked per low-wage worker. There are, however, data that permit us to estimate the overall average annual hours worked per employee by industry. If we apply this figure to our low-wage employment estimates, we can estimate what the aggregate hours worked by low-wage labor would be in the case where all labor is assumed to work the same per capita hours in a given industry.[6] Thus we have

$$h_{it} = \frac{H_{it}}{E_{it}} \tag{4.3}$$

and

$$H_{\ell it} = h_{it} E_{\ell it}, \tag{4.4}$$

where h_{it} is the average annual hours per worker in industry i in year t; H_{it} is aggregate hours worked in industry i in year t; and $H_{\ell it}$ is the estimated aggregate hours of low-wage labor in industry i in year t.

It can easily be shown from (4.2), (4.3), and (4.4) that the estimated low-wage share of aggregate hours is constrained to be the same as the low-wage share of total employment. Estimated low-wage man-hours employed was used as the labor input for low-wage labor. Estimates of this measure obtained from the simulation model were divided by the exogenously determined h_{it} to obtain estimates of the employment of low-wage labor.

Given our measures of the hourly compensation and aggregate hours of low-wage labor, derivation of the corresponding measures for high-wage labor is straight forward. The aggregate hours of high-wage labor are obtained as a residual from reported total aggregate hours for the particular industry:

$$H_{hit} = H_{it} - H_{\ell it}, \tag{4.5}$$

where H_{hit} is the estimated aggregate hours of high-wage labor in industry i in year t. Although the average hourly wage rate of high-wage labor in a given industry is defined to be the conditional mean wage of all workers earning above the low-wage cutoff, the imputed average hourly compensation of high-wage labor is residually calculated from

$$W_{hit} = \frac{W_{it} - W_{\ell it}\hat{P}_{\ell it}}{1 - \hat{P}_{\ell it}}, \tag{4.6}$$

where W_{hit} is the imputed average hourly compensation of high wage labor in industry i in year t, and W_{it} is the weighted average hourly compensation among all wage and salary workers obtained as the ratio of total labor compensation to total hours worked.

Our third factor input is a residual category that includes labor inputs of the self-employed as well as all nonlabor inputs. Although there are data available from the NIPA that would permit the measurement of aggregate hours worked by the self-employed by industry, there are no data pertaining to the hourly inputs of the nonlabor factors. While there are no direct measures of prices of the residual input, we were able to use proxy measures. These measures are as follows: implicit price deflator for purchases of agricultural machinery (except tractors); implicit price deflator for purchases of construction machinery (except tractors); implicit price deflator for purchases of mining and oilfield machinery; implicit price deflator for purchases of service industry machinery; implicit price deflator for nonresidential gross private fixed domestic investment; and the Wholesale Price Index for producer finished goods. The Wholesale Price Index for producer finished goods is a Bureau of Labor Statistics series. The remaining measures are available from the NIPA. Industry specific residual input price indexes are used for their respective industries. The remaining industries are assigned either the implicit price deflator for nonresidential gross private domestic investment, or the Wholesale Price Index for producer finished goods. The particular assignment depends on which one performs better in estimation and simulation for the given industry.

V. ESTIMATION

Annual time series data for the period 1955–1978 were used in the estimation of the model's stochastic equations. Except when corrections were made for first-order autocorrelation in the residuals, ordinary least squares was the estimator used. Corrections for autocorrelation were carried out by estimating equations in quasi-first-difference form. A simple estimator of the first-order autocorrelation coefficient, ρ, is given by $\hat{\rho} = 1 - 0.5d$, where d is the Durbin–Watson statistic calculated from the original least squares residuals. The estimates obtained from this procedure were then used to form the quasi-first-difference variables. In the case of the factor share equations, the restriction that the residuals add to zero across equations led to the estimation of a single autocorrelation coefficient. The simple estimate was calculated on the basis of an average of the Durbin–Watson statistics across equations.

The estimated equations of the model are presented in Appendix B along with their associated statistics. It is perhaps useful to offer some general remarks about the estimation results. The effective minimum wage variable in each industry always had a positive effect on the hourly compensation of low-wage workers. Although symmetry restrictions were not imposed on the factor share equations, the homogeneity restrictions were imposed. Because the low-wage factor share in mining was miniscule, typically on the order of 0.4%, it was made exogenous in order to avoid simulation problems with negative low-wage share estimates.[7] The nonemployee factor share in mining was residually determined from the exogenous low-wage factor share and the estimated high-wage factor share. Under the NIPA the contribution of the government sector to GDP consists almost entirely of the wage bill. A very negligible and volatile category consisting of profits from government enterprises makes up the difference. Consequently, this "factor" share was made exogenous, and the estimated factor share equations in government did not include a price index for capital goods. In the end, the high-wage factor share in government was determined residually from the estimated factor share equation for low-wage labor and the exogenously determined nonemployee factor share. Finally, the estimated output demand functions all exhibited positive income effects and negative own-price elasticities.

VI. SIMULATION MODEL

The simulation model contains two blocks of equations—a recursive block and a simultaneous block.

A. The Recursive Equations

The high-wage labor factor supply price function for industry i in year t is

$$W_{hit} = P_{t-1}[\exp(\alpha_{i0} + \alpha_{i1}T_t)] \left[\frac{W_{hjt-1}}{P_{t-1}}\right]^{\alpha_{i2}} \left[\frac{(I/P)_{t-1}}{POP_{t-1}}\right]^{\alpha_{i3}} \cdot \left[\frac{H_{hit-1}}{POP16_{t-1}}\right]^{\alpha_{i4}}, \tag{6.1}$$

where W_{hit} is average hourly compensation of high-wage labor in industry i in year t; P_{t-1} is the implicit price deflator for GDP in year $t - 1$; T_t is the value of a time trend variable in year t; W_{hjt-1} is the average hourly compensation of high-wage labor in (the opportunity cost) industry j ($\neq$ i) in year t − 1; $(I/P)_{t-1}$ is aggregate contribution of nonemployee inputs to constant dollar GDP in year t − 1; POP_{t-1} is the total U.S. population in year t − 1; H_{hit-1} is total wage and salary man-hours employed of high-wage labor in industry i in year t − 1; $POP16_{t-1}$ is the total U.S. population 16 years and older in year t − 1; and the α_{ik} values (k = 0, 1, . . . , 4) are the estimated parameters. Note that, with W_{hit} determined by the right-hand side of (6.1), the real high-wage labor supply price (W_{hit}/P_{t-1}) is homogeneous of degree zero in the opportunity cost wage rate (W_{hjt-1}), the nonemployee income variable (I_{t-1}), and the price level variable (P_{t-1}).

The effective minimum wage variable is

$$M_{it} = \ln\left[\left(\frac{W_{mit}C_{it}}{P_{t-1}}\right) + 1\right], \tag{6.2}$$

where M_{it} is the effective minimum wage variable for industry i in year t; W_{mit} is the average basic adult minimum wage, if industry i is not Agriculture, or the average farm minimum wage, if industry i is Agriculture, in year t; C_{it} is the fraction of nonsupervisory employees covered by the minimum wage in industry i in year t; and P_{t-1} is defined as above.

The low-wage labor factor supply price function for industry i in year t is

$$W_{\ell it} = P_{t-1}[\exp(\beta_{i0} + \beta_{i1}T_t + \beta_{i2}M_{it})]\left[\frac{W_{\ell jt-1}}{P_{t-1}}\right]^{\beta_{i3}} \cdot \left[\frac{(I/P)_{t-1}}{POP_{t-1}}\right]^{\beta_{i4}}\left[\frac{H_{\ell it-1}}{POP16_{t-1}}\right]^{\beta_{i5}}, \tag{6.3}$$

where $W_{\ell it}$ is average hourly compensation of low-wage labor in industry i in year t; $W_{\ell jt-1}$ is the average hourly compenstion of low-wage labor in (the opportunity cost) industry j ($\neq$ i) in year t − 1; $H_{\ell it-1}$ is total wage and salary man-hours employed of low-wage labor in industry i in year t − 1; and the β_{ik} values (k = 0, 1, . . . , 5) are the estimated parameters; and the other variables are defined as above. Statements (6.2) and (6.3) imply that, with $W_{\ell it}$ determined by the right-hand side of (6.3), the real low-wage labor supply price ($W_{\ell it}/P_{t-1}$) is homogeneous of degree zero in the legal minimum wage (W_{mit}), the opportunity cost wage rate ($W_{\ell jt-1}$), the nonemployee income variable (I_{t-1}), and the price level variable (P_{t-1}).

The high-wage labor factor share equation for industry i in year t is

$$V_{hit} = \gamma_{i0} + \gamma_{i1}T_t + \gamma_{i2}\ln\left(\frac{W_{hit}}{W_{\ell it}}\right) + \gamma_{i3}\ln\left(\frac{R_{it}}{W_{\ell it}}\right), \tag{6.4}$$

where V_{hit} is the high-wage labor factor share in the ith industry's contribution to GDP in year t; R_{it} is value of the price index for producer goods purchases in industry i in year t; and the γ_{ik} values (k = 0, 1, . . . , 1, . . . , 3) are the estimated parameters; and the other variables are defined as above. Note that the functional form of factor share equation (6.4) is that implied by a translog cost function for a linearly homogeneous production technology with technological change that can be zero (γ_{i1} = 0), neutual ($\gamma_{i1} = 0$) or nonneutral ($\gamma_{i1} \neq 0$).

The low-wage labor factor share equation for industry i in year t is

$$V_{\ell it} = \delta_{io} + \delta_{i1}T_t + \delta_{i2}\ln\left(\frac{W_{hit}}{W_{\ell it}}\right) + \delta_{i3}\ln\left(\frac{R_{it}}{W_{\ell it}}\right), \qquad (6.5)$$

where $V_{\ell it}$ is the low-wage labor factor share in the ith industry's contribution to GDP in year t; and the δ_{ik} values (k = 0, 1, . . . , 3) are the estimated parameters; and the other variables are defined as above. Factor share equation (6.5) has the same properties as does (6.4), which is explained above.

The definitional identities for the two-period averages of the low- and high-wage labor factor shares are

$$V^*_{hit} = \frac{V_{hit} + V_{hit-1}}{2} \qquad (6.6)$$

and

$$V^*_{\ell it} = \frac{V_{\ell it} + V_{\ell it-1}}{2}. \qquad (6.7)$$

The product supply price function for industry i in year t is

$$\begin{aligned} P_{it} = P_{it-1}\exp\Bigg\{ & V^*_{\ell it}\ln\left(\frac{W_{\ell it}}{W_{\ell it-1}}\right) + V^*_{hit}\ln\left(\frac{W_{hit}}{W_{hit-1}}\right) \\ & + (1 - V^*_{\ell it} - V^*_{hit})\ln\left(\frac{R_{it}}{R_{it-1}}\right) \\ & + \left[\delta_{i1}\ln\left(\frac{W_{\ell it}}{R_{it}}\right) + \gamma_{i1}\ln\left(\frac{W_{hit}}{R_{it}}\right)\right](T_t - T_{t-1})\Bigg\} \qquad (6.8) \end{aligned}$$

where P_{it} is the implicit price deflator for the product (contribution to GDP) of industry i in year t, with i = 1 denoting the manufacturing industry; and all other variables and parameters are defined as above. Supply price function (6.8) is implied by competitive profit maximization and a translog cost function for a linearly homogeneous production technology with zero, neutral, or nonneutral technological change.

B. The Simultaneous Equations

The demand function for the product of industry i in year t is

$$Q_{it} = POP_t\,[\exp(\eta_{i0} + \eta_{i1}T_t)] \left[\prod_{k=2}^{9} \left(\frac{P_{kt}}{P_{1t}}\right)^{\eta_{ik}}\right] \cdot \left[\frac{(PQ)_t}{POP_t P_{1t})}\right]^{\eta_{i10}}, \tag{6.9}$$

where Q_{it} is quantity of output produced in industry i in year t; $(PQ)_t$ is current dollar GDP in year t; and the η_{ik} values ($k = 0, 1, \ldots, 10$) are the estimated parameters; and all other variables are defined as above. Equation (6.9) is a demand function that is log linear and zero degree homogeneous in prices (P_{kt}) and income $[(PQ)_t]$.

The output quantity and current dollar GDP aggregation identities are

$$Q_t = \sum_{i=1}^{9} Q_{it} \tag{6.10}$$

and

$$(PQ)_t = \sum_{i=1}^{9} P_{it}Q_{it}. \tag{6.11}$$

The implicit GDP price deflator is defined by

$$P_t = \frac{(PQ)_t}{Q_t}. \tag{6.12}$$

The high- and low-wage labor factor employment equations are

$$H_{hit} = \frac{V_{hit}P_{it}Q_{it}}{W_{hit}} \tag{6.13}$$

and

$$H_{\ell it} = \frac{V_{\ell it}P_{it}Q_{it}}{W_{\ell it}}. \tag{6.14}$$

Note that (6.13) and (6.14) are identities. However, during the simulations, (6.1) and (6.3) are used to determine the values of W_{hit} and $W_{\ell it}$ in (6.13) and (6.14); therefore, the simulations impose low- and high-wage labor market equilibrium. The total labor hours used in industry i in year t is given by the identity

$$H_{it} = H_{hit} + H_{\ell it}. \tag{6.15}$$

Low-wage labor's share of total employment in industry i in year t is assumed to be the same as its share of total labor hours used in industry i in year t:

$$\left(\frac{E_\ell}{E}\right)_{it} = \frac{H_{\ell it}}{H_{hit} + H_{\ell it}} . \tag{6.16}$$

Note that (6.16) imposes equality of hours per worker for all workers. Data limitations are the only justification for (6.16): only aggregate hours and employment for all wage and salary workers are reported in the data. The low- and high-wage employment variables are constructed as explained in Section V and Appendix A.

