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VAKGROEP MACRO-ECONOMIE

A theoretical and empirical micro-economic labour time model

Joseph PLASMANS

Annemie VANROELEN*

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Universitaire Faculteiten St.-Ignatius

Prinsstraat 13 - B 2000 Antwerpen

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A b s t r a c t

In this paper a micro-economic production model, allowing for substitution between potential labour input and capital stock in the long run and mainly between workers and average per capita working hours in the short run, is analyzed. Special attention is devoted to the impact of non-wage labour cost, as well in the long run as in the short run, and to the costs of overtime work in the short run. The complete model will be applied on annual data for five Belgian industrial sectors (chemicals, paper, textiles - clothes - leather, food - beverages - tobacco, metals - metal products) for the sample period 1960-'84.

C o n t e n t s

1. Introduction

Assuming that the firms' decision process on the production technology can be subdivided into two successive optimization rounds, a micro production model for the long run and for the short run will be derived. The long run production model is assumed to allow for substitution between capital stock and potential labour input according to a profit maximizing CES production technology with factor augmenting technical progress. The long run decision variables are the production capacity, the potential labour input and the capital stock operating at full capacity output.

The short run production model is assumed to allow for a limited substitution between labour and capital, according to a cost minimizing CES production technology with Hicks neutral technical progress. The short run decision variables are the number of employees and the average number of working hours per employee, including overtime work.

Hence, basically, it is assumed that labour and capital are substitutes in the long run and are complements in the short run. Special emphasis will be given to non-wage labour costs (short and long run) and to the costs of overtime work (short run).

Finally, a time-series analysis will be applied on annual data of five industrial sectors covering the period 1960-'84.

In section 2, a brief review on micro-production models for labour time in the literature will be given, while our model will be presented in section 3. Section 4 contains the empirical results on sectoral models and section 5 concludes.

2. Micro-economic labour time models - a brief overview of the literature

2.1. Introduction

In this section, we throw a short look on some recent papers concerning micro-economic labour time behaviour. We focus on the firms' level, hence excluding models concerning the trade unions' side, using e.g., employees' utility maximization (see, e.g., Hoel (1984) and Calmfors (1985)).
This overview is restricted to static production models.
Since we are interested in the impact of a reduction of working time (RWT) on employment (a.o.), we distinguish between the number of workers and the average working time per employee. Special emphasis is devoted to the impact of non-wage labour costs. These quasi-fixed labour costs contain - among others - employers' contributions to social security, recruitment costs, vocational training costs, certain social allowances (e.g., end-of-year premiums, additional insurance costs), clothes, canteen payments or accomodation, profit shares, labour dividends, additional life insurances, service cars and payments for days not worked. Hart (1984) estimates the ratio between quasi-fixed non-wage labour costs and total variable labour costs (i.e., per man hour costs) at about 30 % in the U.S.A. and the U.K. during the late 70's - beginning 80's. Vleminckx (1986) has observed that this ratio increased from 31.5 % in 1981 to 35.4 % in 1984 for workers in the Belgian chemical sector, from 33 % in 1981 to 34.5 % in 1984 for workers in the Belgian metal sector and from 38.4 % in 1981 to 40.4 % in 1984 for workers in the Belgian construction industry.

Writing the total enterpreneurial cost of labour as :

$$C_L = w(H)LH + zL$$

with

- w the hourly wage rate, which may be expressed as a function of the average number of working hours per employee,
- L the total employment of the enterprise,
- H the average number of working hours worked per employee,
- z the (quasi) fixed costs per worker.

Hence, the marginal labour cost of an employee is $\frac{\partial C_L}{\partial L} = wH + z$ and the cost of an extra hour of labour amounts : $\frac{\partial C_L}{\partial H} = Lw(1+\varepsilon)$, with ε the elasticity of the wage rate with respect to the average number of working hours ($\varepsilon := \frac{\partial w}{\partial H} \cdot \frac{H}{w}$).

As observed by Vleminckx (1986) for Belgium, the non-wage labour costs rather than the wages themselves increase. What is now the effect of an increase in z when w remains constant ?

a) The total employers' labour demand will decrease with a quantity equal to the product of the labour-demand elasticity and the percentage increase in total labour costs for a given employment level; one impact of this decrease is thus a decline in the total number of working hours demanded, LH;

b) The second effect is a substitution effect on the firm's relative demand for employees and working hours; the relative price of these 2 labour inputs, i.e. $\frac{wH + z}{Lw(1+\varepsilon)}$, rises, so that employment is substituted by (more) hours per worker; as long as some substitution is possible, the above imposed change will induce employers to lengthen working weeks by adding overtime hours, to reduce employment and to prevent new recruitments to achieve a given rate of output (insider-outsider theory).

c) The third effect arises from the heterogeneity of labour inputs : in general, a constant nominal increase in the fixed costs of employment will cause a greater percentage increase in the price of working hours of low- than of high-wage employees, and a greater increase in the price of employment relative to hours among low- than among high-skilled workers, so that more high-skilled workers will be employed.

In subsection 2.2., we investigate the short run labour time models occurring in the literature. Subsection 2.3 treats the long run approaches, while subsection 2.4 contains some concluding remarks of this literature

investigation and provides a link to section 3, where our own static short and long term models are presented.
We always investigate the specification of the production function, the cost function and the objective function successively.

2.2. Short run labour time models in the literature

There exist several recent papers approaching a RWT by a short run model at the firm's level, i.e., Lubrano & Sneessens (1982), de Regt (1984), Késenne & Butzen (1984), Brunstadt & Holm (1984) and Toedter (1986). The **production functions** used in the different models are of several types, i.e., Cobb Douglas functions (Késenne & Butzen (1984)), Leontief functions (Lubrano & Sneessens (1982), de Regt (1984)) and C.E.S. production functions (Toedter (1988)). In the short run, the capital-labour ratio is rigid, such that there are only very limited substitution effects between capital and labour. That is why several authors use a Leontief production function, with as inputs employment and hours of work, and an exogenous capital stock level is only used by Késenne and Butzen (1984). A C.E.S. production function specification is equally possible, allowing for a negligible substitution between labour and capital and, e.g., for a larger substitution between hours of work and people at work.

The second important equation, for the purpose of this paper, is the **cost function.** Total costs consist of labour costs and capital costs, the latter being known in the short run. The labour costs can be subdivided into wages for normal hours of work, wages for overtime, and non-wage labour costs (Késenne & Butzen (1984)). Since in the short run, overtime work is easily possible and can be paid at an other wage level than the contractual hours of work, we consider that these costs should be taken into consideration. Non-wage labour costs are even more considerable.
In the short run cost function, capital costs do not change with labour costs. The optimization program can be worked out in two different ways, which are strongly interrelated. Some authors consider the RWT-problem as a cost minimization program (Hart (1984), Késenne and Butzen (1984), Lubrano and Sneessens (1982)). Firms try to minimize total costs, subject

to the production (capacity) function constraint. In other articles, profit maximization, also under the production constraint, is the objective program (e.g., Brunstadt & Holm (1984) and Toedter (1988)).

2.3. Long run labour time models in the literature

For this subsection, we will give an overview of long run optimization programs, as they are worked out by Lubrano & Sneessens (1982), Sneessens (1984), de Regt (1984) and Toedter (1986).

The (potential) **production function** is in all cases of the C.E.S.-type, because of the substitutability between the two variables, labour and capital. The functions all take technological innovation into consideration. Lubrano & Sneessens (1982) built in the possibility of variable returns to scale, while Sneessens (1984) and de Regt (1984) did not.

Most long term **cost functions** only consider the wage labour costs and the user's costs of capital (Lubrano and Sneessens (1982), Sneessens (1984), de Regt (1984)) as variables. They do not consider any non-wage labour costs, nor any overtime payments. Overtime work could be neglected in the long run, because of the agreement in most sectors to compensate for overtime work by days off within a rather short time period. On the contrary, quasi-fixed non-wage labour costs should be taken into consideration in the long run either. As a consequence, there should remain at least three kinds of costs then, i.e., labour costs for contractual hours of work, non-wage labour costs and the user's cost of capital.

