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LABOUR HOARDING OVER THE BUSINESS CYCLE: TESTING THE QUADRATIC ADJUSTMENT COST HYPOTHESIS†

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ABSTRACT: This paper tests the quadratic labour cost adjustment model of Nickell (1986) with Finnish microdata. The observations are firms' answers to questions in the Finnish business survey and are thus categorical. Ordered probit and continuation ratio models are considered as statistical representations of the theoretical model. The theoretical model is extended by allowing different parameter sets for different phases of the business cycle, and the original model is tested against the extension. The hypothesis of constant quadratic adjustment cost is clearly rejected for forest industries and metal and engineering industries. Reasons for the rejections are also discussed.

KEYWORDS: business survey data, continuation ratio model, demand for labour, Finnish manufacturing, microeconometric modelling, ordered probit model

JEL Classification: 211, 631, 824

1. INTRODUCTION

The firms' adjustment costs of labour and the tendency to hold excess labour have received considerable attention in the literature. A theory explaining labour hoarding by taking account of these costs has been developed; see e.g. Nickell (1986) and Hamermesh (1988) for discussion. Most of the empirical effort in analyzing the short-run relationship between output and employment has gone into estimating the elasticity of labour with respect to output. This has usually been done by using aggregated data at the industry level. Hamermesh (1976) and Nickell (1986) have surveyed the literature; see also Sims (1974) who argued that there is no statistical justification for making labour the dependent variable in the regressions for estimating the elasticity. He estimated the labour - output relation by using monthly data and regressions with both variables in turn as dependent variables.

A notable exception to the rule of using aggregated data is the study Fay and Medoff (1985) conducted with data from a specially collected sample of U.S. manufacturing companies. Their paper shows that labour hoarding does occur and they are even able to give estimates of its average size. Fair (1985) confirmed their results by a macro study and underlines the necessity of taking the labour hoarding into account in any production function study. The paper of Fay and Medoff (1985) convincingly demonstrates the usefulness of micro data in empirical labour demand research. The present paper can be seen as another example of the use of micro data, this time categorical, in the same area. Our aim is to study labour hoarding using data from the Finnish Business Survey. Regular business surveys exist in most OECD countries, and the firms' answers are most commonly trichotomous of type "larger than"/"unchanged"/"smaller than". The surveys usually contain questions concerning the change in the labour force of the responding firms. In spite of this, to the best of our knowledge there only exists one single study (Frick et al., 1988) conducted with such micro data and related to labour hoarding. The authors used Swiss business survey data to construct an ordinal variable meant to be positively associated with labour hoarding. Nevertheless, business survey data have been used in microeconometric labour market research to shed light on firms' employment strategies in general. Bouissou et al. (1986) investigated the nature of French unemployment using such data and a two-market disequilibrium model. König and Zimmermann (1986) studied German firms' demand for labour by making use of answers to a special question in the business survey of the Ifo-Institut für Wirtschaftsforschung in October 1980. Finally, Rahiala et al. (1987) investigated the revisions in Finnish firms' short-term employment plans starting from a theoretical model of labour demand in Layard and Nickell (1986).

The theoretical starting-point of the present paper is a labour demand model for a firm developed by Nickell (1986). The cost function of labour adjustments is supposed to be quadratic because this assumption leads to a testable linear model. Although the assumption is technically plausible, it may be too restrictive in practice. The validity of the derived model should thus be tested. The idea of this paper is to test the model implied by the theory against alternatives that allow meaningful interpretations to deviations from the theoretical model. The empirical analysis reveals that the two most important branches in Finnish manufacturing, forest industries and metal and engineering industries, respectively, have rather different employment adjustment policies.

The plan of the paper is as follows. In section 2 we discuss theoretical adjustment cost models, in particular the one we shall apply. Section 3 presents the data set and section 4 considers the statistical methods of the paper. Sections 5 and 6 are devoted to the specification search for a proper statistical model. Section 7 tests the cyclical invariance of the quadratic adjustment cost functions and section 8 concludes.

2. THEORETICAL MODEL

We shall first discuss a firm's demand for labour in the framework of Nickell (1986). Define the firm's gross output function as

$$y(t) = f(N(t), z(t), t)$$

where $y(t)$ is output at time t, $N(t)$ is employment and $z(t)$ is a vector of completely flexible inputs. Let $R(N(t), t)$ be the net revenue function of the firm with $R_N > 0$, $R_{NN} \leq 0$ and assume that the capital stock is exogenous or predetermined and all the other factors are optimally deployed. Consider now the adjustment of labour and assume the adjustment cost to be a function of

$$x(t) = \dot{N}(t) + \delta N(t) \tag{2.1}$$

where $0 < \delta < 1$.
A positive value of $x(t)$ means hiring, whereas $x(t) < 0$ indicates firing. Voluntary separation is assumed to bear no direct cost to the firm and to take place at a constant rate δ.
Assume next that the firm is to make an employment decision at $t = 0$ and holds point expectations about future values of exogenous variables. It wants to maximize the present discounted value of its earnings stream defined as

$$\int_0^\infty e^{-\phi(t)}\{p(t)R(N(t), t) - w(t)N(t) - C(x(t))\}dt \tag{2.2}$$

where $N(0)$ is given, $w(t)$ is the wage rate exogenous to the firms, and $p(t)$ is the price of output or the exogenous industry average output price if the firm is not a price-taker but rather imperfectly competitive. Furthermore, C is the adjustment cost function , C' and x are of the same sign, $C'' > 0$ and $C(0) = C'(0) = 0$. The cost function C is thus a strictly convex function of x. If $r(t)$ is the interest rate at t, the discount factor $\phi(t)$ is defined by

