

Ilmakunnas, Pekka

Working Paper

Working Time, Productivity and Labor Demand in Finnish Manufacturing

ETLA Discussion Papers, No. 362

Provided in Cooperation with:

The Research Institute of the Finnish Economy (ETLA), Helsinki

Suggested Citation: Ilmakunnas, Pekka (1991) : Working Time, Productivity and Labor Demand in Finnish Manufacturing, ETLA Discussion Papers, No. 362, The Research Institute of the Finnish Economy (ETLA), Helsinki

This Version is available at:

<https://hdl.handle.net/10419/187064>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Keskusteluaiheita - Discussion papers

No. 362

Pekka Ilmakunnas

WORKING TIME, PRODUCTIVITY AND LABOR DEMAND IN FINNISH MANUFACTURING

This series consists of papers with limited circulation intended to stimulate discussion. The papers must not be referred to or quoted without the authors' permission.

ILMAKUNNAS, Pekka, WORKING TIME, PRODUCTIVITY AND LABOR DEMAND IN FINNISH MANUFACTURING. Helsinki : ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1991. 40 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; no. 362).

ABSTRACT: The effects of reductions in standard working time on productivity and on the demand for workers and their average hours are studied. The data is a pooled sample of five Finnish manufacturing industries. Also the returns to workers and hours are estimated. The results show that although the returns to workers are slightly larger than those to average hours, statistically they are not significantly different from each other. Both returns are below one, which implies that reduced working time would, other things equal, lead to increased productivity of working hours. Overtime hours seem to be equally productive as standard hours. Reductions in working time have had a slight employment increasing effect, but no effect on overtime hours. The ratio of indirect to direct worker costs seems to be positively related to overtime hours, but has no significant impact on the number of workers.

KEY WORDS: working time, employment, labor utilization, production functions

ILMAKUNNAS, Pekka, WORKING TIME, PRODUCTIVITY AND LABOR DEMAND IN FINNISH MANUFACTURING. Helsinki : ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1991. 40 s. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; no. 362).

TIIVISTELMÄ: Tutkimuksessa tarkastellaan normaalityöajan lyhentämisen vaikutusta työvoiman määrään ja keskimääräisiin työtunteihin. Aineisto on yhdistetty aikasarja- ja poikkileikkausaineisto viideltä teollisuustoimialalta. Tutkimuksessa estimoidaan myös työntekijöiden ja keskimääräisten työtuntien tuottavuus. Tulokset osoittavat, että työntekijöiden tuottavuus on hieman suurempi kuin työtuntien, mutta ne eivät ole tilastollisesti merkitsevästi toisistaan poikkeavia. Tuotannon jousto sekä työntekijöiden että työtuntien suhteen on alle ykkösen. Tämä osoittaa, että keskimääräisen työajan lyheneminen kasvattaisi työtuntien tuottavuutta. Ylityötunnit näyttävät olevan yhtä tuottavia kuin normaalityötunnit. Työajan lyhennyksillä on ollut lievä työllisyyttä lisäävä vaikutus, muttei vaikutusta ylityötunteihin. Ylityötunnit riippuvat positiivisesti välillisten ja välittömien työvoimakustannusten suhteesta, mutta tällä ei ole merkitsevää vaikutusta työntekijöiden lukumäärään.

AVAINSANAT: työaika, työllisyys, tuotantofunktiot

1. Introduction

The discussion on the reductions on working time in the 1970's and 1980's concentrated much on the effects of these reductions on employment. Views on the impact of changes in the standard working time on employment have varied considerably. On one hand, reduced working time was seen as an important means to combating increasing unemployment, but on the other hand, it was argued that the main effect of the reductions would be increased overtime work and actually reduced employment. The latter view has been supported by many theoretical studies, although even in these models the outcome is often inconclusive. This discussion has been extensively surveyed in Hart (1987). The overall employment effects depend not only on the existing technology of the firms but also on the effects of working time reductions on productivity and on wages.

The conclusion that there would be adverse employment effects is based on a model of optimizing behavior by firms which face a technology where the number of workers and their average hours are imperfect substitutes. In the cost side, there are fixed worker costs which do not depend on the number of hours worked. On the other hand, for overtime hours, a premium wage has to be paid. The effect of working time reductions is to increase the cost of hiring a worker relative to the cost of using overtime hours for the existing workers. Therefore firms would tend to substitute hours for workers. Essential to this conclusion is that the overtime premium does not increase very fast with overtime hours. On the other hand, typically the maximization of profits or minimization of costs leads in these models to the condition that the productivity of workers has to be greater than that of hours. Hence a one percent increase in the number of workers should give a relatively larger increase in production than a one percent increase in

average hours worked. It is sometimes argued that the productivity of overtime hours may be lower than that of standard hours. This may change the conclusion of the effects of a reduction in standard hours, since there is less incentive to substitute hours for workers.

Another interesting issue is whether working time reductions will increase productivity. If productivity is measured as returns to working hours, i.e. as an output elasticity as explained above, decreases in working hours increase productivity if the output elasticity is less than one. That is, a one percent reduction in average hours worked decreases output by less than one percent. However, since reductions in standard working time may increase overtime hours, the total productivity effect is difficult to assess. The issue is made even more difficult by the fact that working time reductions may cause firms to invest in new technology, so that returns to hours estimated from the old technology may no longer be relevant.

Since the theoretical models leave the conclusion open, the question of the impact of working time has to be settled empirically. Two kinds of approaches have been used. First, one can estimate production functions, where workers and hours are separate inputs. This allows testing whether the conditions given for an inverse relationship between standard working time and employment in the theoretical models hold empirically. Given the parameters of the production function it is in principle possible to derive the corresponding demand functions for workers and hours. Also the productivity effects can be inferred from the production functions.

Another approach is to estimate demand functions for workers and hours that have been derived from a theoretical model. However, even for a fairly simple production functions the demand functions are nonlinear due to the nonlinearity of

the cost structure. In this case a practical approach is to use a linear estimation form which can be regarded as an approximation to the true nonlinear one. The demand functions make it possible to directly study the effect of standard working time and other variables on the demand for workers and hours.

It should be emphasized that the empirical work cannot easily find an answer to the question whether working time changes influence the technology of the firms. The testing of the effects of working time reductions is done assuming the same production structure for the whole period under study. It would, however, be possible to test the structural stability of the models, although this still does not tell whether structural breaks have been caused by working time reductions.

In this paper the kind of models described above will be estimated using a pooled data on Finnish industries. In section 2, the theoretical background is explained. Section 3 presents various production functions and section 4 the estimation results. In section 5 the estimation results for demand functions for workers and hours are discussed. Section 6 concludes the paper.

2. Theoretical background

The basic ingredients in the theoretical analysis of working time are the specifications of the production technology and the cost structure. Abstracting from the other inputs, assume that labor services L are needed in the production process. On the other hand, these services are produced by combining the number of workers N and their average hours, H . It is assumed that workers and hours are imperfect substitutes so that the labor services are a function $L=f(N,H)$. Often in theoretical and empirical analyses various simplifications for the function are used, e.g. the Cobb-Douglas form $L=AN^{\alpha}H^{\beta}$.

There are two parts in the cost structure. Some costs, e.g. hiring and training costs, and various fringe benefits, are more or less fixed and do not depend on hours worked. These are denoted zN , where z is the fixed per worker cost. If H_s denotes standard hours, the wage cost for these hours is wNH_s , where w is hourly wage. For overtime hours, $H_o=H-H_s$ (it is assumed that the firm operates in the overtime region so that $H>H_s$), a premium wage is paid. The total cost of the overtime hours is $aw(H-H_s)$, where a is the overtime premium. It is possible to treat the premium as a constant, or to assume that it is an increasing function of overtime hours.

