INSTITUT FÜR VOLKSWIRTSCHAFTSLEHRE

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WORKERS AND HOURS IN A DYNAMIC MODEL OF LABOUR DEMAND - WEST-GERMAN MANUFACTURING INDUSTRIES 1962 - 1985

von

Georg Licht
Viktor Steiner

Beitrag Nr. 32

Universität Augsburg
Memminger Str. 14
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Zusammenfassung

In dieser Arbeit wird unter der Annahme der Kostenminimierung ein Modell der Arbeitsnachfrage abgeleitet und für 30 Branchen des Verarbeitenden Gewerbes über den Zeitraum 1960-85 geschätzt. Beschäftigte und Arbeitsstunden gehen in die Produktionsfunktion mit unterschiedlichen Produktionselastizitäten ein, um Substitutionsmöglichkeiten zwischen diesen Komponenten und den Effekt relativer Arbeitskosten auf die Beschäftigung zu berücksichtigen. Die Modellierung der dynamischen Anpassung zwischen Beschäftigten und Arbeitsstunden erfolgt im Rahmen eines rekursiven Modells, wobei das Ausmass des Ungleichgewichts in der Nachfrage nach Arbeitern als Regressor in die Schätzung der Stundengleichung eingeht. Dieses Ungleichgewicht übt einen statistisch signifikanten Effekt auf die nachgefragten Arbeitsstunden aus. Der Stundenlohn und die fixen Arbeitskosten sind quantitativ nur von geringer Bedeutung. Eine Verkürzung der tariflichen Arbeitszeit führt zu einem signifikanten Anstieg der Beschäftigung.

Abstract

A simple neoclassical labour demand model is derived from cost minimization and estimated for 30 West-German manufacturing industries for the period 1962-85. To account for substitution possibilities between workers and hours in labour demand, we allow for different production elasticities of these two labour input components and the effect of their relative prices. Dynamic adjustment of workers and hours is explicitely modelled within a recursive framework allowing for spillovers from disequlibrium in the demand for workers to hours, which we find statistically significant. The hourly wage and fixed employment costs are only of minor importance for employment determination. A reduction in standard working time will increase employment of workers significantly.

Workers and Hours in a Dynamic Model of Labour Demand - West-German Manufacturing Industries 1962 - 1985

by

Georg Licht and Viktor Steiner[1]

1. Introduction

As in most other countries manufacturing employment in West-Germany has sharply decreased after the first oil price shock and has never regained its former level. It thus has substantially contributed to the unemployment problem in West-Germany.

The decline in manufacturing employment has been attributed to various reasons ranging from the alleged maladjustment of relative factor prices following the huge oil price increases in the seventies to effective demand failures and the "microelectronics revolution", the employment impact of which seems particularly frightening to the man in the street. Likewise, policy recommendations include measures to reduce labour costs, an expansion in aggregate demand and a reduction in working time. Specifically, considerable attention has recently been attached both by economists (especially Hart 1984, 1987) and in policy debates (see OECD 1986, 1987) to fixed and non-wage labour costs and their effects on workers-hours substitution.

Some possible causes for the high level of unemployment in the West-Germany have recently been investigated by Franz

[1] We would like to thank our collegue Gebhard Flaig for very helpful suggestions, although we were unable to incorporate them all into our paper. Useful comments were also received from seminar participants at the University of Augsburg. Last not least, we are grateful to the IFO-Institut für Wirtschaftsforschung, Munich, for providing us with their capital stock data.

and König (1986). They note that for the FRG "even in periods of severe recession there still exists a considerable amount of overtime work on average" (p. S224). Alleged reasons for persistent overtime work in face of a high level of unemployment are fixed employment costs and institutional legislations that make it somewhat more difficult or expensive for firms to fire workers in face of declining product demand (see e.g. OECD 1987).

The importance of the distinction between different kinds of labour costs as well as workers and hours for labour market analyses and the evaluation of labour market policies such as a reduction in working time has recently been stressed by, inter alia, Franz and König (1986), Hart (1987) and Gerlach and Hübler (1987). Following the work of Hart, in this paper we set up a simple neoclassical labour demand model derived from cost minimization, incorporating relative factor prices as well as the demand for manufacturing output. To account for substitution possibilities between workers and hours in labour demand, we allow for different production elasticities of these two labour input components and the effect of their relative prices.

Compared to other studies for West-German manufacturing, there are some distinct features of our model, which refer to model specification and estimation as well as the level of disaggregation of our data base. We estimate the model for a cross-section of thirty manufacturing industries over the time period 1962 to 1985 using alternative approaches for pooling panel data. Section 2 outlines our theoretical model, section 3 describes the adjustment process of workers and hours in some detail. Our estimation procedures are discussed in section 4. Empirical results are summarized in section 5, section 6 contains some conclusions. Some additional information is contained in appendices.

2. The theoretical model

We consider an industry producing an homogenous good using labour, intermediate goods and a given capital stock as inputs. The industry is assumed to operate under conditions of imperfect competition in the output market facing given factor prices. Labour input is composed of the number of workers and hours per worker, which can be regarded as the utilization rate of labour services. Due to the assumption of a fixed capital stock capital-labour substitution is ruled out in our model. Allowing for a variable capital stock would greatly complicate matters as the utilization rate of capital would have to be modelled simultaneously. Correspondingly, we do not account for the role of inventories in smoothing production (see e.g. Topel 1982, Rossana 1985).

The disaggregation of labour input into workers and hours has a long tradition in labour demand studies (see e.g. Brechling 1965, Feldstein 1967, Hart and Sharot 1978). As the productivity of workers and hours probably differ, they enter the production function seperately, i.e. we allow for different elasticities of production with respect to workers and hours. We do not, however, account for different productivities of standard and overtime hours, although there is some controversy about the relative importance of the marginal contribution of labour services (for a summary of the debate see Hart and McGregor 1988).