The **optimization program** reads in two alternative ways : as a cost minimization problem or as a profit maximization one. The cost minimization approach, under the production function constraint, is followed by Lubrano & Sneessens (1982), Sneessens (1984) and de Regt (1984). Hoel & Vale (1985) and Toedter (1983), on the contrary, maximize the firm's profit, subject to the production function; Toedter does so under different price regimes. In this second approximation, production is an endogenous variable, while it is an exogenous one in the cost minimization approach. For the profit maximization approach, we need to know the prices of the firm's commodities either.

Solving and rearranging all the models mentioned before, leads to the employment function and the optimal effective hours of work per employee.

Some authors have estimated their models for several countries. Lubrano & Sneessens (1982) did so for the French manufacturing sector, Sneessens (1984) for France, Germany, Italy, the United Kingdom and the United States. De Regt (1984) applies his model on the manufacturing sector of the Netherlands. Bayar a.o. (1986) concentrate upon some Belgian manufacturing sectors.

2.4. What can we learn from the literature ?

Out of all the static models investigated, that are described sub. 2.2. and 2.3., we are able to build our own model, which can be used for estimation procedures in section 4. The construction of that static model is described in detail in section 3.

- For the **short run** approach, we will use a **C.E.S. production** function, with a limited substitution between labour and capital. The output elasticity of **labour time** will generally be different from the returns to scale parameter. Returns to scale are assumed to be variable. The **cost function** contains as well the labour costs related to the wage bill (wages of contractual hours of work and of overtime work), as the fixed and quasi-fixed labour costs (that depend only on the number of employees and not on the hours worked). The **optimization problem** is one of **cost minimization.** We choose for a cost function instead of a profit function, in order to preserve the exogeneity of output.
- For the **long run**, we opted for a **profit maximization C.E.S. production** model, allowing for substitution between capital and labour. Technological progress is considered to be factor augmenting; variable returns to scale are supposed as well [1].

  In the long run, non-wage labour costs, wage costs for contractual hours of work and the user's cost of capital form the basic elements of the **profit function**, together with the prices of products. In the long run, overtime work does not seem to be important.

  The optimization program can be formulated as a profit maximization problem, subject to the production function constraint.

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[1] Notice, however, that profit maximization under perfect market conditions (known and exogenous prices) implies non-increasing returns to scale.

3. A brief description of a long and short run micro production model for RWT

Following Sneessens (1984), we assume that the firms' decision process can be divided into two successive optimization rounds, one determining long run decision variables like production capacities and the production technology, the other determining short run decision variables like overtime work and employment. The long run is considered as that period of time, which is long enough to permit a substitution between capital and labour inputs. In the short run, capital stock is assumed to be exogenous, and there is no room for an ample factor substitution.

Alternatively, a long run optimization program implies an endogenous determination of the production capacity, the efficient labour input at this full production capacity and the capital stock in use at this full capacity level in a C.E.S. profit maximizing context.
In the short run, actual production may of course diverge substantially from its long run full capacity level, affected as it will be by cyclical final demand fluctuations. Hence, actual production is determined exogenously in the short run and a quasi-Leontief cost minimizing behaviour can be assumed determining optimal working time, the optimal number of shifts and the optimal short run level of employment.

Assuming that in the long run normal (or contractual) working time $\bar{H}$ and the normal (contractual) number of shifts $\bar{s}$ are determined by bargaining between employers and employees, the optimal production capacity, the labour input and the capital stock to yield this optimal production capacity, should be computed.

Hence, introducing standard wage costs, costs for overtime work (only in the short run, assuming that overtime work does not occur in the long run), non-wage labour costs and (standard) capital costs, the long run (LR) and short run (SR) optimization programs can be written in a perfectly competitive world as :

$$\text{LR}: \max_{\{Q^p, L^p, K\}} \quad q_t\, Q_t^p - w_t\, \bar{H}_t\, L_t^p - z_t\, L_t^p - c_t\, K_t$$

$$\text{s.t.} \quad Q_t^p = A[\alpha(e^{\gamma_1 t}\, L_t^p\, \bar{H}_t)^{-\rho} + (1-\alpha)\,(e^{\gamma_2 t}\, K_t\, \bar{s}_t\, \bar{H}_t)^{-\rho}]^{-\frac{\mu}{\rho}} \qquad (1)$$

and

$$\text{SR}: \min_{\{L,H\}} \quad w_t\, \bar{H}_t\, L_t + \phi\, w_{o,t}\, w_t\,(H_t - \bar{H}_t + H_{h,t})\, L_t + z_t\, L_t + C_{f,t}$$

where $\phi\, w_o = w_o$, if $H_t \geqq \bar{H}_t - H_{h,t}$

$\phi\, w_o = w_1$, if $H_t < \bar{H}_t - H_{h,t}$ $\quad (w_o \geqq 1 \geqq w_1 \geqq 0)$

$$\text{s.t.} \quad Q_t = Be^{\gamma t}\, [\beta(\frac{L_t}{L_t^p})^{-\theta} + (1-\beta)\,(\frac{sK_t}{L_t^p})^{-\theta}]^{-\frac{\nu}{\theta}}\, H_t^{\eta} \qquad ^{1)}\ (2)$$

respectively, with

Q_t^p the production capacity at period t with unit output price q_t,

L_t^p the potential labour input (i.e., the efficient employment at full production capacity) at period t,

L_t the employment at period t,

K_t the available capital stock, i.e., the capital stock in use at full production capacity at period t,

w_t the (exogenous) hourly wage rate at period t, with $w_{o,t}$ the average hourly mark-up cost for overtime work at period t, and $w_{1,t}$ the average employers' payments for employees' illness or for other employees' time not worked per working hour at period t,

[1] In order to require that the LR-production capacity function is the envelope curve of the SR-production functions (1), then $Q = Q^p$ and $H = \bar{H}$ should imply that $L = L^p$, so that B should satisfy :

$$B = \frac{A[\alpha e^{-\gamma_1 t\rho} + (1-\alpha)\,(e^{-\gamma_2 t\rho}\,(k\bar{s})^{-\rho})]^{-\frac{\mu}{\rho}}}{e^{\gamma t} \cdot [\beta + (1-\beta)\,(ks)^{-\theta}]^{-\frac{\nu}{\theta}}}\, L^{p\mu}\, \bar{H}^{\mu-\eta}, \text{ with } k := \frac{K}{L^p}.$$

z_t the (exogenous) non-wage labour cost per worker at period t,

c_t the (exogenous) user's cost per unit of capital stock at period t,

H_t the average number of working hours per labourer, actually worked at period t, with $\bar{H}_t$ the (average) contractual number of working hours per worker at time t, i.e., $\bar{H}_t$ is the number of working hours, contractually paid by the firm at period t,

$H_{h,t}$ the (average) number of holiday time hours per worker at period t,

$\bar{s}_t$ the contractual number of shifts at period t,

$C_{f,t}$ fixed costs at period t,

A,B the scale parameters (A, B > 0),

$\alpha(\beta)$ the distribution parameter in the long run (short run) CES production function ($0 < \alpha, \beta < 1$),

γ_1, γ_2 labour- and capital-augmenting technological progress parameters in the long run CES-function ($\gamma_1, \gamma_2 > 0$),

γ a Hicks-neutral technical progress parameter ($\gamma > 0$),

$\rho(\theta)$ the LR(SR) substitution parameter ($\rho, \theta > -1$),

$\mu(\nu)$ the LR(SR) returns to scale parameter ($\mu, \nu > 0$)

(see also appendix A).

