

## **OUTPUT, WAGES AND THE DEMAND FOR LABOUR: Evidence from panel data\***

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*Using a sample of small and medium sized firms, we investigate the relationship between wages and employment. Our data reveal a stable cross-section correlation between wages and productivity, consistent with the neoclassical demand for labour theory in general and the Cobb-Douglas assumptions in particular. These results do not indicate anything about the direction of causation. A positive correlation between wages and productivity can arise from capital-labour substitution as wages change but other explanations are also plausible. Intervening variables are for example a particular concern in the analysis of panel data.*

*In this paper, the neoclassical theory is tested in the generalized random effects framework put forward by Chamberlain. A series of exogeneity tests gives some support to the neoclassical notion that at the micro level, wages affect employment and productivity but not vice versa. The evidence presented is rather weak, however, and our data do not reject a restriction to a purely static relationship. In this specification, parameter estimates are not neoclassical.*

*The wage-elasticity estimates obtained from the neoclassical cost-minimization model are of order 0.2—0.4, which is quite reasonable. Our results give support to the hypothesis that measurement errors have biased some of the earlier elasticity estimates from panel data towards 1.*

### *I. Introduction*

Wages and productivity tend to grow together, while output and employment show rather different trends in different countries and at different times. A comparison of recent developments in major OECD countries suggests a negative correlation between real

wages and employment. It is often argued that the direction of causation runs from wages to employment and productivity and hence that unemployment is best explicable in terms of real wage rigidity. This somewhat neoclassical notion has evoked much policy discussion and economic research in many European countries, most notably in the U.K. (For some research examples, see Bruno and Sachs (1985), Symons and Layard (1983) and Layard and Nickell (1985)).<sup>1</sup>

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<sup>1</sup> So far, Finland has largely escaped the European debate about real wage resistance together with its some-

Most econometric studies of the wage — employment relationship are based on aggregate time series evidence. Indispensable and useful as these studies are, the evidence as a whole leaves the impression that almost any theory or any set of parameter values is likely to be consistent with aggregate time series. The difficulty of obtaining well-determined parameter estimates for the employment equation can be illustrated by considering the macroeconomic models of the Finnish economy. The definitions of the variables and data used in estimation in different models are broadly speaking comparable. Nevertheless, the long-run response of labour demand and employment to a permanent one per cent increase in real wages varies between zero and three per cent.

In this paper, the wage-employment relationship is discussed from a microeconomic point of view. Using panel data information for a sample of Finnish manufacturing firms over the period 1976—1982, we first establish the existence of a stable positive cross-section correlation between wages and productivity. One explanation for this correlation is provided by exogeneous wages and labour input adjustment up to point where marginal productivity equals wage rate.

We test this theory using methods proposed by Chamberlain (1984). In addition, some estimates of the wage elasticity of the labour demand are presented. In our data set, the wage rate variable is measured independently of the employment variable and thus, one source of measurement error is removed. A comparison of results with those obtained by Mairesse and Dormont (1985) reveals that correlated errors in employment and wage variables can be responsible for severely biased elasticity estimates.

*times disheartening overtones. It is not difficult to explain the difference in public interest. Although the Finnish unemployment rate has been high by post-war standards throughout the 1980s, it remains well below West European levels. Even more remarkable is the growth of employment. Since 1978, employment has increased by some 250 000 persons, or more than 10 per cent, whereas in the rest of OECD-Europe it has on average been stagnant or declined. Though this development has been relatively favourable for Finland in general terms, it has exerted a depressing effect on labour market studies. There are some recent labour market studies in Finland, however, such as Eriksson (1985) and Santamäki (1986).*

## 2. The neoclassical demand for labour function

Consider the demand for labour of a single firm. The standard neoclassical model assumes perfect competition in the labour market so that the firm takes the wage rate as exogenous. The amount of employment offered is determined by the familiar conditions according to which in equilibrium the revenue product of the marginal employee is equal to the wage rate. Other things being equal, a lower wage rate means more employment and less productivity. There exists a stable negative relationship between wages and employment and, at the level of an individual firm, the direction of causation runs from wages to employment.

The demand theory outlined above is devoid of any empirical content without some notion of exogeneity. The one adopted in this paper builds on timing evidence, leading to the exclusion of wage leads from the demand for labour function. This is very much in accord with the mainstream of employment studies, although leads are usually rejected on common-sense grounds only.