The wage paid for a worker within the time period under consideration (W) depends on standard hours (H^S), overtime hours ($H - H^S$), the wage for standard hours (w) and the wage for overtime hours (τw) in the following simple fashion (see Hart 1987, Chapter 5)

$$W = wH^S + \tau w \; (H - H^S) \tag{1}$$

where $\tau >= 1$ is the ratio of the wage for overtime to standard hours, which we label relative overtime wage, and $(\tau-1)$ is the overtime premium.

The rationale for this specification can be seen in the institutional fact that overtime hours ($H - H^S$) are paid above the standard wage. This specifiation requires that actual hours never fall short of standard hours, which is usually simply assumed in empirical work (see e.g. Hart 1987, König and Pohlmeier 1987). Although this assumption is hardly adequate at the individual firm level, it seems empirically valid at a more aggregate level (see Franz and König 1986, p.

S224). At the industry level, with the exception of a few cases (see Appendix B), there too has always been overtime work over the whole period 1960 to 1985. Therefore, the above specification seems justifiable in this respect, although the linearity assumption may seem somewhat restrictive (see Franz and König 1986 for a slightly more general treatment).

Besides direct labour costs firms bear additional costs for employing a worker (fringe benefits etc.) which do not depend on hours worked and which we denote by Z. Therefore, total labour costs incurred by employing N workers are given by

$$C_L = wH^S \cdot N + \tau w \cdot (H - H^S) \cdot N + ZN \qquad (2)$$

Adding costs for intermediate goods and fixed capital costs, we have total costs

$$C = wHN + \tau w \cdot (H - H^S) \cdot N + ZN + mM + F \qquad (3)$$

where F = fixed capital costs, M = quantity and m = price of intermediate goods.

The industry is assumed to minimize total costs as given by eq. (3) for a predetermined level of output Y* subject to a production function with workers, actual hours, intermediate goods and a fixed capital stock ($\bar{K}$) as factors of production: $Y = Y(A(t), N, H, M, \bar{K})$, where A(t) is a term representing technical progress. Cost-minimization seems to us a more useful assumption than profit maximization in deriving a labour demand schedule, because the former does not depend on the questionable assumption that firms are never rationed in the output market. We realize, however, that this may not always be an adequate assumption, especially in the upturn of the business cycle. Furthermore, to interpret the employment equation to be derived below as a demand schedule for workers, we make the realistic assumption that employment is determinded by the demand side of the labour market.

The Lagrangian function of this optimization problem is

$$L = C(w,\ \tau,\ m,\ Z,\ N^{S}_{,}\ H\ ,\ M,\ F) + \mu(Y^{*} - Y) \tag{4}$$

where μ is the Lagrangian multiplier. The first order conditions for a minimum are

$$\delta C/\delta H = \tau w N - \mu(\delta Y/\delta H) = 0 \tag{5.1}$$

$$\delta C/\delta N = wH^{S} + \tau w(H - H^{S}) + Z - \mu(\delta Y/\delta N) = 0 \tag{5.2}$$

$$\delta C/\delta M = m - \mu(\delta Y/\delta M) = 0 \tag{5.3}$$

$$Y^{*} - Y(A(t)\ N,\ H,\ M,\ \bar{K}) = 0 \tag{5.4}$$

Following usual practice, the production function is assumed to be of the Cobb-Douglas type, i. e.

$$Y = A(t)\ N^{a}\ H^{b}\ \bar{K}^{c}\ M^{d} \tag{6}$$

Our specification of the production technology is, of course, rather restrictive. However, to derive the corresponding demand functions for workers and hours explicitly, we have adopted this standard specification here (for an alternative approach see König and Pohlmeier 1987).

Solving the equilibrium conditions (5.1) to (5.4), taking logs and rearranging, we arrive at the following log-linear demand equations for workers and hours, respectively,

$$\begin{aligned} \ln N = {} & \frac{1}{a+d}\left[d\cdot\ln\frac{b}{d} - (d+b)\cdot\ln\frac{b}{a-b}\right] + \frac{b}{a+d}\cdot\ln\tau \\ & + \frac{d}{a+d}\cdot\ln\frac{m}{w} + \frac{1}{a+d}\cdot\ln Y - \frac{1}{a+d}\cdot\ln A(t) \\ & - \frac{c}{a+d}\cdot\ln\bar{K} - \frac{d+b}{a+d}\cdot\ln H^{S} - \frac{d+b}{a+d}\cdot\ln z^{r} \end{aligned} \tag{7}$$

where $z^{r} = (Z/wH^{S} - (\tau-1))$ and

$$\ln H = \ln\frac{b}{a-b} - \ln\tau + \ln H^{S} + \ln z^{r} \tag{8}$$

We do not explicitly derive the second order conditions for a minimum here. However, it may be interesting to note that for a minimum it is necessary the returns to workers exceed the returns to hours, i.e. a > b (see also Hart and McGregor 1988 in a similar context).

Eq. (7) shows optimal demand for workers to depend on output, the relative overtime wage, the relative price of intermediate goods (m/w), standard hours, the fixed capital stock, the technology index and the term z^r we have defined above. This term is composed of the difference of fixed employment costs per worker, divided by a worker's per period income for standard hours, and the overtime premium. It depends negatively on the components of variable labour costs τ, w, H^S and positively on fixed employment costs Z. This term we therefore label relative fixed labour costs.

As expected, relative fixed labour costs play a role in the determination of optimal hours, which also depend on the overtime-premium, institutionally determined standard hours and a constant term composed of the production elasticities of workers and hours. The idiosyncratic form of eq. (8), i.e. the exclusion of the output variable from the hours equation and the unit constraints on all coefficients, is due to the assumed form of the production function and would not arise in case of a more general specification.