Assume that the firm minimizes the sum of the three cost items given above, under the constraint given by the labor services function of the Cobb-Douglas form. This model is discussed e.g. in Hart (1987), so that the details are omitted here. The second order condition for cost minimization requires that $\alpha < \beta < 1$, i.e. that the productivity (or elasticity of output with respect to an input) of workers is greater than that of the hours, and both returns are below one. Given this restriction, the implication is that the number of workers N should be

positively related to standard hours H_s , labor services L (or output) and overtime premium a , and negatively related to the ratio of fixed and variable labor costs, z/wH_s . The hours per worker H (or overtime hours $H-H_s$) should be negatively related to the overtime premium and positively related to z/wH_s , but given the assumed form of the labor services function, L (or output) should not influence average hours. This so called scale invariance of average hours need not hold for more complicated production functions.

The implication of this simple model is that working time reductions should reduce the number of workers and increase overtime hours. There are, however, instances where the above conclusion does not hold. Santamäki (1988) discusses the case where overtime hours are less productive than normal hours. This increases the likelihood of firms reacting to working time reductions by having to increase the number of workers. Another case discussed by Santamäki (1988) is such that the overtime premium increases sufficiently fast when hours are increased. The result is that it may be optimal for the firms to decrease average hours.

Whether overtime is less or more productive than standard working time is an open issue. It can be argued that because of fatigue, productivity decreases when working time is increased. Therefore overtime hours may be less productive. Also, the type of work done during overtime hours may be maintenance or set up work rather than actual production work so that the measured productivity is lower during the overtime period¹⁾. On the other hand, fairly large estimates of the returns to hours have been obtained in some empirical studies. This has been explained by the fact that at least part of the set-up time or other breaks concentrate to the standard hours. Hence, although this is not always explicitly stated, one could expect overtime hours to be

more productive than standard hours.

The value of the output elasticity of hours can be used for assessing the productivity effects of working time reductions. Given a Cobb-Douglas production function, a decrease in working hours increases the productivity of hours if the output elasticity β is smaller than one. A working time reduction leads to a relatively smaller reduction in output and therefore productivity must be higher.

Since both the productivity effects and employment effects of working time reductions depend on the magnitudes of the key parameters, empirical work is needed to settle the question of the probable effects.

3. Specification of production functions

It is useful to analyze such production function forms where overtime hours are explicitly included. Two such approaches have been suggested. One variant is to include overtime hours as a separate variable in the model. Another one is to convert the overtime hours to standard hour equivalents.

Santamäki (1988) has suggested the following modification of the Cobb-Douglas function

$$Q_t = AN_t^\alpha H_{st}^{\beta_1} ((H_{st} + H_{ot}) / H_{st})^{\beta_2} K_t^\gamma U_{kt}^\delta e^{\tau t} \quad (1)$$

which can be written as

$$Q_t = AN_t^\alpha H_{st}^{\beta_1} (1 + U_{lt})^{\beta_2} K_t^\gamma U_{kt}^\delta e^{\tau t} \quad (2)$$

where $U_L = H_o/H_s$ can be called utilization rate of the labor input. Capital stock K , capacity utilization U_k and a time trend that accounts for neutral technical change have been included in these equations, since they will be used in the empirical work. Variants of equation (2) have been estimated by Muellbauer (1984)²⁾.

Interesting special cases are obtained when restrictions are imposed on the parameters of the function. If $\alpha = \beta_1$, workers and standard hours are equally productive, and total standard hours NH_s appears as a variable. If overtime and standard hours are equally productive, i.e. $\beta_1 = \beta_2$, average total hours, H , appears in the model; this is the traditional Cobb-Douglas form used in most empirical studies in this field. If both constraints hold, total hours NH appears in the equation.

Above the term "productivity" has been used somewhat loosely. It is useful to write out the definitions of the different productivities. First, the parameter α has the

interpretation of returns to workers, since the output elasticity of workers is $\partial \log Q / \partial \log N = \alpha$. However, β_1 cannot be directly interpreted as returns to standard hours. Instead, if standard hours are changed, keeping the utilization rate U_L fixed (i.e. allowing overtime hours to change), the returns to standard hours are $\partial \log Q / \partial \log H_s |_{U_L \text{ fixed}} = \beta_1$. In turn, parameter β_2 has the interpretation of returns to total hours, keeping standard hours fixed: $\partial \log Q / \partial \log H |_{H_s \text{ fixed}} = \beta_2$. That is, total hours have been changed by changing overtime hours alone. In this sense β_1 and β_2 are not quite comparable. The returns to standard hours that correspond to β_2 are obtained when total hours are increased by increasing standard hours only, keeping overtime hours constant. Noting that $H_s = H - H_o$, $\partial \log Q / \partial \log H |_{H_o \text{ fixed}} = (\beta_1 - \beta_2)(H/H_s) + \beta_2 = \beta_1 + (\beta_1 - \beta_2)U_L$. Hence returns to total hours from one additional standard hour or one additional overtime hour are equal if $\beta_1 + (\beta_1 - \beta_2)U_L = \beta_2$ or $\beta_1 = \beta_2$.

In the other line of approach, the following function has been used in empirical work by Hart and McGregor (1988):

$$Q_t = AN_t^\alpha (H_{st} + \lambda H_{ot})^\beta K_t^\gamma U_{Kt}^\delta e^{\tau t} \quad (3)$$

The parameter λ measures the productivity of overtime hours relative to standard hours. If $\lambda=0$, the function reduces to the Cobb-Douglas function.

Besides these various modifications of the Cobb-Douglas function, some more general functional forms have been used in studies of worker-hours relationships. Recently Anxo and Bingsten (1989) have used a translog function. However, they did not consider overtime hours separately from standard hours. A notable feature of the translog model is that it allows the elasticity of substitution of hours and workers to deviate from unity, which is the case in the Cobb-Douglas

function³⁾. In addition, in the translog function the returns to each input depend on the levels of all the inputs. Given the large number of variables in the translog function and the accompanying multicollinearity problems, this function does not seem very useful for the analysis of the overtime effects.

In the present study, the functions (2) and (3) will be used in logarithmic form. Table 1 shows the relationships of the various special cases of these functional forms to each other. Besides the forms shown in the table, additional ones are obtained if $\gamma = \delta$, i.e. capital stock and capacity utilization are equally productive.

Table 1: Production functions

A: $\log Q_t = \log A + \alpha \log N_t + \beta_1 \log H_{st} + \beta_2 \log (1 + U_{Lt}) + \gamma \log K_t + \delta \log U_{Kt} + \tau t$

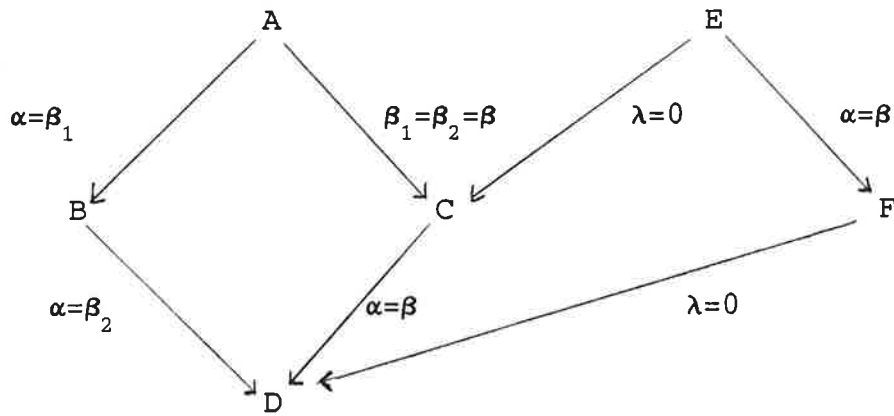
B: $\log Q_t = \log A + \alpha \log N_t H_{st} + \beta_2 \log (1 + U_{Lt}) + \gamma \log K_t + \delta \log U_{Kt} + \tau t$

C: $\log Q_t = \log A + \alpha \log N_t + \beta \log H_t + \gamma \log K_t + \delta \log U_{Kt} + \tau t$

D: $\log Q_t = \log A + \alpha \log N_t H_t + \gamma \log K_t + \delta \log U_{Kt} + \tau t$

E: $\log Q_t = \log A + \alpha \log N_t + \beta \log (H_{st} + \lambda H_{ot}) + \gamma \log K_t + \delta \log U_{Kt} + \tau t$

F: $\log Q_t = \log A + \alpha \log N_t (H_{st} + \lambda H_{ot}) + \gamma \log K_t + \delta \log U_{Kt} + \tau t$



4. Estimation of production functions

The models shown in Table 1 were estimated using annual data from five Finnish industries: food, textiles and clothing, chemicals, metal and engineering, and forest industry. The data period varies slightly depending on industry and on which variables are used.