Let  $l_t$  and  $w_t$  denote the demand for labour and the wage rate, respectively, at time  $t$ . Omitting other exogenous variables, a Sims (1972) definition for the exogeneity of wages can be written as

$$E^*(l_t | \dots, w_{t-1}, w_t, w_{t+1}, \dots) = E^*(l_t | \dots, w_{t-1}, w_t)$$

where  $E^*(l_t | Z)$  denotes the (minimum mean-square error) linear predictor of  $l_t$  conditional on an information set  $Z$ . The knowledge of future wages does not improve the fit of the labour demand equation because future wages — or more precisely, their »innovations» — do not belong to the firm's information set at the time of the employment decision, and because wages are independent of the employment decision.<sup>2</sup>

The definition of exogeneity adopted here does not exclude the purely contemporaneous

<sup>2</sup> As is well known, Sims exogeneity is in practice equivalent to Granger non-causality, defined as

$$E^*(w_{t+j} | \dots, w_{t-1}, w_t \text{ and } \dots, l_{t-1}, l_t) \\ E^*(w_{t+j} | \dots, w_{t-1}, w_t)$$

relation between the two variables. A static relationship between the two variables

$$E^*(l_t | \dots, w_t, \dots) = (E^*(l_t | w_t)),$$

does not allow any inferences about the direction of causation on the basis of timing evidence only.

For each  $t$ , the exogeneity definition implies a demand for labour equation. Assuming stationarity, these can be written as

$$(E_t^*) \quad l_t = c_0 + b_0 w_t + b_1 w_{t-1} + b_2 w_{t-2} + \dots + u_t$$

for  $t = \dots, 0, \dots$ . In these equations,  $c_0$ ,  $b_0$ ,  $b_1$ ,  $\dots$  are constants and  $u_t$  denotes an error term.

A more parsimonious presentation for the underlying dynamic employment process is usually obtained by also including lagged values of the endogenous variable in the set of explanatory variables. In the model  $(E_t^*)$  lags tend to be longer and even the restriction to finite order can be suspected on general grounds. However, this specification helps to bypass some of the econometric difficulties which arise using panel data.

Data on wages and employment are available for a limited number of periods only. Suppose we have data for periods  $1, \dots, T$ . An operational counterpart for the set of equations  $(E_t^*)$  is as follows:

$$(E'_1) \quad l_1 = a_0 + b_0 w_1 + u_1$$

⋮  
⋮  
⋮

$$(E'_t) \quad l_t = a_0 + b_{t-1} w_1 + \dots + b_0 w_t + u_t$$

⋮  
⋮  
⋮

$$(E'_T) \quad l_T = a_0 + b_{T-1} w_1 + \dots + b_0 w_T + u_T.$$

However, a formulation with time-variant coefficients is preferable, especially if the data cover only a few periods.

$$(E_t) \quad l_t = a_{t,0} + b_{t,0} w_t + u_t$$

⋮  
⋮  
⋮

$$(E_t) \quad l_t = a_{t,0} + b_{t,t-1} w_1 + \dots + b_{t,0} w_t + u_t$$

⋮  
⋮  
⋮

$$(E_T) \quad l_T = a_{T,0} + b_{T,T-1} w_1 + \dots + b_{T,0} w_T + u_T$$

One reason for time-variant coefficients is the lag truncation problem. Even if the relationship described by  $(E_t^*)$  remain constant as  $t$  changes, time-varying parameters can be excluded only if the wage variables  $\dots, w_{t-1}, w_0, w_1, \dots$  are assumed to be orthogonal, which is very restrictive. In addition, the coefficients in  $(E_t^*)$  tend to change, because of the existence of various misspecification errors. Inappropriately excluded variables show up in unstable parameters.

The model  $(E_t)$ — $(E_T)$  with time-variant negative coefficients can be regarded as an adequate presentation of the competitive neoclassical demand for labour function, at least if no information is available on output and input prices (apart from wages), demand conditions and fixed inputs. If variables are measured in logarithmic units, the row sum of wage coefficients gives the »long-run» wage elasticity of labour demand. A complicated lag structure can result in some of the individual coefficients becoming positive, and hence, the coefficients in  $(E_t)$ — $(E_T)$  have to be negative only on average. The main testable implication of the neoclassical theory is the exogeneity of wages.