The real total compensation of all wage and salary workers in industry i and year t is given by the identity

$$\left(\frac{W_i H_i}{P}\right)_t = \frac{W_{hit} H_{hit} + W_{\ell it} H_{\ell it}}{P_t} . \tag{6.17}$$

The real average hourly compensation of all wage and salary workers in industry i in year t is given by

$$\left(\frac{W_i}{P}\right)_t = \frac{(W_i H_i/P)_t}{H_{it}} . \tag{6.18}$$

The constant dollar contribution of nonemployee inputs to GDP in industry i in year t is determined, using (6.17), as the residual

$$\left(\frac{I_i}{P}\right)_t = \left(\frac{P_{it} Q_{it}}{P_t}\right) - \left(\frac{W_i h_i}{P}\right)_t . \tag{6.19}$$

Real average hourly compensation of high-wage and low-wage labor by industry and year are given, respectively, by

$$\left(\frac{W_{hi}}{P}\right)_t = \frac{W_{hit}}{P_t} \tag{6.20}$$

and

$$\left(\frac{W_{\ell i}}{P}\right)_t = \frac{W_{\ell it}}{P_t} . \tag{6.21}$$

Real total compensation of high-wage and low-wage labor by industry and year are given, respectively, by

$$\left(\frac{W_{hi} H_{hi}}{P}\right)_t = \frac{W_{hit} H_{hit}}{P_t} \tag{6.22}$$

and

$$\left(\frac{W_{\ell i} H_{\ell i}}{P}\right)_t = \frac{W_{\ell it} H_{\ell it}}{P_t} . \tag{6.23}$$

The high-wage, low-wage, and total labor hours aggregation identities are, respectively,

$$H_{ht} = \sum_{i=1}^{9} H_{hit}; \tag{6.24}$$

$$H_{\ell t} = \sum_{i=1}^{9} H_{\ell it}; \tag{6.25}$$

$$H_t = H_{ht} + H_{\ell t}. \tag{6.26}$$

Aggregate average hourly compensation of high-wage and low-wage labor by year are given, respectively, by

$$W_{ht} = \sum_{i=1}^{9} \frac{W_{hit}H_{hit}}{H_{ht}} \tag{6.27}$$

and

$$W_{\ell t} = \sum_{i=1}^{9} \frac{W_{\ell it}H_{\ell it}}{H_{\ell t}}. \tag{6.28}$$

Real aggregate compensation and real average hourly compensation of wage and salary workers in all domestic industries are given, respectively, by

$$\left(\frac{WH}{P}\right)_t = \frac{W_{ht}H_{ht} + W_{\ell t}H_{\ell t}}{P_t} \tag{6.29}$$

and

$$\left(\frac{W}{P}\right)_t = \frac{(WH/P)_t}{H_t}. \tag{6.30}$$

The aggregate contribution of nonemployee inputs to constant dollar GDP in year t is

$$\left(\frac{I}{P}\right)_t = Q_t - \left(\frac{WH}{P}\right)_t. \tag{6.31}$$

Aggregate employment of high-wage and low-wage labor by year are determined by

$$E_{ht} = \sum_{i=1}^{9} \left(\frac{H_{hit}}{h_{it}}\right) \tag{6.32}$$

and

$$E_{\ell t} = \sum_{i=1}^{9} \left(\frac{H_{\ell it}}{h_{it}}\right). \tag{6.33}$$

In (6.32), aggregate employment of high-wage labor in year t (E_{ht}) is the sum over all industries of total high-wage labor hours by industry in year t (H_{hit}) divided by hours per worker by industry in year t (h_{it}). The h_{it} are exogenously determined. A similar explanation applies to (6.33). Aggregate wage and salary employment by year is given by

$$E_t = E_{ht} + E_{\ell t}. \tag{6.34}$$

Low-wage labor's share of aggregate wage and salary employment by year is given by the identity

$$\left(\frac{E_\ell}{E}\right)_t = \frac{E_{\ell t}}{E_t}. \tag{6.35}$$

The nonemployee input share of GDP by year is given by the identity

$$\left(\frac{I}{PQ}\right)_t = \frac{(I/P)_t}{Q_t}. \tag{6.36}$$

High-wage and low-wage labor factor shares of GDP by year are given, respectively, by the identities

$$\left(\frac{W_h H_h}{PQ}\right)_t = \frac{W_{ht} H_{ht}}{P_t Q_t} \tag{6.37}$$

and

$$\left(\frac{W_\ell H_\ell}{PQ}\right)_t = \frac{W_{\ell t} H_{\ell t}}{P_t Q_t}. \tag{6.38}$$

Real average hourly compensation of high-wage and low-wage labor in all domestic industries by year are given, respectively, by the identities

$$\left(\frac{W_h}{P}\right)_t = \frac{W_{ht}}{P_t} \tag{6.39}$$

and

$$\left(\frac{W_t}{P}\right)_t = \frac{W_{\ell t}}{P_t}. \tag{6.40}$$

Finally, real aggregate compensation of high-wage and low-wage labor in all domestic industries by year are given, respectively, by the identities

$$\left(\frac{W_h H_h}{P}\right)_t = \frac{W_{ht} H_{ht}}{P_t} \tag{6.41}$$

and

$$\left(\frac{W_\ell H_\ell}{P}\right)_t = \frac{W_{\ell t} H_{\ell t}}{P_t}. \tag{6.42}$$

VII. SIMULATION RESULTS

The simulation model described in Section VI, above, was used to simulate the effects during the years 1975–1978 of abolishing legal minimum wages in 1975. The results of the simulation are reported in Tables 1 and 2a–2e. We will begin by discussing the simulation results for the aggregate variables reported in Table 1. Consider the figures reported in the first row of Table 1. They indicate that Q, which is GDP in constant 1972 dollars, would have been 0.58% lower in 1975 if legal minimum wage rates had been abolished in 1975. Also, Q would have been lower by 1.34%, 2.08%, and 3.83%, respectively, in 1976, 1977, and 1978 if minimum wages had been abolished in 1975. This "increasing over time" aspect of the simulation is a result of the increasing (actual, historical) values of the minimum wage rates in the control simulation and of the recursive structure of the simulation model, which captures the increasing impact of a policy change as its indirect effects "feed back" on the variables of interest. An alternative way of describing the figures in the first row of Table 1 is the following. Because of the legal minimum wage rates in effect during 1975–1978, real GDP was higher by approximately 0.58%, 1.34%, 2.08%, and 3.83%, respectively, during the years 1975, 1976, 1977, and 1978.[8] Finally, the last column of Table 1 reports the average of the

Table 1. Simulated Effects of Abolishing Minimum Wages

Row	*Variable*	*1975*	*1976*	*1977*	*1978*	*av.*
1	Q	−0.58%	−1.34%	−2.08%	−3.83%	−1.96%
2	H_ℓ	5.96	5.91	10.41	10.82	8.28
3	H_h	−2.24	−2.70	−3.32	−4.63	−3.22
4	H	−0.46	−0.81	−0.23	−0.96	−0.62
5	E_ℓ	5.84	5.72	10.22	10.71	8.12
6	E_h	−2.15	−2.52	−3.12	−4.38	−3.04
7	E	−0.40	−0.69	−0.07	−0.74	−0.48
8	E_ℓ/E	6.23	6.39	10.27	11.44	8.58
9	H_ℓ/E_ℓ	0.12	0.19	0.19	0.11	0.15
10	H_h/E_h	−0.09	−0.18	−0.20	−0.25	−0.18
11	H/E	−0.06	−0.12	−0.16	−0.22	−0.14
12	P	−0.32	−1.17	−1.81	−2.66	−1.49
13	W_ℓ/P	−7.36	−12.03	−17.61	−21.29	−14.57
14	W_h/P	0.36	0.18	0.23	−0.03	0.19
15	W/P	−1.38	−1.98	−3.19	−4.16	−2.68
16	$W_\ell H_\ell/P$	−1.39	−6.13	−7.21	−10.47	−6.30
17	$W_h H_h/P$	−1.88	−2.51	−3.10	−4.66	−3.04
18	WH/P	−1.84	−2.79	−3.42	−5.12	−3.29
19	$(PQ - WH)/P$	1.41	0.91	−0.07	−1.92	0.08
20	G	2.55	0.31	6.38	6.72	3.99
21	$[(P_t/P_{t-1})^\circ - (P_t/P_{t-1})^c] \times 100$	—	−0.92	−0.68	−0.95	−0.85

individual year figures in the preceding columns. Thus, on average, real GDP would have been 1.96% lower during the years 1975–1978 if legal minimum wage rates had been abolished in 1975.

It might seem counterintuitive that abolition of legal wage floors could cause real GDP to decrease. However, there is no valid a priori reason for believing that abolition of legal wage floors would cause real GDP to increase because there are other "distortions" in the economy. Furthermore, the structure of our model does not rule out other sources of inefficiency. For example, in an earlier version of our model we included a measure of the extent of unionization by industry as an explanatory variable in the high-wage labor supply functions. It turned out that this variable varied substantially across industries but not over time within industries. Hence it affected only the estimates of the constant terms in the time-series regressions and was dropped from the equations. The point here is that our model does not rule out such distortions and, therefore, "second best" considerations are present. Finally, it is worth noting that the earlier empirical study by Wolff and Nadiri (1981) found that an increase in the minimum wage led to an increase in real GNP. Furthermore, Pettengill's (1981) mathematical model with labor upgrading is consistent with a positive relationship between real GDP and the minimum wage.

The second through fourth rows of Table 1 report the simulated effects of abolishing minimum wage rates on aggregate wage and salary man-hours employed of low-wage labor (H_ℓ), high-wage labor (H_h), and total (low-wage plus high-wage) labor (H). Thus, we observe that total (low- and high-wage) labor hours employed would have been, on average, 0.62% lower, with individual year percentage changes varying between -0.23 and -0.96. These decreases in total man-hours would have been the result of increases in low-wage man-hours that were more than offset by declines in high-wage man-hours. Abolition of legal wage floors in 1975 would have led to increases in low-wage labor man-hours that averaged 8.28%, with a low of 5.91% in 1976 and a high of 10.82% in 1978. Apparently, these increases in low-wage man-hours would have resulted from substitutions of low-wage for high-wage man-hours that would have been quantitatively large enough to overwhelm the man-hour–decreasing effect of the fall in GDP discussed above (i.e., the "scale effect"). Both scale and substitution effects serve to decrease high-wage man-hours, leading to an average reduction of 3.22%, with yearly reductions varying between 2.24% and 4.63%.

Rows 5–7 of Table 1 report the simulated effect of minimum wage abolition on low-wage employment (E_ℓ), high-wage employment (E_h), and total (low-wage plus high-wage) employment (E). The effects on employment parallel the effects on man-hours, with only minor differences between percentage figures in corresponding rows and columns. Row 8 reports the effects of minimum wage abolition on the low-wage share of total employment. On average, that share would have increased by 8.58%, with yearly percentage increases varying from 6.23% to 11.44%.

Rows 9–11 report the effects of minimum wage abolition on hours per employee of low-wage labor (H_ℓ/E_ℓ), high-wage labor (H_h/E_h), and total labor (H/E). Low-wage hours per employee would have increased, on average, by 0.15%, with yearly increases varying from 0.11% in 1978 to 0.19% in 1976 and 1977. High-wage hours per employee would have decreased, on average, by 0.18%, with individual year decreases ranging between 0.09% and 0.25%. The net effect on total (low- and high-wage) labor hours per employee would have been an average decrease of 0.14%, with yearly decreases varying from 0.06% in 1975 to 0.22% in 1978.

The effects of minimum wage abolition on the price level, as measured by the implicit GDP price deflator (P), are reported in row 12 of Table 1. We observe that, on average, the price index would have been 1.49% lower, with individual year decreases in the index ranging from 0.32% in 1975 to 2.66% in 1978.

Rows 13–15 of Table 1 report the effects of eliminating the wage floors on the real average hourly compensation of low-wage workers (W_ℓ/P), high-wage workers (W_h/P), and all workers (W/P). Real average hourly compensation of low-wage workers would have decreased, on average, for the years 1975–1978 by 14.57%, with yearly reductions varying from 7.36% in 1975 to 21.29% in 1978. Real average hourly compensation of high-wage workers would have increased, on average, by 0.19%, with yearly changes ranging from a decrease of 0.03% in 1978 to an increase of 0.36% in 1975. The net effect on the average hourly compensation of all workers would have been an average decrease of 2.68%, with yearly decreases varying from 1.38% in 1975 to 4.16% in 1978.