The data is pooled assuming that there are fixed industry effects, i.e. industry dummy variables were included in the model. In the basic model the time effects are included through a time trend whose coefficient has the interpretation of the rate of neutral technical change. In an alternative model the trend was replaced by fixed time effects, i.e. year-specific dummy variables. The year dummies measure the deviation of each year's intercept from the basic year's (i.e. the one for which no dummy is included) intercept. Therefore the restriction that the differences of each two consecutive years' intercepts are equal, gives the trend model. Hence the trend specification can be tested.

The fixed effect specification was chosen because of the fairly small number of cross-section observations, which makes it difficult to obtain good estimates of the variance of the industry effects for a random effect estimation. Another justification for the fixed effects model is that the industry effects are of interest themselves, especially if besides the intercepts also the slopes vary by industry.

There was data available on the number of bluecollar and whitecollar workers, their working hours, and the overtime hours of the whitecollar workers. Since the data on the overtime hours of the whitecollar workers was not available, it is likely that the coefficient of the labor utilization rate will be biased upwards if it is calculated as the ratio

of bluecollar overtime hours to standard hours of both blue and whitecollar workers. (See Appendix for details of this argument.) Therefore it was decided that the production functions will be estimated using data on the bluecollar workers only. Besides the utilization rate, this affects also the number of workers and standards hours variables. There is no reason to expect a systematic bias in the coefficients in this case. These conclusions were also confirmed empirically, since estimations with a utilization rate variable calculated for all workers, but without knowledge of bluecollar overtime hours, gave a much higher coefficient for the utilization rate.

When data for bluecollar workers only was used, the estimation period was 1968-1986 for the forest and metal industries and 1975-1986 for the other industries.

Estimation results are presented in Tables 2 and 3 and tests of the models in Table 4. Estimates for model A show that the coefficient of the number of workers is larger than that of standard hours, which is in accordance with the theoretical arguments. However, tests of the model show that the restriction that the coefficients are equal can be accepted. The coefficient of the utilization rate is not very well determined. It is, however, fairly close to the coefficient of standard hours and is statistically not significantly different from it. This shows that overtime hours probably do not differ from standard hours in terms of productivity. These results are confirmed also in Table 3, where the estimates from models E and F are presented. The coefficient λ , which transforms overtime hours to standard hour equivalents, is close to one, but has a low t-value.

Table 4 shows that all the parameter restrictions tested can be accepted. Since this implies that hours and workers are easily substitutable, there would be scope for positive employment effects from working time reductions.

Table 2: Production functions:

OLS estimates, fixed industry effects

	A	B	C	D
$\log N_t$	0.733*** (5.462)		0.730*** (5.702)	
$\log H_t$			0.602** (2.239)	
$\log N_t H_t$				0.732*** (5.750)
$\log H_{st}$	0.593** (2.052)			
$\log N_t H_{st}$		0.725*** (5.469)		
$\log(1+U_{Lt})$	0.669 (0.855)	0.583 (0.767)		
$\log U_{Kt} K_t$	0.695*** (5.770)	0.697*** (5.833)	0.698*** (6.060)	0.691*** (6.068)
t	0.020*** (3.538)	0.021*** (3.780)	0.020*** (3.606)	0.021*** (4.142)
\bar{R}^2	0.990	0.990	0.990	0.990
SEE	0.0449	0.0446	0.0446	0.0443
logL	130.017	129.863	130.012	129.841

Tests of variable slopes

	F(4,60)	F(4,61)	F(4,61)	F(4,60)
$\log N_t$	1.529		1.521	
$\log H_t$			2.818**	
$\log N_t H_t$				0.707
$\log H_{st}$	3.332**			
$\log N_t H_{st}$		0.578		
$\log(1+U_{Lt})$	3.853***	3.643***		
$\log U_{Kt} K_t$	16.877***	16.907***	14.642***	13.112***
t	14.503***	14.667***	12.641***	12.717***

Table 3: Production functions:
ML estimates, fixed firm effects

	E	F
$\log N_t$	0.733*** (5.659)	
$\log(H_{st} + \lambda H_{ot})$	0.592** (2.214)	
$\log N_t (H_{st} + \lambda H_{ot})$		0.725*** (5.846)
$\log U_{kt} K_t$	0.694*** (6.084)	0.697*** (6.199)
t	0.020*** (3.702)	0.021*** (4.019)
λ	1.140 (0.829)	0.800 (0.829)
LogL	130.018	129.863

Significance level:

*** 1 percent, ** 5 percent, * 10 percent
t-values in parentheses

In the estimations shown, the capital stock and capacity utilization variables were combined to a utilized capital variable U_K . When U_K and K were entered the equation separately, the coefficient of the labor utilization rate was fairly high. This may be caused by a positive correlation between U_K and U_L . More reasonable results were obtained when the utilized capital variable was used. Equality of the coefficients of U_K and K was actually accepted in the fixed time effect model, but rejected in the trend model. An estimation without the capacity utilization rate was also tried. This gave a higher coefficient to the labor utilization rate and in model C, to the average hours. It is likely that in the absence of the capacity utilization variable, overtime hours or average total hours pick up capacity utilization effects.

To test the homogeneity of the slope coefficients, models A, B, C, and D were estimated by replacing one of the variables at a time by five variables which were the variable in question, multiplied by the five industry dummies. The results from the tests of the equality of the slopes are shown in the bottom of Table 2. Especially returns to capital and rate of technical change vary across industries. When these slopes were allowed to vary by industry, the coefficient of the labor utilization variable was very high. A possible explanation of this result is that within industries, capital stock is highly correlated with the time trend. In the pooled sample their correlation is much lower, but when capital multiplied by industry dummies is added in the model, the correlations of these interaction terms with the trend are high. The same happens when the trend is allowed to have industry specific intercepts. Since labor utilization is somewhat correlated with capacity utilization, the multicollinearity affects also the coefficient of U_L .