If instead of profit maximization only cost minimization is assumed, the model has to be supplemented with an exogenous output variable.<sup>3</sup>

### 3. Exogeneity in panel data models

Panel data are useful in estimating models like  $(E_t)$ — $(E_T)$ , and in testing exogeneity assumptions. However, model specification requires some care and usually one has to make some allowance for differences between firms. There are firm-specific variables which affect the employment decision but nevertheless remain unobserved or unmeasured.

We assume that the coefficients of wage and output variables are equal across firms. Thus, latent variables enter into the model additively as firm-specific intercepts and can be dealt

<sup>3</sup> The delayed response assumed throughout this paper is usually motivated by sluggish expectations or by various adjustment costs. Implicitly,  $(E_t)$ — $(E_T)$  assumes that wages are forecast from their own lagged values. Sargent (1978) and Altonji and Ashenfelter (1980) provide some evidence which shows that this assumption is not completely unreasonable.

with by the specification of the error term in  $(E_1)$ — $(E_T)$ . The firm subscript  $i$  is now kept explicitly in sight and so the error term is written as  $u_{it}$ .

The usual assumption in panel data models is

$$(1) \quad u_{it} = v_i + e_{it}$$

where  $v_i$  is the firm-specific latent variable capturing unobserved »individual effects« and  $e_{it}$  is the error term proper, assumed to be independent of the explanatory variables as well as of the  $v_i$ 's.

In the random effects model  $v_i$ 's are treated as a random sample from some given distribution. In a model with time-invariant coefficients this assumption leads to the use of quasi-mean deviations like  $w_{it} - c \cdot w_i$  with  $c$  a constant to be estimated and  $w_i$  the average of the wage variable for the  $i$ 'th firm.<sup>4</sup>

Here, we adopt the somewhat more general random effects specification put forward by Chamberlain. For ease of exposition, we can again restrict attention to the profit maximization case only. In this case, it is assumed that

$$(2) \quad E^*(v_i | w_{i1}, \dots, w_{iT}) = v + f_1 w_{i1} + \dots + f_T w_{iT}$$

with  $v, f_1, \dots,$  and  $f_T$  as constants. This is a generalization of the standard random effects model, where the coefficients  $f_i$  are restricted to be zero.

Adopting the specification (2) for the random latent variable  $v_i$ , consider the linear regression of  $l_{it}$  on  $w_{i1}, \dots, w_{iT}$ . The expected value of each  $l_{it}$ , i.e.,  $E^*(l_{it} | w_{i1}, \dots, w_{iT})$ , is a linear combination of the  $w_{it}$ 's, and hence we obtain

$$l_{it} = \alpha_i + \beta_{1i} w_{i1} + \dots + \beta_{iT} w_{iT} + e_{it}$$

<sup>4</sup> The random effects estimator provides, in a sense, a compromise between ordinary least square estimates in levels and fixed effect estimates. They approach the level estimates corresponding to assumption (2) if the variance  $\sigma_v^2$  of the firm-specific random variable approaches zero, and the fixed effects corresponding to (3) if  $\sigma_v^2 \rightarrow \infty$ . In the intermediate cases  $0 < \sigma_v^2 < \infty$  the random effects estimator is efficient, provided that the  $v_i$ 's are uncorrelated with the explanatory variables.

$$(3) \quad \begin{matrix} l_{i1} = \alpha_i + \beta_{1i} w_{i1} + \dots + \beta_{iT} w_{iT} + e_{i1} \\ \vdots \\ l_{iT} = \alpha_i + \beta_{1i} w_{i1} + \dots + \beta_{iT} w_{iT} + e_{iT} \end{matrix}$$

with constants  $\alpha$  and  $\beta$ . The matrix of  $\beta$ -coefficients is not lower triangular even if wages are in fact exogenous. The coefficients above the diagonal capture the effects of the latent variable and tell nothing about the direction of causation.