$$\phi(t) = \int_0^t r(\tau)d\tau.$$

In empirical work, we need a discrete version of (2.2),

$$\sum_{t=0}^{\infty} \phi^*(t)\{p(t)R^*(N(t),h(t),t) - w(t)w^*(h(t),t)N(t) - w(t)C(N(t) - N(t-1))\} \tag{2.3}$$

where

$$\phi^*(t) = \{\prod_{\tau=1}^{t}(1+r(\tau))\}^{-1}$$

is the discount factor and $h(t)$ is the amount of efficiency hours, i.e., actual hours standardized with respect to output giving each the same addition to the net revenues R^*. The function w^* denotes earnings as a function of efficiency hours. Furthermore, the cost function $C(x)$ in (2.3) is supposed to be a quadratic function of employment,

$$C(x) = \frac{b}{2}x^2 \quad . \tag{2.4}$$

The first order conditions of the problem of maximizing (2.3) are

$$\begin{aligned} &R_N^*(N(t),h(t),t) - \tilde{w}(t)w^*(h(t),t) - \tilde{w}(t)b\{N(t) - N(t-1)\} \\ &\qquad + \frac{p(t+1)\tilde{w}(t+1)b}{p(t)(1+r(t))}\{N(t+1) - N(t)\} = 0 \end{aligned} \tag{2.5}$$

for positive t, where $\tilde{w} = \frac{w}{p}$ is the real wage, $N(0)$ is given and

$$R_h^*(N(t),h(t),t) - \tilde{w}(t)w_h^*(h(t),t)N(t) = 0 \tag{2.6}$$

for non-negative t. To linearize (2.5), we first assume

$$\frac{p(t+1)}{p(t)(1+r(t))} \simeq \frac{1}{1+\rho}$$

where ρ is the constant positive real interest rate. To impose structure on the real revenue function R^* we suppose

$$R^*(N(t),h(t),t) = R_o(t) + N(t)^{\epsilon}h(t)\omega(t) \tag{2.7}$$

for some $0 < \epsilon < 1$, where $R_o(t)$ and $\omega(t)$ are shift variables. The former may be regarded as a kind of "basic revenue" whereas $\omega(t)$ contains the real prices of the variable factors, a trend representing technical progress and the capital stock not explicitly included in the model.

Next define the short period equilibrium levels of hours and employment $h^*(t)$ and $N^*(t)$ under the condition of no adjustment costs. They are obtained from (2.5) and (2.6) by setting $b = 0$ and making use of (2.7) and are thus defined by two heavily non-linear equations. After a series of simplifying assumptions including the one stating that the expected real wage growth is constant, $g = \frac{\tilde{w}(t+1)}{\tilde{w}(t)}$, we obtain a linear difference equation

$$\alpha bN(t+1) - \{(1+\alpha)b - \theta\}N(t) + bN(t-1) = \theta N^*(t) \tag{2.8}$$

for positive t, where $\alpha \simeq \frac{1}{1+\rho-g}$ and θ is another parameter due to linearization (Nickell, 1986). Solving (2.8) , see Nickell (1986) for details and references , yields

$$N(t) = \mu N(t-1) + (1-\mu)(1-\alpha\mu)\sum_{s=0}^{\infty}(\alpha\mu)^s N^*(t+s) \tag{2.9}$$

where $0 < \alpha\mu < 1$. For empirical work, we have to specify N^*. The assumption of Cobb- Douglas technology, implicit in previous considerations, allows us to write N^* in log linear form. If we then approximate the whole equation (2.9) by the corresponding logarithmic form, we obtain

$$\log\ N(t) = \mu \log\ N(t-1) + (1-\mu)(1-\alpha\mu)\sum_{s=0}^{\infty}(\alpha\mu)^s \log\ N^*(t+s). \tag{2.10}$$

Suppose now , following Sims (1974) , that the elasticity of $N^*(t)$ to output is unity. This makes it possible to write (2.10) as

$$\log\ N(t) = \mu \log\ N(t-1) + (1-\mu)(1-\alpha\mu)\sum_{s=0}^{\infty}(\alpha\mu)^s \log\ y^*(t+s). \tag{2.11}$$

Differencing (2.11) yields

$$\Delta \log\ N(t) = \mu\Delta \log\ N(t-1) + (1-\mu)(1-\alpha\mu)\sum_{s=0}^{\infty}(\alpha\mu)^s \Delta \log\ y^*(t+s).$$

As to our application, we can observe $\Delta^* \log\ y^*(t+1) = \log\ y^*(t+1) - \log\ y(t)$. If we assume rational expectations and that output follows an ARI(3,1) process, we can generate all subsequent $\log\ y^*(t+s)$, $s \geq 2$, starting from $\Delta^* \log\ y^*(t+1)$, $\Delta \log\ y(t)$ and $\Delta \log\ y(t-1)$. Thus,

$$\Delta \log\ N(t) = \tilde{f}(\Delta \log\ N(t-1), \Delta^* \log\ y^*(t+1), \Delta \log\ y(t), \Delta \log\ y(t-1)). \tag{2.13}$$

Model (2.13) will be the basic labour demand model of this study.

The quadratic form (2.4) is not the only possible choice for the adjustment cost function C. Nickell (1986) also discusses a piecewise linear, v-shaped function which has the advantage of allowing asymmetry in adjustment cost. His final model (2.9) is nevertheless based on the quadratic adjustment cost assumption (2.4) mainly because, contrary to the piecewise linear adjustment, it leads to a closed-form solution.