Table 4: Tests of the models

Fixed firm effects		
Hypothesis		Test statistic
$\alpha = \beta_2$	(A vs. B)	$t_{64} = 0.517$
$\beta_1 = \beta_2 = \beta$	(A vs. C)	$t_{64} = 0.092$
$\alpha = \beta_2$	(B vs. D)	$t_{65} = 0.198$
$\alpha = \beta$	(C vs. D)	$t_{65} = 0.198$
$\alpha = \beta$	(E vs. F)	$\chi_1 = 0.010$
$\lambda = 0$	(E vs. C)	$\chi_1 = 0.310$
$\lambda = 0$	(F vs. D)	$\chi_1 = 0.044$

Fixed firm and time effects		
Hypothesis		Test statistic
$\alpha = \beta_2$	(A vs. B)	$t_{47} = 1.480$
$\beta_1 = \beta_2 = \beta$	(A vs. C)	$t_{47} = 0.452$
$\alpha = \beta_2$	(B vs. D)	$t_{48} = 0.755$
$\alpha = \beta$	(C vs. D)	$t_{48} = 1.616$

The estimates for the fixed time effects model in Table 5 show higher returns to workers, above one. Returns to standard hours are close to that obtained in Table 2, but the coefficient of the utilization rate is negative and not significant. This shows that the systematic year-to-year variation leaves very little explanatory power to the utilization rate. Even in the fixed time effect model the parameter restrictions are accepted, so that the data cannot differentiate between the returns to workers and hours. Tests of the fixed time effects model show that the trend specification can be accepted. In Table 2 the coefficient of the trend variable is approximately 0.02, implying a two per cent annual rate of technical change.

As noted above, the estimated coefficients cannot be directly regarded as returns to various components of working hours. Consider the estimates from model A. The returns to the number of workers are 0.73. Since the sample mean of U_L is 0.028, the returns to hours when only standard hours are changed, are $0.59 + (0.59 - 0.67) * 0.028 = 0.59$, so that in this case the returns are approximately the same as coefficient β_1 . When only overtime hours are changed, the returns are 0.67. From model C, where overtime and standard hours are equally productive, the returns to hours are 0.60. Since the returns to hours in all models are smaller than one, reductions in working hours, other things equal, would not decrease production proportionally as much. Therefore, the average productivity of working hours would increase.

Table 5: Production functions:

OLS estimates, fixed industry and time effects

	A	B	C	D
$\log N_t$	1.232*** (5.525)		1.198*** (5.759)	
$\log H_t$			0.611* (1.873)	
$\log N_t H_t$				1.045*** (5.551)
$\log H_{st}$	0.679* (1.877)			
$\log N_t H_{st}$		1.116*** (5.281)		
$\log(1+U_{Lt})$	-0.247 (-0.128)	-0.418 (-0.214)		
$\log U_{Kt} K_t$	0.598*** (4.097)	0.622*** (4.237)	0.619*** (4.494)	0.660*** (4.802)
\bar{R}^2	0.990	0.990	0.990	0.990
SEE	0.0443	0.0448	0.0439	0.0446
logL	142.466	140.781	142.305	140.345
Test of fixed time effects vs. trend				
	F(17,47)	F(17,48)	F(17,48)	F(17,49)
	1.467	1.342	1.480	1.328

5. Estimation of demand functions

As discussed above, the theory of cost minimization implies that the number of workers is likely to be positively related to standard hours and negatively related to the ratio of fixed worker costs and variable worker costs. On the other hand, the utilization rate U_L is expected to vary inversely with standard hours and be positively related to the fixed cost/variable cost ratio. For many production functions, the hours (or utilization rate) is scale invariant so that output should not affect the hours decision, but will affect the decision on the number of workers. This applies also to technical change. If the production function has the form $Q=f(N,H)e^{\tau t}$, the result is the same whether costs are minimized subject to this function or subject to $Q^*=f(N,H)$, where $Q^*=Qe^{-\tau t}$. Hence, if there is scale invariance, there is also invariance of hours with respect to technical change.

It should be noted that implicitly it is assumed that all workers work the same number of hours, including overtime hours. In practice, the determination of the incidence of overtime, i.e. the proportion of workers on overtime, may be different from the determinants of overtime hours for those on overtime (see Bosworth and Westaway (1987)). There was, however, no data available on the incidence of overtime.

Since the functional form for the demand equations is nonlinear even with a Cobb-Douglas technology, the true functions will be approximated with linear ones⁴⁾. As a consequence, no cross-equation parameter restrictions will be imposed. The following demand equations for workers and hours will be used

$$\log N_t^* = \alpha_N + \beta_N \log H_{st} + \gamma_N M/wH_{st} + \tau_N t + \phi_N \log Q_t \quad (4)$$

$$U_{Lt}^* = \alpha_H + \beta_H \log H_{st} + \gamma_H M/wH_t \quad (5)$$

To introduce dynamics, partial adjustment is assumed both for the utilization rate and the number of workers. In case of workers, this reflects the costs involved in the hiring and firing of workers, but may also be a result of unexpected demand changes to which the firms have not been able to respond by changing the number of workers. In case of the utilization rate, partial adjustment reflects partly the fact that in some firms there is customarily some overtime work, since the workers may regard overtime pay as a part of the regular compensation package. Therefore the overtime/standard hours ratio changes slowly.

There may also be cross effects between the equations. A partial adjustment scheme is assumed, where the adjustments of the utilization rate and workers are interrelated⁵⁾:

$$\begin{bmatrix} \log N_t - \log N_{t-1} \\ U_{Lt} - U_{L,t-1} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \log N_t^* - \log N_{t-1} \\ U_{Lt}^* - U_{L,t-1} \end{bmatrix} \quad (6)$$

where the a_{ij} 's are adjustment coefficients. It is possible that the cross effects are asymmetric. The substitutability of workers and hours implies that when optimal $\log N_t^*$ is larger than last period's employment $\log N_{t-1}$, the utilization rate should be lowered, so that the same labor services would be produced with more workers and less hours per worker. Therefore, the coefficient a_{21} would be negative, and lagged employment should enter the utilization rate equation with a positive sign. On the other hand, a positive value for a_{21} can be justified by larger costs of adjusting the labor input. When the number of workers is smaller than what is optimal, the utilization rate may increase, since it is slow and costly to adjust the labor input by changing the number of workers only. In contrast,

the adjustment of the utilization rate is much easier, and much of the cyclical adjustment of the labor input is likely to happen through overtime hours. By the same argument, when the number of workers is larger than optimal, the utilization rate may fall, since it takes time to decrease the number of workers. This justifies a positive value for a_{21} and hence a negative value for the lagged employment variable in the utilization rate equation.

Similarly, it can be argued that a negative value for a_{12} is consistent with the view that hours and workers are substituted to minimize the costs of given total labor services. In this case, a disequilibrium in the utilization rate would lead to a change in the number of workers in the opposite direction, and the lagged utilization rate would have a positive sign in the employment equation. Finally, if it were easier to adjust the number of workers than the utilization rate, a_{12} would be positive, and lagged utilization rate would enter the employment equation with a negative sign.

Although hours or utilization rate may be scale invariant, i.e. U_L does not depend on $\log Q$ or the time trend in (5), the dynamic specification in (6) implies that U_L may still depend on $\log N^*$ and hence on $\log Q$ and time. The invariance can be rejected, if the coefficients of $\log Q$ and t are significant in the utilization rate equation, and simultaneously the cross effect from the lagged employment, i.e. parameter a_{21} , is zero.

From equations (6), the long run impact of the explanatory variables is easily obtained. Denote $y_t = (\log N_t, U_{Lt})'$, and X_t a $k \times 1$ vector that includes all the separate variables from equations (4) and (5). b'_i is a $1 \times k$ vector of coefficients from equation i ($i=1,2$) and $B = [b'_1, b'_2]'$ is a $2 \times k$ matrix. Finally, $A = [a_{ij}]$ is the 2×2 matrix of adjustment coefficients. The model is estimated in the form

$y_t = CX_t + (I-A)y_{t-1}$, where the matrix $C=AB$ is the matrix of short run impacts of the explanatory variables X_t in the two models. The long run impacts are obtained from the equation $y_t = A^{-1}CX_t$.

These equations were estimated using pooled annual data for the five industries from 1974 to 1986. The equations were estimated separately for all workers and for bluecollar workers. As noted above, the overtime hours for all workers are likely to be underestimated, but since the utilization rate is the dependent variable of the model, this should not lead to biases when the model is estimated for all workers (see the Appendix). For the bluecollar workers, estimations were made also for a longer period 1965 to 1986 to test the stability of the model over time.