Taking the random latent variable into account, the exogeneity restrictions on  $\beta$ -coefficients become

$$(4) \quad (\beta_{ij}) = \begin{pmatrix} \beta_{11} & f_2 & f_3 & f_4 & \dots & f_T \\ \beta_{21} & \beta_{22} & f_3 & f_4 & \dots & f_T \\ \beta_{31} & \beta_{32} & \beta_{33} & f_4 & \dots & f_T \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \beta_{T1} & \beta_{T2} & \beta_{T3} & \beta_{T4} & \dots & \beta_{TT} \end{pmatrix}$$

provided that  $T > 4$ . Chamberlain calls this notion exogeneity conditional on a random latent variable.

If wages are exogenous, and we estimate the coefficients of the wage variables using panel data without any restrictions on lead and lag structure, the elements of the estimated  $\beta$ -matrix should be approximately equal to each other in each column above the diagonal. Formally, exogeneity can be tested by imposing the restrictions in (4) and comparing the results of restricted and unrestricted estimations.

Some of the coefficients of  $(E_1)$ — $(E_T)$  can be evaluated from the restricted estimates. Equations  $(E_1)$ — $(E_T)$  and (2) imply

$$(5) \quad \begin{matrix} b_{2,0} = \beta_{22} - f_2 \\ b_{3,0} = \beta_{33} - f_3, \quad b_{31} = \beta_{32} - f_2 \\ \vdots \\ b_{T,2} = \beta_{T2} - f_2, \quad \dots, \quad b_{T,0} = \beta_{TT} - f_T \end{matrix}$$

The first column of the matrix  $b$  — the coefficients  $b_{10}, b_{21}, \dots, b_{T,T-1}$  — cannot be identified from the estimates.

#### 4. Empirical results

Our data are drawn from a survey conducted by Teollistamisrahaisto (see Myllyniemi and Solttila (1984) for details on the construction of the original sample and on the definitions and measurement of the variables). The sample consisted of 69 small and medium-sized firms. The data covered the years 1975—1982 and for each year we had information on value added, debts, interest payments, number of hours worked, number of employees, wage costs and investment. The data for 1975 were rather scanty, with many missing observations, and therefore only the years 1976—1982 were included in the analysis. Other missing observations were replaced by linear projections on firm- and year-dummies.<sup>5</sup>

The wage rate variable was obtained by dividing wage costs by the number of hours worked. The number of employees was used as the employment variable and value added as the output variable. Wage and output variables were deflated by the price of industrial output before estimation. In the regressions below, all variables appear in logarithmic units.

In Table 1, we present some cross-section estimates from regressing employment on output, wages and a constant. In each regression, the employment, output and wage variables all come from the same cross-section and thus in these equations all leads and lags are excluded. The results presented in Table 1 were obtained by seven ordinary least square regressions, one for each year. Lines  $E_{76}$ , ... and  $E_{82}$  give the results for cross-section regressions 1976, ... and 1982, respectively.

Table 1 provides evidence of a stable positive relationship between wages and productivity. The coefficient of the output variable is equal to 1 in every cross-section whereas the coefficient of the wage variable is about  $-.4$ . These are plausible parameter values for a (long-run) neoclassical demand for labour function. In particular, estimates are consistent with cost minimization and the value added Cobb-Douglas production function if labour and capital both are treated as varia-

ble factors. Other interpretations are also feasible. Cost minimization with Cobb-Douglas assumptions implies that the coefficient of the wage variable is equal to the income share of capital. Incidentally, the well-determined parameter estimates for the wage variable imply some degree of heterogeneity in the labour market. We would not be able to distinguish between the wage variable and the constant term in a cross-section analysis if there were no differences in wage rates between firms.

Although the results of Table 1 are consistent with the neoclassical theory, they tell nothing about the direction of causation and hence do not help to discriminate between neoclassical and alternative explanations for a positive wage-productivity relationship. The alternatives assert either that, even at the micro level, causation runs in the reverse direction, from output to wages, or that the observed correlation between the two variables is spurious.<sup>6</sup>

We first consider the exogeneity of wages. Table 2 contains results for unrestricted cross-section estimates corresponding to the set of equations (3) with a maximal lead and lag structure. Employment in 1978, for example, is regressed on output and wages not only in 1978 but also in the preceding years 1976—1977 and in the subsequent period 1977—1982.