Although our application will be based on (2.13) it is worthwhile to mention another recent contribution to the theory of labour adjustment of the firm. Hamermesh (1988) considers a model in which the adjustment cost, unlike in Nickell (1986), contains a fixed positive component. The adjustment cost can be written as

$$C_1(\dot{N}(t)) = \frac{b}{2}\dot{N}(t)^2 + k\ \emptyset(\dot{N}(t) \neq 0) \tag{2.14}$$

where $\emptyset$ is a zero-one indicator function and $k > 0$ is the fixed cost of labour adjustment. In case of constant interest rate $r \equiv r(\tau)$, the discounted earnings stream to be maximized becomes

$$\int_0^T e^{-rt}\{p(t)R(N(t),t) - w(t)N(t) - C_1(\dot{N}(t))\}dt + \frac{1}{r}\, e^{-rT}\{p(T)R(N(T),T) - w(T)N(T)\}$$

where $T > 0$ is the point when the firm stops adjusting its labour force to the shock occurring at time zero. Hamermesh (1988) showed that in the general case $b, k > 0$, the above leads to an adjustment path in which the firm does not adjust its labour force if the shock is relatively small. Employment remains unchanged in response to small demand shocks but reaches instantaneously a new long-run equilibrium if the shocks are large. The labour demand model that Hamermesh obtained does not belong to the class (2.13) but is of the switching regression type. Anyway, the form of his model shows that the assumptions about the cost function are crucial for the final employment model. Thus, if it turns out that the form of the relationship (2.13) changes, a plausible explanation is a change either in the functional form of the adjustment cost function (2.4) or in its parameters.

3. THE DATA

The Confederation of Finnish Industries has conducted a quarterly business survey since 1966. Presently, a panel of more than 500 firms including all the large enterprises participate in the survey. The questionnaires have to be returned by 15 March, June, September and December, respectively, that is, just before the end of each quarter. The answers to most questions are trichotomous the alternatives being "larger than", "unchanged" or "smaller than". The firms are asked to give seasonally adjusted answers and the tolerance limits for the "unchanged" category are always ± 2 per cent. The data set to be used in this analysis comprises the individual answers from the years 1976-1987. The questions relevant to this study are listed in Appendix 1.

Because the number of firms in each survey is small, it is necessary to aggregate answers from several quarters in order to have sufficient amount of information for statistical inference. The aggregation over time is even more necessary because we have a priori reasons to believe that firms' employment strategies may vary across branches. As a result we disaggregate manufacturing into three categories: metal and engineering industries, forest industries and miscellaneous manufacturing. The last category is admittedly a rather heterogeneous group of industries, but it cannot be disaggregated further because of the size of the sample.

The answers to questions L_t, Q^*_{t+1} and Q_t in Appendix 1 can be given the following interpretation:

L_t = categorized version of $\Delta \log\ N(t)$

Q^*_{t+1} = categorized version of $\Delta^* \log\ y^*(t+1)$

Q_t = categorized version of $\Delta \log\ y(t)$

The questionnaire also contains questions with a time span of one year. This makes it possible to extend the time unit in (2.13) from one quarter to one year and to investigate if our findings based on quarterly data still hold when a more long-term view is adopted. However, the absence of a question concerning the 12-month production plan of the firm constitutes a problem. The only solution available to us is to use the quarterly information Q^*_{t+1}.

4. STATISTICAL METHODS

As is obvious from above, our statistical information is categorical. There are various ways of formulating categorical models that are consistent with the relationship stated in formula (2.13). One may first categorize (2.13) with respect to the ***dependent*** variable $\Delta \log\ N(t)$ and then simply replace the vector of independent variables

$$Z(t) = (\,\Delta \log\ N(t-1) \quad \Delta^* \log\ y^*(t+1) \quad \Delta \log\ y(t) \quad \Delta \log\ y(t-1)\,)'$$

by a categorized version

$$Z_t = (\,L'_{t-1} \quad Q^*_{t+1}{}' \quad Q'_t \quad Q'_{t-1}\,)'$$

where $Q_t = (\,Q_{t,1} \quad Q_{t,2} \quad Q_{t,3}\,)' \in \Re^3$ and one of the components equals unity whereas the remaining two equal zero. We have

$Q_{t,1} = 1 \longleftrightarrow$ "the volume of production quarter t is larger than previous quarter"

$Q_{t,2} = 1 \longleftrightarrow$ "the volume of production quarter t is the same as previous quarter"

$Q_{t,3} = 1 \longleftrightarrow$ "the volume of production quarter t is smaller than previous quarter".

The other three vectors are defined accordingly. In L_t and L_{t-1}, $L_{t,1} = 1$ and $L_{t-1,1} = 1$, respectively, also represent an increase in labour force.