The fixed cost/variable cost ratio that was used in the estimation, is a proxy variable. Values for the payments for days not worked (holidays, sickness etc.), social security and welfare payments, and voluntary labor costs (mostly fringe benefits), relative to total remuneration, were available for the years 1965, 1970, 1973, 1977, 1982 and 1988 from surveys made by the Research Institute of the Finnish Economy (ETLA). For the other years, the values were obtained by interpolation. From these, it was possible to calculate the ratio of fixed (or indirect) labor costs to variable (or direct) labor costs, z/wH , which was defined as voluntary labor costs divided by the sum of the other labor costs (pay for days worked, pay for days not worked, social security). It is assumed that the sum of the direct worker costs per worker can be written as wH , i.e. all payments, including holiday payments, can be transformed to hourly wage equivalents. Although the used measure of fixed costs is not a perfect equivalent of the theoretical fixed worker cost concept, z , most of the items in the voluntary labor cost category do not depend on hours worked.

Since in the theoretical model the relevant variable was defined as z/wH_s , the obtained figures were still adjusted to account for overtime premiums. Assuming the premium to be a fixed value a , the sum of the variable costs per worker is $wH_s+aw(H-H_s)$. The relevant variable is therefore obtained as $z/wH_s=(z/wH)(1+aU_L)$. The value $a=1.25$, i.e. a 25 percent premium was used in the calculations. Alternatively, the variable could be adjusted so that the pay for days not worked is not affected by the overtime premium. However, adjustment of the cost variable for overtime pay did not have much impact on the results.

In addition to the variables discussed so far, it is possible that there are other determinants of the variation of hours and employment across industries. In the empirical work on labor demand, various variables including the quit rate, orders, stocks, the degree of unionization, the share of female workers in all workers, etc. have been used as control variables⁶⁾. Some of this data, like orders and stocks were not available, and for some variables it can be argued that the influences are captured by the fixed industry effects. For example, in the food and textile industries the share of female workers is higher than in the other industries. Since there has not been much variation in this share during the data period, the effect appears in the industry specific intercepts.

Table 6 presents the OLS estimates for the demand for all workers. In the first column are the results from a model where there are no time effects. Standard hours have a positive coefficient, although its t-value is just below the ten percent critical value. There is hence at most very weak evidence for working time reductions to decrease employment. The ratio of fixed to variable labor costs has a positive, but insignificant coefficient. The sign is contrary to what was expected. The main explanatory variable is lagged employment. In the second column, the time effect is

Table 6: Demand for all workers: OLS estimates

	Dependent variable $\log N_t$		
	Fixed industry effects	Fixed industry effects	Fixed industry and time effects
$\log H_{st}$	0.469 (1.610)	-0.308 (-1.232)	-0.446* (-1.964)
z/wH_{st}	1.670 (1.258)	1.390 (1.397)	1.234 (1.474)
$\log Q_t$	0.054 (1.402)	0.410*** (6.494)	0.180** (2.595)
t		-0.018*** (-6.342)	
$\log N_{t-1}$	0.827*** (8.816)	0.483*** (5.541)	0.675*** (6.840)
$U_{L,t-1}$	0.034 (0.040)	-0.343 (-0.537)	2.900*** (2.184)
\bar{R}^2	0.997	0.998	0.999
SEE	0.0312	0.0234	0.0184
Tests of variable slopes			
	F(4,46)	F(4,45)	F(4,35)
$\log H_{st}$	3.802***	1.249	2.383
z/wH_{st}	0.515	3.033**	1.100
$\log Q_t$	3.452**	2.364	0.734
t		3.256**	
$\log N_{t-1}$	3.527**	7.216***	4.990***
$U_{L,t-1}$	0.559	0.739	1.070
Test of fixed time effects			F(11,39) 4.048***
Test of fixed time effects vs. trend			F(10,39) 4.048***

included in the form of a time variable that accounts for technical change. Now the coefficient of standard hours is negative, but not significant. The coefficient of output has increased and is highly significant. The time trend has a significant negative coefficient.

Finally, in the third column the time effect is taken into account by including fixed time effects through year dummy variables. Now standard hours has a negative and significant coefficient, the coefficient of the cost variable is still positive, but not significant and the coefficient of the output variable has decreased. Lagged employment is still highly significant, but now also the lagged utilization rate has a significant positive influence on employment, which is an accordance with workers-hours substitution.

In each model, it was tested whether the coefficients of the explanatory variables vary by industry. The first two columns show some rejections of the equality of the slope coefficients, but in the model with fixed industry and time effects only the coefficient of the lagged employment variable varies significantly across industries. The fixed time effect specification is also accepted when tested against the model with a time trend or the model without time effects.

Table 7 shows the estimation results for the utilization rate equations for all workers. In the first column is a specification where scale invariance of hours is assumed and the model has no time effects. The sign of the standard hours variable is negative, implying that working time reductions increase the utilization of labor through more overtime hours. The cost variable does not have a significant coefficient and the strongest influence seems to come from the lagged utilization rate.

Column two shows the results when output and a time trend

are included. Output has a significant positive coefficient, whereas the trend variable has a negative and insignificant coefficient. When the trend was included in the model without the output variable, the trend had a small positive coefficient, which was significant. There seems to be a slow upward trend in the utilization rate, but it is difficult to distinguish from the influence of output.

Inclusion of output in the model changes the sign of the coefficient of standard hours to positive, but it is not significant. The coefficient of the cost variable increases and it is significant with the expected positive sign. The implication is that if one allows for scale invariance of hours, standard hours have practically no impact on the utilization rate. On the other hand, high fixed labor costs relative to variable labor costs have a positive influence on overtime hours.

Column three shows results from a model where output is included, but fixed time effects are taken into account by adding year dummy variables in the model. The results are fairly similar to those in column two. The main effect of including the fixed time effects has been to lower the coefficients of lagged utilization rate and lagged employment. Since lagged employment is not significant, but output is, it can be concluded that hours are not scale invariant. Tests of the fixed time effect specification show that it is accepted both against the hypothesis of no time effects and against the model with a time trend.

In sum, the evidence seems to favor the view that working time reductions have had a small positive effect on employment, but no effect on the utilization rate. From the last column of Table 6, the short run elasticity of employment with respect to standard hours is approximately -0.45. The long run elasticity, obtained using the estimates from the last columns of Tables 6 and 7 and setting the

Table 7: Utilization rate of all workers: OLS estimates

	Dependent variable U_L		
	Fixed industry effects	Fixed industry effects	Fixed industry and time effects
$\log H_{st}$	-0.048* (-1.894)	0.004 (0.187)	0.013 (0.572)
z/wH_{st}	0.055 (0.444)	0.256*** (2.711)	0.239*** (2.850)
$\log Q_t$		0.026*** (4.396)	0.016** (2.264)
t		-0.0004 (-1.335)	
$U_{L,t-1}$	0.426*** (5.061)	0.431*** (7.125)	0.233* (1.750)
$\log N_{t-1}$	-0.007 (-0.735)	-0.026*** (-3.083)	-0.007 (-0.735)
\bar{R}^2	0.589	0.790	0.854
SEE	0.0031	0.0022	0.0018

Tests of variable slopes

	F(4, 47)	F(4, 45)	F(4, 35)
$\log H_{st}$	2.323	0.806	0.607
z/wH_{st}	2.040	0.099	1.258
$\log Q_t$		0.209	0.280
t		0.616	
$U_{L,t-1}$	0.304	0.563	3.831**
$\log N_{t-1}$	1.175	0.875	0.614

Test of fixed time effects

F(11, 39)
8.233***

Test of fixed time effects vs. trend

F(10, 39)
3.179***

cross effect from lagged employment to the utilization rate equal to zero, is -1.22. Since $U_L \approx \log(1+U_L) = \log(H/H_s)$, the elasticity of total hours with respect to standard hours is 1.01, i.e. reduction in standard hours leads to a corresponding reduction in total hours. The long run elasticity is 1.02.