Above, we discussed the empirical implications of time invariant firm characteristics. These defy causal interpretation but turn out to be spurious leads in the regressions. If all leads are due to a latent variable, we would expect that in Table 2 the coefficients above the two diagonals should be equal to each other in every column. The coefficients of the wage variable are  $w_{78}$ ,  $-.53$  and  $-.53$ ; in column  $w_{79}$ , they are  $.20$ ,  $.29$  and  $.27$ ; etc. The differences between the coefficients seem negligible, at least compared with the standard errors. These results clearly suggest that a model with a time-invariant latent variable and wages exogenous is consistent with the data.

<sup>5</sup> In the analyses, no attempt was made in order to correct for the degrees of freedom lost in replacing missing observations.

<sup>6</sup> For example, if work is monotonous and boring in capital-intensive branches, some remuneration is required in order to prevent labour shortages. An alternative explanation for the observed correlation is that wages tend to follow productivity, for example because productive individuals are well paid. Wages also follow productivity if employees regard themselves as entitled to the profits of the firm and are able to defend their income share.

Table 1.\* Some descriptive regression results. Standard errors in parentheses.

	q <sub>76</sub>	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	w <sub>76</sub>	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	C
E <sub>76</sub>	1.02 (0.4)							-.47 (.12)							-3.07 (.39)
E <sub>77</sub>		.93 (.04)							-.28 (.19)						2.80 (.47)
E <sub>78</sub>			1.00 (5.0)							-.39 (.12)					-3.17 (.48)
E <sub>79</sub>				1.00 (.04)							-.31 (.11)				3.45 (.43)
E <sub>80</sub>					1.02 (.03)							-.46 (.08)			-3.08 (.34)
E <sub>81</sub>						.99 (.04)							-.35 (.09)		-3.18 (.37)
E <sub>82</sub>							.95 (.05)							-.35 (.13)	-2.75 (.48)

\* In Tables 1—7 C denotes the constant term.

Table 2. Estimation results: unrestricted model. Minimum distance asymptotic standard errors in parentheses.

	q <sub>76</sub>	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	w <sub>76</sub>	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	C
E <sub>76</sub>	1.02 (.16)	-.16 (.15)	-.59 (.21)	0.3 (.22)	.61 (.25)	.21 (.23)	.01 (.14)	-.10 (.36)	-.02 (.33)	-.53 (.33)	.20 (.44)	-.15 (.29)	-.27 (.39)	.16 (.38)	-3.21 (.48)
E <sub>77</sub>	.70 (.14)	-.01 (.14)	-.27 (.19)	.00 (.20)	.57 (.23)	.19 (.21)	.07 (.13)	-.12 (.34)	.07 (.30)	-.53 (.30)	.29 (.41)	-.13 (.27)	-.31 (.36)	.07 (.35)	-3.06 (.44)
E <sub>78</sub>	.53 (.14)	.06 (.14)	-.27 (.19)	-.01 (.20)	.42 (.23)	.16 (.21)	.15 (.13)	.29 (.33)	-.08 (.30)	-.68 (.30)	.27 (.40)	-.01 (.26)	-.36 (.35)	.00 (.34)	-2.92 (.43)
E <sub>79</sub>	.34 (.13)	.01 (.13)	-.39 (.18)	.27 (.18)	.56 (.22)	.14 (.20)	.09 (.12)	.36 (.32)	-.11 (.29)	-.54 (.28)	.25 (.38)	-.04 (.25)	-.45 (.34)	.03 (.33)	-2.87 (.38)
E <sub>80</sub>	.25 (.12)	.06 (.12)	-.44 (.16)	.11 (.17)	.61 (.20)	.35 (.18)	.06 (.11)	.38 (.29)	-.34 (.26)	-.51 (.26)	.18 (.35)	-.12 (.23)	-.26 (.31)	-.14 (.30)	-2.83 (.40)
E <sub>81</sub>	.09 (.13)	.19 (.13)	-.39 (.17)	.09 (.18)	.33 (.21)	.51 (.19)	.14 (.12)	.54 (.30)	-.17 (.27)	-.41 (.27)	.06 (.36)	.26 (.36)	.26 (.24)	-.30 (.32)	-2.90 (.44)
E <sub>82</sub>	.02 (.14)	.15 (.14)	-.27 (.19)	.13 (.20)	.31 (.23)	.47 (.21)	.27 (.13)	.75 (.33)	-.16 (.30)	-.44 (.40)	.02 (.26)	.14 (.36)	-.38 (.36)	.24 (.44)	-2.90 (.44)