The elasticities of employment with respect to the variables of interest in our model are given by the following formulae, where the theoretical constraints as given by eq. (7) have been imposed.

$$\epsilon_{N,Y} = \frac{1}{a+d} > 0 \tag{9.1}$$

$$\epsilon_{N,H^S} = -\frac{d+b}{a+d}\cdot[1 - \frac{1}{(1-\tau)wH^S/Z + 1}] \gtrless 0 \tag{9.2}$$

$$\epsilon_{N,w} = -\frac{d}{a+d} + \frac{d+b}{a+d}\cdot[\frac{1}{(1-\tau)wH^S/Z + 1}] \gtrless 0 \tag{9.3}$$

$$\epsilon_{N,Z} = -\frac{d+b}{a+d}\cdot[\frac{1}{(1-\tau)wH^S/Z + 1}] \gtrless 0 \tag{9.4}$$

$$\epsilon_{N,m} = \frac{d}{a+d} > 0 \tag{9.5}$$

$$\epsilon_{N,\tau} = \frac{b}{a+d} + \frac{\tau}{1-\tau+(Z/wH^S)} \gtrless 0 \tag{9.6}$$

Due to the hours dimension of labour input, the clear-cut comparative results of traditional labour demand theory no longer hold in our model. The elasticity of employment is theoretically determined only for the output variable and the price of intermediate goods. In all other cases the sign depends on the size of the term in brackets, which is a transformation of relative fixed labour costs. An interesting and to some readers probably rather surprising feature of the model is the possibility of a positive wage elasticity, which is due to a substitution effect between workers and hours following a change in relative fixed labour costs.

The total effect of a reduction in standard hours depends on the size of fixed labour costs and the overtime wage, empirically a negative sign seems more likely. For plausible values of τ and Z the elasticity of employment will be negative with respect to fixed labour costs, and positive with respect to the overtime wage indicating substitution between workers and hours due to a change in their relative price.

The elasticities for the demand of actual hours with respect to normal hours, the hourly wage, fixed employment costs and the relative overtime-wage are given by, respectively

$$\epsilon_{H,H^S} = 1 - \frac{Z}{wH^S}\cdot[1 - \tau + \frac{Z}{wH^S}]^{-2} > 0 \tag{10.1}$$

$$\epsilon_{H,w} = -\frac{Z}{wH^S}\cdot[1 - \tau + \frac{Z}{wH^S}]^{-2} < 0 \tag{10.2}$$

$$\epsilon_{H,Z} = \frac{b}{a-b}\cdot\frac{Z}{\tau w}\cdot > 0 \tag{10.3}$$

$$\epsilon_{H,\tau} = -[1 + \frac{\tau^2}{(1-\tau+\frac{Z}{wH^S})^2}] < 0 \tag{10.4}$$

These elasticities are all unambiguously determined and in accordance with intuition as well. Inspection of eq. (10.1) reveals that the elasticity of actual hours to standard hours must be less than one if there are fixed employment costs. This constraint may be considered a further test of the model.

3. Adjustment of workers and hours

So far a firm's employment decision has been modelled without explicit consideration of adjustment lags in the employment equation. Furthermore, it has been assumed that all variables determining employment are known with certainty to the firm. In this section the model is extended to account for partial adjustment in the demand for workers as well as for the formation of expectations.

To begin with the latter extension, it seems quite realistic to assume that firms base their labour demand decisions not on current values of prices and demand for their output, but on the expected values of these variables. A familiar, although somewhat old-fashioned method to formalize expectations formation is to assume adaptive behaviour, which implies that expectations are updated each period on the basis of the latest information about the actual values of the variables. Formally,

$$X_t^* - X_{t-1}^* = (1 - \Phi_1)(X_t - X_{t-1}^*) \tag{11}$$

where X_t^* stands for the vector of the expected values of the exogenous variables formed at the end of period t, when information about the current level of these variables has become available. Adjustment of expectations depends on the parameter Φ_1 which is assumed to fall into the intervall [0,1].

As already noted, due to adjustment costs the number of employed workers will not immediately be adjusted to its optimal level. A simple specification for the adjustment process is given by the familiar partial adjustment hypothesis, which arises under the assumption of quadratic adjustment costs (for a summary see Nickell 1986). In this specification the speed of adjustment of actual employment of workers to its desired (optimal) level is assumed to depend on the adjustment coefficient Φ_2 defined over the interval [0, 1]:

$$N_t - N_{t-1} = (1 - \Phi_2)(N_t^* - N_{t-1}) \tag{12}$$

where N_t^* is the optimal employment of workers at time t.

Combining our expectation-augmented optimal employment equation with the partial adjustment model in eq. (12) gives

$$N_t = \frac{(1-\Phi_1)(1-\Phi_2)}{(1-\Phi_1 L)(1-\Phi_2 L)} \cdot X_t \beta \tag{13}$$

where β is a vector of coefficients conforming to the matrix X of the explanatory variables in the employment equation and L is the familiar backward-shift operator.

Having derived the employment equation, we now turn to the specification of the hours equation. Although there may also be adjustment costs for hours, we consider them negligible relative to those for workers. Therefore, by assumption, hours are always adjusted immediately to bring forth the required amount of labour input.

Following the work of Hart and Sharot (1978), we assume workers and hours to be recursively determined. The assumption here is that optimal employment of workers is predetermined, which can be rationalized by our maintained hypothesis that hours adjust much more quickly to fluctuating demand for output than workers.