The fixed/variable labor cost ratio does not seem to influence employment (the coefficient of the variable is not significant in any specification), but has a positive effect on the utilization rate. A one percentage point increase in the Z/wH_s ratio increases the utilization rate by 0.0024. The corresponding long run effect is approximately 0.0031. The output elasticity of the demand for workers is 0.18 and the corresponding long run effect is 0.74. The change in the utilization rate from a one percent increase in output (or an increase of 0.01 in $\log Q$) is 0.00016, and the long run effect is slightly larger, 0.00021. Alternatively, the elasticity of total hours with respect to output is 0.016 in the short run and 0.021 in the long run. These effects are quantitatively fairly small, although statistically significant.

There seems to be a significant employment reducing effect from technical change, but this effect varies significantly from year to year. The annual rate of reduction is 1.8 percent. Interestingly, if this time effect is not taken into account in the estimations, one obtains a completely opposite conclusion of the effect of working hours reductions on employment.

The coefficient of lagged employment is negative, although not significant in all specifications. This gives at least weak support to the view that it is easier to adjust the utilization rate than the number of workers. In any case, the cross effects of hours and employment are asymmetric. An increase in the number of workers decreases the future need

to use overtime hours, but an increase in the utilization rate increases future demand for workers.

Table 8 presents the estimation results for the demand for bluecollar workers. The results are fairly similar to those for all workers. In the model without any time effects, standard hours are positively related to employment, but inclusion of the time trend or fixed time effects reverses this conclusion. The relative cost variable is again positive, but either nonsignificant or weakly significant. The coefficients are slightly larger than in the models for all workers, except for the lagged variables which have slightly smaller coefficients in the preferred fixed time effects model.

The tests of the variability of the slope coefficients again indicate that in the model with the fixed time effects most of the slopes are equal across industries. The trend model is rejected when tested against the fixed time effect model or the model without time effects. The model for bluecollar workers was also estimated for the longer time period 1965-1986. In a Chow test the stability of the model was rejected at the one percent significance level when the cutoff point is 1974. Hence here only the results for the 1974-1986 period are presented.

Table 9 finally presents the results for the utilization rate equation of the bluecollar workers. Most of the results are fairly similar to those for all workers. The most notable difference is that the coefficient of the cost variable is larger. There are no signs of variability of slope coefficients. The fixed time effect model is again preferred. When the model was estimated for the longer time period, its stability was rejected in a Chow test at the one percent significance level.

Table 8: Demand for bluecollar workers: OLS estimates

	Dependent variable $\log N_t$		
	Fixed industry effects	Fixed industry effects	Fixed industry and time effects
$\log H_{st}$	0.260 (1.010)	-0.343 (-1.654)	-0.581*** (-3.526)
z/wH_{st}	3.152** (2.006)	1.345 (1.141)	1.550* (1.872)
$\log Q_t$	0.042 (0.980)	0.442*** (6.560)	0.250*** (3.891)
t		-0.024*** (-6.694)	
$\log N_{t-1}$	0.826*** (7.853)	0.353*** (3.391)	0.400*** (3.578)
$U_{L,t-1}$	-0.378 (-0.517)	-0.452 (-0.847)	2.270** (2.538)
\bar{R}^2	0.996	0.998	0.999
SEE	0.0359	0.0262	0.0178

Tests of variable slopes

	F(4, 46)	F(4, 45)	F(4, 35)
$\log H_{st}$	3.623**	0.548	2.190
z/wH_{st}	0.052	3.285**	3.807**
$\log Q_t$	3.974***	2.790**	1.310
t		3.021**	
$\log N_{t-1}$	1.520	1.590	1.294
$U_{L,t-1}$	0.514	1.054	1.124

Test of fixed time effects

F(11, 39)
14.902***

Test of fixed time effects vs. trend

F(10, 39)
6.699***

Table 9: Utilization rate of bluecollar workers:
OLS estimates

	Dependent variable U_L		
	Fixed industry effects	Fixed industry effects	Fixed industry and time effects
$\log H_{st}$	-0.047 (-1.668)	0.003 (0.140)	0.019 (0.794)
z/wH_{st}	0.115 (0.638)	0.319** (2.268)	0.362*** (2.970)
$\log Q_t$		0.033*** (4.079)	0.018* (1.895)
t		-0.0004 (-1.108)	
$U_{L,t-1}$	0.505*** (5.810)	0.479*** (7.523)	0.297** (2.257)
$\log N_{t-1}$	-0.027** (-2.145)	-0.034*** (-2.733)	-0.001 (-0.046)
\bar{R}^2	0.652	0.814	0.869
SEE	0.0043	0.0031	0.0026

Tests of variable slopes

	F(4, 47)	F(4, 45)	F(4, 35)
$\log H_{st}$	2.864**	0.725	0.657
z/wH_{st}	3.743**	0.113	1.035
$\log Q_t$		0.294	0.707
t		0.501	
$U_{L,t-1}$	0.139	0.808	2.308
$\log N_{t-1}$	1.917	0.431	1.147

Test of fixed time effects

F(11, 39)
2.961***

Test of fixed time effects vs. trend

F(10, 39)
3.082***

The short run elasticity of the number of workers with respect to standard working time is from the fixed time effect model -0.58. The corresponding long run effect (setting the cross effect of lagged employment on the utilization rate equal to zero) is -0.87. Hence the long run employment impact of working time reductions is smaller for bluecollar workers than for all workers, although the short run impact is larger. The effect on the utilization rate is negligible. Again, the elasticity of total hours with respect to standard hours is therefore close to one.

The cost variable has an insignificant or barely significant sign in the employment models, but a strongly significant one in the utilization rate equations. A one percentage point increase in the fixed cost/variable cost ratio increases the utilization rate by 0.0025 and the long run effect is 0.0052. The output elasticity of demand for workers is 0.25 and the long run elasticity is 0.51. In the short run, a one percent increase in output increases the utilization rate by 0.00018, and in the long run by 0.00026. There is a significant employment reducing effect from technical change, although again there is much year-to-year variation. The reduction is approximately 2.4 percent, which is slightly larger than in the case of all workers.

All the results discussed have been based on OLS estimates of the models. Since it is likely that optimization errors in the choice of workers and hours are correlated, the error terms of the workers and utilization rate equations may be contemporaneously correlated. Also approximation errors and omission of relevant variables from equations may lead to the errors being correlated. The preferred fixed time effect models were estimated as a seemingly unrelated regression system. However, the results did not differ noticeably from the OLS estimates. Furthermore, the Breusch-Pagan LR-test led to the acceptance of the hypothesis that the cross equation error correlation is equal to zero.

Another issue is whether the model should be estimated using instrumental variables. This can be justified firstly by the errors-in-variables problem associated with the cost variable, which has been interpolated for the years with missing data. Secondly, instead of actual output, it may be more reasonable to use expected output or unanticipated output shocks (see e.g. Rossana (1985), Kraft (1989a)). If the expected output is replaced by the realized one, the resulting equations look like the ones estimated here, but this approach to expectations leads to another errors-in-variables problem. Generation of the expectations or unanticipated shocks from e.g. ARIMA models leads to generated regressors, which would again call for instrumental variable estimation.