Rows 16–18 of Table 1 report the effects of abolishing wage floors on the real aggregate compensation of low-wage workers ($W_\ell H_\ell/P$), the real aggregate compensation of high-wage workers ($W_h H_h/P$), and the real aggregate compensation of all wage and salary workers in domestic industries (WH/P). Abolition of wage floors would have decreased real aggregate compensation of low-wage workers by 6.30%, on average for the years 1975–1978, with yearly decreases varying between 1.39 and 10.47%. The decreases in real aggregate compensation of high-wage workers would have varied from 1.88% in 1975 to 4.66% in 1978, with an average decrease of 3.04%. Real aggregate compensation of all domestic wage and salary workers would have decreased by percentages varying from 1.84 in 1975 to 5.12 in 1978, with the average percentage decrease being 3.29.

Row 19 of Table 1 reports the effects of minimum wage abolition on the real aggregate compensation of nonemployee factor inputs. This real compensation would have increased, on average, by 0.08%, with yearly percentage changes varying from −1.92 in 1978 to +1.41 in 1975.

Row 20 of Table 1 reports the simulated effects of wage floor abolition on the Gini coefficient of concentration for the distribution of hourly wage rates for all wage and salary workers. The Gini coefficient would have increased, on average, by 3.99%, with yearly increases varying from a low of 0.31% in 1976 to a high of 6.72% in 1978.

Finally, row 21 of Table 1 reports the simulated effects of abolishing legal minimum wages in 1975 on the rates of inflation, as measured by the implicit price deflator for GDP, for the years 1975–1978. On average, the rate of inflation would have been lower by 0.85 percentage points, with yearly rates of inflation being reduced by percentage points varying from 0.68 in 1977 to 0.95 in 1978.

Having discussed all of the results of the simulation for the total economy reported in Table 1, we will now examine some selected figures from the individual one-digit industry results reported in Tables 2a–2e. Only the average figures for the years 1975–1978 will be discussed; the interested reader can examine the individual year figures for each industry.

The contribution to GDP in constant 1972 dollars (Q_i) is decreased in every industry on the average for 1975–1978. The average decreases in Q_i vary from 1.01% for Government to 3.84% for Services. There are great differences among the individual industry results for the average effects on low-wage man-hours ($H_{\ell i}$), high-wage man-hours (H_{hi}), and total man-hours (H_i). Total man-hours increase, on the average, in Agriculture, Trade, Services, and Finance, Insurance, and Real Estate whereas they decrease in the other industries. Within the former group of industries, low-wage man-hours increase in all industries and high-wage man-hours decrease in all industries except Services. The results are even more mixed for Mining, Construction, Manufacturing, Government, and Transportation, Communications, and Utilities. Total man-hours are decreased in all of these industries. However, in Mining and Manufacturing low-wage man-hours are increased, whereas they are decreased in Construction, Government, and Transportation, Communications, and Utilities. High-wage man-hours decrease in all industries in this group except Construction.

Low-wage labor's share of employment ($E_{\ell i}/E_i$) increases in Agriculture, Mining, Manufacturing, Trade, Services, and Finance, Insurance, and Real Estate, whereas it decreases in Construction, Government, and Transportation, Communications, and Utilities.

Changes in real average hourly compensation of low-wage workers ($W_{\ell i}/P$), high-wage workers (W_{hi}/P), and all wage and salary workers (W_i/P) are quite diverse across industries; W_i/P decreases in Agriculture, Min-

Table 2a. Simulated Industry Effects of Abolishing Minimum Wages

Row	Variable	Agriculture 1975	Agriculture 1976	Agriculture 1977	Agriculture 1978	Agriculture av.	Mining 1975	Mining 1976	Mining 1977	Mining 1978	Mining av.
1	Q_i	−0.40%	−0.75%	−1.69%	−3.41%	−1.56%	−0.54%	−1.29%	−1.91%	−3.80%	−1.89%
2	H_{ei}	2.79	7.73	14.47	16.53	10.38	9.51	10.59	15.46	14.85	12.60
3	H_{hi}	−7.81	−19.26	−26.28	−26.80	−20.04	−3.87	−4.23	−6.68	−7.65	−5.61
4	H_i	0.04	0.82	4.37	5.17	2.60	−3.29	−3.52	−5.55	−6.64	−4.75
5	E_{ei}/E_i	2.76	6.92	10.10	11.36	7.79	12.88	14.14	20.91	21.47	17.35
6	W_{ei}/P	−5.55	−14.13	−21.59	−23.22	−16.12	−9.70	−11.65	−16.48	−17.64	−13.87
7	W_{hi}/P	0.32	0.30	−1.75	−2.83	−0.99	0.32	−1.05	−0.50	−1.80	−0.76
8	W_i/P	−5.03	−13.30	−21.59	−23.47	−15.85	−0.20	−1.70	−1.55	−2.74	−1.55
9	$W_{ei}H_{ei}/P$	−2.76	−6.40	−7.12	−6.69	−5.74	−0.19	−1.05	−1.02	−2.79	−1.26
10	$W_{hi}H_{hi}/P$	−7.49	−18.97	−28.03	−29.63	−21.03	−3.54	−5.28	−7.18	−9.46	−6.37
11	W_iH_i/P	−4.99	−12.49	−17.23	−18.30	−13.25	−3.50	−5.22	−7.10	−9.37	−6.30
12	P_i	0.00	−0.93	−1.82	−2.30	−1.26	0.03	−0.93	−0.92	−1.65	−0.87
13	$(P_iQ_i - W_iH_i)/P$	0.92	1.86	1.39	0.00	1.04	1.66	1.19	2.20	0.72	1.44
14	P_iQ_i/P	−0.08	−0.51	−1.70	−3.05	−1.35	−0.19	−1.05	−1.02	−2.79	−1.26
15	G_i	53.35	41.85	46.15	43.48	46.21	−1.26	−1.41	1.39	3.88	0.65

Table 2b. Simulated Industry Effects of Abolishing Minimum Wages

Row	Variable	Construction					Manufacturing				
		1975	*1976*	*1977*	*1978*	*av.*	*1975*	*1976*	*1977*	*1978*	*av.*
1	Q_i	−0.82%	−2.11%	−3.11%	−5.02%	−2.77%	−0.47%	−0.70%	−1.09%	−2.09%	−1.09%
2	H_{ei}	−4.66	−18.53	−20.78	−31.02	−18.75	3.77	4.47	3.63	3.22	3.77
3	H_{hi}	0.57	1.42	0.97	0.13	0.77	−4.02	−6.09	−6.46	−8.69	−6.32
4	H_i	0.12	−0.13	−0.73	−2.17	−0.73	−3.20	−4.90	−5.28	−7.08	−5.12
5	E_{ei}/E_i	−4.74	−18.47	−20.02	−28.92	−18.04	12.88	14.14	20.91	21.47	17.35
6	W_{ei}/P	−8.56	−20.64	−23.88	−30.29	−20.84	−8.84	−16.04	−17.33	−21.58	−15.95
7	W_{hi}/P	0.32	1.29	1.18	1.00	0.95	0.32	−0.53	−0.89	−1.49	−0.65
8	W_i/P	0.36	1.86	1.77	1.98	1.49	−0.55	−1.92	−2.33	−3.47	−2.07
9	$W_{ei}H_{ei}/P$	−13.22	−39.17	−44.66	−61.31	−39.59	−5.06	−11.57	−13.69	−18.36	−12.17
10	$W_{hi}H_{hi}/P$	0.89	2.70	2.14	1.14	1.72	−3.70	−6.62	−7.35	−10.18	−6.96
11	W_iH_i/P	0.48	1.73	1.04	−0.19	0.77	−3.75	−6.82	−7.62	−10.56	−7.19
12	P_i	−0.25	−0.31	−0.94	−1.79	−0.82	−0.19	−1.52	−2.26	−3.50	−1.87
13	$(P_iQ_i - W_iH_i)/P$	−4.58	−11.45	−13.54	−18.20	−11.94	7.14	9.85	9.32	9.07	8.85
14	P_iQ_i/P	−0.75	−1.25	−2.24	−4.15	−2.10	−0.34	−1.05	−1.54	−2.93	−1.47
15	G_i	−4.98	−5.20	−0.35	−5.20	−3.93	−2.29	−2.29	2.96	1.02	−0.15

Table 2c. Simulated Industry Effects of Abolishing Minimum Wages

Row	Variable	Trans., Comm., & Util.					Trade				
		1975	*1976*	*1977*	*1978*	*av.*	*1975*	*1976*	*1977*	*1978*	*av.*
1	Q_i	−0.87%	−2.13%	−3.29%	−6.17%	−3.12%	−0.46%	−1.48%	−2.22%	−4.68%	−2.21%
2	$H_{\ell i}$	−9.72	−12.36	−18.99	−26.43	−16.88	16.61	16.81	27.84	28.66	22.48
3	H_{hi}	−1.43	−2.69	−3.44	−6.41	−3.49	−4.50	−4.62	−7.83	−10.32	−6.82
4	H_i	−1.98	−3.34	−4.41	−7.64	−4.34	3.31	3.41	5.88	5.94	4.64
5	$E_{\ell i}/E_i$	−7.78	−9.10	−14.50	−18.83	−12.55	13.32	13.39	21.96	22.70	17.84
6	$W_{\ell i}/P$	−10.66	−12.29	−15.07	−17.66	−13.92	−11.53	−13.29	−21.58	−25.11	−17.88
7	W_{hi}/P	0.32	0.66	−0.17	0.32	0.28	0.32	−0.99	−1.10	−2.32	−1.02
8	W_i/P	0.49	0.85	0.27	0.89	0.63	−5.99	−7.53	−12.30	−15.76	−10.40
9	$W_{\ell i}H_{\ell i}/P$	−20.39	−24.65	−34.06	−44.08	−30.80	5.08	3.52	6.26	3.55	4.60
10	$W_{hi}H_{hi}/P$	−1.10	−2.03	−3.61	−6.09	−3.21	−4.17	−5.61	−8.93	−12.64	−7.84
11	W_iH_i/P	−1.49	−2.49	−4.15	−6.75	−3.72	−2.68	−4.12	−6.42	−9.81	−5.76
12	P_i	−0.11	−0.44	−1.28	−1.51	−0.84	−1.06	−2.38	−3.59	−5.17	−3.05
13	$(P_iQ_i - W_iH_i)/P$	0.31	−0.14	−1.21	−3.12	−1.04	0.82	−0.73	−0.71	−3.67	−1.07
14	P_iQ_i/P	−0.66	−1.40	−2.76	−5.02	−2.46	−1.20	−2.69	−4.00	−7.19	−3.77
15	G_i	−3.33	−2.88	−3.40	−2.73	−3.09	4.72	4.92	8.24	12.32	7.55

Table 2d. Simulated Industry Effects of Abolishing Minimum Wages

		Fin., Ins., & Real Estate					*Services*				
Row	*Variable*	*1975*	*1976*	*1977*	*1978*	*av.*	*1975*	*1976*	*1977*	*1978*	*av.*
1	Q_i	−0.11%	−0.99%	−1.58%	−2.75%	−1.36%	−1.19%	−2.48%	−4.30%	−7.38%	−3.84%
2	H_{ei}	12.49	16.36	19.67	23.75	18.07	−0.33	2.18	3.48	3.97	2.33
3	H_{hi}	−0.97	−2.03	−1.76	−2.74	−1.88	−0.51	1.06	1.58	0.86	0.75
4	H_i	1.11	0.95	1.78	1.80	1.41	−0.44	1.45	2.23	1.93	1.29
5	E_{ei}/E_i	11.39	15.42	17.92	21.96	16.67	0.11	0.72	1.25	2.03	1.03
6	W_{ei}/P	−17.37	−23.41	−27.30	−33.47	−25.39	−0.79	−4.88	−7.95	−11.30	−6.23
7	W_{hi}/P	0.32	0.95	0.18	0.34	0.45	0.32	0.82	1.66	2.45	1.31
8	W_i/P	−2.00	−2.35	−3.69	−4.59	−3.16	0.12	−0.20	−0.04	0.01	−0.03
9	$W_{ei}H_{ei}/P$	−4.88	−7.04	−7.62	−9.73	−7.32	−1.12	−2.71	−4.47	−7.33	−3.91
10	$W_{hi}H_{hi}/P$	−0.64	−1.08	−1.58	−2.40	−1.43	−0.18	1.88	3.23	3.30	2.06
11	W_iH_i/P	−0.88	−1.40	−1.91	−2.80	−1.75	−0.32	1.25	2.19	1.94	1.27
12	P_i	−0.23	−0.38	−0.77	−1.02	−0.60	−0.14	−0.75	−0.90	−1.04	−0.71
13	$(P_iQ_i - W_iH_i)/P$	0.25	0.16	−0.10	−0.57	−0.07	−2.84	−13.12	−21.92	−36.18	−18.52
14	P_iQ_i/P	−0.02	−0.20	−0.54	−1.11	−0.47	−1.01	−2.06	−3.39	−5.76	−3.06
15	G_i	−1.45	3.79	3.36	6.16	2.97	0.59	1.36	6.19	8.13	4.07