Actual hours demanded in a given time period then become a function of the discrepancy between optimally demanded and actually employed workers. Taking account of this disequilibrium term, a straightforward specification for the hours equation is

$$H_t = H_t^* + \Phi_3 \cdot (N_t^* - N_t) \quad (14)$$

where H_t^* is optimal hours, N_t^* is optimal employment of workers at time t, and N_t and H_t are the actual quantities of these variables at time t. Φ_3 is a positive coefficient that measures the spillover from the disequlibrium in the demand for hours. Although this specification may seem somewhat restrictive as it implies symmetric adjustment behaviour over the cycle, we a priori consider it a reasonable approximation.

4. Estimation of the model

We use a time series of cross-sections of manufacturing industries to estimate the model set up above. Our data refer to thirty West-German manufacturing industries on a yearly basis for the period 1960 to 1985. As there are two lags in the employment equation, we loose two years in estimating the model. Exact definitions of the variables and references to data sources are supplied in Appendix B.

There are at least three reasons for pooling time series with individual cross sections. First, as there are 30 industries in our sample, the interpretation of the results of single time series regressions would obviously become rather cumbersome. Secondly, compared to the usual time series regressions for individual industries, pooling allows for a considerable increase in the number of observations which is particularly important in face of a possible structural break in the employment equation which may have occurred after the first oil pice shock. Thirdly, preliminary investigations for individual industries have revealed severe multicollinearity between individual regressors in the employment equation for single industries. As pooling observations increases the variability in the data, this estimation procedure may mitigate the multicollinearity problem.

There are, however, some problems with the adoption of the simple pooling procedure. Specifically, the implied assumption that all industries behave identically with respect to employment behaviour may not be warranted in face of varied technological shocks between industries and differing exposure to international competition. A straightforward, but somewhat restrictive method to allow for different employment behaviour between industries is the adoption of the so-called dummy variables or fixed-effects model (see e.g. Judge et al. 1985, Chapter 13). In its simplest form this model assumes identical slope parameters for all groups (i.e., industries) and implies that group differences can be accounted for by including a constant term for each group into the regression. Although it is principally possible to allow for time variation in the industry dummies (see Judge et al. 1985, Chapter 13, Hart and McGregor for an application in the present context), due to the construction of our fixed employment costs variable (see Appendix B) we could not apply this more general specification here.

Another possible estimation procedure would be the so-called error-components or random-effects model, which assumes that group differences can be merged with the error term in the equation (see Judge et al. 1985, Chapter 13). If this model was a correct specification, it would allow more efficient estimation of the model parameters. However, in case of misspecification this estimator would produce inconsistent results.

Our estimation strategy in this paper is, first to estimate the fixed-effects specification and then to test it against both the simple pooling model and the error-components model. Due to the recursive structure of the model, we may adopt a two-step estimation procedure. We first estimate the employment equation from which we derive an estimate of the optimal number of workers in any given year. We then use this estimate to calculate the disequilibrium in the demand for workers as difference between optimal and actual employment and insert it as a regressor in the hours equation. Together with the determinants of optimal hours derived from eq. (8) above, this completes the estimating equation for actual hours.

As it is obvious from eq. (7) and eq. (8), due to the assumed form of the production function our model implies some very special parameter restrictions which naturally should be imposed onto the estimating equations. Unfortunately, when imposing these restrictions we obtained statistically very poor results (as measured by R^2) for the hours equation, although the estimated coefficients were significant in most cases bearing the expected signs. However, freely estimated coefficients were not very different between the restricted and unrestricted form of the employment equation. Therefore, we decided to estimate the unrestricted form of the model, which seemed to us the best strategy to adopt in view of the rather disappointing results for the hours equation.

The estimating equation for workers, corresponding to the unrestricted form of eq. (13) and taking account of the pooled nature of our data is given by eq. (15) below. Assuming neutral technical progress, the technology index is proxied by an exponential trend. Although usual practice in the literature (see Hazledine 1981 for a critical appraisal), we realise the limitations of this specification. In order to allow for differences in technology between industries, we have specified the technology index for the i-th industry as $A(t)_i = \exp(\sigma_i + \alpha_8 t)$, the proportionality factor σ_i being merged with the constant term in eq. (15). Likewise, due to data restrictions we have assumed that τ_i remains constant over time for all i, so it can be merged with the individual industry dummies. We consider this somewhat restrictive assumption justifiable on empirical grounds, because in most industries the overtime premium has hardly changed over time (see Appendix B).

$$\ln N_{it} = \alpha_{0i} + \alpha_1 \ln Y_{it} + \alpha_2 \ln(m/w)_{it} + \alpha_3 \ln z^r_{it} + \alpha_4 \ln H^s_t + $$
$$+ \alpha_5 \ln \bar{K}_{it} + \alpha_6 \ln N_{i,t-1} + \alpha_7 \ln N_{i,t-2} + \alpha_8 t + u_{it}$$
$$(i = 1,2,\ldots,30;\ t = 62,63,\ldots,85) \qquad (15)$$

where $\alpha_{0i} = \frac{\theta}{a+d} \cdot [d\ln\frac{b}{d} - (d+b)\ln\frac{b}{a-b}] + \frac{1}{a+d} \cdot [b\ln\tau_i + \sigma_i]$;

$\alpha_1 = \frac{\theta}{a+d}$; $\alpha_2 = \frac{\theta d}{a+d}$; $\alpha_3 = -\frac{\theta(d+b)}{a+d}$;

$\alpha_4 = -\frac{\theta(d+b)}{a+d}$; $\alpha_5 = -\frac{\theta c}{a+d}$; $\alpha_8 = -\frac{\theta}{a+d}$;

$\alpha_6 = (\Phi_1 + \Phi_2)$; $\alpha_7 = -\Phi_1\Phi_2$

with $\theta = (1-\Phi_1)(1-\Phi_2)$ and u_{it} = error term.