Next, it may be assumed that $\Delta \log\ N(t)$ be normally distributed with constant variance σ^2 and an expectation which is a linear function of $Z(t)$, i.e., $\Delta \log\ N(t) \sim N(\mu + \alpha' Z(t), \sigma^2)$. This yields the following probabilities for the three categories of L_t:

$$(4.1) \qquad \begin{cases} P(L_{t,1} = 1) = 1 - \Phi(\frac{c_2 - \mu - \alpha' Z(t)}{\sigma}) \\ P(L_{t,3} = 1) = \Phi(\frac{c_1 - \mu - \alpha' Z(t)}{\sigma}) \\ P(L_{t,2} = 1) = 1 - P(L_{t,1} = 1) - P(L_{t,3} = 1) \end{cases}$$

where $c_1 = \log 0.98$, $c_2 = \log 1.02$ and Φ stands for the standard normal distribution function. By substituting $\gamma' Z_t$ for $\alpha' Z(t)$ in (4.1) one obtains a model for the categorized observations stating that L_t should be trinomial with the following probabilities

$$(4.2) \qquad \begin{cases} P(L_{t,1} = 1) = 1 - \Phi(\frac{c_2 - \mu - \gamma' Z_t}{\sigma}) \\ P(L_{t,2} = 1) = \Phi(\frac{c_2 - \mu - \gamma' Z_t}{\sigma}) - \Phi(\frac{c_1 - \mu - \gamma' Z_t}{\sigma}) \\ P(L_{t,3} = 1) = \Phi(\frac{c_1 - \mu - \gamma' Z_t}{\sigma}) \ . \end{cases}$$

This is a standard ordered probit model (cf. Maddala, 1983) with only one inequality restriction , $\sigma > 0$, for the parameters.

In some applications, the above normality assumption may well be considered too restrictive. If that is the case, one may construct a contender for model (4.2) by studying the conditional distribution of $n(t) = \frac{N(t)}{N(t-1)}$ given $n(t-1)$. Let the cumulative distribution function of this conditional distribution be $F_{n(t)|n(t-1)}$ and the corresponding density function $f_{n(t)|n(t-1)}$. Because $n(t)$ is nonnegative, the conditional distribution can be efficiently characterized by the hazard function

$$h_{n(t)|n(t-1)}(s) = \frac{f_{n(t)|n(t-1)}(s)}{1 - F_{n(t)|n(t-1)}(s)}.$$

Note that (2.13) may be written in the form

$$n(t) = e^{g(\log\ n(t-1), Y(t))} = e^{g(Z(t))}$$

where

$$Y(t) = (\,\Delta^* \log\ y^*(t+1) \quad \Delta \log\ y(t) \quad \Delta \log\ y(t-1)\,)' .$$

The conditional distribution $F_{n(t)|n(t-1)}$ thus depends on $Y(t)$, and an attractive alternative for characterizing this dependence is Cox's proportional hazards model (Cox, 1972)

$$(4.3) \qquad h_{n(t)|n(t-1)}(s) = h_o(s \mid n(t-1)) e^{\beta' Y(t)}$$

where h_o stands for the basic hazard of $n(t)$ given $n(t-1)$ when the output of the firm remains constant. As Rahiala and Teräsvirta (1988) showed, model (4.3) definitely implies the categorized version

$$(4.4) \qquad log\{-log(1 - \delta_j(n(t-1), Y(t)))\} = \mu_j(n(t-1)) + \beta' Y(t)$$

where

$$\delta_j(n(t-1), Y(t)) = \frac{P(L_{t,j} = 1 \mid n(t-1), Y(t))}{\sum_{\nu=1}^{j} P(L_{t,\nu} = 1 \mid n(t-1), Y(t))}$$

and

$$\mu_j(n(t-1)) = \int_{c_{3-j}}^{c_{3-j+1}} h_o(s \mid n(t-1))ds \ , \qquad j = 1,2,3,$$

$c_o = 0, c_1 = 0.98,\ c_2 = 1.02$, and $c_3 = \infty$.

By substituting Z_t for $Z(t)$ we obtain the corresponding categorical model

$$G^{-1}(\delta_j(Z_t)) = \sum_{\nu=1}^{3} \mu_{j\nu} \emptyset(L_{t-1,\nu} = 1) + \tilde{\beta}' Y_t, \tag{4.5}$$

where $Y_t = (\,Q^{*}_{t+1}{}' \quad Q'_t \quad Q'_{t-1}\,)'$, and $\emptyset$ denotes a zero-one indicator function . Moreover,

$$G^{-1}(\delta) = \log\{-\log(1-\delta)\}$$

is the so-called link function in the "generalized linear model" interpretation of model (4.5). Another possible choice for the link function is the logit-transformation

$$G^{-1}(\delta) = \log \frac{\delta}{1-\delta}.$$

Note that in neither model (4.2) nor model (4.5) are the parameters identified, because for $X_t = L_t, Q_t$ and Q^*_t , respectively ,

$$(1 \quad 1 \quad 1)\,X_t = 1\ .$$

To avoid this unidentifiability problem, we reformulate (4.5) so that it only contains the so-called contrast parameters to the first level ("increases") of each explanatory factor. The final model then becomes

$$\begin{aligned} G^{-1}(\delta_j(Z_t)) = \mu^* + \sum_{\nu=2}^{3} \{ & \mu^*_{j\nu} \emptyset(L_{t-1,\nu} = 1) + \beta^{(Q)}_\nu \emptyset(Q_{t,\nu} = 1) \\ & + \beta^{(Q^*)}_\nu \emptyset(Q^*_{t+1,\nu} = 1) + \beta^{(Q_{-1})}_\nu \emptyset(Q_{t-1,\nu} = 1) \}\ . \end{aligned} \tag{4.6}$$

A similar reformulation is necessary if one chooses to work with (4.2).