The models used in this paper have been based on the assumption of cost minimization by firms. If firms are assumed to be profit maximizers, the demand equation for workers should also include a real wage variable. This has been found to be significant in some work in this field (e.g. Kraft (1989b)). It should be noted that simultaneity is likely to be a problem in this model. If firms choose the inputs to maximize profits, output is simultaneously determined, and the error terms of the demand equations are correlated with the output variable.

Simultaneity may arise also from the wage rate. If, instead of being exogenously determined, wages are negotiated centrally, or the firms face an upward sloping labor supply curve, the choice of working hours and employment affects the wage rate. There has been empirical work on the effects of working time reductions, where the wage effect has been taken into account⁷⁾.

These refinements will be explored in future work.

6. Conclusions

The results of this paper show that the elasticity of output with respect to working hours is less than one in Finnish manufacturing. Therefore the productivity of working hours may increase when working time is reduced. However, possible changes in the whole structure of production that may result from working time changes cannot be identified with the available data. On the other hand, the productivities of workers and hours are statistically not significantly different. This implies that there may be scope for positive employment effects from working time reductions. The productivity of overtime is difficult to estimate separately, since it picks up capacity utilization effects. However, the results seem to indicate that overtime has the same productivity as standard hours.

Demand for workers is negatively related to standard working time, whereas overtime hours relative to standard hours do not react to working hour reductions. Therefore there seems to have been small positive employment effects from working time reductions. The ratio of fixed and variable labor costs does not have a significant impact on employment, but significantly increases overtime hours relative to standard hours.

Footnotes

1) These arguments are discussed in more detail in Hart (1987); the fatigue argument has been formalized by Hübler (1989).

2) Noting that $\log(1+U_L)$ is approximately equal to U_L , Muellbauer (1984) suggests that it is possible to account for a possible nonlinearity in the effect of overtime hours by replacing in the logarithmic form of the model the term $\log(1+U_L)$ by two terms, U_L and U_L^{-1} . Even in this model variant it is possible to test different hypotheses about the relative productivities of workers, standard hours and overtime hours. Another variation is that suggested by Bell (1988). He notes that equation (1) is homogeneous in standard and overtime hours. To allow for nonhomogeneity, $\log(1+U_L)$ could be replaced by $\log(1+H_o)$. Estimation results for these models did not differ much from those presented in the text.

3) Mizon (1977) has estimated various CES-type functions, which allow the elasticity of substitution of hours and workers to deviate from unity.

4) König and Pohlmeier (1989) have estimated linear demand equations, where the prices of the number of workers and average hours are equal to the marginal prices from the nonlinear cost scheme.

5) See Nadiri and Rosen (1973). In some models, where workers and hours are imperfect substitutes, the dynamics is explicitly derived from cost of adjustment. Shapiro (1986) assumes that there are costs of adjusting both the number of workers and average hours. Bils (1987), De Regt (1988) and Nakamura (1990) assume adjustment costs only for the number of workers. An alternative way of deriving the dynamics, is

the error correction approach, which has been used by Bodo and Giannini (1985) in this kind of models.

6) E.g. Hart and Wilson (1987), Topel (1982), Rossana (1985), Kraft (1989a), Bosworth and Westaway (1987), Earle and Pencavel (1990).

7) See Bernake (1986), Brunello (1989), Nymoer (1989), Pencavel and Holmlund (1988).

References

- Anxo, D. and Bingsten, A.: "Working hours and productivity in Swedish manufacturing", *Scandinavian Journal of Economics*, 91, 1989, 613-619
- Bell, D.N.F.: "Comment", Hart, ed. (1988), 107-111
- Bernake, B.S.: "Employment, hours and earnings in the depression: an analysis of eight manufacturing industries", *American Economic Review*, 76, 1986, 82-109
- Bils, M.: "The cyclical behavior of marginal cost and price", *American Economic Review*, 77, 1987, 838-855
- Bodo, G. and Giannini, C.: "Average working time and the influence of contractual hours: an empirical investigation for the Italian industry", *Oxford Bulletin of Economics and Statistics*, 47, 1985, 131-151
- Bosworth, D. and Westaway, T.: "The demand for hours of work", *Scottish Journal of Political Economy*, 34, 1987, 368-
- Brunello, G.: "The employment effects of shorter working hours: An application to Japanese data", *Economica*, 56, 1989, 473-486
- De Regt, E.R.: "Labor demand and standard working time in Dutch manufacturing, 1954-1982", Hart, ed. (1988), 185-205
- Earle, J.S. and Pencavel, J.: "Hours of work and trade unionism", *Journal of Labor Economics*, 8, 1990, Supplement, 150-174
- Hart, R.A.: *Working Time and Employment*, London: Allen & Unwin, 1987
- Hart, R.A., ed.: *Employment, Unemployment and Labor Utilization*, Boston: Unwin Hyman, 1988
- Hart, R.A. and McGregor, P.G.: "The returns to labour services in West German manufacturing industry", *European Economic Review*, 32, 1988, 947-963
- Hart, R.A. and Wilson, N.: "The demand for workers and hours: Micro evidence from the UK metal working industry", Hart, ed. (1988), 162-179
- Hübler, O.: "Effort and the reduction in standard working hours", presented at the Congress of the European Economic Association, Augsburg, 1989

König, H. and Pohlmeier, W.: "Worksharing and factor prices: A comparison of three flexible functional forms for nonlinear cost schemes", *Journal of Institutional and Theoretical Economics*, 145, 1989, 343-357

Kraft, K.: "Expectations and the adjustment of hours and employment", *Applied Economics*, 21, 1989, 487-495 (a)

Kraft, K.: "Arbeitszeitverkürzung, Beschäftigung und tatsächliche Arbeitszeit", *Jahrbücher für Nationalökonomie und Statistik*, 206, 1989, 243-251 (b)

Mizon, G.E.: "Inferential procedures in nonlinear models: an application in a UK industrial cross section study of factor substitution and returns to scale", *Econometrica*, 45, 1977, 1221-1242

Muellbauer, J.: "Aggregate production functions and productivity measurement: a new look", *CEPR Discussion Paper*, No. 34, 1984

Nadiri, M.I. and Rosen, S.: *A Disequilibrium Model of Demand for Factors of Production*, New York: NBER, 1973

Nakamura, S.: "An adjustment cost model of long term unemployment", presented at the Econometric Society World Congress, Barcelona, 1990

Nymoén, R.: "Wages and the length of the working day: An empirical test based on Norwegian quarterly manufacturing data", *Scandinavian Journal of Economics*, 91, 1989, 599-612

Pencavel, J. and Holmlund, B.: "The determination of wages, employment and hours of work in an economy with centralised wage-setting: Sweden 1950-1983", *Economic Journal*, 98, 1988, 1105-1126

Rossana, R.J.: "Buffer stocks and labor demand: further evidence", *Review of Economics and Statistics*, 67, 1985, 16-26

Santamäki, T.: "Implications of the nonhomogeneity of standard and overtime hours on the structure and cyclical adjustment of labor input", Hart, ed. (1988), 90-106

Shapiro, M.D.: "The dynamic demand for capital and labor", *Quarterly Journal of Economics*, 101, 1986, 513-542

Topel, R.H.: "Inventories, Layoffs, and the short-run demand for labor", *American Economic Review*, 72, 1982, 769-787