The employment equation is estimated by applying the within-estimator to eq. (15). This amounts to premultiplying each variable in the model by a transformation matrix which is orthogonal to the vector of dummy variables, thereby purging the fixed-effects from the estimating equation. As a consequence of this transformation the variables of the model are measured as deviations from their unit sample means. The resulting equation can then be estimated by OLS, provided that the error term in this equation is homoscedastic and nonautocorrelated (see e.g. Judge et al. 1985, Chapter 13).

The assumption of spherical errors may not be appropriate, however. In our time series-cross section framework heteroscedasticity as well as serial correlation may be present, the former being possibly due to differing size between industries. The estimation procedure outlined above can be accomodated, however, to the possible violation of the homoscedasticity assumption by applying a Generalized Least Squares (GLS) estimator (see e.g. Kmenta 1986, Chapter 12-2).

The estimating equation for hours in its unrestricted form is

$$\ln H_{it} = \beta_{0i} + \beta_1 \ln H^s_{it} + \beta_2 \ln z^r_{it} + \beta_3 \ln(\hat{N}^*_t - N_t) + \epsilon_{it} \qquad (16)$$

where

$$\beta_{0i} = \ln\frac{b}{a-b} - \ln\tau_i \quad , \quad \epsilon_{it} = \text{error term}$$

and $(\hat{N}^*_t - N_t)$ is the estimated difference between optimal and actual workers demanded at time period t. An estimate for the optimal demand for workers can be derived from the following formula

$$\hat{N}^*_t = \frac{\hat{N}_t - (\hat{\Phi}_1 + \hat{\Phi}_2)N_{t-1} + \hat{\Phi}_1\hat{\Phi}_2 N_{t-2}}{1 - (\hat{\Phi}_1 + \hat{\Phi}_2) + \hat{\Phi}_1\hat{\Phi}_2}, \tag{17}$$

where the estimated coefficients from eq. (15) have been inserted.

Applying the estimation approach outlined above for the employment equation to the hours equation completes the estimation of the model.

5. Empirical Results[2]

In order to account for a possible structural break in the employment equation following the first oil price shock, we performed a Chow-test for structural change in 1974. As the ordinary Chow-test is known to be applicable only in case of identical variances in both subperiods (see e.g. Pesaran, Smith and Yeo 1985), we performed an F-test and obtained a test statistic of $F(352,352) = 1.13$ indicating identical variances in both periods, which allowed us to proceed in the usual manner. We obtained a value for the test statistic of $F(8, 704) = 51.06$ and therefore had to reject the null of parameter constancy. Thus, we have split the estimation period accordingly and estimated our model for these two subperiods seperately.

The estimation results for the employment equation obtained by applying the OLS estimator to the transformed data in eq. (15) are summarized in the left part of Table 1. In order to account for the potential presence of heteroscedasticity

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[2] Estimation was performed with RATS, Version 2.10b.

sticity between industries, possibly caused by the different absolute size of the industries or by the somewhat restrictive assumption of a Cobb-Douglas technology in all industries, we also estimated this equation by the method of Generalized Least Squares. An estimate for the variance-covariance matrix was obtained from the residuals of the OLS regression (see e.g. Kmenta 1986, Chapter 12-2). GLS estimates are reported in the right part of Table 1.

Table 1: Employment equation, fixed- effects model, dependent variable: N_t; estimation periods: 1962-73, 1974-85

Regressor	Time Period			
	OLS estimation		GLS estimation	
	1962-73	1974-85	1962-73	1974-85
Y_t	0.259 (14.0)	0.236 (12.2)	0.241 (12.4)	0.219 (10.6)
$(m/w)_t$	0.142 (5.3)	0.120 (5.9)	0.140 (4.8)	0.140 (6.3)
z^r_t	-0.009 (1.0)	-0.007 (0.6)	-0.021 (2.1)	-0.010 (0.8)
H_t^s	-0.168 (2.0)	-0.680 (6.6)	-0.210 (2.3)	-0.652 (5.6)
$\bar{K}_t$	0.017 (0.6)	0.019 (0.6)	0.041 (1.3)	0.022 (0.7)
N_{t-1}	0.706 (14.9)	0.681 (14.9)	0.680 (13.8)	0.686 (14.7)
N_{t-2}	-0.067 (1.6)	-0.048 (1.2)	-0.067 (1.5)	-0.063 (1.5)
t	-0.008 (3.2)	-0.009 (8.3)	-0.008 (3.0)	-0.008 (7.4)
Summary statistics:				
R^2(adj.)	0.88	0.92	0.87	0.89
s.e.e.	0.0292	0.0274	0.0054	0.0050
Durbin's h	0.307	0.17	0.423	0.199
Condition number	16.1	8.4	16.1	8.4
Breusch-Pagan test	10.94	68.88	-	-
Number of observations	360	360	360	360

Note: Asymptotic t-statistics in paranthesis.

The explanatory variables in the employment equation have been used to calculate the test statistic for heteroscedasticity proposed by Breusch and Pagan (1979). This statistic has a chi^2-distribution with 8 degrees of freedom as we allow for the possibility that all explanatory variables in the model may cause heteroscedasticity. Therefore, the null hypothesis of homoscedastic errors has to be rejected for the second subperiod. Although the null need not be rejected at the ten percent level for the first estimation period, we report the GLS estimates as well.