Solving the LR-optimization program (1) and dropping the time-index t whenever possible, we get the familiar marginal productivity conditions :

$$qA[\alpha(e^{\gamma_1 t}\hat{L}^p \bar{H})^{-\rho} + (1-\alpha)(e^{\gamma_2 t}\hat{K}\bar{s}\bar{H})^{-\rho}]^{-\frac{\mu}{\rho}-1} \mu\,\alpha\, e^{-\gamma_1\rho t}\,\bar{H}^{-\rho}(\hat{L}^p)^{-\rho-1} = w\bar{H}+z$$

and

$$qA[\alpha(e^{\gamma_1 t}\hat{L}^p \bar{H})^{-\rho} + (1-\alpha)(e^{\gamma_2 t}\hat{K}\bar{s}\bar{H})^{-\rho}]^{-\frac{\mu}{\rho}-1} \mu(1-\alpha)e^{-\gamma_2\rho t}\,\bar{s}^{-\rho}\,\bar{H}^{-\rho}\,\hat{K}^{-\rho-1} = c, \tag{3}$$

or, taking account of the LR - C.E.S. production function, we find that the optimal (potential) factor demands satisfy :

$$\hat{L}^p = (\hat{Q}^p)^{\frac{\mu+\rho}{\mu(\rho+1)}}\, q^{\frac{1}{\rho+1}}\, \mu^{\frac{1}{\rho+1}}\, \alpha^{\frac{1}{\rho+1}}\, e^{\frac{-\gamma_1\rho t}{\rho+1}}\, \bar{H}^{\frac{-\rho}{\rho+1}}\, (w\bar{H}+z)^{\frac{-1}{\rho+1}}\, A^{\frac{-\rho}{\mu(\rho+1)}}$$

$$\hat{K} = (\hat{Q}^p)^{\frac{\mu+\rho}{\mu(\rho+1)}}\, c^{-\frac{1}{\rho+1}}\, q^{\frac{1}{\rho+1}}\, \mu^{\frac{1}{\rho+1}}\, (1-\alpha)^{\frac{1}{\rho+1}}\, e^{\frac{-\gamma_2\rho t}{\rho+1}}\, \bar{s}^{\frac{-\rho}{\rho+1}}\, \bar{H}^{\frac{-\rho}{\rho+1}}\, A^{\frac{-\rho}{\mu(\rho+1)}} \tag{4}$$

Hence, the optimal long run capital-labour ratio or capital intensity amounts from (4) :

$$\hat{k} = \frac{\hat{K}}{\hat{L}^p} = c^{-\frac{1}{\rho+1}}\, (w\bar{H}+z)^{\frac{1}{\rho+1}}\, (\frac{1-\alpha}{\alpha})^{\frac{1}{\rho+1}}\, e^{-\frac{\rho}{\rho+1}(\gamma_2-\gamma_1)t}\, \bar{s}^{\frac{-\rho}{\rho+1}}, \tag{5}$$

or, transferring to natural logarithms and using the expression of the long-run elasticity of substitution between capital and labour ($\sigma := (1+\rho)^{-1}$) :

$$\ln \hat{k} = \sigma \ln (\frac{1-\alpha}{\alpha}) - \sigma \ln c + \sigma \ln(w\bar{H}+z) + (\sigma-1)(\gamma_2-\gamma_1)t + (\sigma-1)\ln \bar{s} \tag{6}$$

so that the optimal long run capital intensity is scale invariant and is inversely related to the ratio of the unit costs of capital and labour inputs (wage and non-wage labour costs) according to the value of the elasticity of substitution.

Moreover, the impact of the factor augmenting technical progress terms depends, just like that of the contractual number of shifts, on the property that whether or not this elasticity is exceeding one. Finally, the contractual working time is positively related to the optimal long run capital intensity according to the value of the elasticity of substitution.

The optimal production capacity, corresponding to the optimal long run capital intensity (5), can easily be derived now as a reduced form expression by substituting (4) into the LR-CES production function in (1), or

$$\hat{Q}^p = A^{\frac{1}{\rho+1}} (\hat{Q}^p)^{\frac{\mu+\rho}{\rho+1}} q^{\frac{\mu}{\rho+1}} \mu^{\frac{\mu}{\rho+1}} \bar{H}^{\frac{\mu}{\rho+1}} [\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} (w\bar{H}+z)^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}}]^{-\frac{\mu}{\rho}} , \qquad (7)$$

so that the power of the optimal production capacity $\hat{Q}^p$ in the left hand side of (7) becomes $\frac{1-\mu}{\rho+1}$, and, raising both sides to the power $\frac{\rho+1}{1-\mu}$ and taking logarithms, the optimal production capacity has as reduced form :

$$\ell n\ \hat{Q}^p = \frac{1}{1-\mu} \ell n\ A + \frac{\mu}{1-\mu} \ell n\ \mu + \frac{\mu}{1-\mu} \ell n\ q - \frac{\mu(\rho+1)}{\rho(1-\mu)} \ell n\ [\alpha^{\frac{1}{\rho+1}} . e^{\frac{-\gamma_1 \rho t}{\rho+1}} (w\bar{H}+z)^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}}] + \frac{\mu}{1-\mu} \ln \bar{H} \qquad (8)$$

The term between square brackets in the r.h.s. of (8) is highly non-linear in the factor prices. If we would like to linearize it in some way, we can follow a procedure set forth by Kmenta (1967)[1]: if the true value of

[1] See Kmenta (1967) and comments by Thursby and Knox Lovell (1978).

the substitution parameter ρ does not depart from zero too much (the Cobb-Douglas case), the logarithm of the term between [ ] in (8) can satisfactorily be approximated by a second order truncated Taylor series expansion around $\rho = 0$. The tedious computation is performed in appendix B.

Substituting reduced form expression (8) (or its approximation) for the optimal production capacity into (the natural logarithm of) the optimal long run potential employment input in (4), we find the reduced form expression of this optimal potential employment :

$$\ln \hat{L}^p = \frac{1}{1-\mu} \ln A + \frac{1}{1-\mu} \ln \mu + \frac{1}{\rho+1} \ln \alpha + \frac{1}{1-\mu} \ln q - \frac{1}{\rho+1} \ln (w\bar{H}+z) + \frac{\mu}{1-\mu} \ln \bar{H}$$

$$- \frac{\mu+\rho}{\rho(1-\mu)} \ln [\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} (w\bar{H}+z)^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}}]$$

$$- \frac{\gamma_1 \rho t}{\rho+1} \qquad (9)$$

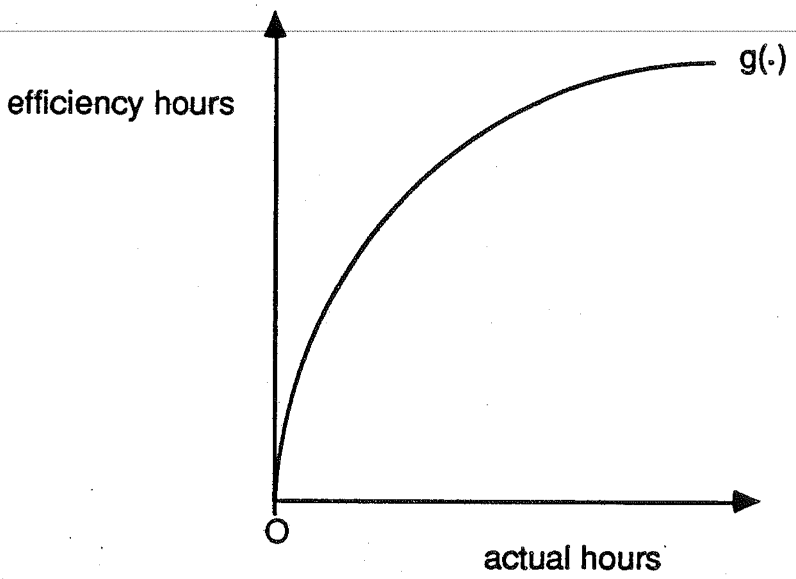
The optimal (long run) capital stock can similarly be found.

In the <u>short run</u>, actual production may of course diverge substantially from its long run full capacity level, although the long run production function should be the envelope curve of the short run production function points.

In general, we can specify the firm's short run production function for one shift as :

$$Q = f(L, K, t)\ g(H), \qquad (10)$$

where the term $g(H)$ can be conceived as the number of "efficiency hours" corresponding to H actual hours and where f is the level of output for one efficiency hour. In fact, when workers become more tired, more actual working hours are needed in order to obtain an equal increase in efficiency hours, as, e.g., shown by the following figure, where function g is increasing when the number of actual hours rise ($g'(H) > 0$) but at a lower pace ($g''(H) < 0$).