5. EXTENDING THE THEORETICAL MODEL

Model (2.13) is based on the assumption of quadratic adjustment costs for which there is no solid theoretical underpinning. Indeed, Nickell (1986) also discusses a piecewise linear cost function, and Hamermesh (1988) introduces the fixed component adjustment cost. If the assumption of quadratic adjustment cost does not hold in practice, (2.13) may be a rather poor description of a typical firm's demand for labour. Nickell (1986) points out other reasons for possible inadequacy of (2.13) like misspecified dynamics and the existence of different types of labour which the model ignores. Thus we are already amply warned that (4.2) and (4.6) may not adequately represent the data generating process. In this situation, it is advisable to try and extend (2.13) in such a way that the extended model becomes a more accurate description of reality. However, given the set of variables we have observed, we may not be able to argue that any of our extensions is an adequate description of the data generating process. What we can do is to choose the extension in such a way that the extended model is statistically adequate. It may then be used for judging where the most serious weaknesses of the basic model actually lie. What our data set allows us to do in this respect is to make an assumption that the parameters of the model vary with the phase of the business cycle. If we define two phases, expansion and contraction, we may typically expect a firm to be in a different situation during each of these phases. During a contraction, a firm's output may decline for several consecutive quarters. Possible lay-offs of workers may then have a character different from those during an expansion when output reductions are often temporary. Testing (4.2) and (4.6) against thus augmented models constitutes a tough test for the quadratic cost adjustment model (2.13). We have at our disposal the time series of the quarterly volume of output for the three branches of manufacturing considered in this paper. A firm's relative position in the labour market depends on the situation in the industry as a whole. Therefore, we construct a general dichotomous business cycle indicator , B_t , to indicate expansion or contraction, respectively, within the branch. We select typical quarters of recession and recovery using the annual growth rate of the output in the branch as the selection criterion, and estimate separate sets of parameters for these two phases. The equality of parameters representing the impact of diminishing output on firms' employment strategies in these two sets is the main hypothesis we shall test. The selected quarters for the three branches of manufacturing are as follows:

Recession:

Metal and engineering: 1976/2, 1977/2, 1982/3, 1982/4, 1983/1, 1983/2, 1983/3, 1983/4

Forest industries: 1981/1, 1981/2, 1981/3, 1981/4, 1982/1, 1982/2, 1982/3, 1982/4

Miscellaneous manufacturing: 1976/1, 1976/2, 1977/1, 1977/2, 1982/1, 1983/1, 1984/2, 1984/3

Recovery:

Metal and engineering: 1980/1, 1980/2, 1980/3, 1980/4, 1985/1, 1985/2, 1985/3, 1985/4

Forest industries: 1983/2, 1983/3, 1983/4, 1984/1, 1986/1, 1986/2, 1986/3, 1986/4

Miscellaneous manufacturing: 1980/1, 1980/2, 1980/3, 1980/4, 1986/1, 1986/2, 1986/3, 1986/4

Although we shall consider the situation by branch, the firms within a branch are not identical. In particular, they may experience the peaks and troughs of the cycle at different times. Furthermore, we may argue that the business outlook of the firm affects the structure of its employment plans. A firm amidst an expansion may apply an employment strategy different from that of a firm experiencing a recession. If (2.13) holds, this is of course not true because the whole situation of the firm is adequately reflected in the rational expectations $N^*(t+s)$.

The Finnish Business Survey contains (see Appendix 1) a question about the level of the order backlog of the firm ("large"/"normal"/"small"). We interpret the answers as describing firm-specific fluctuations in activity. In accord with the assumptions we just made about the firms' employment plans we estimate separate sets of parameters for each level of the order backlog S_t^a. The distinction between the indicators B_t and S_t^a is clear-cut. General fluctuations on the labour market may cause changes in the labour adjustment costs within the whole branch. The branch-level indicator B_t is designed to take account of these fluctuations. On the other hand, the rôle of the firm-specific indicator S_t^a is to allow for structural changes caused by the business cycle fluctuations in the planning of employment in individual firms.

Moreover, the theoretical model (2.13) implies that the firm is capable of responding to demand shocks by changing output without ever hitting a capacity ceiling. This is not always the case in real life, and it may not be realistic to assume that the hiring and firing processes of the firm are identical in the presence and absence, respectively, of idle production capacity. The business survey contains a question K_t about the existence of idle production capacity and we define a corresponding variable $K_t = (\,K_{t,1} \quad K_{t,2}\,)' \in \Re^2$ where one of the arguments equals unity and the other zero. This makes it possible to allow a separate set of parameters for the capacity constrained firms in models (4.2) and (4.6). In view of all the above, the maintained version of model (4.6) becomes

$$
\begin{aligned}
(5.1) \qquad G^{-1}(\delta_j(Z_t)) = \sum_{i=1}^{2}\sum_{k=1}^{2}\sum_{l=1}^{3} \emptyset(B_t = i, K_{t,k} = 1, S_{t,l}^a = 1)\ [\ \mu_{ikl}^{*(B,K,S^a)} \\
+ \sum_{\nu=2}^{3}\{\mu_{j\nu;ikl}^{*(B,K,S^a)}\emptyset(L_{t-1,\nu} = 1) + \beta_{\nu ikl}^{(Q,B,K,S^a)}\emptyset(Q_{t,\nu} = 1) \\
+ \beta_{\nu ikl}^{(Q^*,B,K,S^a)}\emptyset(Q_{t+1,\nu}^* = 1) + \beta_{\nu ikl}^{(Q_{-1},B,K,S^a)}\emptyset(Q_{t-1,\nu} = 1)\}]\ .
\end{aligned}
$$

Model (4.2) will be generalized similarly by replacing parameters c_1, c_2, μ, σ and γ by a varying set of parameters

$$
(5.2) \qquad c_{1,ikl}^{(B,K,S^a)}, c_{2,ikl}^{(B,K,S^a)}, \mu_{ikl}^{(B,K,S^a)}, \sigma_{ikl}^{(B,K,S^a)}, \gamma_{ikl}^{(B,K,S^a)}
$$

for $i, k = 1, 2$ and $l = 1, 2, 3$. Various hypotheses will be tested with models (5.1) and (5.2) using customary likelihood ratio tests. For details of the maximum likelihood estimation of continuation ratio models the reader is referred to Rahiala and Teräsvirta (1988).