In order to test the exogeneity assumption we imposed restrictions (4) for wages and estimated the equations (E<sub>76</sub>)—(E<sub>82</sub>) with minimum distance procedures.<sup>7</sup> Assuming normal distribution for the error term, the information required for the likelihood ratio test is provided on the first line of Table 8. The number of degrees of freedom, 15, is given by the

<sup>7</sup> The usual distance norm was used instead of the optimal norm proposed by Chamberlain. If the error term is heteroskedastic, the simple estimation procedure adopted here may be problematic.

number of independent linear restrictions on coefficients. The hypothesis that wages are exogenous is very easily accepted by the data. Results also lend support to the exogeneity of output, although the evidence is not as strong as with wages and hence we can assume cost minimization instead of profit maximization. Of course, an exogenous output variable greatly enhances the explanatory power of the employment equation.

With output and wages taken as exogenous, we can consider neoclassical models with or

Table 3.\*\* Estimation results: output and wages exogenous. Minimum distance asymptotic standard errors in parentheses.

	q <sub>76</sub>	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	w <sub>76</sub>	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	C
E <sub>76</sub>	.96 (.14)	-.17 (.14)	-.42 (.17)	-.06 (.17)	.36 (.19)	.38 (.16)	.08 (.10)	-.11 (.32)	.02 (.29)	-.52 (.27)	.19 (.35)	.07 (.22)	-.23 (.27)	-.21 (.26)	3.13 (.41)
E <sub>77</sub>	.73 (.13)	.01 (.13)						-.09 (.31)	.08 (.28)						2.93 (.39)
E <sub>78</sub>	.59 (.13)	.06 (.12)	-.36 (.17)					.31 (.30)	-.07 (.26)	-.67 (.27)					2.82 (.39)
E <sub>79</sub>	.40 (.12)	.05 (.12)	-.48 (.16)	.24 (.17)				.42 (.29)	-.16 (.29)	-.57 (.26)	.10 (.33)				2.75 (.37)
E <sub>80</sub>	.25 (.11)	.06 (.11)	-.43 (.14)	.10 (.15)	.56 (.17)			.39 (.26)	-.04 (.23)	-.51 (.23)	.17 (.23)	-.08 (.20)			2.65 (.33)
E <sub>81</sub>	.11 (.12)	.19 (.11)	-.43 (.15)	.09 (.16)	.29 (.18)	.64 (.16)		.67 (.27)	-.16 (.24)	-.39 (.24)	-.01 (.36)	.06 (.21)	-.30 (.28)		2.82 (.35)
E <sub>82</sub>	.04 (.13)	.15 (.12)	-.31 (.17)	.01 (.18)	.27 (.20)	.59 (.18)	.22 (.11)	.76 (.30)	-.15 (.27)	-.42 (.27)	-.06 (.35)	.17 (.23)	-.38 (.31)	-.24 (.29)	2.90 (.38)

\*\* In Tables 3 and 5 the missing elements in the coefficient matrices are equal to the first element in the respective column.

Table 4.\*\*\* Output and wage elasticity estimates from Table 3.

	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	Row sum	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	Row sum
E <sub>77</sub>	.18						.18	.06						.06
E <sub>78</sub>	.23	.06					.29	-.09	.15					.06
E <sub>79</sub>	.22	-.06	.30				.46	-.18	-.05	-.09				-.32
E <sub>80</sub>	.23	-.01	.16	.20			.58	-.06	.01	-.02	-.15			-.22
E <sub>81</sub>	.36	-.01	.15	-.07	.26		.69	-.18	.13	-.20	-.01	-.07		-.33
E <sub>82</sub>	.33	.09	.07	-.09	.21	.14	.74	-.17	.10	-.25	-.07	-.15	-.03	-.40

\*\*\* In Tables 4 and 6 the elasticity estimates are based on equations (5).

without further restrictions on the lag structure or exclude wages altogether from the model. The estimation results for the unrestricted model with exogenous wages and output are presented in Table 3, together with the implied elasticities in Table 4. At first sight the results are encouraging from the point of view of the neoclassical model. The response to output changes is rather slow but the long-run output elasticity .74 is reasonable. The long-run wage elasticity  $-.40$  is in accord with the cross-section estimates.