In this spirit and following Bodo's and Giannini's approach (G. BODO and C. GIANNINI (1985)), we may specify the following simplified SR-model in labour costs only :

$$\min_{L,H} C_L = wLH + zL, \text{ if } H < \bar{H}$$

$$\min_{L,H} C_L = wL\bar{H} + awL(H-\bar{H}) + zL, \text{ if } H \geqq \bar{H} \qquad (11)$$

s.t. (10), with a > 1 a wage increase component for overtime work. Constrained short run cost minimization of (11) w.r.t. L and H leads to the following first order conditions with Lagrange parameter λ :

- for employment :

$$\lambda \frac{\partial f(L,K,t)}{\partial L} g(H) = wH + z, \text{ if } H < \bar{H}$$
$$= w\bar{H} + aw(H-\bar{H}) + z, \text{ if } H \geqq \bar{H} \qquad (12a)$$

- and for working hours :

$$\lambda\ f(L,K,t)\ g'(H) = wL, \text{ if } H < \bar{H}$$

$$= awL, \text{ if } H \geqq \bar{H} \qquad (12b)$$

Hence,

$$\frac{\frac{\partial f(L,K,t)}{\partial L}\, g(H)\, L}{f(L,K,t)\ g'(H)} = \frac{wH + z}{w}, \text{ if } H < \bar{H}$$

$$= \frac{w\bar{H} + z}{aw} + (H-\bar{H}), \text{ if } H > \bar{H} \qquad (13)^{1)}$$

From (13) it is directly verified that, by assuming the ratio between the marginal product of labour and the average product of labour being constant (as, e.g., in the Cobb Douglas case), the relationship between the normal working time $\bar{H}$ and the actual working time H depends on non-wage labour income z, on the overtime premium and on wages w.
For example, introducing a Cobb Douglas optimal (long run) derived employment demand :

$$\ln L_t^* = \alpha_0 + \alpha_1 \ln Q_t + \alpha_2 \ln K_t + \alpha_3 t - \alpha_4 \ln \bar{H}_t \qquad (14),$$

$(\alpha_2, \alpha_3 < 0)$

the short run demands for employment and working hours may be given, respectively by the error correction process in employment:

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1)

$$\text{If } H = \bar{H}, \frac{w\bar{H} + z}{aw} \leqq \frac{\frac{\partial f(L,K,t)}{\partial L}\, g(H)L}{f(L,K,t)\ g'(H)} \leqq \frac{w\bar{H} + z}{w}$$

$$\Delta \ln L_t = \beta_0 + \beta_1 \Delta \ln L_t^* + \beta_3(\ln L_{t-1}^* - \ln L_{t-1}) \tag{15}$$

and by the log linear empirical specification :

$$\ln H_t = a_0 + a_1 \ln Q_t + a_2 \ln Q_{t-1} + a_3 \ln K_t + a_4 \ln K_{t-1} + a_5 \ln \bar{H}_t + a_6 \ln \bar{H}_{t-1} \tag{16}$$

Alternatively, assuming a general number of shifts, the SR-production technology, characterized by the capital intensity, may vary only limitedly around its (optimal) LR-level $\frac{\bar{s}\hat{K}}{\hat{L}^p}$ (Leontief production technology). The short run optimization program (2) can then be solved w.r.t. the number of employees L and the (average) number of working hours per employee H, taking account of the property that the number of efficiency hours g(H) in (10) satisfies $g'(H) > 0$ and $g''(H) < 0$, so that the short run output elasticity of labour time in the production function of (2) satisfies $0 < \eta < 1$.

The following marginal productivity conditions result :

$$w\bar{H} + \phi\, w_o w\, (H-\bar{H}+H_h) + z = \lambda\, \nu\beta\, Q^{\frac{\theta+\nu}{\nu}} B^{-\frac{\theta}{\nu}} e^{-\frac{\gamma t\theta}{\nu}} L^{-(\theta+1)} L^{p\theta} H^{-\frac{\eta\theta}{\nu}}$$

$$\phi\, w_o w\, L = \lambda\, \eta\, Q\, H^{-1} \tag{17}$$

with λ the corresponding Lagrange multiplier.

Deriving this Lagrange multiplier from the first marginal productivity condition and substituting it into the second, we get

$$\phi w_o w L = [w\bar{H}+\phi w_o w(H-\bar{H}+H_h)+z]\frac{\eta}{\nu\beta} Q^{-\frac{\theta}{\nu}} B^{\frac{\theta}{\nu}} e^{\frac{\gamma t\theta}{\nu}} L^{\theta+1} (L^p)^{-\theta} H^{\frac{\eta\theta}{\nu}-1} \tag{18}$$

so that the short run demand for employment can be derived in logaritmic form as :

$$\ln L = \frac{1}{\theta}\ln(\phi w_o)w - \frac{1}{\theta}\ln[w\bar{H}+\phi w_o w(H-\bar{H}+H_h) + z]$$

$$- \frac{1}{\theta}\ln\frac{\eta}{\nu\beta} + \frac{1}{\nu}\ln Q - \frac{1}{\nu}\ln B - \frac{\gamma t}{\nu}$$

$$+ \ln L^p - (\frac{\eta\theta-\nu}{\nu\theta})\ln H \qquad (19)$$

which is establishing, a.o., the relationship between the short run demand for employment and the short run demand for (the average number of) working hours per employee [1].

Next step is to separate both effects, the employment and the hours of work effect. We can derive the implicit form of the demand for hours by substituting the Lagrange multiplier from the 2nd relation of (17) into the 1st marginal productivity condition, leading to

$$-\phi w_o wH + \phi w_o w \frac{\nu}{\eta}\beta Q^{\frac{\theta}{\nu}} B^{-\frac{\theta}{\nu}} e^{-\frac{\gamma t\theta}{\nu}} L^{-\theta} (L^p)^{\theta} H^{-\eta\frac{\theta}{\nu}+1}$$

$$= w\bar{H} + \phi w_o w(-\bar{H} + H_h) + z. \qquad (20)$$

---

1) A time invariant relationship between H and L does not exist, because H also emerges in the cost part of (19), i.e., in $\ln[w\bar{H} + \phi w_o w (H-\bar{H}+H_h) + z]$.

Nevertheless, an approximation to the employment elasticity of labour time is

$$\frac{\partial \ln L}{\partial \ln H} \cong (\frac{-\eta\theta+\nu}{\nu\theta}) = \frac{-\eta}{\nu} + \frac{1}{\theta},$$

which can be either positive or negative. A positive employment effect of a reduction in working time (RWT) emerges in the short run if

$$\frac{\partial \ln L}{\partial \ln H} = \frac{-\eta}{\nu} + \frac{1}{\theta} < 0,$$

i.e., if the short-run production elasticity of working hours satisfies $\eta > \frac{\nu}{\theta}$, which, although η should satisfy $0 < \eta < 1$, is likely to happen in the short run since θ is very large then (Leontief hypothesis); otherwise a negative employment effect of RWT appears in the short run.

This implicit non-linear form in H should be iterated, together with equation (19), to find an optimal SR-solution for H and L.

The short run employment demand (19) can be compared to the long run potential employment demand (6), the latter being rewritten as

$$\ell n \hat{L}^{P} = \sigma \, \ell n(\frac{\alpha}{1-\alpha}) + \sigma \, \ell n \, c - \sigma \, \ln(w\bar{H}+z) + (1-\sigma)(\gamma_2-\gamma_1)t$$

$$+ (1-\sigma) \, \ell n \, \bar{s} + \ell n \, \hat{K} \qquad (6a)$$

Out of (19) and (6a), it can be seen that both, the SR-employment function and the LR-potential employment function, depend on costs (wages and non-wage labour costs in the SR, wages, non-wage labour costs and user's cost of capital in the LR), on the working time (actual working time H in the SR, contractual working time $\bar{H}$ in the LR), and on the distribution parameters α and β. The capital variable K and the number of shifts $\bar{s}$ only appear in the LR-potential employment function, while in the SR, employment is a function of the potential employment and of the output per year.

4. Empirical results

4.1. Introduction

In this section, we present the estimation results of our model for five industrial subsectors of the Belgian economy, e.g.,

1) chemicals (NACE 25-26-48),
2) paper-editors (NACE 47),
3) textiles - clothes - leather (NACE 43-44-45),
4) food - beverages - tobacco (NACE 41-42),
5) metals - metal products (NACE 21-22-31).

We use annual data for the sample period 1960-'84. Most data can be found in the National Accounts of the National Institute of Statistics (NIS, yearly); see appendix A for a more detailed data set description. The estimation results of the long and the short run models are discussed in subsections 4.2. and 4.3. respectively. In subsection 4.4., a comparison with the estimations of another model for the Belgian economy, i.e., the model of Bayar a.o. can be found (Bayar, Deimezis, Guillaume, Meulders (1986)).