6. SELECTING THE STATISTICAL MODEL

As discussed in section 4, we have two statistical models to choose among in this work. They are the ordered probit model based on an assumption of a latent normal variable representing the logarithmic change of the work force and the continuation ratio model which does not require any assumptions concerning the form of the distribution of L_t. Our first task is to find out which of the two models fits the data better. How to compare them is not self-evident, because even the number of categories is different in the two models. In (5.2) there are *three* frequencies for each level of Z_t that can be taken as mutually independent Poisson variables (cf. Baker and Nelder, 1978), whereas the likelihood of (5.1) consists of the contributions of *two* mutually independent binomial frequencies for each Z_t (see Rahiala and Teräsvirta, 1988). For technical reasons, we use the latter setup for the comparison and compute the Pearson χ^2- statistics from the fitted values of the binomial frequencies for the two competing models. Table I displays the so-called deviances (cf. Baker and Nelder, 1978; Hastie, 1987), the χ^2- statistics and the degrees of freedom for the estimated pairs of models, quarterly as well as annual. No parameter estimates are reported, because the number of parameters is prohibitively large, around 120.

The continuation ratio model (5.1) seems superior to the ordered probit model (5.2). The χ^2- statistic is smaller for the latter only in the quarterly models for forest industries and miscellaneous manufacturing. However, the deviance measures for model (5.2) are without exception far larger than those for (5.1). We thus select (5.1) as our maintained model. Similarly, the complementary log-log link seems to outperform the logit link function. If the goodness of fit is judged using these statistics, all the models seem to constitute a reasonable basis for valid statistical inference. This is exactly the purpose of these models. We do not claim the maintained model to be the data generating process; we only want it to be an appropriate alternative to the stationary quadratic adjustment cost hypothesis.

Because the models contain a large amount of parameters, it is advisable to try and reduce the dimension of the maintained model before embarking upon further testing. Our first test to this end concerns the effect of the capacity constraints in the employment model (5.1), the null hypothesis of no effect being

$$H_A\text{: All parameters are constant over } K_t$$

From table II it is seen that H_A is rejected in all models in favour of its negation, so that the inclusion of the production capacity variable K_t in the models seems motivated. Next, consider the firm-specific business cycle indicator based on the firm's assessment of its backlog of orders. We formulate

H_B: All parameters are constant over S_t^a

The results in Table II indicate that the firm-specific business cycle indicator cannot be omitted. Thus the expectations structure inherent in (2.13) is too simple for this particular application. Within the framework of (2.13) the rejection of H_B may be interpreted as evidence against the rational expectations hypothesis. It seems rather that firms' employment planning mechanisms do vary over the business cycle. This does not contradict our prior expectations, because there is evidence (cf. e.g. Sims, 1974) indicating that many firms tend to increase their labour hoarding during contractions. It may be mentioned that Rahiala and Teräsvirta (1988) rejected the rational expectations hypothesis of firms' output plans for metal and engineering industries but not for forestries nor for miscellaneous manufacturing. On the other hand, the rejection of H_B cannot be interpreted to indicate that the quadratic adjustment cost function is unrealistic.

Our last tentative simplification concerns the basic conditional hazard $h_o(\cdot \mid L_{t-1})$: can we regard it as invariant of the phase of the business cycle? The answer is negative, but the variation seems to concentrate on the case $L_{t-1,3} = 1$. This leads us to

H_C: $h_o(\cdot \mid L_{t-1,\nu} = 1)$ is the same for both phases of the business

cycle for $\nu = 1, 2$, i.e. $\mu_{1kl}^{*(B,K,S^a)} = \mu_{2kl}^{*(B,K,S^a)}$ and

$\mu_{j\nu;1kl}^{*(B,K,S^a)} = \mu_{j\nu;2kl}^{*(B,K,S^a)}$ for all j, k and l .

It is seen from Table II that H_C is accepted in all cases but one which is the quarterly model for miscellaneous manufacturing. As to the annual model for forestries, the situation is slightly ambivalent, but fortunately in this case the choice between the reduced model and (5.1) has hardly any influence on the outcome of further tests. We are thus able to make our maintained model more parsimonious by accepting H_C except in the case of the quarterly model for miscellaneous manufacturing.