Appendix: The bias from the omission of whitecollar overtime hours

The true measure of labor utilization is $U_L = (H_{OB} + H_{OW}) / (H_{SB} + H_{SW})$, where the subscripts B and W refer to bluecollar and whitecollar workers, respectively. The measured utilization rate is $U_L^* = H_{OB} / (H_{SB} + H_{SW})$, i.e. there is no information on the whitecollar workers' overtime hours. The true and actual measures are related through $U_L - U_L^* = H_{OW} / (H_{SB} + H_{SW}) = U_L^{**}$. Since $\log(1 + U_L) \approx U_L$, the model (A) to be estimated is (ignoring capital input and technical change for simplicity) $\log Q = \log A + \alpha \log N + \beta_1 \log H + \beta_2 U_L^* + \varepsilon^*$, where $\varepsilon^* = \varepsilon + \beta_2 H_{OW} / (H_{SB} + H_{SW}) = \varepsilon + \beta_2 U_L^{**}$ and ε is the error term of the true model. Denote $y = \log Q$, X a matrix with typical row $(1, \log N_t, \log H_t, U_L^*)_t$ and $\theta = (\log A, \alpha, \beta_1, \beta_2)'$ the corresponding vector of parameters. The OLS estimate of θ is $\hat{\theta} = (X'X)^{-1}X'y = \theta + (X'X)^{-1}X'\varepsilon^*$, which has expectation $E\hat{\theta} = \theta + \beta_2 \mu$, where μ is the expectation of $(X'X)^{-1}X'U_L^{**}$, the vector of coefficients from a regression of U_L^{**} on X . The OLS estimate is unbiased, if U_L^{**} is uncorrelated with the explanatory variables of the model. In particular, consider the coefficient of the measured utilization rate U_L^* . The expectation of the estimate $\hat{\beta}_2$ is $E\hat{\beta}_2 = \beta_2(1 + \mu_4)$, where μ_4 is the fourth element of μ , i.e. the coefficient of U_L^* in a regression of U_L^{**} on X . If bluecollar and whitecollar overtime hours are positively correlated, the estimate $\hat{\beta}_2$ will be biased upwards when the measured utilization rate U_L^* is used. The other coefficients, too, will be biased, although the directions of the biases may be more difficult to justify a priori.

As an alternative, it is possible to use only the data on bluecollar workers in the estimation of the model. The utilization rate is now $U_{LB} = H_{OB} / H_{SB}$, which is related to the true measure through $U_L - U_{LB} = (U_{LW} - U_{LB})S_W$, where $U_{LW} = H_{OW} / H_{SW}$ and $S_W = H_{SW} / (H_{SB} + H_{SW})$. The matrix of explanatory variables X

has now typical row $(1, \log N_{Bt}, \log H_{SBt}, U_{LBt})$ and the error term is $\epsilon^* = \epsilon + Z\theta$, where Z is a matrix with typical row $(0, \log N_t - \log N_{Bt}, \log H_{St} - \log H_{SBt}, (U_{LW} - U_{LB})S_w)$. It is likely that although OLS estimates may be biased, there are no systematic biases in any specific direction in this case. Therefore it seems that using data on bluecollar workers only at least partly alleviates the biases.

In the demand equations the situation is different, since the incorrectly measured utilization rate appears as the dependent variable. The measurement error can be included as a part of the stochastic error term and causes no biases in estimation.

ELINKEINOELÄMÄN TUTKIMUSLAITOS (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, SF-00120 HELSINKI

Puh./Tel. (90) 601 322
Int. 358-0-601 322

Telefax (90) 601 753
Int. 358-0-601 753

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

- No 335 VEIJO KAITALA - MATTI POHJOLA - OLLI TAHVONEN, An Economic Analysis of Transboundary Air Pollution between Finland and the Soviet Union. 01.10.1990. 23 p.
- No 336 TIMO MYLLYNTAUS, Ympäristöhistorian tutkimus Suomessa. 08.10.1990. 35 p.
- No 337 KÅRE P. HAGEN - VESA KANNIAINEN, The R&D Effort and Taxation of Capital Income. 15.10.1990. 34 p.
- No 338 PEKKA YLÄ-ANTTILA - RAIMO LOVIO, Flexible Production, Industrial Networks and Company Structure - Some Scandinavian Evidence. 25.10.1990. 19 p.
- No 339 VESA KANNIAINEN, Destroying the Market for Drugs: An Economic Analysis. 01.11.1990. 32 p.
- No 340 PENTTI PÖYHÖNEN - RISTO SULLSTRÖM, The EES and Trade in Manufactured Goods. 09.11.1990. 14 p.
- No 341 PEKKA SUOMINEN, Ulkomaalaista koskevat investointirajoitukset Länsi-Euroopan maissa. 20.11.1990. 66 s.
- No 342 KARI ALHO, Identification of Barriers in International Trade under Imperfect Competition. 21.11.1990. 27 p.
- No 343 JUSSI RAUMOLIN, The Impact of Technological Change on Rural and Regional Forestry in Finland. 22.11.1990. 84 p.
- No 344 VEIJO KAITALA - MATTI POHJOLA - OLLI TAHVONEN, Transboundary Air Pollution and Soil Acidification: A Dynamic Analysis of an Acid Rain Game between Finland and the USSR. 23.11.1990. 29 p.
- No 345 ROBERT MICHAEL BERRY, Deep Waters Run Slowly. Elements of Continuity in European Integration. 10.12.1990. 31 p.
- No 346 ANTHONY J. VENABLES, New Developments in the Study of Economic Integration. 17.12.1990. 30 p.
- No 347 JUSSI RAUMOLIN, Euroopan Yhteisön ympäristöpolitiikka. 20.12.1990. 52 s.

- No 348 VESA KANNIAINEN, Optimal Production of Innovations Under Uncertainty. 07.01.1991. 39 p.
- No 349 KARI ALHO, Bilateral Transfers and Lending in International Environmental Cooperation. 16.01.1991. 24 p.
- No 350 VESA KANNIAINEN, Yritysten rahoituspolitiikka: selvitys Suomen pörssiyrityksistä 1983-87. 24.01.1991. 19 s.
- No 351 MARI HARNI - JUKKA LASSILA - HEIKKI VAJANNE, Transformation and Graphics in ETLAs Economic Database System. 25.01.1991. 12 p.
- No 352 JUHA KETTUNEN, Heterogeneity in Unemployment Duration Models. 31.01.1991. 22 p.
- No 353 PENTTI VARTIA, Experiences from Growth and Transformation in the Post-war Period - The Country Study for Finland. 12.02.1991. 20 p.
- No 354 VEIJO KAITALA - MATTI POHJOLA - OLLI TAHVONEN, An Analysis of SO₂ Negotiations between Finland and the Soviet Union. 18.02.1991. 17 p.
- No 355 JUHA KETTUNEN, Transition Intensities from Unemployment. 27.02.1991. 24 p.
- No 356 MARKKU KOTILAINEN, Exchange Rate Unions: A Comparison to Currency Basket and Floating Rate Regimes. 15.03.1991. 54 p.
- No 357 SYNNOVE VUORI, Returns to R&D in Nordic Manufacturing Industries, 1964 to 1983. 20.03.1991. 42 p.
- No 358 VEIJO KAITALA - MATTI POHJOLA - OLLI TAHVONEN, A Finnish-Soviet Acid Rain Game: "Club Solutions", Noncooperative Equilibria and Cost Efficiency. 22.03.1991. 18 p.
- No 359 JUHA KETTUNEN, Occupational Mobility of Unemployed Workers. 25.03.1991. 29 p.
- No 360 JUSSI RAUMOLIN, Logistiikan näkymiä yhdentyvässä Euroopassa. 25.03.1991. 17 s.
- No 361 MARKKU OLLIKAINEN, Kestävä kehitys - ongelmia ja tulkintoja. 08.04.1991. 24 s.
- No 362 PEKKA ILMAKUNNAS, Working Time, Productivity and Labor Demand in Finnish Manufacturing. 22.04.1991. 40 p.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on rajoitetusti saatavissa ETLAn kirjastosta tai ao. tutkijalta. Papers in this series are reports on preliminary research results and on studies in progress; they can be obtained, on request, by the author's permission.

E:\sekal\DPjulk.chp/22.04.1991