Table 2e. Simulated Industry Effects of Abolishing Minimum Wages

Row	Variable	*Government* 1975	1976	1977	1978	av.
1	Q_i	−0.62%	−1.03%	−1.02%	−1.35%	−1.01%
2	$H_{\ell i}$	−5.53	−18.16	−30.79	−43.85	−24.58
3	H_{hi}	−0.40	−0.32	0.02	−0.10	−0.20
4	H_i	−0.98	−2.25	−3.02	−3.97	−2.56
5	$E_{\ell i}/E_i$	−4.57	−15.94	−27.74	−39.85	−22.03
6	$W_{\ell i}/P$	−3.79	−11.66	−15.80	−18.39	−12.41
7	W_{hi}/P	0.32	0.61	1.00	0.68	0.65
8	W_i/P	0.51	1.36	2.42	2.72	1.75
9	$W_{\ell i}H_{\ell i}/P$	−9.32	−29.81	−46.59	−62.24	−36.99
10	$W_{hi}H_{hi}/P$	−0.07	0.29	1.02	0.58	0.46
11	W_iH_i/P	−0.47	−0.90	−0.60	−1.25	−0.81
12	P_i	−0.17	−1.04	−1.38	−2.56	−1.29
13	$(P_iQ_i - W_iH_i)/P$	−0.47	−0.90	−0.60	−1.25	−0.81
14	P_iQ_i/P	−0.47	−0.90	−0.59	−1.25	−0.80
15	G_i	−4.77	−4.90	−2.96	−7.80	−5.11

ing, Manufacturing, Trade, Services, and Finance, Insurance, and Real Estate, whereas it increases in Construction, Government, and Transportation, Communications, and Utilities. Real average hourly compensation of low-wage workers decreases in all industries. In contrast, real average hourly compensation of high-wage workers decreases in Agriculture, Mining, Manufacturing, and Trade, whereas it increases in Construction, Services, Government, Transportation, Communications, and Utilities, and Finance, Insurance, and Real Estate.

Next, consider rows 9–11 of Tables 2a–2e, which report the simulation results for real aggregate compensation of low-wage workers ($W_{\ell i}H_{\ell i}/P$), high-wage workers ($W_{hi}H_{hi}/P$), and all wage and salary workers (W_iH_i/P). Real aggregate compensation of low-wage workers decreases in all industries except Trade and real aggregate compensation of high-wage workers decreases in all industries except Construction, Services, and Government. Real aggregate compensation of all wage and salary workers decreases in all industries except Construction and Services.

Rows 12 of Tables 2a–2e report the simulation results for the implicit price deflators for the product (contribution to GDP) of individual industries. The price index for every industry is decreased by the simulated abolition of minimum wage rates.

Simulation results for the real compensation of nonemployee inputs by industry [$(P_iQ_i - W_iH_i)/P$] are reported on rows 13 of the tables. Real nonemployee compensation increases in Agriculture, Mining, and Manufacturing, whereas it decreases in the other industries.

Rows 14 of Tables 2a–2e report that the simulated abolition of minimum wages implies that real income (contribution to GDP) falls in every industry. Finally, the last rows of the tables report the simulation results for the Gini concentration coefficient of earnings for all wage and salary workers in each industry (G_i). The concentration coefficient is increased in Agriculture, Mining, Trade, Services, and Finance, Insurance, and Real Estate. It is decreased in Construction, Manufacturing, Government, and Transportation, Communications, and Utilities.

VIII. SUMMARY AND CONCLUSIONS

This paper develops a nine-sector model of the U.S. economy, presents estimates of the parameters of the equations of that model, and uses the estimated equations to simulate the effects for 1975–1978 of abolishing legal minimum wage rates in 1975. This multiequation, systems approach to estimating the effects of minimum wage rates can be contrasted with the single-equation approach used in most of the literature on minimum wages. A single-equation model includes a minimum wage variable as one of the explanatory variables in the equation of interest. The estimated value of the parameter for the minimum wage variable is then used as a measure of the effect of changes in legal wage floors on the (dependent) variable of interest. The problem with this approach is that it ignores the indirect effects of changes in the minimum wage variable on the dependent variable that would result from induced changes in other explanatory variables. The nature of the problem with the single-equation technique can be illustrated by deriving single-equation results from our model and comparing them with results from the full model simulation.

As an example, static, partial equilibrium effects of minimum wage abolition are estimated for three selected variables: average hourly compensation of low-wage labor, total low-wage man-hours employed, and the Gini concentration ratio for the aggregate wage distribution. From (6.3) it may be seen that the (estimated) partial equilibrium proportionate change in average hourly compensation of low-wage workers in the ith industry during period t is given by

$$\Delta \ln W_{\ell it} = -\beta_{i2} M_{it} \tag{8.1}$$

since for the abolition of the minimum wage (6.2) implies

$$\Delta M_{it} = -M_{it}. \tag{8.2}$$

The static partial equilibrium approach to predicting the change in average hourly compensation of low-wage labor stemming from abolition of minimum wage rates would hold constant low-wage employment; in our model, this yields

$$\Delta \ln W_{\ell t} = \frac{\sum_i W_{\ell it}H_{\ell it}\, \Delta \ln W_{\ell it}}{\sum_j W_{\ell jt}H_{\ell jt}}, \tag{8.3}$$

where upon substitution of (8.1) into (8.3) we arrive at

$$\Delta \ln W_{\ell t} = -\frac{\sum_i \beta_{i2}M_{it}W_{\ell it}H_{\ell it}}{\sum_j W_{\ell jt}H_{\ell jt}}. \tag{8.4}$$

It should be noted that (8.1) and (8.4) also estimate proportionate changes in real average hourly compensation. This is, of course, because the ceteris paribus effect of the minimum wage on average hourly compensation does not permit any change in the price level.

The static, partial equilibrium effects on low-wage employment in each industry can be obtained from the low-wage employment equation (6.14). Following the usual assumptions when estimating single-equation employment models, we "hold constant" price and output.[9] Thus the proportionate change in low wage employment in industry i during period t is given by

$$\Delta \ln H_{\ell it} = \Delta \ln V_{\ell it} - \Delta \ln W_{\ell it}, \tag{8.5}$$

where

$$\Delta \ln V_{\ell it} = \frac{\Delta V_{\ell it}}{V_{\ell it}}. \tag{8.6}$$

Now the estimated partial effect of minimum wage abolition on the low-wage factor share is obtained from (6.5) as

$$\Delta \ln V_{\ell it} = -\frac{(\delta_{i2} + \delta_{i3})\, \Delta \ln W_{\ell it}}{V_{\ell it}}. \tag{8.7}$$

Upon substitution of (8.7) and (8.1) into (8.5) we have

$$\Delta \ln H_{\ell it} = \frac{(\delta_{i2} + \delta_{i3} + V_{\ell it})\beta_{i2}M_{it}}{V_{\ell it}}. \tag{8.8}$$

The proportionate partial equilibrium effect of minimum wage abolition on total low-wage employment/man-hours is given by

$$\Delta \ln H_{\ell t} = \frac{\sum_i H_{\ell it}\, \Delta \ln H_{\ell it}}{\sum_j H_{\ell jt}}. \tag{8.9}$$

Substitution of (8.8) into (8.9) yields

$$\Delta \ln H_{\ell t} = \frac{\sum_i H_{\ell it}[(\delta_{i2} + \delta_{i3} + V_{\ell it})\beta_{i2}M_{it}/V_{\ell it}]}{\sum_j H_{\ell jt}} . \tag{8.10}$$

The Gini concentration ratio is estimated from

$$G_t = \left[\frac{\overline{w}_t}{\overline{w}_t + \tau_t}\right]\left[2F\left(\frac{\hat{\sigma}_t}{\sqrt{2}}\right) - 1\right], \tag{8.11}$$

where $\overline{w}_t$ is the average hourly wage; τ_t is a lower bound parameter of a three-parameter log normal distribution; $\hat{\sigma}_t$ is a variance related parameter of the log normal distribution; and $F(\cdot)$ is the standard normal cumulative distribution function (see Aitchison and Brown, 1957). For reasons discussed in Appendix A, τ_t is approximated as 0.25 times the basic adult minimum wage. Our partial equilibrium effects are estimated by appropriately changing τ_t while holding constant the parameter $\hat{\sigma}_t$. The implied change in $\overline{w}_t$ does not enter the calculation when τ_t is set equal to zero in accordance with the hypothesized abolition of minimum wages. Thus, the partial equilibrium estimated Gini concentration ratio in the absence of the minimum wage is

$$G_t^o = 2F\left(\frac{\hat{\sigma}_t}{\sqrt{2}}\right) - 1. \tag{8.12}$$

The resulting proportionate change is estimated by

$$\Delta \ln G_t = \ln\left(\frac{G_t^o}{G_t}\right) = \ln\left[1 + \left(\frac{\tau_t}{\overline{w}_t}\right)\right]. \tag{8.13}$$

Table 3 presents the static, partial equilibrium effects of minimum wage abolition on the average hourly compensation of low-wage labor, total low-wage man-hours employed, and the overall Gini concentration ratio as calculated from (8.4), (8.10), and (8.13), respectively. It is seen that the partial equilibrium estimate of the real wage effect of minimum wage abolition indicates a reduction of about 8.4% in the real average hourly compensation of low-wage labor. By contrast the full model simulation

Table 3. Selected Partial Equilibrium Effects of Abolishing Minimum Wages

Variable	*1975*	*1976*	*1977*	*1978*	*Av.*
W_ℓ, W_ℓ/P	−8.78%	−8.42%	−8.21%	−8.04%	−8.36%
H_ℓ	8.96	9.25	9.06	9.61	9.22
G	9.00	9.17	8.60	9.19	8.99

indicated real wage reductions for low-wage labor averaging 14.6% a year. On the other hand, the estimated low-wage employment increases are closer as between partial equilibrium and full model simulation results. The partial equilibrium estimate of a 9.2% rise in low-wage employment exceeds the simulation estimate of 8.3% by about 10% (0.9 percentage points). One can also approximate the partial equilibrium estimate of the minimum wage effect on the real total labor compensation of low-wage labor by adding together the first two rows of Table 3. Doing so implies that abolition of the minimum wage would have *raised* the real total labor compensation of low-wage labor by about 0.9%. On the other hand, the full model simulation predicts that real total labor compensation of low-wage labor would have *fallen* by 6.3%. Finally, the partial equilibrium estimate of the effect of abolishing minimum wages indicates a 9% rise in the Gini coefficient, that is, $2\frac{1}{4}$ times the simulated rise of 4%. Although many comparisons could be made for other variables in the model, these three examples illustrate the possibilities for significant discrepancies between static partial equilibrium predictions and full model simulation results.

We have presented the results of a full model simulation of the effects for 1975–1978 of abolishing legal wage floors in 1975. Since minimum wages were, of course, not abolished, our results are properly interpreted as estimates of the opportunity costs of the minimum wage policy of 1975–1978. Our results cannot be interpreted as the negative of the effects of implementing legal minimum wage rates unless one is willing to accept the hypothesis that the growth path followed by the economy has been independent of the minimum wage policy.

Our simulation model indicates that abolition of minimum wage rates would have:

1. Increased employment of low-wage labor
2. Decreased employment of high-wage labor
3. Decreased real GDP
4. Decreased real average hourly compensation of low-wage workers
5. Increased real average hourly compensation of high-wage workers
6. Decreased real total compensation of low-wage workers
7. Decreased real total compensation of high-wage workers
8. Decreased the rate of inflation, as measured by the GDP implicit price deflator

Of all these results, perhaps only item 3 is counterintuitive. However, one must keep in mind that there are other "distortions" in the economy; therefore, there is no valid a priori reason for believing that abolition of legal minimum wage rates should cause aggregate real output to increase.