7. TESTING THE CYCLICAL INVARIANCE OF THE STATISTICAL MODEL

The above tests have been conducted to simplify the model but their outcome does not yet tell us much about the validity of the assumption of quadratic cost adjustment. As we have pointed out, this is a crucial assumption for (2.13), and it is therefore of considerable interest to conduct tests that could shed light on its validity. In order to do so, we shall focus on the third level of variables Q_t, Q_{t-1} and Q^*_{t+1} as compared to the first level, i.e., we compare the firms with diminishing output to the firms with growing output. If some of the firms do hoard labour more during the contractive than the expansive phase of the business cycle, the ratio between the frequencies of category $(Q_t = 3, L_t = 2)$ and the category $(Q_t = 3, L_t = 3)$ should be larger during downturns than during upswings. This leads us to test the constancy of the contrast parameters attached to the third level of Q_t, Q_{t-1} and Q^*_{t+1} over the business cycle. This constancy hypothesis can be formulated in terms of (5.1) as follows:

$$H_D\colon \beta^{(X,B,K,S^a)}_{\nu 1kl} = \beta^{(X,B,K,S^a)}_{\nu 2kl} \quad \text{for } \nu = 3 \ , \ X = Q, Q_{-1} \text{ and } \ Q^* \ ;$$

$$k = 1,2 \quad ; \quad l = 1,2,3 \ .$$

We shall call H_D the ***strong hypothesis of constant quadratic adjustment cost structure during diminishing production*** . Accepting H_D within the framework of the maintained model is equivalent to accepting the view that the firms' employment strategies do not vary with the business cycle. We should thus have no reason to suspect any changes in the adjustment cost function C over the cycle.

Taking special account of the *immediate* effects of diminishing output on the labour force, we can also test the hypothesis

$$H_E\colon \beta^{(Q,B,K,S^a)}_{\nu 1kl} = \beta^{(Q,B,K,S^a)}_{\nu 2kl} \quad \text{for } \ \nu = 3 \ , \ \ k = 1,2 \text{ and } \ l = 1,2,3 \ .$$

Hypothesis H_E will be called the *weak* hypothesis of constant adjustment cost structure during diminishing production.

Table III contains the results for testing H_D and H_E using likelihood ratio tests. Consider first the forest industries. It is seen that both hypotheses of no change in parameters are rejected. The parameter estimates not reported here indicate that an average firm does hoard more labour during a recession than during a recovery. It is interesting to note that the phenomenon is rather persistent in the sense that it is still visible in the annual framework. Nevertheless, there may be plausible explanations to these results. The Finnish paper-, pulp- and sawmills are often located in fairly small communities in the country where the firm regularly is the largest employer. Furthermore, business cycle fluctuations are most pronounced just in the forest sector of the economy. While it may be relatively easy to lay off unskilled workers whenever necessary, the situation is different when skilled labour is concerned. Because the community is small, a forest company often has no way of maintaining a reserve of skilled labour except on its own payroll. Such a reserve may be necessary, because the firm has to secure the availability of skilled labour for the next upswing. Miller (1971) contains a discussion of this reserve labour hypothesis. The plant is therefore likely to postpone all maintenance and repair work it can to contraction periods in order to keep skilled labour on as long as possible. On the other hand, during a cyclical upswing in the industry the output reductions of single firms tend to be of more temporary character, and adjusting the amount of unskilled labour may be sufficient. This would explain the differences in behaviour during contractions and expansions we see in Table III. This interpretation points at the necessity of differentiating between categories of labour with vastly different adjustment costs. The conclusions in Nickell (1986) underline the same thing. They are perhaps more related to the use of aggregated than microdata, but the point may be equally valid at the firm level.

Further quantification of the above results is difficult, but some illustrative numbers are available. We may calculate the marginal frequencies of categories $(L_t = 2, Q_t = 3)$ and $(L_t = 3, Q_t = 3)$ from the fitted maintained models. If we compare the frequency of the category $(L_t = 2, Q_t = 3)$ and that of $(L_t = 3, Q_t = 3)$, we find out that this ratio is 27 per cent larger during a contraction than during an expansion in forest industries at the quarterly level. Computed from the annual model, the corresponding figure is still as high as 22 per cent. This means that one fourth of the companies whose production diminishes by more than two per cent and who would then trim their work force by at least two per cent during a recovery, refrain from doing this in a comparable situation during a recession.

Next take the metal and engineering industries. Table III shows that the hypotheses H_D and H_E of an unchanged structure are strongly rejected at the quarterly but not at the annual level. Thus the inadequacy of H_D and H_E is only obvious when the time span is short. Another important distinction with the previous case lies in the relevant parameter estimates of the maintained model. They indicate that in metal and engineering, lay-offs occur more frequently in connection of diminishing output during a recession than during a recovery. The two marginal frequency tables with Q_t and L_t as classifiers illustrate the situation:

Downturn:

		L_t		
		1	2	3
Q_t	1	68	121	43
	2	30	253	108
	3	9	67	94

Upswing:

		L_t		
		1	2	3
Q_t	1	173	161	43
	2	92	318	59
	3	6	64	58

One possible explanation for this finding might be the presence of a fixed adjustment cost component as in (2.14). As negative demand shocks are less frequent and presumably smaller during recoveries than during recessions, consequent adjustments of labour might occur less frequently during recoveries.

Other interpretations are possible as well. Throughout the 1980's, Finnish metal and engineering industries have been plagued by a severe shortage of skilled labour at the peaks of the business cycle. When a firm in this environment experiences a negative demand shock during a strong cyclical upswing, it probably expects the shock to be temporary and is unwilling to give up any of its labour. This is because the firm may later be unable to quickly rehire skilled employees even for higher pay. This interpretation emphasizes the possibility of a firm being constrained in the labour market that model (2.13) does not accommodate.

A partial explanation for the above rejections could also be the inappropriateness of the rational expectations assumption made in connection with (2.13). If this assumption does not hold, it may contribute to the rejection of the hypotheses H_D and H_E in spite of the inclusion of the firm-specific business cycle indicator S_t^a.