4.2. Long run model estimations

While z is set equal to zero, due to the lack of data, we can simplify the equations (4) until (9). It can be derived that the equations to be estimated when z = 0, are as follows :

$$\hat{L}^p = (\hat{Q}^p)^{\frac{\mu+\rho}{\mu(\rho+1)}} w^{-\frac{1}{\rho+1}} q^{\frac{1}{\rho+1}} \mu^{\frac{1}{\rho+1}} \alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} \bar{H}^{-1} A^{\frac{-\rho}{\mu(\rho+1)}}$$

$$\hat{K} = (\hat{Q}^p)^{\frac{\mu+\rho}{\mu(\rho+1)}} c^{-\frac{1}{\rho+1}} q^{\frac{1}{\rho+1}} \mu^{\frac{1}{\rho+1}} (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} \bar{s}^{\frac{-\rho}{\rho+1}} \bar{H}^{\frac{-\rho}{\rho+1}} A^{\frac{-\rho}{\mu(\rho+1)}} \qquad (4')$$

$$\hat{k} = \frac{\hat{K}}{\hat{L}^p} = \left(\frac{c}{w}\right)^{-\frac{1}{\rho+1}} \left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\rho+1}} e^{-\frac{\rho}{\rho+1}(\gamma_2-\gamma_1)t} \bar{s}^{\frac{-\rho}{\rho+1}} \bar{H}^{\frac{1}{\rho+1}}, \qquad (5')$$

$$\ell n\ \hat{k} = \sigma\ \ell n\ (\frac{1-\alpha}{\alpha}) - \sigma\ \ell n\ (\frac{c}{w}) + (\sigma - 1)(\gamma_2 - \gamma_1)t + (\sigma - 1)\ell n\ \bar{s} + \sigma\ \ell n\ \bar{H}, \tag{6'}$$

$$\ell n\ \hat{L}^p = \sigma\ \ell n(\frac{\alpha}{1-\alpha}) + \sigma\ \ell n(\frac{c}{w}) + (1-\sigma)\ (\gamma_2-\gamma_1)t$$
$$+ (1-\sigma)\ \ell n\ \bar{s} - \sigma\ \ell n\ \bar{H} + \ell n\ \hat{K} \tag{6a'}$$

$$\hat{Q}^p = A^{\frac{1}{\rho+1}}\ (\hat{Q}^p)^{\frac{\mu+\rho}{\rho+1}}\ q^{\frac{\mu}{\rho+1}}\ \mu^{\frac{\mu}{\rho+1}}\ \ \ [\alpha^{\frac{1}{\rho+1}}\ e^{\frac{-\gamma_1\rho t}{\rho+1}}\ w^{\frac{\rho}{\rho+1}}$$
$$+ (1-\alpha)^{\frac{1}{\rho+1}}\ e^{\frac{-\gamma_2\rho t}{\rho+1}}\ (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}}\ c^{\frac{\rho}{\rho+1}}]^{-\frac{\mu}{\rho}}\ , \tag{7'}$$

$$\ell n\ \hat{Q}^p = \frac{1}{1-\mu}\ \ell n\ A + \frac{\mu}{1-\mu}\ \ell n\ \mu + \frac{\mu}{1-\mu}\ \ell n\ q - \frac{\mu(\rho+1)}{\rho(1-\mu)}\ \ell n\ [\alpha^{\frac{1}{\rho+1}}\ \cdot$$
$$e^{\frac{-\gamma_1\rho t}{\rho+1}}\ w^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}}\ e^{\frac{-\gamma_2\rho t}{\rho+1}}\ (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}}\ c^{\frac{\rho}{\rho+1}}] \tag{8'}$$

$$\ell n\ \hat{L}^p = \frac{1}{1-\mu}\ \ell n\ A + \frac{1}{1-\mu}\ \ell n\ \mu + \frac{1}{\rho+1}\ \ell n\ \alpha + \frac{1}{1-\mu}\ \ell n\ q - \frac{1}{\rho+1}\ \ell n\ w$$
$$- \frac{\mu+\rho}{\rho(1-\mu)}\ \ell n\ [\alpha^{\frac{1}{\rho+1}}\ e^{\frac{-\gamma_1\rho t}{\rho+1}}\ w^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}}\ e^{\frac{-\gamma_2\rho t}{\rho+1}}\ (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}}\ c^{\frac{\rho}{\rho+1}}]$$
$$- \frac{\gamma_1\rho t}{\rho+1} - \ell n\ \bar{H} \tag{9'}$$

As a first approach, we estimated the linearized potential employment function (6a'), where the contractual number of shifts, $\bar{s}$, is set equal to one, by ordinary least squares (OLS). Secondly, a partial adjustment process is introduced. Since we observed positive serial autocorrelation of the error terms, we reestimated both equations by an AR1 procedure with a Cochrane-Orcutt iterative technique. However, some positive serial autocorrelation of the error terms in chemicals and food remains.

The results of the four estimations are in table 1 (standard errors between brackets).

The best results can be found in the Cochrane-Orcutt AR1 estimations with partial adjustment for paper and textiles and in the AR1 estimation without PA for metals. For the sectors where some positive autocorrelation of the error terms remains in the AR1 procedure and where the fit is low, i.e., in chemicals and food, we opted for the ordinary least squares estimations with partial adjustment. In the rest of the paragraph, we only describe the results of the preferred equations.
It is noticeable that there exists some multicollinearity between the explanatory variables.

The coefficient of $(\ln \frac{c}{w} - \ln \bar{H})_t$ should be nonnegative, as it is an estimate of σ, the elasticity of substitution; moreover, it can be seen as the effect of a reduction of contractual working time on employment (it is the negative of the employment elasticity of contractual working time). In four sectors (the sole exception is the chemical sector), this coefficient is significantly positive but rather small (standard error between brackets): 0.06 (0.03) (paper), 0.08 (0.04) (textiles), 0.06 (0.02) (metals) and 0.76 (0.42) (food). This means that a reduction of contractual working time leads only very partially to a hiring of new employees, which was also found in our macro-economic study with the Maribel model (Plasmans, Vanroelen (1986)). Only in the food sector there is a significant employment effect of a reduction of working time. The elasticity of substitution is also small. In the chemical sector, the parameter σ is estimated to be negative; we have a perverse functioning of the labour market : a reduction of contractual working time leads to a reduction of employment. This

Table 1 : Estimation results of equation 6a'(standard error between brackets)
dependent variable : $\ln L_t^p$

variable [parameter] \ procedure	OLS	AR1, Cochrane-Orcutt	OLS, partial adjustment	AR1, partial adjustment
	CHEMICALS			
constant	-19.49 (2.24)	-16.81 (0.83)	8.26 (14.03)	-21.81 (7.87)
$(\ln\frac{c}{w}-\ln\bar{H})_t$ [$=\theta$]	-0.37 (0.15)	-0.10 (0.04)	-0.33 (0.14)	-0.09 (0.05)
t	-0.03 (0.01)	0.02 (0.02)	-0.01 (0.01)	0.02 (0.02)
$\ln L_{t-1}^p$	------	------	-2.44 (1.22)	0.44 (0.70)
[$\hat{a}$];[$(\hat{\gamma}_2-\hat{\gamma}_1)$]	~1; -0.02(0.01)	~1; -0.02(0.01)	~0; -0.008(0.10)	---; 0.02(2.01)
R^2; $\bar{R}^2$	0.82; 0.80	0.22; 0.15	0.85; 0.83	0.24; 0.12
DW/h[(1)]	0.31	0.77	------	------
£; U[(2)]	10.97; 0.02	36.20; 0.003	13.16; 0.01	36.44; 0.003
	PAPER			
constant	-6.67 (3.40)	-11.93 (0.39)	13.12 (4.73)	-8.51 (1.54)
$(\ln\frac{c}{w}-\ln\bar{H})_t$ [$=\theta$]	0.38 (0.22)	0.07 (0.02)	-0.07 (0.18)	0.06 (0.03)
t	-0.09 (0.01)	-0.05 (0.00)	-0.07 (0.01)	-0.05 (0.00)
$\ln L_{t-1}^p$	------	------	-2.42 (0.50)	-0.32 (0.15)
[$\hat{a}$];[$(\hat{\gamma}_2-\hat{\gamma}_1)$]	~0; -0.15(0.07)	~0; -0.05(0.03)	~0; -0.06(0.01)	~1; -0.05(0.02)
R^2; $\bar{R}^2$	0.83; 0.81	0.97; 0.97	0.92; 0.91	0.98; 0.97
DW/h	0.51	1.64	------	------
£; U	2.93; 0.02	54.97; 0.002	12.23; 0.01	55.48; 0.002
	TEXTILES			
constant	-3.20 (2.88)	-10.21 (0.57)	47.10 (12.14)	-3.51 (3.66)
$(\ln\frac{c}{w}-\ln\bar{H})_t$ [$=\hat{\sigma}$]	0.52 (0.20)	0.08 (0.04)	0.17 (0.17)	0.08 (0.04)
t	-0.11 (0.01)	-0.06 (0.00)	-0.20 (0.02)	-0.08 (0.00)
$\ln L_{t-1}^p$	------	------	-4.41 (1.05)	-0.53 (0.29)
[$\hat{a}$]; [$(\hat{\gamma}_2-\hat{\gamma}_1)$]	~0.002;-0.23 (0.10)	~0; -0.07 (0.03)	---; -0.24(0.05)	~0; -0.09 (0.04)
R^2; $\bar{R}^2$	0.89; 0.88	0.95; 0.94	0.94; 0.93	0.96; 0.96
DW/h	0.33	1.77	------	------
£; U	-1.33; 0.02	46.32; 0.003	6.29; 0.02	47.34; 0.003