APPENDIX A: ESTIMATION AND USE OF INDUSTRY WAGE DISTRIBUTIONS

The Three-Parameter Log Normal Distribution

Given a definition of low wage, we estimated the proportion of each one-digit industry's employment who were low-wage workers. This was accomplished by approximating the hourly wage distribution in each industry by a three-parameter log normal distribution:

$$W_{it} \sim LN\,(\tau_t, u_{it}, \sigma_i^2), \tag{A1}$$

where W_{it} is a random variable that represents a worker's hourly wage in industry i in period t; τ_t is a parameter that can vary over time but does not vary across industries; u_{it} is a parameter that can vary over time and across industries; and σ_i^2 is a parameter that does not vary over time but can vary across industries. The density function corresponding to the three-parameter log normal distribution is given by

$$\lambda(w_{it}) = \frac{\exp\{-[\ln(w_{it} - \tau_t) - u_{it}]^2/2\sigma_i^2\}}{(w_{it} - \tau_t)\sigma_i\sqrt{2\pi}} \qquad (\tau_t < w_{it} < \infty). \tag{A2}$$

The distribution function is given by

$$\begin{aligned} \Lambda(w_{it}|\tau_t, u_{it}, \sigma_i^2) &= 0 \qquad (w_{it} \leq \tau_t); \\ \Lambda(w_{it}|\tau_t, u_{it}, \sigma_i^2) &= \int_{\tau_t}^{w_{it}} \lambda(W_{it})dW_{it} \qquad (\tau_t < w_{it} < \infty). \end{aligned} \tag{A3}$$

For convenience the wage distributions can be recast in the form of the standard normal distribution:

$$\frac{\ln(W_{it} - \tau_t) - u_{it}}{\sigma_i} \sim N(0, 1), \tag{A4}$$

since for the three-parameter log normal distribution

$$\ln(W_{it} - \tau_t) \sim N(u_{it}, \sigma_i^2). \tag{A5}$$

The density function corresponding to (A4) is given by

$$f(z_{it}) = \frac{\exp(-z_{it}^2/2)}{\sqrt{2\pi}}, \tag{A6}$$

where

$$z_{it} = \frac{\ln(w_{it} - \tau_t) - u_{it}}{\sigma_i}. \tag{A7}$$

The standard normal distribution function is given by

$$F(z_{it}) = \int_{-\infty}^{z_{it}} f(Z_{it})dZ_{it} \ , \tag{A8}$$

where

$$Z_{it} = \frac{\ln(W_{it} - \tau_t) - u_{it}}{\sigma_i} \ . \tag{A9}$$

Thus it is clear that

$$\begin{aligned} \Lambda(w_{it}|\tau_t, u_{it}, \sigma_i^2) &= F(z_{it}) \qquad (\text{for } \tau_t < w_{it} < \infty) \\ &= P(\tau_t < W_{it} \leqslant w_{it}), \end{aligned} \tag{A10}$$

where $P(\cdot)$ is the probability of a wage less than or equal to w_{it}, or equivalently the proportion of workers earning an hourly wage less than or equal to w_{it}.

Moments of the wage distribution are derived from the general expression for the jth moment about τ_t:

$$E(W_{it} - \tau_t)^j = \exp(ju_{it} + 0.5j^2\sigma_i^2). \tag{A11}$$

The mean of the wage distribution is obtained from

$$\begin{aligned} E(W_{it}) &= E(W_{it} - \tau_t) + \tau_t \\ &= \exp(u_{it} + 0.5\sigma_i^2) + \tau_t \ . \end{aligned} \tag{A12}$$

The variance of the wage distribution is obtained from

$$\begin{aligned} \operatorname{Var}(W_{it}) &= E[W_{it} - E(W_{it})]^2 \\ &= E[(W_{it} - \tau_t) - E(W_{it} - \tau_t)]^2 \\ &= E(W_{it} - \tau_t)^2 - [E(W_{it} - \tau_t)]^2 \\ &= \exp(2u_{it} + 2\sigma_i^2) - \exp(2u_{it} + \sigma_i^2) \\ &= [\exp(2u_{it} + \sigma_i^2)]\,[\exp(\sigma_i^2) - 1]. \end{aligned} \tag{A13}$$

The expressions for the median wage, w_{it}^{med}, and the modal wage, w_{it}^{mod}, are, respectively,

$$w_{it}^{med} = \exp(u_{it}) + \tau_t \tag{A14}$$

and

$$w_{it}^{mod} = \exp(u_{it} - \sigma_i^2) + \tau_t. \tag{A15}$$

Estimation of the Parameters of the Log Normal Distribution

The parameter τ_t determines the lower bound for all industry wage distributions. For present purposes we specified this parameter to be proportional to the basic legal minimum wage for adults. The constant of proportionality selected was 0.25; thus we have

$$\tau_t = 0.25\ w_t^m, \tag{A16}$$

where w_t^m is the minimum wage rate in effect in year t. When the minimum wage rate was changed during a calendar year, a weighted average of the minimum wage rates was used to represent the minimum wage for the year. The weights used were the numbers of months each rate was in effect during the year divided by 12.

The choice of 0.25 as the constant of proportionality was not entirely arbitrary. An examination of the earnings distribution of year-round, full-time workers from the May 1978 Current Population Reports for the year 1977 shows that there were workers who reported annual earnings between \$1.00 and \$999 (or losses) and between \$1000 and \$1499. The minimal annual hours of work that could have been worked by a person defined to be a year-round, full-time worker is 1750 hours (35 hours/week × 50 weeks/year). Division of \$1000 by 1750 hours yields an implied hourly wage rate of approximately \$0.57/hour, which is one-fourth of the minimum wage rate prevailing in 1977. Naturally, over time \$0.57/hour would become a decreasing fraction of a growing minimum wage. However, the number of year-round full-time workers in the intervals \$1.00 to \$999 and \$1000 to \$1499 would approach zero. Consequently, the midpoint of \$1000 should be replaced by a higher figure for the purposes of division by 1750 hours to establish a lower bound hourly wage rate that can be related to the prevailing minimum wage. Thus, the choice of 0.25 as the constant of proportionality should provide a reasonable approximation to the lower bound, which by definition is such that no one is earning at or below the lower bound wage rate.

The parameter σ_i^2 was estimated for each one-digit industry from unpublished data taken from the May CPS for the years 1973–1978. These data consist of the number and proportion of workers 14 years and older in each industry who received a wage rate less than or equal to the prevailing minimum wage plus 5 cents, and the average hourly wage in the industry. The professional staff of the Minimum Wage Study Commission made these data available to us.

From (A8) and (A9) we can write

$$P_{it}^{\circ} = F\left[\frac{\ln(w_t^{\circ} - \tau_t) - u_{it}}{\sigma_i}\right], \tag{A17}$$

where w_t° is the minimum wage rate at time t plus 5 cents, and P_{it}° is the known sample proportion of workers in industry i at time t whose wage rates were less than or equal to w_t°. Thus by (A7) we have

$$z_{it}^{\circ} = \frac{\ln(w_t^{\circ} - \tau_t) - u_{it}}{\sigma_i}, \tag{A18}$$

where $z_{it}^{o} = F^{-1}(P_{it}^{o})$ and is obtained from the table of the standard normal cumulative distribution. Now (A12) implies that u_{it} may be expressed as

$$u_{it} = \ln[E(W_{it}) - \tau_t] - 0.5\sigma_i^2. \tag{A19}$$

Next we substitute (A19) into (A18) and replace σ_i, σ_i^2, τ_t, and $E(W_{it})$ by $\hat{\sigma}_{it}$, $\hat{\sigma}_{it}^2$, (A16), and $\overline{w}_{it}$, respectively, to obtain

$$z_{it}^{o} = \frac{\ln[(w_t^{o} - 0.25w_t^{m})/(\overline{w}_{it} - 0.25w_t^{m})] + 0.5\hat{\sigma}_{it}^2}{\hat{\sigma}_{it}}, \tag{A20}$$

where $\overline{w}_{it}$ is the sample average hourly wage in industry i at time t, and $\hat{\sigma}_{it}$ is a residual estimate of σ_i.

Expression (A20) can be rewritten as

$$0.5\hat{\sigma}_{it}^2 - z_{it}^{o}\hat{\sigma}_{it} + \ln[(w_t^{o} - 0.25w_t^{m})/(\overline{w}_{it} - 0.25w_t^{m})] = 0. \tag{A21}$$

Given that $w_t^{o} < \overline{w}_{it}$ and that z_{it}^{o} turns out to be always negative with the single exception of one very small positive value in Agriculture in 1974, (A21) always has real roots in $\hat{\sigma}_{it}$—one positive and one negative. The positive root becomes our estimate of $\hat{\sigma}_i$:

$$\hat{\sigma}_{it} = z_{it}^{o} + \sqrt{(z_{it}^{o})^2 - 2\ln[(w_t^{o} - 0.25w_t^{m})/(\overline{w}_{it} - 0.25w_t^{m})]}. \tag{A22}$$

For each industry we have six estimates of σ_i corresponding to the month of May in the years covering the period 1973–1978. Our final estimate of σ_i for each industry is obtained as a simple average of the individual estimates:

$$\hat{\sigma}_i = \sum_{t=1973}^{1978} \frac{\hat{\sigma}_{it}}{6}. \tag{A23}$$

Because employment variation was relatively small in each industry over the six-year period, the employment weighted average of the individual year estimates of σ_i yielded identical estimates of $\hat{\sigma}_i$:

$$\tilde{\sigma}_i = \frac{\sum_{t=1973}^{1978} E_{it}\hat{\sigma}_{it}}{\sum_{t=1973}^{1978} E_{it}}, \tag{A24}$$

where E_{it} is the total CPS employment in industry i in May of year t; and, as it turned out, $\tilde{\sigma}_i = \hat{\sigma}_i$.

Estimates of σ_i^2 are simply obtained as $(\hat{\sigma}_i)^2$. In Table A-1 we report our estimates of σ_i^2 for each industry and all industries combined. Estimates of u_{it} can be obtained from the expression

$$\hat{u}_{it} = \ln(\overline{w}_{it} - 0.25w_t^{m}) - 0.5\hat{\sigma}_i^2. \tag{A25}$$

These estimates are not reported since they are not used directly and will in general differ between data sets in which $\hat{\sigma}_i^2$ is the same but $\overline{w}_{it}$ differs.

Table A-1. Estimates of σ^2 from Unpublished CPS Data

Industry	σ^2
Agriculture	0.404
Mining	0.252
Construction	0.308
Manufacturing	0.264
Transportation, Communications, and Utilities	0.294
Trade	0.471
Finance, Insurance, and Real Estate	0.296
Services	0.501
Public Administration	0.310
All Industries	0.420

Low-Wage Workers by Industry

Given our approximation of the wage distribution by a three-parameter log normal distribution, the proportion of workers in an industry who are considered to be low-wage workers is given by

$$P_{\ell it} = F\left[\frac{\ln(w_t^{\ell o} - \tau_t) - u_{it}}{\sigma_i}\right], \tag{A26}$$

where $w_t^{\ell o}$ is a threshold, low-wage cutoff such that any worker earning at or below $w_t^{\ell o}$ is defined to be low-wage. The low-wage threshold is obtained from

$$w_t^{\ell o} = 0.65\hat{w}_t^{med}, \tag{A27}$$

where $\hat{w}_t^{med}$ is an estimate of the overall median wage rate. Our estimate of the median wage rate in year t was obtained from the expression

$$\hat{w}_t^{med} = [\exp(-0.5\hat{\sigma}^2)][\overline{w}_t - 0.25w_t^m] + 0.25w_t^m, \tag{A28}$$

where $\hat{\sigma}^2$ is the parameter estimated for all industries from the CPS data, and $\overline{w}_t$ is the average hourly wage in year t for all domestic industries obtained from the NIPA data. Expression (A28) was derived by dropping the industry subscript i and substituting (A16) and (A25) into (A14). The fixed percentage factor of 0.65 in (A27) was selected so as to ensure that the low-wage cutoff lies somewhat above historical values of the minimum wage.

The estimated proportions of low-wage workers were calculated from

$$\hat{P}_{\ell it} = F\left[\frac{\ln[(0.65\hat{w}_t^{med} - 0.25w_t^m)/(\overline{w}_{it} - 0.25w_t^m)] + 0.5\hat{\sigma}_i^2}{\hat{\sigma}_i}\right], \tag{A29}$$

where $\overline{w}_{it}$ is the average hourly wage in industry i in year t obtained from the NIPA data. Expression (A29) was obtained by substitution of (A16), (A23), (A25), and (A27) into (A26).

The overall proportion of low-wage labor, $\hat{P}_t^{\ell}$, was estimated from the individual industry estimates by

$$\hat{P}_{\ell t} = \frac{\sum_{i=1}^{9} E_{it}\hat{P}_{it}^{\ell}}{\sum_{i=1}^{9} E_{it}}, \tag{A30}$$

where E_{it} is the employment of wage and salary workers in industry i in year t. An alternative estimator of the overall low-wage labor proportion can be obtained directly from

$$\hat{\hat{P}}_{\ell t} = F\left[\frac{\ln[0.65\hat{w}_t^{med} - 0.25w_t^m)/(\overline{w}_t - 0.25w_t^m)] + 0.5\hat{\sigma}^2}{\hat{\sigma}}\right], \tag{A31}$$

where $\overline{w}_t$ is the average hourly wage across all industries, and $\hat{\sigma}$ is the corresponding estimate of σ for all domestic industries. There is of course no guarantee that the two estimates of P_t^{ℓ} will be the same. Even though we have assumed the wage distribution in each industry to be a three-parameter log normal distribution, we still know nothing about the wage distribution for all industries combined. The three-parameter log normal distribution has been used to approximate the overall wage distribution in order to permit us to obtain estimates of the overall median wage and hence of the low-wage cutoff. As it turns out, these two sets of estimates of the low-wage proportion are virtually identical.