In miscellaneous manufacturing, the strong hypothesis of constant adjustment cost structure is rejected as well when the model is quarterly. The hoarding of labour seems to intensify during cyclical downturns. To illustrate the rejection numerically, we have that the increase in the ratio between the fitted frequencies of the category ($L_t = 2, Q_t = 3$) and the category ($L_t = 3, Q_t = 3$) is about 16 per cent during contractions as compared to expansions. The other hypotheses are not rejected at the 10 per cent level. This does not necessarily mean that in this very heterogenous collection of industries, the weak hypothesis of constant quadratic adjustment cost structure is to be believed. Nickell (1986) calls attention to the problems of aggregation, and also in our case aggregation over vastly different industries from chemicals to textiles may weaken the power of statistical tests.

8. CONCLUSIONS

We have used Nickell's (1986) model of demand for labour as a starting point for our study on labour demand and labour hoarding in Finnish manufacturing. The model is based on the assumption of quadratic adjustment costs for adjusting the size of the workforce. As may be expected, the model is rejected as too restrictive, but it is not completely clear if the quadratic adjustment cost assumption is the sole culprit. In forest industries, inability to discriminate between skilled and unskilled labour may have contributed to the rejection of the null model. In metal and engineering, possible but ignored constraints in the labour market may have been one of the reasons for rejection. However, the results seem to confirm that labour hoarding exists in Finnish manufacturing and demonstrate the possibilities and importance of microeconometric research on labour demand.

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Table I:

Goodness of fit of models (4.2) and (4.6) for the quarterly and annual data

	Ordered probit	Continuation ratio	
		logit link	log-log link
QUARTERLY MODELS			
Metal and engineering industries			
Deviance	902.5	815.8	809.8
χ^2	993.2	909.9	875.2
df	1383	770	770
Forest industries			
Deviance	612.23	546.45	538.89
χ^2	353.5	588.3	555.3
df	1120	605	605
Miscellaneous manufacturing			
Deviance	1317.2	1137.2	1132.1
χ^2	616.3	1162.0	1164.0
df	1665	982	982
ANNUAL MODELS			
Metal and engineering industries			
Deviance	863.20	811.75	808.57
χ^2	986.1	753.3	738.5
df	1251	635	635
Forest industries			
Deviance	652.31	567.1	560.43
χ^2	528.9	507.9	490.8
df	1079	542	542
Miscellaneous manufacturing			
Deviance	1248.7	1144.2	1147.7
χ^2	1214.0	1028.0	1039.0
df	1602	907	907

Table II:

Logarithmic versions of the likelihood ratio test statistics (LR) for testing three reductions of the maintained model

	Reduction		
	Hypothesis H_A	Hypothesis H_B	Hypothesis H_C
QUARTERLY MODELS			
Metal and engineering industries			
LR	142.6	186.2	22.0
df	72	96	18
p-value	10^{-6}	10^{-7}	0.232
Forest industries			
LR	105.71	119.01	13.01
df	65	87	12
p-value	0.001	0.009	0.368
Miscellaneous manufacturing			
LR	128.7	193.1	35.6
df	72	96	18
p-value	$5 \cdot 10^{-5}$	$2 \cdot 10^{-8}$	0.008
ANNUAL MODELS			
Metal and engineering industries			
LR	112.08	156.13	18.88
df	71	95	17
p-value	0.001	$8 \cdot 10^{-5}$	0.335
Forest industries			
LR	99.93	155.51	21.61
df	62	85	15
p-value	0.002	$5 \cdot 10^{-6}$	0.118
Miscellaneous manufacturing			
LR	100.3	111.1	13.0
df	72	96	18
p-value	0.015	0.139	0.792

Table III:

Test results of the labour hoarding hypotheses H_D and H_E within the framework of the maintained models for each case

	Hypothesis H_D	Hypothesis H_E
QUARTERLY MODELS		
Metal and engineering industries		
LR	48.6*	26.4*
df	18	6
p-value	10^{-4}	$2 \cdot 10^{-4}$
Forest industries		
LR	$25.8^{(\dagger)}$	$12.9^{\dagger}$
df	16	5
p-value	0.057	0.024
Miscellaneous manufacturing		
LR	$28.3^{(\dagger)}$	7.9
df	18	6
p-value	0.058	0.246
ANNUAL MODELS		
Metal and engineering industries		
LR	21.3	6.4
df	18	6
p-value	0.267	0.385
Forest industries		
LR	$27.5^{\dagger}$	7.7
df	13	4
p-value	0.011	0.104
Miscellaneous manufacturing		
LR	21.2	10.1
df	18	6
p-value	0.269	0.121

† : statistically significant; hoarding intensifies during downturns
(†) : statistically almost significant
* : statistically significant; hoarding more common during upswings

APPENDIX 1:

QUESTIONS OF THE FINNISH BUSINESS SURVEY RELEVANT IN THIS STUDY

Symbol	Question
L_t	Is the number of employees in your company this quarter larger than / the same as / smaller than previous quarter?
$L_t^{\triangle}$	Is the number of employees in your company this quarter larger than / the same as / smaller than a year ago?
Q_t	Is the production [volume] of your company this quarter larger than / the same as / smaller than previous quarter?
$Q_t^{\triangle}$	Is the production [volume] of your company this quarter larger than / the same as / smaller than a year ago?
Q_{t+1}^*	Do you expect the production [volume] of your company next quarter to be larger than / the same as / smaller than this quarter?
S_t^a	Do you consider your present backlog of orders large / normal / small ?
K_t	Does your company have idle production capacity at the moment (yes / no) ?

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