---

1) The usual Durbin Watson test does not make sense if the lagged dependent variable is used as explanatory variable; in this case, we calculate $h = (1 - \frac{DW}{2})\sqrt{\frac{n}{1-nV(b)}}$ (with V(b) = variance of the coefficient of the lagged variable), and test h as a normal variate (Durbin, 1970). If nV(b) is however larger than one the Durbin test is not possible. (n = number of observations)

2) Theil's inequality coefficient is defined as : $U = \sqrt{\frac{\sum_i (P_i - A_i)^2}{\sum_i A_i^2}}$; where P_i is the predicted and A_i the actual value. This coefficient should be zero in the case of a perfect sample estimation (Theil, 1966).

Table 1 : (continuation)

procedure / variable [parameter]	OLS	AR1, Cochrane-Orcutt	OLS, partial adjustment	AR1, partial adjustment
	FOOD			
constant	4.08 (8.68)	-14.20 (0.91)	130.18 (29.43)	-17.51 (6.63)
$(\ln\frac{c}{w}-\ln\bar{H})_t$ [=θ]	1.09 (0.57)	-0.05 (0.08)	0.76 (0.42)	-0.06 (0.06)
t	-0.12 (0.03)	-0.03 (0.00)	0.08 (0.02)	-0.03 (0.00)
$\ln L^p_{t-1}$	-----	-----	-11.25 (2.56)	0.27 (0.54)
[δ];[($\varphi_2-\varphi_1$)]	0.98; 1.33 (8.13)	---- ; -0.03 (0.03)	~1; 0.33 (0.51)	---- ; -0.03 (0.03)
R^2; $\bar{R}^2$	0.79; 0.77	0.85; 0.83	0.89; 0.88	0.85; 0.83
DW/h(1)	0.54	1.04	-----	-----
£; U(2)	-1.90; 0.02	49.28; 0.002	6.19; 0.01	49.43; 0.002
	METALS			
constant	-8.92 (3.54)	-11.81 (0.29)	21.99 (9.95)	-12.48 (1.91)
$(\ln\frac{c}{w}-\ln\bar{H})_t$ [=θ]	0.21 (0.23)	0.06 (0.02)	0.09 (0.19)	0.06 (0.02)
t	-0.08 (0.01)	-0.04 (0.00)	-0.08 (0.01)	-0.04 (0.00)
$\ln L^p_{t-1}$	-----	-----	-2.49 (0.77)	0.05 (0.14)
[δ];[($\varphi_2-\varphi_1$)]	~0; -0.10 (0.04)	~0; -0.04 (0.03)	-----; -0.09 (0.03)	~0; -0.04 (0.02)
R^2; $\bar{R}^2$	0.79; 0.77	0.97; 0.97	0.87; 0.85	0.97; 0.97
DW/h	0.31	1.27	-----	-----
£; U	-0.96; 0.02	60.43; 0.001	4.13; 0.02	60.54; 0.001

R^2 = coefficient of determination

$\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom

DW = Durbin Watson test statistic

h = Durbin test statistic if there is a lagged dependent variable as explanatory variable

£ = log of likelihood function

U = Theil's inequality coefficient

---

1) The usual Durbin Watson test does not make sense if the lagged dependent variable is used as explanatory variable; in this case, we calculate $h = (1 - \frac{DW}{2})\sqrt{\frac{n}{1-nV(b)}}$ (with V(b) = variance of the coefficient of the lagged variable), and test h as a normal variate (Durbin, 1970). If nV(b) is however larger than one the Durbin test is not possible. (n = number of observations)

2) Theil's inequality coefficient is defined as : $U = \sqrt{\frac{\Sigma_i(P_i-A_i)^2}{\Sigma_i A_i^2}}$; where P_i is the predicted and A_i the actual value. This coefficient should be zero in the case of a perfect sample estimation (Theil, 1966).

is presumably due to the joint phenomenon of labour hoarding and high unit labour costs which are both considerable in this sector : because of high hiring and firing costs (high insider costs), people are not dismissed immediately in times of slackness, but kept at work (insider-outsider problem). We observe that the highest labour hoarding is present in capital intensive sectors. The chemical sector is very capital intensive (α, the distribution parameter of labour, is negligible); however, it is the only sector considered where capital and labour are both increasing over time. Hence, within the context of this model, complementarity between labour and capital is observed in the chemical sector, while in the other sectors there is a limited substitution between these two production factors[1].

The long run distribution parameter, α, reflects the labour intensity of production. The results have to be interpreted with a lot of care, because α is only calculated from the constant. In general, this parameter mostly approaches 0 or 1, meaning that the sectors should use either capital or labour, which is of course an unrealistic situation. We find that the sectors paper and food are very labour intensive, while chemicals, textiles and metals are capital intensive.

By dividing the coefficient of the time variable by $(1-\sigma)$, we find the difference between the capital and labour augmenting technical progress parameters, $\gamma_2-\gamma_1$. If $\gamma_2-\gamma_1$ is negative, the capital augmenting technological progress is smaller than the innovation growth of labour. This higher labour productivity exists in four sectors, i.e., chemicals (-0.008), paper (-0.05), textiles (-0.09) and metals (-0.04). The results for food are rather impossible : the labour augmenting technological progress should be 33 % a year larger than the capital augmenting technological progress.

The parameters γ_2 and γ_1 cannot be estimated separately from equation (6a'); we shall try to distinguish these parameters when we estimate the non linear long run employment equation, i.e. relationship (9').

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[1] Notice also that when firms allow for overtime work with overtime premiums, RWT may lead to more overtime work, which has the same effect as increasing the fixed cost per worker and, hence, induces the firms to substitute from number of workers to hours worked, i.e., increases the actual working time per worker. Further, if in the medium or long run the demand elasticity is higher than one or just below one, a RWT will induce a declining employment rate under an unchanged yearly wage rate. Moreover, if the demand elasticity for labour is less than one, it may be that, as in the chemical sector, each firm adjusts its wages to the (increased) other wages in the sector and, since turnover costs have become relatively more important, the new equilibrium rate of unemployment becomes higher than the equilibrium rate before working time was reduced.

We first estimate the alternative long run employment equation (14), suggested by Bodo and Giannini. The results of the estimation by ordinary least squares are in table 2. Since there is positive serial autocorrelation for paper, textiles and food and no conclusion for chemicals, we reestimated equation (14) by a maximum likelihood iterative technique in an AR1 procedure. For the metal sector, there is neither positive nor negative autocorrelation. The fit is extremely high (1.00), but some coefficients are insignificant.
The inverse of the output elasticity, the coefficient of ln Q_t, is everywhere positive but not always significant. It is larger than one in the chemical sector : a boom in production is leading to an extra increase in optimal labour. In the other sectors, the effect is much smaller : an increase of production only leads to a partial increase in labour.
The employment elasticity of capital, the coefficient of ln K_t, is in the range of 0.13 to 0.36, except for the chemical sector where it is less than 0.10. This coefficient is significant for all the sectors considered. The small value of the coefficient is different from the Leontief case, where this elasticity is equal to one. The positive sign of the coefficient we estimated means that an increase of capital should lead to an increase in optimal labour, i.e., that (optimal) capital and (optimal) labour are both increasing over time.
However, we observe from our data that only in the chemical sector observed labour and observed capital are positively related to each other. The coefficient of the time variable is for all the sectors negative and significant, in the range of - 5 % to - 1 % per year. This means that the technological progress is labour saving, which confirms the previous result of larger labour saving technological progress than capital saving technological progress.
The negative of the coefficient of ln H_t is the impact of a reduction of actual working time on optimal employment. This effect is everywhere positive : a reduction of actual working time leads to an increase in employment. This increase is larger than one in the metal sector; this can be due to the existing multicollinearity (1 % reduction of working time results in a 1.02 % increase in employment). The effect is small in the chemical sector : a decrease of actual working time with 1 % only leads to an increase of optimal employment with 0.07 %, again reflecting labour hoarding in this sector.