Before we comment on the results in Table 1, we may note that according to formal testing neither the simple pooling model nor the random-effects model seems to be an adequate estimation procedure for our employment model. We tested the fixed-effect specification against the null hypothesis that all individual effects are equal, i.e. $\beta_i = 0$ for all i (i = 1, 2, ... 30) using an ordinary F-test. To test the fixed-effects model against the random-effects model, we performed a Hausman-test, which is based on the difference between the vector of estimated slope parameters obtained from, respectively, the fixed-effects and the random-effects estimator, weighted by the difference of the corresponding covariance matrices (see e.g. Judge et al. 1985, p. 528-9). This statistic has an asymptotic chi^2-distribution with degrees of freedom equal to the number of slope parameters in the model. We obtained the following test-statistics under the assumption of homoscedastic errors

Table 2: Testing the fixed-effects model against the simple pooling model and the random-effects model

	Time period	
	1962-73	1974-85
simple pooling	10.14 (30,321)	13.56 (30,321)
random effects	23.54 (8)	60.26 (6)

Note: Degrees of Freedom in paranthesis.

The simple pooling model is clearly rejected by the data in both subperiods. The hypothesis that the individual error-components are uncorrelated with the exogenous variables of the model can also be rejected for both subperiods at the one percent level. As two diagonal elements of the weighting matrix became negativ in calculating the test statistic for the Hausman-test in the second subperiod, we deleted them from the estimated weighting matrix and adjusted the degrees of freedom accordingly[3]. For reason of comparison we summarize the results for the random-effects model in Appendix A. Although they apparently are inconsistent, with the exception of the capital stock variable they do not differ qualitatively from those obtained by the fixed-effects estimator.

We may therefore conclude that for our data set the fixed-effects specification is the most appropriate estimation procedure among these alternatives and now proceed to discuss the results in Table 1. There is little difference between the OLS and the GLS estimates in Table 1, although the latter estimation shows a considerably smaller standard error for both time periods. We therefore comment only on results obtained from the GLS regressions.

The overall fit of the model seems to be quite satisfactory, the explained variance of employment is about 90 percent in both subperiods. Because of the lagged endogenous variable in the regression, we obtained Durbin's h statistic which shows no indication of serial correlation. To account for the possibility of multicollinearity between the regressors, we have obtained the condition number of the matrix of explanatory variables in the model. This diagnostics is based on the ratio of the square root of the maximum eigenvalue to the square root of the minimum eigenvalue of this matrix (see Belsley, Kuh and Welsch 1980, Chapter 3.2). The calculated values of this diagnostic suggest that estimation results are not affected by collinearity between regressors. We may therefore interpret individual coefficients in Table 1 with some confidence[4].

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[3] This procedure seems to be usual practice among econometricians and is also recommended in the Time Series Processor manual. We would like to thank our collegue Gebhard Flaig for drawing our attention to this solution.

[4] It must be noted, however, that the existence of lagged endogeneous variables in the estimating equation may pose problems. For short time periods the fixed-effects estimator no longer is unbiased and consistent (see e.g. Hsiao 1986, Chapter 4).

With the exception of the capital stock and, for the second time period, relative fixed labour costs all coefficients in the employment equation (GLS estimation) are statistically well determined. The insignificance of the capital stock variable may derive from the inclusion of the time trend in the regression.

The effect of output and relative prices on the demand for workers can best be illustrated by calculating the respective elasticities. As is born out by the highly significant coefficients on lagged employment, there is sluggish adjustment of actual to optimal workers. We therefore calculate both the implied short-run as well as long-run elasticities of employment with respect to output and relative prices, where the "short-run" is defined as adjustment within two years. The estimated elasticities[5] based on GLS and evaluated at sample means are summerized in Table 3.

Table 3: Response of employment to variations in output and relative prices (GLS-estimation)

Elasticity of employment with respect to	short-run elasticity		long-run elasticity	
	1962-73	1974-85	1962-73	1974-85
real production	0.404	0.369	0.621	0.580
price of intermediate goods	0.235	0.236	0.361	0.372
standard hours	-0.278	-1.079	-0.427	-1.698
hourly wage	-0.159	-0.215	-0.245	-0.339
fixed employment cost	-0.075	-0.021[1)]	-0.116	-0.034[1)]

[1] Coefficient of the variable is not statistically significant at the 10 percent level.

There is little difference both in the short-run and in the long-run elasticity of employment with respect to real output in the two subperiods. The estimated short-run elasticities

[5] As these elasticities correspond to the unrestricted form of the model, formulae (9.1) to (9.5) have to be adapted accordingly.

in Table 3 indicate that only about two thirds of the employment response to variations in output are adjusted within two years. Although the estimated long-run elasticity may seem rather low on a priori grounds, it comes fairly close to the estimates of two recent studies for West-German manufacturing. König and Pohlmeier (1987, Table 2) in one specification of a more general production technology obtained an elastictiy of workers with respect to output of 0.698. Using time-series regression with quarterly data, Flaig and Steiner (1988) estimated a value of 0.612 on the basis of a loglinear specification of the employment equation. We must note, however, that Franz and König (1986, Table 12) obtained an estimate for the elasticity of demand for jobs with respect to output of approximately one for the West-German manufacturing sector employing a Cobb-Douglas production function as well.

The price of intermediate goods has a relatively strong positive effect on employment indicating that workers and intermediate goods are substitutes in the production process. Surprisingly, according to our estimates elasticties have remained fairly constant after the first oil price shock.

The elasticity of the demand for workers with respect to the wage for standard hours is somewhat higher in the second time period both in the short-run and in the long-run. It is always negative as one would usually expect on a priori grounds, although as can be seen from eq. (10.3) this need not necessarily be the case in our model. According to our estimates the hourly wage plays only a relatively minor role, which is in contrast to popular views about its paramount importance for employment determination. The estimated long-run elasticity is comparable to the value obtained by König and Pohlmeier (1987, Table 2), although it is considerably higher than estimated by Flaig and Steiner (1988), and markedly below the value of -0.54 in the study of Franz and König (1986, Table 12). Note, however, that all these estimates have been obtained for a given output level.