Mean Wage Rates for Low Wage and High Wage Workers

In order to obtain the conditional mean wage rates for low-wage and high-wage labor it is convenient to work in terms of the first moment distribution, $\Lambda_1(w|\tau, u, \sigma^2)$, defined by

$$\begin{aligned}\Lambda_1(w|\tau, u, \sigma^2) &= \frac{1}{\tau + \alpha}\int_{\tau}^{w} W d\Lambda(w|\tau, u, \sigma^2) \\ &= \frac{\tau\Lambda(w|\tau, u, \sigma^2) + \alpha\,\Lambda(w|\tau, u + \sigma^2, \sigma^2)}{\tau + \alpha},\end{aligned} \tag{A32}$$

where $\alpha = E(W) - \tau = \exp(u + 0.5\sigma^2)$.

The conditional mean wage rate for low-wage workers is given by

$$E(W|\tau < W < w^{\ell o}) = \frac{\int_{\tau}^{w^{\ell o}} W d\Lambda(W|\tau, u, \sigma^2)}{\int_{\tau}^{w^{\ell o}} d\Lambda(W|\tau, u, \sigma^2)}, \tag{A33}$$

Let $w_\ell = E(W|\tau < W < w^{\ell o})$ and $P_\ell = \int_\tau^{w^{\ell o}} d\Lambda(W|\tau, u, \sigma^2) = \Lambda(w^{\ell o}|\tau, u, \sigma^2)$. From (A32) we have

$$\int_\tau^{w^{\ell o}} Wd\Lambda(w|\tau, u, \sigma^2) = [\tau + \alpha][\Lambda_1(w^{\ell o}|\tau, u, \sigma^2)]. \tag{A34}$$

By making the appropriate substitutions in (A33) we obtain

$$\begin{aligned} w_\ell &= \frac{[\tau + \alpha][\Lambda_1(w^{\ell o}|\tau, u, \sigma^2)]}{P_\ell} \\ &= \tau + \frac{\alpha\Lambda(w^{\ell o}|\tau, u + \sigma^2, \sigma^2)}{P_\ell}. \end{aligned} \tag{A35}$$

For the ith industry at time t, we have

$$w_{\ell it} = \tau_t + \frac{\alpha_{it}\ \Lambda(w^{\ell o}|\tau_t, u_{it} + \sigma_i^2, \sigma_i^2)}{P_{\ell it}}, \tag{A36}$$

where $\alpha_{it} = E(W_{it}) - \tau_t$. In practice $E(W_{it})$ is replaced by the observed estimate of the mean wage, $\overline{w}_{it}$.

The conditional mean wage rate for high-wage labor, w_{hit}, can be obtained in a similar fashion. However, it is simpler to recognize that the unconditional mean wage rate is a weighted average of the conditional mean wage rates of low-wage and high-wage workers:

$$\overline{w}_{it} = (P_{\ell it})(w_{\ell it}) + (1 - P_{\ell it})(w_{hit}). \tag{A37}$$

In turn (A37) implies

$$w_{hit} = \frac{\overline{w}_{it} - (P_{\ell it})(w_{\ell it})}{1 - P_{\ell it}}. \tag{A38}$$

Data Considerations

The May CPS data used to estimate the σ_i parameters correspond to Census industry categories. On the other hand, the estimates of σ_i were applied to NIPA data which correspond to the Standard Industrial Classification (SIC) system. Although at the one digit level of industry aggregation the two classification systems are quite similar, there are important differences between the two systems. One important difference is that in the CPS data government employment is distributed across industry categories most closely related to the nature of the employment. Only the category of Public Administration appears separately for government employment by industry division. Although the 1972 SIC system no longer codes government as a separate industry, the data continue to identify private sector employment by industry and government employment separately. To the extent that government employment involves proportionately less low-wage employment, the proportions of workers earning less than the minimum wage will tend to be smaller in the CPS data compared with the same industry categories in the NIPA data. Consequently, the estimates of σ_i obtained from the unpublished CPS data may produce underestimates of the low-wage proportions in the corresponding NIPA/SIC industries. Also the estimate of σ_i for Public Administration in the CPS data was applied to the NIPA government employment data to obtain estimates of the low-wage proportions in government. In this case it is not clear what the direction of the bias is, or even whether one exists.

Apart from different industry classification systems, there also remains the fact that the CPS data are based entirely on household survey data and the NIPA data are based in large part on establishment survey data. Furthermore, the CPS data correspond to a single month, whereas the NIPA data refer to annual averages.

A related consideration stems from the fact that because of data limitations the average hourly wage rates computed from the NIPA data were weighted averages. For each industry and all industries combined, these average wage rates were computed as the ratios of aggregate wages and salaries to aggregate hours worked by employees. Thus each wage rate was in effect weighted by the annual hours worked by the corresponding worker. On the other hand, the average wage rates obtained from the unpublished CPS data were arithmetic averages in which each worker was assigned equal weight.

The effects on the estimated proportions of low-wage workers of using weighted average wage rates rather than arithmetic averages cannot be determined a priori. Inspection of (A29) reveals that it depends on how the estimates of the overall median wage are affected relative to the industry wage rates. Because of the nature of the issues surrounding the use of the May CPS data to estimate the σ_i parameters, which are then used to obtain estimates of the proportion of low-wage workers from NIPA data, we cannot say what the net effect is on these estimates. However, it is interesting to note that, with few exceptions, the estimates of $P_{\ell it}$ and $P_{\ell t}$ for 1973–1978 obtained with the use of the NIPA data corresponded quite closely with estimates obtained from the May CPS.

APPENDIX B: ESTIMATED EQUATIONS AND DOCUMENTATION

Our primary data source is the *National Income and Product Accounts of the United States* (NIPA). These data are supplemented with U.S. Bureau of Labor Statistics data on various price indexes for producer goods in different industries. The model was estimated over the period 1955–1978 by ordinary least squares from the PLANETS software package. Dynamic simulations were conducted for the period 1975–1978 with the Econometric Forecasting Program (EFP) package. The EFP package employs the Gauss–Seidel method for numerically approximating the model solution for the values of the endogenous variables. The control simulation was obtained by setting all of the exogenous variables and minimum wages to their actual historical values. Policy simulations involving minimum wages were obtained by making the appropriate changes in the determination of minimum wages over the simulation period. The proportionate effects of different minimum wage policies were then calculated from the expression

$$100 \times \ln\left(\frac{X_t^p}{X_t^c}\right),$$

where X_t^p and X_t^c refer to the policy simulation and control simulation values, respectively, for some variable of interest.

In the actual simulations there were three variables which were set exogenously but which were originally endogenous in the theoretical model. Two of these were the low-wage factor share in Mining and the nonemployee residual factor share in Government. Each of these factor shares were miniscule and varied little from their respective means of 0.46% and 0.91% over the period 1975–1978. The third variable was the implicit price deflator for Agriculture. Its value was exogenously determined for 1975 but endogenously determined for the remainder of the simulation period. The reason was that its 1975 value was not simulated very accurately in the control simulation.

The actual regression results are reported below, and are followed by a section containing the definitions of the regression variables. t-ratios are reported in parentheses.

Estimated Equations (1955–1978)

1. Factor Supply Price Equations—Low-Wage Labor:

$$\text{AGRCL1} - 0.571\ \text{AGRCL1}(-1) =$$

$$\underset{(-3.23)}{-1.353} + \underset{(2.24)}{0.114}(\text{AGCOV1} - 0.571\ \text{AGCOV1}(-1))$$

$$+ \underset{(6.89)}{1.063}(\text{MARCL}(-1) - 0.571\ \text{MARCL}(-2))$$

$$+ \underset{(2.68)}{0.370}\ (\text{RXDIP}(-1) - 0.571\ \text{RXDIP}(-2))$$

$$\bar{R}^2 = 0.957, \qquad \text{DW} = 1.935$$

$$\begin{aligned} \text{MIRCL1} = {} & \underset{(-1.03)}{-0.615} + \underset{(1.59)}{0.097}\ \text{MICOV1} + \underset{(2.98)}{0.431}\ \text{CORCL}(-1) \\ & + \underset{(1.19)}{0.100}\ \text{RXDIP}(-1) + \underset{(2.60)}{0.107}\ \text{MIHLP1}(-1) \\ & + \underset{(3.58)}{0.012}\ \text{T} \end{aligned}$$

$\overline{R}^2 = 0.995, \quad DW = 1.364$

$$\begin{aligned} \text{CORCL1} = {} & \underset{(-1.62)}{-0.859} + \underset{(1.81)}{0.087}\ \text{COCOV1} + \underset{(6.50)}{1.262}\ \text{MIRCL}(-1) \\ & + \underset{(1.73)}{0.075}\ \text{COHLP1}(-1) + \underset{(1.44)}{10.801}\ \text{T2} \end{aligned}$$

$\overline{R}^2 = 0.990, \quad DW = 1.775$

$$\begin{aligned} \text{MARCL1} = {} & \underset{(1.64)}{0.090}\ \text{MACOV1} + \underset{(14.04)}{0.836}\ \text{MIRCL}(-1) \\ & + \underset{(3.13)}{0.088}\ \text{MAHLP1}(-1) - \underset{(-3.37)}{3.968}\ \text{T2} \end{aligned}$$

$\overline{R}^2 = 0.994, \quad DW = 1.343$

$$\begin{aligned} \text{TCURCL1} = {} & \underset{(-1.57)}{-0.901} + \underset{(1.83)}{0.107}\ \text{TCUCOV1} + \underset{(2.55)}{0.356}\ \text{GORCL}(-1) \\ & + \underset{(1.33)}{0.111}\ \text{RXDIP}(-1) + \underset{(3.41)}{0.108}\ \text{TCUHLP1}(-1) \\ & + \underset{(4.00)}{0.013}\ \text{T} \end{aligned}$$

$\overline{R}^2 = 0.995, \quad DW = 1.641$

$$\begin{aligned} \text{WRTRCL1} = {} & \underset{(-2.98)}{-1.307} + \underset{(3.19)}{0.141}\ \text{WRTCOV1} + \underset{(6.01)}{1.091}\ \text{GORCL}(-1) \\ & + \underset{(1.32)}{0.130}\ \text{WRTHLP1}(-1) + \underset{(1.97)}{11.442}\ \text{T2} \end{aligned}$$

$\overline{R}^2 = 0.994, \quad DW = 1.877$

$$\text{FRRCL1} = \underset{(-2.66)}{-0.792} + \underset{(3.17)}{0.204}\ \text{FRCOV1} + \underset{(9.37)}{1.079}\ \text{DIRCL}(-1)$$

$$+\ 0.101\ \text{FRHLP1}(-1) + 11.339\ \text{T2}$$
$$\quad(3.39) \qquad\qquad\qquad (2.69)$$

$\overline{R}^2 = 0.995, \quad DW = 2.98$

$$\text{SRCL1} = 0.075\ \text{SCOV1} + 0.630\ \text{DIRCL}(-1)$$
$$\qquad (3.30) \qquad\qquad (7.80)$$
$$+\ 0.013\ \text{SHLP1}(-1) + 0.056 \times 10^{-1}\ \text{T}$$
$$\quad (5.18) \qquad\qquad\qquad (3.25)$$

$\overline{R}^2 = 0.996, \quad DW = 1.877$

$$\text{GORCL1} = 0.040\ \text{GOCOV1} + 0.619\ \text{FRRCL}(-1)$$
$$\qquad (2.94) \qquad\qquad (5.67)$$
$$+\ 0.026\ \text{GOHLP1}(-1) + 0.088 \times 10^{-1}\ \text{T}$$
$$\quad (3.58) \qquad\qquad\qquad (4.16)$$

$\overline{R}^2 = 0.993, \quad DW = 2.003$

2. Factor Supply Price Equations—High-Wage Labor:

$$\text{AGRCH1} = -2.743 + 0.369\ \text{GORCH}(-1) + 0.377\ \text{RXDIP}(-1)$$
$$\qquad (-2.36) \quad (1.74) \qquad\qquad\qquad (2.33)$$
$$+\ 0.154\ \text{AGHHP1}(-1) + 0.013\ \text{T}$$
$$\quad (3.26) \qquad\qquad\qquad (2.22)$$

$\overline{R}^2 = 0.992, \quad DW = 1.386$

$$\text{MICORCH1} = 0.574\ \text{MIHHP1}(-1) - 23.578\ \text{T2}$$
$$\qquad (9.30) \qquad\qquad\qquad (-8.58)$$

$\overline{R}^2 = 0.758, \quad DW = 1.081$

$$\text{CORCH1} = -1.277 + 0.421\ \text{MARCH}(-1)$$
$$\qquad (-2.23) \quad (1.02)$$
$$+\ 0.537\ \text{COHHP1}(-1) + 0.014\ \text{T}$$
$$\quad (6.66) \qquad\qquad\qquad (1.69)$$

$\overline{R}^2 = 0.986, \quad DW = 1.222$

$$\text{MARCH1} = 1.182\ \text{TCURCH}(-1) - 0.290\ \text{RXDIP}(-1)$$
$$\qquad (13.729) \qquad\qquad (-3.58)$$
$$+\ 0.336\ \text{MAHHP1}(-1)$$
$$\quad (3.96)$$