Table 2 : Estimation results of equation (14)
(standard error between brackets)
dependent variable : $\ln L_t^*$

	OLS	AR1	OLS	AR1
	CHEMICALS		PAPER	
constant	-49.66(44.82)	-40.29(41.73)	-11.31(14.84)	-8.05(11.03)
$\ln Q_t$	2.34 (1.81)	1.95 (1.68)	0.50 (0.63)	0.45 (0.43)
$\ln K_t$	0.09 (0.03)	0.10 (0.03)	0.36 (0.08)	0.29 (0.07)
t	-0.01(0.002)	-0.009(0.003)	-0.03(0.007)	-0.03 (0.01)
$\ln H_t$	-0.12 (0.12)	-0.07 (0.12)	-0.22 (0.46)	0.16 (0.38)
$R^2;\bar{R}^2$	0.75;0.70	1.00;1.00	0.89;0.87	1.00;1.00
DW	1.43	1.74	0.58	1.34
£	65.41	65.79	41.39	49.67
U	0.01	0.001	0.004	0.001
	TEXTILES		FOOD	
constant	-11.07 (9.83)	-0.90 (7.83)	5.39 (9.00)	3.27 (6.88)
$\ln Q_t$	0.65 (0.39)	0.26 (0.29)	0.09 (0.31)	0.16 (0.25)
$\ln K_t$	0.22 (0.09)	0.23 (0.07)	0.15 (0.03)	0.13 (0.03)
t	-0.05 (0.01)	-0.05 (0.01)	-0.02(0.003)	-0.01 (0.003)
$\ln H_t$	-0.32 (0.35)	0.23 (0.25)	-0.05 (0.18)	0.15 (0.14)
$R^2;\bar{R}^2$	0.97;0.97	1.00;1.00	0.94;0.93	1.00;1.00
DW	0.65	1.31	0.87	1.59
£	38.82	44.38	61.45	66.66
U	0.004	0.003	0.002	0.001
	METALS			
constant	-5.23 (4.52)	-5.39 (4.43)		
$\ln Q_t$	0.83 (0.16)	0.84 (0.16)		
$\ln K_t$	0.18 (0.04)	0.17 (0.04)		
t	-0.05(0.005)	-0.05 (0.005)		
$\ln H_t$	-1.01 (0.23)	-1.02 (0.23)		
$R^2;\bar{R}^2$	0.94;0.93	0.97;0.97		
DW	2.04	2.02		
£	52.52	52.53		
U	0.002	0.002		

Sample : 1962-'84 (annual data)

In a last step, we estimated equation (9') for optimal labour and its relating equation for capital stock, the long run employment function and the long run capital stock function simultaneously. This is done by full information maximum likelihood (FIML), using the Gauss method, assuming that the error terms follow a bivariate normal distribution. The results of this procedure are given in table 3. Because of the relatively small number of observations and the complex form to be estimated, we had to consider A and α as constants in order to have the opportunity of estimating the parameters of technological progress (γ_1 and γ_2), of returns to scale (μ) and the substitution parameter (ρ, where $\frac{1}{\rho+1}$ is the elasticity of substitution).

After some trials, the parameter A is set equal to one, while α, the distribution parameter of labour, is fixed at 0.3. If A is set equal to 100 or 1000, all coefficients become insignificant. Higher or lower values of α do not change the results considerably.

Positive serial autocorrelation of the error terms remains in the long run capital stock equation for all the five sectors, as shown in table 3. In the long run employment functions, significant positive autocorrelation of the error terms remains for the sectors textiles and food, while the Durbin-Watson test is inconclusive for chemicals, paper and metals.

We find increasing returns to scale for all the sectors : μ is everywhere significantly larger than one (from 1.33 in textiles to 1.43 in chemicals). The long run elasticity of substitution, σ, is in the range of 0.25 to 0.43. The parameter is the smallest in the textile sector but the largest in chemicals. This is contrary to what we found in the OLS and AR1 estimations of equation (6a') in table 1, where σ was negative for chemicals, smaller than 0.10 for paper, textiles and metals, and 0.76 for food; these results were however in the partial adjustment case. In the estimations of equations (9') and (9b') for chemicals, we discover however a high multicollinearity between the vectors of the first order partial derivatives of equation (9') with respect to μ, γ_1 and γ_2 on the one hand and ρ on the other hand, so that the results for chemicals in table 3 are somewhat unreliable.

Table 3 : Estimation results of equation (9') and the relating capital stock equation simultaneously, by FIML (method : Gauss) (standard errors between brackets)
Dependent variables : $\ln L^p$ and $\ln K$

	CHEMICALS	PAPER	TEXTILES	FOOD	METALS
γ_1	-0.04(0.002)	-0.02(0.001)	0.003(0.002)	-0.02(0.001)	-0.02(0.002)
γ_2	-0.16(0.01)	-0.15(0.01)	-0.14 (0.01)	-0.16(0.01)	-0.15(0.01)
ρ	1.31(0.04)	1.88(0.03)	3.03 (0.09)	1.83(0.04)	2.09(0.04)
$=>\sigma$	0.43(0.007)	0.35(0.004)	0.25 (0.000)	0.35(0.000)	0.32(0.000)
μ	1.43(0.005)	1.40(0.002)	1.33(0.004)	1.38(0.003)	1.37(0.002)
£	8.24	21.97	-2.86	9.61	8.13
$\ln L^p$					
DW	1.16	1.23	0.81	0.55	1.23
SSR[(a)]	0.73	0.30	1.472	0.54	0.66
SER[(b)]	0.17	0.11	0.25	0.15	0.17
$\ln K$					
DW	0.44	0.93	0.54	0.39	0.58
SSR[(a)]	2.20	1.16	2.98	1.79	2.39
SER[(b)]	0.30	0.22	0.35	0.27	0.32

sample : 1961-'84

(a) SSR = sum of squared residuals

(b) SER = standard error of the regression

The parameters of labour augmenting and capital augmenting technological progress, γ_1 and γ_2, are almost everywhere significantly negative. For some sectors, these parameters turn to be positive if A is very large, but, as mentioned before, in that case all parameters are insignificant and the Durbin-Watson statistic is at about 0.0002.
The negative sign of the technological progress parameters can be explained by the existing relationship between returns to scale and technological progress. The effects of innovation can be divided in 3 elements, i.e., returns to scale, labour augmenting and capital augmenting technological progress. If these effects are correlated, it is hard to see which effect is at work (Fuss & Waverman (1978)). The correlation can be detected by calculating the multicollinearity existing between the vectors of the first order partial derivatives of equation (9') with respect to μ, γ_1 and γ_2. These correlation coefficients are for all sectors in the range (-) 0.75 to (-) 0.99, except for the correlation between the partial derivatives w.r.t. μ and γ_2 for textiles, which is -0.51.

4.3. Short run model estimations

Similarly as for the long run, we first estimate our own short run employment function (equation (19)) by OLS. The Durbin-Watson test for serial autocorrelation of the error is inconclusive concerning positive autocorrelation. We reestimate by adding the lagged employment as an explanatory variable. Most autocorrelation disappears in these partial adjustment equations as can be concluded from the Durbin test, although there still remains some positive autocorrelation. It is important to know that there is multicollinearity between the explanatory variables, especially for chemicals and paper. The correlation between the costs and the time variable is larger than 0.9 for chemicals, paper and food; but this correlation coefficient is only 0.54 for textiles and 0.05 for metals. Multicollinearity also exists between the costs and the variable ln H in the sectors chemicals, paper and food : the coefficient is -0.99 for those three sectors, but small for textiles (-0.45) and metals (0.05). The coefficient of correlation between the variables time and ln H is larger than -0.95 for all the five sectors. The variable z, the non wage labour cost, is not introduced in the estimations due to the lack of data at the sectoral level. This means that total labour costs are not fully observed.