According to our estimates the quantitative effect of fixed employment costs overall is of minor importance and became statistically insignificant in the second subperiod. This may seem somewhat unexpected in face of the alleged drastic increase in fixed employment costs for labour during the time period under consideration, a topic featuring quite prominently in recent policy discussions (see e.g. OECD 1987, pp. 17).

The elasticity of workers demanded with respect to standard hours seems extremely high in the second time period, but overall our estimates compare quite favorable with the value of -1.09 obtained by Franz and König (1986, Table 12) in their study for the whole period 1964 to 1984. According to our estimate for the period 1974 to 1985, a reduction in standard hours will have a strong positive effect on employment. This would support the view held by labour unions that a reduction in working time will have a strong positive employment effect. However, this result has been derived under the assumption of a given wage, and hence no compensation in wages to keep income levels constant is allowed for in this calculation. Furthermore, the rather restrictive specification and partial nature of our model must be taken into account, which may render results quite sensitive to variations in assumptions (see e.g. König and Pohlmeier 1987). In this context it should be noted that in the restricted form of the employment equation estimated elasticities always were below one.

We now turn to the estimation of the hours equation. Following the recursive estimation procedure described above, in the next step we calculated the difference between the estimated optimal demand for workers as obtained from eq. (17) (GLS estimation) and actual workers and inserted it as a regressor into the hours equation. We then estimated this equation by the dummy-variables method both by OLS and GLS in order to account for possible heterogeneity in the errors[6]. Again, an estimate for the variance-covariance matrix was obtained from the residuals of the OLS regression. The estimation results for the hours equation are summarized in Table 4.

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[6] Correlation between the errors in the employment and hours equations may pose simultanity problems. To account for this possibility we tried instrumental variable estimation with the rank order of ($N^*_t - N_t$) as an instrument (see Hart and Sharot 1978). Results of this estimation procedure are almost identical to that reported in Table 4 and therefore are not reported here.

Table 4: Hours equation, fixed-effects model, dependent variable: H_t; estimation periods (1962-1973, 1974-1985)

Regressor	Time Period			
	OLS estimation		GLS estimation	
	1962-73	1974-85	1962-73	1974-85
H_t^s	0.725 (29.3)	0.962 (19.2)	0.717 (27.0)	1.021 (17.0)
z^r_t	0.017 (4.8)	0.0003 (0.05)	0.017 (4.4)	-0.0006 (0.1)
$(\hat{N}^* - N)_t$	0.085 (5.9)	0.146 (7.2)	0.082 (5.4)	0.139 (5.6)
Summary statistics:				
R^2(adj.)	0.85	0.57	0.83	0.50
s.e.e.	0.0136	0.0195	0.0016	0.00318
D.W.	1.48	1.30	1.49	1.31
Condition number	3.0	1.8	3.0	1.8
Breusch-Pagan	5.33	16.31	-	-
Number of observations	360	360	360	360

Note: Asymptotic t-statistics in paranthesis.

The fit of the model is considerably better for the first time period. The Breusch-Pagan test (based on the three explanatory variables in the hours equation) clearly rejects the null of homoscedastic errors for the second subperiod. Although there seems to be some autocorrelation in the errors, we do not consider it very severe and did not try to take account of it. Actual hours worked, are of course, more or less determined by standard hours, although this relationship is much looser in the second time period. The estimated coefficient of the disequilibrium term in the hours equation has the expected sign and is always highly significant.

Finally, we calculate the elasticity of actual hours with respect to standard hours based on the assumption that workers employed have been adjusted to the optimal level. As has been shown in the theoretical section (see eq. (11.1)), the theoretically derived upper bound for this elasticity is one if there are fixed employment costs. On the basis of the estimates in Table 4 we obtained the following elasticities.

Table 5: Elasticity of actual hours with respect to standard hours.

	Time period	
	1962-73	1974-85
OLS estimation	0.69	0.96
GLS estimation	0.68	1.02

The estimated elasticity is considerably lower for the first period and the GLS estimate for the second period is just above the theoretical upper-bound. Whereas a reduction in working time has to a large extent been absorbed by overtime in the first period, in the second time period actual hours have been reduced approximately by the same percentage. The rather low elasticity in the first period probably is due to the prevalent labour shortage in the sixties and early seventies. Our estimates for the second period come rather close to those of Franz and König (1986, Table 12) who obtained a value of 0.99 for their estimation period. It may be interesting to note that in a related study for a similiar sample of West-German manufacturing industries over the period 1969-81 Hart (1987, Table 6.1) contrary to his theoretical predictions obtained an elasticity of 1.21.

6. Conclusions

The results of our study have born out the importance of a seperate treatment of workers and hours in explaining employment behaviour. We allowed for differing production elasticities of workers and hours within the usual cost minimization framework to derive demand equations for both components of labour input. The adjustment of workers and hours to their optimal levels was modelled under the assumption that in the short-run labour input requirements are adjusted mainly by varying hours. Assuming a recursive structure between the demand equations for workers and hours, we estimated the difference between the optimal demand for workers and its realized level for any given year. The hours equation was then estimated, incorporating this disequilibrium term.

Our main findings for West-German manufacturing industries over the years 1962-85 can be summarized as follows. There seems to have occurred a structural break in the employment equation in the mid-seventies. We therefore estimated our model seperately for the two subperiods using a fixed-effects specification and in some cases found marked differences in estimated coefficients between the two estimation periods. We calculated both short-run and long-run elasticities for the demand for workers with respect to output, standard hours and relative prices. In most cases the direction of the effect of a particular variable accords with those theoretically expected and/or with intuition. The elasticity of workers demanded with respect to output was estimated to be considerably below one, the hourly wage and fixed employment costs turned out to be only of minor importance for employment determination. Comparing short-run and long-run employment elasticities reveals a considerable time-lag in the adjustment process. The disequilibrium between the optimal demand for workers and the number actually employed has a highly significant effect on actual hours. Finally, according to our estimates for the time period 1974 to 1985 a reduction in working time will result in a considerable increase in the demand for workers. Subject to the mentioned qualifications, this result may be of some interest to those engaging in the current policy debate on a reduction in working time.