However, a closer inspection of the estimation results raises doubts and one may even wonder whether the wage variable is signifi-

cant at all. Thus, we test whether the wage variable can be omitted from the employment function altogether except as a proxy for non-causal latent variables. The test information provided in Table 8 implies that the restriction to a latent relation only is firmly rejected. In view of our data, wages cannot be excluded from the demand for labour function altogether but a static relationship between wages and employment appears to be acceptable.

With a static wage-employment relationship, the estimate of output elasticity increases slightly. An increase of ten per cent in output increases employment during the same year by

Table 5.\*\*\* Estimation results: output exogenous, static wage — employment relationship. Minimum distance asymptotic standard errors in parentheses.

	q <sub>76</sub>	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	w <sub>76</sub>	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	C
E <sub>76</sub>	.94 (.14)	-.11 (.14)	-.52 (.17)	-.02 (.17)	.37 (.19)	.37 (.16)	.08 (.10)	.30 (.25)	-.10 (.22)	-.45 (.22)	.15 (.30)	-.11 (.20)	-.26 (.27)	-.14 (.26)	-3.30 (.41)
E <sub>77</sub>		.70 (.14)	.09 (.13)					.47 (.25)	-.20 (.20)						-3.04 (.39)
E <sub>78</sub>		.57 (.13)	.07 (.12)	-.40 (.17)						-.53 (.23)					-2.92 (.38)
E <sub>79</sub>		.39 (.12)	.04 (.12)	-.49 (.16)	.27 (.17)						.08 (.30)				-2.82 (.37)
E <sub>80</sub>		.24 (.11)	.07 (.11)	-.45 (.14)	.11 (.15)	.58 (.17)						-.15 (.20)			-2.69 (.33)
E <sub>81</sub>		.12 (.12)	.15 (.11)	-.40 (.15)	.04 (.16)	.40 (.18)	.58 (.16)						-.20 (.27)		-2.87 (.35)
E <sub>82</sub>		.06 (.13)	.08 (.12)	-.26 (.17)	-.05 (.18)	.45 (.20)	.50 (.18)	.23 (.11)						-.06 (.27)	-3.06 (.39)

\*\*\* The estimate of  $t_{76}$  is given on line E<sub>77</sub>.

Table 6. Output and wage elasticity estimates from table 5.

	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	Row sum	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>
E <sub>77</sub>	.20						.20	-.10					
E <sub>78</sub>	.18	.12					.30		-.08				
E <sub>79</sub>	.15	.3	.29				.47			-.07			
E <sub>80</sub>	.18	.7	.13	.21			.59				-.04		
E <sub>81</sub>	.24	.12	.6	.3	.21		.66					.06	
E <sub>82</sub>	.19	.26	-.3	.10	.13	.23	.88						.08

about 2 per cent.

The static wage elasticities in Table 6 are disappointing from the neoclassical point of view. The estimated «elasticity» is initially negative but increases during the estimation period to become finally positive. This result may be due to correlation between the explanatory variables. In our equations, a common trend in output and wages is captured by the year dummies but a positive correlation between output growth and wages at the firm level provides one explanation for the positive correlation between employment growth and wages implied by the estimates in Table 6.

Mairesse and Dormont (1985) used year-

differenced variables to eliminate firm-specific latent variables. In all data sets, the long-run elasticity of labour demand estimates were about  $-.8$  with respect to the wage rate and about  $.3-.5$  with respect to output. For comparison we estimated the unrestricted model with exogenous wage and output variables using year differences (Table 7). The estimation results were very similar to those obtained by Mairesse and Dormont with respect to output, but wage elasticity was only about  $-.2$ .

One explanation for the differences in estimation results is different measurement errors in wage variables. Mairesse and Dormont



Table 7. Estimation results: difference model, output and wages exogenous. Minimum distance asymptotic standard errors in parentheses.