$\overline{R}^2 = 0.994, \quad DW = 1.432$

$$\begin{aligned}\text{TCURCH1} = \;& \underset{(6.13)}{0.358}\ \text{MIRCH}(-1) + \underset{(5.99)}{0.384}\ \text{GORCH}(-1)\\ & - \underset{(-3.21)}{0.079}\ \text{RXDIP}(-1) + \underset{(4.59)}{0.220}\ \text{TCUHHP1}(-1)\\ & + \underset{(4.69)}{0.013}\ \text{T}\end{aligned}$$

$\bar{R}^2 = 0.999, \quad DW = 2.169$

$$\begin{aligned}\text{WRTRCH1} = \;& \underset{(-5.17)}{-3.025} + \underset{(16.449)}{0.754}\ \text{GORCH}(-1)\\ & + \underset{(1.64)}{0.129}\ \text{RXDIP}(-1) + \underset{(3.26)}{0.502}\ \text{WRTHHP1}\end{aligned}$$

$\bar{R}^2 = 0.996, \quad DW = 1.328$

$$\begin{aligned}\text{FRRCH1} = \;& \underset{(-1.92)}{-1.559} + \underset{(4.65)}{0.543}\ \text{DIRCH}(-1) + \underset{(2.46)}{0.181}\ \text{RXDIP}(-1)\\ & + \underset{(2.33)}{0.358}\ \text{FRHHP1}(-1) - \underset{(-1.76)}{6.266}\ \text{T2}\end{aligned}$$

$\bar{R}^2 = 0.995, \quad DW = 1.303$

$$\begin{aligned}&\text{SRCH1} - 0.574\ \text{SRCH1}(-1) =\\ &\quad \underset{(-2.18)}{-0.931} + \underset{(6.39)}{0.749}\ (\text{GORCH}(-1) - 0.574\ \text{GORCH}(-2))\\ &\quad + \underset{(3.69)}{0.532}\ (\text{SHHP1}(-1) - 0.574\ \text{SHHP1}(-2))\\ &\quad + \underset{(0.37)}{2.689}\ (\text{T2} - 0.573\ \text{T2}(-1))\end{aligned}$$

$\bar{R}^2 = 0.987, \quad DW = 1.669$

$$\begin{aligned}\text{GORCH1} = \;& \underset{(-2.18)}{-2.252} + \underset{(8.75)}{1.232}\ \text{TCURCH}(-1)\\ & - \underset{(-1.87)}{0.261}\ \text{RXDIP}(-1) + \underset{(5.04)}{0.672}\ \text{GOHHP1}(-1)\\ & + \underset{(1.18)}{6.296}\ \text{T2}\end{aligned}$$

$\bar{R}^2 = 0.991, \quad DW = 1.101$

3. Factor Share Equations—Low-Wage Labor:

$$\text{AGFSL} - 0.571\ \text{AGFSL}(-1) =$$

$$\underset{(4.04)}{0.112} - \underset{(-1.58)}{0.137}\ (\text{AGCHL} - 0.571\ \text{AGCHL}(-1))$$

$$+ \underset{(2.26)}{0.096}\ (\text{AGPXL} - 0.571\ \text{AGPXL}(-1))$$

$$+ \underset{(0.03)}{0.039 \times 10^{-3}}\ (\text{T} - 0.571\ \text{T}(-1))$$

$\bar{R}^2 = 0.472$, DW $= 1.467$

MIFSL : Exogenous

$$\text{COFSL} = \underset{(3.15)}{0.113} - \underset{(-1.39)}{0.045}\ \text{COCHL} + \underset{(1.86)}{0.014}\ \text{COPXL} - \underset{(-4.08)}{0.660}\ \text{T2}$$

$\bar{R}^2 = 0.416$, DW $= 0.696$

$$\text{MAFSL} - 0.545\ \text{MAFSL}(-1) =$$

$$\underset{(-0.50)}{-0.057 \times 10^{-1}} + \underset{(1.01)}{0.026}\ (\text{MACHL} - 0.545\ \text{MACHL}(-1))$$

$$- \underset{(-3.91)}{0.039}\ (\text{MAPX2L} - 0.545\ \text{MAPX2L}(-1))$$

$$- \underset{(-1.52)}{0.017 \times 10^{-2}}\ (\text{T2} - 0.545\ \text{T2}(-1))$$

$\bar{R}^2 = 0.768$, DW $= 1.157$

$$\text{TCUFSL} - 0.728\ \text{TCUFSL}(-1) =$$

$$\underset{(5.01)}{0.090 \times 10^{-1}} - \underset{(-3.05)}{0.019}\ (\text{TCUCHL} - 0.728\ \text{TCUCHL}(-1))$$

$$- \underset{(-0.23)}{0.080 \times 10^{-2}}\ (\text{TCUPX1L} - 0.728\ \text{TCUPX1L}(-1))$$

$\bar{R}^2 = 0.260$, DW $= 1.84$

$$\text{WRTFSL} = \underset{(1.67)}{0.056} + \underset{(2.52)}{0.060}\ \text{WRTCHL} - \underset{(-1.43)}{0.011}\ \text{WRTPX2L}$$

$$- \underset{(-2.47)}{0.724}\ \text{T2}$$

$\bar{R}^2 = 0.927$, DW $= 0.938$

$$\begin{aligned}
&\text{FRFSL} - 0.751\ \text{FRFSL}(-1) = \\
&\quad \underset{(2.10)}{0.035 \times 10^{-1}} - \underset{(-1.35)}{0.089 \times 10^{-1}}(\text{FRCHL} - 0.751\ \text{FRCHL}(-1)) \\
&\quad + \underset{(1.15)}{0.052 \times 10^{-1}} (\text{FRPX1L} - 0.751\ \text{FRPX1L}(-1)) \\
&\quad + \underset{(3.83)}{0.038 \times 10^{-2}} (\text{T} - 0.751\ \text{T}(-1))
\end{aligned}$$

$\bar{R}^2 = 0.508, \quad DW = 1.239$

$$\begin{aligned}
\text{SFSL} = &\underset{(5.83)}{0.155} - \underset{(-0.25)}{0.078 \times 10^{-1}}\ \text{SCHL} - \underset{(-0.30)}{0.039 \times 10^{-1}}\ \text{SPXL} \\
&- \underset{(-2.62)}{0.014 \times 10^{-1}}\ \text{T}
\end{aligned}$$

$\bar{R}^2 = 0.933, \quad DW = 0.779$

$$\text{GOFSL} = \underset{(3.46)}{0.103} - \underset{(-4.77)}{0.092}\ \text{GOCHL} + \underset{(3.53)}{0.786}\ \text{T2}$$

$\bar{R}^2 = 0.923, \quad DW = 0.845$

4. Factor Share Equations—High-Wage Labor:

$$\begin{aligned}
&\text{AGFSH} - 0.571\ \text{AGFSH}(-1) = \\
&\quad \underset{(1.19)}{0.023} - \underset{(-1.06)}{0.065} (\text{AGCHL} - 0.571\ \text{AGCHL}(-1)) \\
&\quad - \underset{(-1.18)}{0.035} (\text{AGPXL} - 0.571\ \text{AGPXL}(-1)) \\
&\quad + \underset{(2.84)}{0.027 \times 10^{-1}} (\text{T} - 0.571\ \text{T}(-1))
\end{aligned}$$

$\bar{R}^2 = 0.693, \quad DW = 1.273$

$$\text{MIFSH} = \underset{(3.95)}{0.330} - \underset{(-0.35)}{0.026}\ \text{MICHL} - \underset{(-3.45)}{0.093}\ \text{MIPX1}$$

$\bar{R}^2 = 0.312, \quad DW = 1.173$

$$\text{COFSH} = \underset{(2.73)}{0.337} + \underset{(2.37)}{0.264}\ \text{COCHL} - \underset{(-4.91)}{0.129}\ \text{COPXL} + \underset{(0.79)}{0.441}\ \text{T2}$$

$\bar{R}^2 = 0.794, \quad DW = 1.477$

$$\text{MAFSH} - 0.545\ \text{MAFSH}(-1) =$$

$$\underset{(3.05)}{-0.465} - \underset{(-1.15)}{0.394}\ (\text{MACHL} - 0.545\ \text{MACHL}(-1))$$

$$+ \underset{(1.13)}{0.152}\ (\text{MAPX2L} - 0.545\ \text{MAPX2L}(-1))$$

$$+ \underset{(1.67)}{0.026} \times 10^{-1}\ (\text{T2} - 0.545\ \text{T2}(-1))$$

$\overline{R}^2 = 0.118, \quad DW = 1.769$

$$\text{TCUFSH} - 0.728\ \text{TCUFSH}(-1) =$$

$$\underset{(6.55)}{0.142} - \underset{(-0.09)}{0.069}\ (\text{TCUCHL} - 0.728\ \text{TCUCHL}(-1))$$

$$- \underset{(-0.33)}{0.014}\ (\text{TCUPX1L} - 0.728\ \text{TCUPX1L}(-1))$$

$\overline{R}^2 = -0.089, \quad DW = 1.316$

$$\text{WRTFSH} = \underset{(6.52)}{0.798} - \underset{(-1.84)}{0.160}\ \text{WRTCHL} + \underset{(1.38)}{0.039}\ \text{WRTPX2L}$$

$$- \underset{(-2.46)}{2.625}\ \text{T2}$$

$\overline{R}^2 = 0.322, \quad DW = 2.095$

$$\text{FRFSH} - 0.751\ \text{FRFSH}(-1) =$$

$$\underset{(3.03)}{0.037} + \underset{(0.06)}{0.028} \times 10^{-1}\ (\text{FRCHL} - 0.751\ \text{FRCHL}(-1))$$

$$- \underset{(-0.32)}{0.011}\ (\text{FRPX1L} - 0.751\ \text{FRPX1L}(-1))$$

$$+ \underset{(2.71)}{0.020} \times 10^{-1}\ (\text{T} - 0.751\ \text{T}(-1))$$

$\overline{R}^2 = 0.530, \quad DW = 1.444$

$$\text{SFSH} = \underset{(0.15)}{0.094} \times 10^{-1} + \underset{(5.79)}{0.434}\ \text{SCHL} + \underset{(0.73)}{0.023}\ \text{SPXL}$$

$$+ \underset{(3.64)}{0.046} \times 10^{-1}\ \text{T}$$

$\overline{R}^2 = 0.985, \quad DW = 1.131$

$$\text{GOFSH} = 1 - \text{GOFSL} - \text{GOFSX}$$

5. Factor Share Equations—Nonemployee Residual:

$$\text{AGFSX} - 0.571\ \text{AGFSX}(-1) =$$

$$\underset{(7.35)}{0.294} + \underset{(1.61)}{0.202}\ (\text{AGCHL} - 0.571\ \text{AGCHL}(-1))$$

$$- \underset{(-0.99)}{0.061}\ (\text{AGPXL} - 0.571\ \text{AGPXL}(-1))$$

$$- \underset{(-1.41)}{0.027 \times 10^{-1}}\ (\text{T} - 0.571\ \text{T}(-1))$$

$$\bar{R}^2 = -0.003, \quad DW = 1.490$$

$$\text{MIFSX} = 1 - \text{MIFSL} - \text{MIFSH}$$

$$\text{COFSX} = \underset{(4.32)}{0.550} - \underset{(-1.90)}{0.219}\ \text{COCHL} + \underset{(4.23)}{0.115}\ \text{COPXL} + \underset{(0.38)}{0.219}\ \text{T2}$$

$$\bar{R}^2 = 0.793, \quad DW = 1.441$$

$$\text{MAFSX} - 0.545\ \text{MAFSX}(-1) =$$

$$\underset{(-0.03)}{-0.048 \times 10^{-1}} + \underset{(1.04)}{0.369}\ (\text{MACHL} - 0.545\ \text{MACHL}(-1))$$

$$- \underset{(-0.81)}{0.113}\ (\text{MAPX2L} - 0.545\ \text{MAPX2L}(-1))$$

$$- \underset{(-1.50)}{0.024 \times 10^{-1}}\ (\text{T2} - 0.545\ \text{T2}(-1))$$

$$\bar{R}^2 = 0.171, \quad DW = 1.727$$

$$\text{TCUFSX} - 0.728\ \text{TCUFSX}(-1) =$$

$$\underset{(5.41)}{0.121} + \underset{(0.34)}{0.026}\ (\text{TCUCHL} - 0.728\ \text{TCUCHL}(-1))$$

$$+ \underset{(0.34)}{0.015}\ (\text{TCUPX1L} - 0.728\ \text{TCUPX1L}(-1))$$

$$\bar{R}^2 = -0.086, \quad DW = 1.331$$

$$\text{WRTFSX} = \underset{(1.12)}{0.146} + \underset{(1.08)}{0.100}\ \text{WRTCHL} - \underset{(-0.92)}{0.028}\ \text{WRTPX2L}$$

$$+ \underset{(2.94)}{3.35}\ \text{T2}$$

$$\bar{R}^2 = 0.687, \quad DW = 2.059$$

$$\text{FRFSX} - 0.751\ \text{FRFSX}(-1) =$$

$$\underset{(15.89)}{0.208} + \underset{(0.12)}{0.061} \times 10^{-1}\,(\text{FRCHL} - 0.751\ \text{FRCHL}(-1))$$

$$+ \underset{(0.15)}{0.055} \times 10^{-1}\,(\text{FRPX1L} - 0.751\ \text{FRPX1L}(-1))$$

$$- \underset{(-3.04)}{0.024} \times 10^{-1}\,(\text{T} - 0.751\ \text{T}(-1))$$

$\bar{R}^2 = 0.561, \quad DW = 1.311$

$$\text{SFSX} = \underset{(12.39)}{0.836} - \underset{(-5.43)}{0.426}\,\text{SCHL} - \underset{(-0.58)}{0.019}\,\text{SPXL} - \underset{(-2.45)}{0.032} \times 10^{-1}\,\text{T}$$