Appendix A: Random-effects model

Table A1: Employment equation, random-effects model, dependent variable: N_t, estimation periods: 1962-73, 1974-85.

Regressor	Time period	
	1962-1973	1974-1985
Constant	0.004 (0.1)	0.204 (4.2)
Y_t	0.248 (13.8)	0.228 (11.9)
$(m/w)_t$	0.153 (6.0)	0.102 (5.1)
z^r_t	-0.009 (1.0)	0.002 (0.2)
H_t^S	-0.216 (2.6)	-0.665 (6.5)
$\vec{K}_t$	-0.022 (0.8)	-0.009 (0.3)
N_{t-1}	0.753 (16.3)	0.734 (16.1)
N_{t-2}	-0.044 (1.1)	-0.031 (0.7)
t	-0.005 (2.1)	-0.007 (7.1)
R^2(adj.)	0.91	0.93
s.e.e.	0.0291	0.0278
Number of observations	360	360

Appendix B: Data Description

We use annual data for the period 1960 to 1985 from the disaggregated national income accounts tape (version October 1987) comprising the 30 industries tabulated in Appendix C. As we could not obtain data on overtime premia for the tobacco industry, it was excluded from our sample.

Gross Output and Intermediate Inputs: The data for nominal gross output, nominal intermediate inputs and real value added are taken from the national income accounts (Source: Statistisches Bundesamt (StaBu), Fachserie 18). Real gross output series are obtained as follows: After correcting the producer price index for domestic and foreign sales at the industry level (Source: StaBu, Fachserie 17 and Fachserie M) for the change in the tax system in 1968 (the sales tax was replaced by the value added tax), we obtained weights for the respective bundle of goods in each of our industries from the disaggregated input-output table for 1982 (StaBu, Fachserie 18, Reihe 2, Table 4.2). Then price indices for industry gross output were calculated as a weighted sum of the producer price index. Due to data limitations for industries No. 16 and 17 the implicit value added deflator was used as price index.

An implicit price index for intermediate inputs for each industry can be derived dividing nominal intermediate inputs by the difference between real gross output and real value added.

Capital Stock: As leasing of buildings and machinery has become increasingly important for some industries in recent years, we use capital stock data on the basis of the "user concept" (see IFO-Institut für Wirtschaftsforschung 1984). The capital stock in an industry is calculated as two years average of real fixed assets in use at beginning of the year.

Labour Input and Labour Costs: The number of employees, total compensation, gross wages and salaries are taken from the disaggregated national accounts. For a detailed description of individual components see Statistisches Bundesamt, Volkswirtschaftliche Gesamtrechnungen, Fachserie 18, Reihe S. 9. Ergebnisse der Wirtschaftsbereiche, p. 19.

Yearly actual hours per employee at the industry level have been obtained from the Institut für Arbeitsmarkt- und Berufsforschung, Nürnberg. As time series for annual standard hours are not available at the industry level, we have to use data from several sources. Average weekly standard hours for the year 1978 are calculated as difference between paid and overtime hours per week for male blue-collar employees in 1978 (Source: StaBu, Lohn- und Gehaltsstrukturerhebung 1978, Arbeitsunterlage) Time series for standard hours and weekly hours paid are constructed using indices for weekly contractual and paid hours, respectively (Source: StaBu, Fachserie 16, Reihe 4.3, April 1985 for the years 1960-84 and October 1985 for the remaining year respectively Fachserie 16, Reihe 2.2 April 1985 for 1960-84 and October 1985 for the year 1985.

Industry time series for weekly overtime hours calculated as difference of the two series from above are then transformed to annual series using adjustment factors for yearly varying saturdays, public holidays etc. (Source: Reyher et al. 1983, Table 1 for the years 1960-79 and Institut für Arbeitsmarkt- und Berufsforschung, Zahlen-Fibel 1987, Table 2.6.1 for the years 1980-85). Finally, annual standard hours at the industry level are obtained as difference between actual and overtime hours.

Comparisions of industry-specific overtime premia for the years 1962 and 1978 (the last year for which comparable data are available) reveal that for most industries overtime premia hardly have changed (Source: StaBu, Lohn- und Gehaltsstrukturerhebung 1978, Arbeitsunterlage respectively Lohn- und Gehaltsstrukturerhebung 1962). For those industries we use the 1978 value. For industries with a significant change in the overtime premium (No. 8, 10, 13, 14, 17, 26) we use the mean value for these two years.

Industry-specific fixed labour costs in our definition include all non-wage labour costs except employers' social security contributions and pension benefits. The ratio of nonwage to total labour costs at the industry level is calculated on the basis of "Arbeitskostenerhebung" (Source: StaBu, Fachserie 16) for 1984, the year with the most comparable level of disaggregation to the national income accounts. Industry time series are estimated according to the trend of this ratio for the whole manufacturing sector. This trend is approximated by interpolation between specific base years, for which data are available (Source: StaBu, Fachserie M, Reihe 15 for 1966, 1969, 1972; Fachserie 16, Arbeitskostenerhebung for 1975, 1978, 1981, 1984). In order to make the data from these sources compatible with the disaggregated national income accounts, we calculate fixed labour cost per year as total compensation multiplied by the nonwage ratio minus employers contribution to the social security system and pension benefits. Variable labour costs are calculated as total compensation minus fixed labour costs. Using the formula for variable labour costs (eq. (1) in the text) we obtain hourly compensation per employee.

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