	q <sub>77</sub>	q <sub>78</sub>	q <sub>79</sub>	q <sub>80</sub>	q <sub>81</sub>	q <sub>82</sub>	Row sum	w <sub>77</sub>	w <sub>78</sub>	w <sub>79</sub>	w <sub>80</sub>	w <sub>81</sub>	w <sub>82</sub>	Row sum	C
E <sub>77</sub>	.18 (.04)						.18	.06 (.08)						.06 (.11)	.20 (.11)
E <sub>78</sub>	.10 (.05)	.06 (.04)					.16	-.30 (.10)	-.14 (.08)					-.44 (.13)	.12 (.13)
E <sub>79</sub>	.17 (.05)	.18 (.05)	.29 (.06)				.64	-.07 (.11)	-.01 (.11)	-.09 (.11)				-.16 (.14)	.07 (.14)
E <sub>80</sub>	.12 (.05)	.11 (.05)	.06 (.06)	.20 (.06)			.49	.09 (.11)	-.03 (.11)	-.08 (.11)	-.15 (.07)			-.17 (.14)	.10 (.14)
E <sub>81</sub>	.11 (.05)	-.02 (.05)	-.02 (.06)	-.01 (.06)	.26 (.05)		.32	-.12 (.11)	.00 (.11)	-.12 (.12)	.06 (.10)	-.07 (.09)		-.25 (.17)	-.17 (.14)
E <sub>82</sub>	.07 (.04)	.11 (.04)	-.01 (.05)	.07 (.05)	.09 (.04)	.14 (.03)	.47	-.06 (.08)	-.07 (.08)	-.04 (.09)	.01 (.08)	-.01 (.07)	-.03 (.08)	-.20 (.10)	-.09 (.10)

Table 8. Log-likelihood ratio tests (L) of exogeneity of output and wages at 5 per cent significance level.

S<sub>1</sub> vs. S<sub>2</sub> : L = 4.5 <  $\chi^2_{(15)}$  = 25.0

S<sub>2</sub> vs. S<sub>3</sub> : L = 15.4 <  $\chi^2_{(15)}$  = 25.0

S<sub>3</sub> vs. S<sub>4</sub> : L = 15.3 <  $\chi^2_{(20)}$  = 31.4

S<sub>4</sub> vs. S<sub>5</sub> : L = 23.8 >  $\chi^2_{(7)}$  = 14.1

S<sub>1</sub> = both endogenous

S<sub>2</sub> = output endogenous, wages exogenous

S<sub>3</sub> = both exogenous

S<sub>4</sub> = output exogenous, static relationship between wages and employment

S<sub>5</sub> = output exogenous, wages excluded

commented on their wage elasticity estimates as follows: »The (direct) labor cost elasticities in the labor equation seem too good to be true. Their magnitude is much larger than expected (—0.8 as against —0.3 if the elasticity of substitution of capital and labor  $\sigma$  is about 1). One plausible explanation is the existence of measurement errors in our [employment] measure DL, which by construction would be (negatively) transmitted to our [wage] measure DW. Since the variance of DW is much smaller than that of DL (by a factor of the order of 4), even relatively small errors in DL would lead to relatively large ones in DW. Thus if random errors were responsible for about 20 percent of the observed variance of DL, they could also be responsible for as much as 80 per cent of the observed variance of DW. Such a situation could account for our

estimated elasticities of —0.8, even though the ‘true’ coefficient would be zero.»

The results in this paper give some support to the explanation quoted above. The wage variable employed by Mairesse and Dormont was labour cost per employee. Our wage variable is not directly related to the dependent variable, and hence we expect that measurement errors have less serious effects on the estimates. Empirical results provide some support to this expectation. Our estimates are consistently nearer to zero than those obtained by Mairesse and Dormont.

## 5. Conclusions

Using a sample of small and medium-sized firms, we investigated the relationship between wages and employment. Our data revealed a stable cross-section correlation between wages and productivity, consistent with the neoclassical demand for labour theory. Cross-section results do not indicate anything about the direction of causation. A positive correlation between wages and productivity can arise from capital-labour substitution as wages change but other explanations are also plausible. Intervening variables are a particular concern in the analysis of panel data.

In this paper, we adopt the generalized random effects framework put forward by Chamberlain. A series of exogeneity tests gives some support to the neoclassical notion that at the

micro level, wages affect employment and productivity but not vice versa. The evidence presented is rather weak, however, and our data do not reject a restriction to a purely static relationship. In this specification, parameter estimates are clearly non-neoclassical.

The wage-elasticity estimates obtained from the neoclassical model are of the order 0.2—0.4, which is quite reasonable. These estimates are clearly lower than those obtained by Mairesse and Dortmund. Mairesse and Dortmund argued that measurement errors biased their elasticity estimates towards 1. Our results give support to this interpretation.

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