$\bar{R}^2 = 0.975, \quad DW = 1.308$

GOFSX : Exogenous

6. Output Demand Equations:

$$\text{AGY} = \underset{(0.58)}{1.387} - \underset{(-2.14)}{0.153}\ \text{LP1} + \underset{(4.94)}{0.410}\ \text{LP3} + \underset{(0.82)}{0.225}\ \text{LP4}$$

$$- \underset{(-3.12)}{1.246}\ \text{LP7} + \underset{(1.58)}{0.437}\ \text{RYMAP}$$

$\bar{R}^2 = 0.704, \quad DW = 2.516$

$$\text{MIY} = \underset{(-6.02)}{-3.742} - \underset{(-6.21)}{0.159}\ \text{LP1} - \underset{(-2.12)}{0.079}\ \text{LP2} + \underset{(4.66)}{0.369}\ \text{LP3}$$

$$- \underset{(-3.07)}{0.504}\ \text{LP4} - \underset{(-1.09)}{0.286}\ \text{LP5} - \underset{(-2.78)}{0.633}\ \text{LP8}$$

$$+ \underset{(13.85)}{0.991}\ \text{RYMAP} - \underset{(-2.21)}{0.011}\ \text{T}$$

$\bar{R}^2 = 0.975, \quad DW = 2.334$

$$\text{COY} = \underset{(-5.50)}{-4.561} - \underset{(-5.09)}{0.184}\ \text{LP2} - \underset{(-12.804)}{0.642}\ \text{LP3} + \underset{(0.97)}{0.164}\ \text{LP6}$$

$$- \underset{(-4.71)}{0.485}\ \text{LP8} + \underset{(12.295)}{1.178}\ \text{RYMAP}$$

$\bar{R}^2 = 0.978, \quad DW = 1.592$

$$\underset{(4.14)}{\mathrm{MAY} = 1.229} + \underset{(19.716)}{0.697\ \mathrm{RYMAP}}$$

$$\bar{R}^2 = 0.944, \qquad DW = 0.761$$

$$\begin{aligned}\mathrm{TCUY} = \underset{(-6.21)}{-3.883} &- \underset{(-2.78)}{0.043\ \mathrm{LP1}} - \underset{(-2.22)}{0.046\ \mathrm{LP2}} + \underset{(5.10)}{0.210\ \mathrm{LP3}}\\ &- \underset{(-6.04)}{0.451\ \mathrm{LP4}} - \underset{(5.04)}{0.761\ \mathrm{LP7}} - \underset{(-2.64)}{0.282\ \mathrm{LP8}}\\ &+ \underset{(16.089)}{1.122\ \mathrm{RYMAP}} + \underset{(6.38)}{0.016\ \mathrm{T}}\end{aligned}$$

$$\bar{R}^2 = 0.999, \qquad DW = 2.705$$

$$\begin{aligned}\mathrm{WRTY} = \underset{(-3.47)}{-1.725} &- \underset{(-2.94)}{0.041\ \mathrm{LP1}} - \underset{(-1.86)}{0.108\ \mathrm{LP4}} - \underset{(-4.37)}{0.295\ \mathrm{LP5}}\\ &- \underset{(-6.10)}{0.211\ \mathrm{LP6}} - \underset{(-5.56)}{0.739\ \mathrm{LP7}} + \underset{(8.76)}{0.450\ \mathrm{LP8}}\\ &+ \underset{(17.26)}{0.997\ \mathrm{RYMAP}}\end{aligned}$$

$$\bar{R}^2 = 0.999, \qquad DW = 1.909$$

$$\begin{aligned}\mathrm{FRY} = \underset{(4.25)}{2.141} &- \underset{(-1.15)}{0.023\ \mathrm{LP1}} - \underset{(4.32)}{0.107\ \mathrm{LP2}} + \underset{(3.10)}{0.327\ \mathrm{LP4}}\\ &- \underset{(-1.53)}{0.188\ \mathrm{LP5}} - \underset{(6.47)}{0.861\ \mathrm{LP6}} + \underset{(7.33)}{0.453\ \mathrm{RYMAP}}\\ &+ \underset{(17.459)}{0.025\ \mathrm{T}}\end{aligned}$$

$$\bar{R}^2 = 0.999, \qquad DW = 1.610$$

$$\begin{aligned}\mathrm{SY} = \underset{(-2.48)}{-2.325} &- \underset{(-1.90)}{0.045\ \mathrm{LP1}} - \underset{(-3.92)}{0.096\ \mathrm{LP2}} + \underset{(1.42)}{0.092\ \mathrm{LP3}}\\ &+ \underset{(2.65)}{0.495\ \mathrm{LP5}} + \underset{(1.34)}{0.203\ \mathrm{LP6}} - \underset{(-5.49)}{1.591\ \mathrm{LP7}} - \underset{(-2.43)}{0.368\ \mathrm{LP8}}\\ &+ \underset{(9.00)}{0.908\ \mathrm{RYMAP}} + \underset{(8.05)}{0.037\ \mathrm{T}}\end{aligned}$$

$$\bar{R}^2 = 0.999, \qquad DW = 2.383$$

$$\text{GOY} = \underset{(4.79)}{5.378} - \underset{(-2.41)}{0.048}\ \text{LP2} - \underset{(-1.53)}{0.128}\ \text{LP3} - \underset{(-4.40)}{0.608}\ \text{LP4}$$
$$+ \underset{(2.00)}{0.582}\ \text{LP5} + \underset{(2.37)}{0.706}\ \text{LP7} - \underset{(-1.35)}{0.189}\ \text{LP8}$$
$$+ \underset{(1.09)}{0.141}\ \text{RYMAP}$$
$$\bar{R}^2 = 0.990, \qquad \text{DW} = 1.710$$

Definitions of Regression Variables and Data Sources

The following source abbreviations are used throughout the documentation:

Bus. Stat.	Business Statistics
CPS	Current Population Survey
ERP	Economic Report of the President
ETRP	Employment and Training Report of the President
NIPA	National Income and Product Accounts
SCB	Survey of Current Business

Industries Prefixes (xxx):

AG	Agriculture, Forestry, and Fisheries
MI	Mining
CO	Construction
MA	Manufacturing
TCU	Transportation, Communication, and Electric, Gas, and Sanitary Service
WRT	Wholesale and Retail Trade
FR	Finance, Insurance, and Real Estate
S	Services
GO	Government and Government Enterprises
DI	All domestic industries

Variables:

AGMWA	Average Federal Minimum Wage in farming, dollars per hour. *Source:* Employment Standards Administration, U.S. Department of Labor.
AGPXL	log(PXAG/AGCL)
xxxCH	Average hourly compensation of high-wage workers. *Source:* Constructed from NIPA and CPS data.
xxxCHL	log(xxxCH/xxxCL)
xxxCL	Average hourly compensation of low-wage workers. *Source:* Constructed from NIPA and CPS data.
COPXL	log(PXCON/COCL)
xxxCOV	Estimated proportion of nonsupervisory employees covered by federal minimum wages. *Source:* Based on data from the Employment Standards Administration, U.S. Department of Labor.
xxxCOV1	log((xxxCOV * MWA/DIP(−1)) + 1) For all industries except agriculture, forestry, and fisheries.

	log ((AGCOV * AGMWA/DIP(−1)) + 1) For agriculture, forestry, and fisheries.
xxxF	Estimated proportion of low-wage workers. *Source:* Constructed from NIPA and CPS data.
xxxFSL	(xxxCL * xxxHL1)/(1000 * xxxGNP) Low-wage factor share.
xxxFSH	(xxxCH * xxxHH1)/(1000 * xxxGNP) High-wage factor share.
xxxFSX	1 − xxxFSL − xxxFSH Nonemployee factor share.
FRPX1L	log(PX1/FRCL)
xxxGNP	Sector contribution to GNP, billions of dollars. *Source:* NIPA, Table 6.1.
xxxH	Hours worked by full-time and part-time employees, millions of hours. *Source:* NIPA, Table 6.10.
xxxHH1	(1 − xxxF) * xxxH Estimated hours worked by high wage labor, millions of hours.
xxxHHP1	log(1000 * xxxHH1/POP16)
xxxHL1	xxxH − xxxHH1 Estimated hours worked by low-wage labor, millions of hours.
xxxHLP1	log(1000 * xxxHL1/POP16)
LP1	log(AGP/MAP)
LP2	log(MIP/MAP)
LP3	log(COP/MAP)
LP4	log(TCUP/MAP)
LP5	log(WRTP/MAP)
LP6	log(FRP/MAP)
LP7	log(SP/MAP)
LP8	log(GOP/MAP)
MAPX2L	log(PX2/MACL)
MICORCH1	MIRCH1 − CORCH(−1)
MIPXL	log(PXMIN/MICL)
MWA	Average federal minimum wage. *Source:* Employment Standards Administration, U.S. Department of Labor.
xxxP	xxxGNP/xxxRGNP Implicit price deflator.
POP	Total U.S. population, thousands of persons. *Source:* ERP 1980, Table B-26.
POP16	Noninstitutional U.S. population 16 years and over, thousands of persons. *Source:* ETRP, 1979, Table A-1.
PX1	Implicit Price Deflator for Nonresidential Gross Private Fixed Domestic Investment/100. *Source:* NIPA, Table 7.1.
PX2	Wholesale Price Index for Producer Finished Goods (Capital Equipment)/100. *Source: Bus. Stat. 1975*, p. 45, SCB July 1976, 1979, p. S-8.
PXAG	Implicit Price Deflator for Purchases of Agricultural Machinery (except tractors)/100. *Source:* NIPA, Table 7.14.
PXCON	Implicit Price Deflator for Purchases of Construction Machinery (except tractors)/100. *Source:* NIPA, Table 7.14.
PXMIN	Implicit Price Deflator for Purchases of Mining and Oilfield Machinery/100. *Source:* NIPA, Table 7.14.
PXSERV	Implicit Price Deflator for Purchases of Service Industry Machinery/100. *Source:* NIPA, Table 7.14.
xxxRCH	log(xxxCH/DIP)
xxxRCH1	log(xxxCH/DIP(−1))
xxxRCL	log(xxxCL/DIP)
xxxRCL1	log(xxxCL/DIP(−1))

xxxRGNP	Sector contribution to constant dollar GNP, billions of 1972 constant dollars. *Source:* NIPA, Table 6.2.
xxxRX	[(xxxGNP * 1000) − xxxTC]/DIP Real returns to nonemployee inputs, millions of dollars.
RXDIP	log(1000 * DIRX/POP)
RYMAP	log[1,000,000 * DIGNP/(MAP * POP)]
SPXL	log(PXSERV/SCL)
T	Linear time trend.
T2	10,000/POP
xxxTC	Total Employee Compensation in each sector, millions of dollars. *Source:* NIPA, Table 6.5.
TCUPX1L	log(PX1/TCUCL)
WRTPX2L	log(PX2/WRTCL)
xxxY	log(1,000,000 * xxxRGNP/POP)

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NOTES

1. The first state minimum wage law was adopted by Massachusetts in 1912, and the first federal minimum wage legislation was implemented in 1938.
2. See Cox and Oaxaca (1981a) for a detailed discussion of these feedback effects.
3. The analysis in Cox and Oaxaca (1982) implies that these effects are central to the political economy of the minimum wage.
4. The most general specifications of the equations comprised in parts a–c are presented in the text. Considerations of prediction errors in the control simulation and lack of significance led to the omission of some variables (differing by industry) from the final estimated equations. Hence some of the equations contain only subsets of the variables discussed in the general specifications.
5. These special CPS wage tabulations were made available to us by the staff of the Minimum Wage Study Commission.
6. Similar data problems forced Hamermesh (1982) to assume that each young worker and each adult worker was employed the same number of hours.
7. Hamermesh (1982) mentions the problem of instability with translog derived factor share equations when a factor's share is typically very small.
8. These figures are slightly understated because of the smaller base involved in reversing the direction of the simulation.
9. Gramlich (1976) estimated employment functions derived from the first-order conditions for profit maximization with a CES (constant elasticity of substitution) production function. His specification included output and a measure of the real minimum wage. The estimated partial elasticity of employment with respect to the minimum wage assumes no change in price or output.

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