A partial adjustment process yields a better fit for all sectors considered. However, for paper, textiles and metals, the OLS estimation without partial adjustment yields better results considering the sign and the magnitude of the coefficients and the derived parameters. In what follows, we only consider the partial adjustment estimations for chemicals and food and the simple OLS results for paper, textiles and metals (see table 4).

The inverse of the coefficient of the labour costs variable leads to the parameters θ and σ (the latter being equal to $\frac{1}{1+\theta}$). The parameter θ is significant for chemicals, textiles and metals but not for paper and food. The elasticity of substitution between labour and capital is small for metals (perfect complementarity), textiles (0.06) and chemicals (0.49) but much larger for paper (1.72) and food (3.13).

Table 4 : Estimation results of equation 19 (standard error between brackets)
dependent variable = $\ln L_t$

variables [parameters] \ procedure	OLS	OLS partial adjustment	OLS	OLS partial adjustment
	CHEMICALS		PAPER	
constant	-17.68 (21.39)	-10.70 (22.09)	-9.59 (4.30)	-1.17 (3.12)
$\ln costs_t$ 1)	1.08 (0.20)	0.96 (0.23)	-2.39 (0.60)	-0.67 (0.49)
$\ln Q_t$	0.66 (0.85)	0.35 (0.89)	0.47 (0.15)	-0.08 (0.14)
t	0.001 (0.002)	-0.000 (0.002)	-0.016 (0.003)	-0.006 (0.003)
$\ln H_t$	1.17 (0.22)	1.03 (0.25)	-2.57 (0.65)	-0.57 (0.55)
$\ln L_{t-1}$	-----	0.09 (0.08)	-----	0.23 (0.04)
[θ] [σ]	0.93(0.23);0.52(0.06)	1.04(0.21);0.49(0.05)	-0.42(3.43);1.72(10.2)	1.49(0.22);0.40(0.04)
[ν] [η]	1.52(0.37);-0.14	2.86(0.11)-0.20	2.13(0.03);0.38	-12.5(0.01);1.25
[γ]	-0.002(0.005)	0.000(0.006)	0.034(0.013)	-0.075(0.148)
R^2; $\bar{R}^2$	0.96; 0.95	0.97; 0.96	0.94; 0.93	0.98; 0.97
DW/h	1.30	2.27	1.54	-0.48
£; U	69.43; 0.12	77.85; 0.01	67.10; 0.17	78.85; 0.01
	TEXTILES		FOOD	
constant	-23.22 (5.30)	-4.29 (4.31)	7.28 (6.08)	-10.61 (7.13)
$\ln costs_t$ 1)	0.06 (0.07)	0.06 (0.04)	-2.54 (0.62)	-1.48 (0.58)
$\ln Q_t$	0.80 (0.16)	-0.15 (0.18)	-0.20 (0.23)	0.24 (0.22)
t	-0.011 (0.004)	0.007 (0.004)	-0.018 (0.003)	-0.009 (0.004)
$\ln H_t$	0.49 (0.21)	0.21 (0.13)	-2.80 (0.72)	-1.53 (0.68)
$\ln L_{t-1}$	-----	0.55 (0.09)	-----	0.46 (0.13)
[θ]; [σ];	16.67(0.00);0.06(0.00)	16.67(0.00);0.06(0.00)	-0.39(4.00);1.64(10.8)	-0.68(4.80);3.13(47.0)
[ν]; [η];	1.25(0.10);-0.54	-6.67(0.00);1.00	-5.00(0.002);-1.3	4.17(0.01);0.21
[γ]	0.014(0.007)	0.047(0.049)	-0.09(0.105)	0.038(0.044)
R^2; $\bar{R}^2$	0.94; 0.92	0.98; 0.97	0.95; 0.93	0.97; 0.96
DW/h	0.92	1.65	1.11	1.86
£; U	47.47; 0.003	61.30; 0.01	64.25; 0.13	70.49; 0.10
	METALS			
constant	-9.23 (1.80)	-6.22 (1.30)		
$\ln costs_t$ 1)	-0.03 (0.02)	-0.01 (0.01)		
$\ln Q_t$	0.31 (0.06)	0.11 (0.05)		
t	-0.006 (0.002)	-0.003 (0.001)		
$\ln H_t$	0.11 (0.09)	0.15 (0.06)		
$\ln L_{t-1}$	-----	0.16 (0.03)		
[θ]; [σ];	-33.33(0.00);-0.03(0.00)	-100(0.00);-0.01(0.00)		
[ν]; [η];	3.23(0.00);-0.45	9.09(0.001);-1.45		
[γ]	0.019(-)	0.027(0.013)		
R^2; $\bar{R}^2$	0.93; 0.91	0.97; 0.96		
DW/h	1.22	1.31		
£; U	75.26; 0.15	86.36; 0.11		

R^2 = determination coefficient
$\bar{R}^2$ = adjusted determination coefficient
DW = Durbin Watson statistic
h = Durbin statistic, used if the lagged dependent variable is an explanatory variable
£ = log of likelihood function
U = Theil's inequality coefficient

Sample : 1961-'84

1) $\ln costs := \ln \phi w_o w - \ln[w\bar{H} + \phi w_o w(H - \bar{H} + H_h)]$

The coefficient of ln H is the (short run) elasticity of working time. This elasticity is significant for all the sectors, but its sign is varying : it is positive for chemicals (1.03), textiles (0.49) and metals (0.11) and negative for paper (-2.57) and food (-1.53). A negative sign means that a reduction of actual working time leads to a positive employment effect[1]. This means that a 1 % reduction of actual working time results in a 1.53 % increase of employment in the short run for food and in a 2.57 % increase of employment in the paper sector. This is generally contrary to the effects of a reduction of conventional working time, found in the previous paragraph; this effect was mostly positive but rather small (certainly smaller than one). The parameter η is between zero and one in the short run estimations for food and paper, respectively 0.21 and 0.38. For the other sectors, there is a negative η, representing labour hoarding : η is -0.20 for chemicals, -0.45 for metals and -0.54 for textiles. The labour hoarding is also playing in the chemical sector, as we already noticed in the long run.
The returns to scale parameter of production, ν, is significantly larger than one in all the sectors : 1.25 for textiles, 2.13 for paper, 2.86 for chemicals, 3.23 for metals and 4.17 for food. So we observe, as before, significant increasing returns to scale for all the sectors.

The parameter of technological progress, γ, can be derived from the coefficient of the time variable. This Hicks' neutral technological progress seems to be zero % in chemicals, which is hardly believable. It is between 1 % and 4 % per year for the other sectors, i.e., 1.4 % for textiles, 1.9 % for metals, 3.4 % for paper and 3.8 % for food. The lack of technological progress in chemicals can be explained partly by the multicollinearity existing between the vectors of the first order partial derivations of equation (19) with respect to γ and η : it is difficult to separate the effects of technological progress and of returns to scale of working hours.

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[1] See however the note on page 16.

The distribution parameter β and the efficiency parameter B cannot be identified out of the linear estimations because they only appear in the constant term.

From the equations with the partial adjustment process, we can derive the average delay of adjustment, by dividing the coefficient of the lagged dependent variable by one minus this coefficient. The adjustment coefficient of $\ln L_{t-1}$ is significant in all the five sectors studied. The average adjustment time is somewhat more than 1 month (0.099) for chemicals, 0.190 for metals, 0.300 for paper, 0.852 for food and about 15 months (1.222) for textiles, i.e., a very slow adjustment for this subsidized sector.

We also estimated Bodo's and Giannini's short run equations (15) and (16). Equation (15) however, has to be estimated simultaneously with equation (14), the optimal employment function. The results of this non linear least squares procedure are in table 5 ; equation (14) has been substituted in equation (15). Table 6 represents the results of the working hours equation (16) estimated by OLS and corrected for serial autocorrelation of the error by a maximum likelihood iterative procedure.

The coefficients of the non linear least squares estimation of the employment function (15) are not significant. The fit, R^2, is mostly low.

The coefficients of the estimated equation (16), the log linearized actual-hours-of-work-function, are mostly insignificant; however, R^2 is very high and even 1 in the AR1 ML-estimations.

Finally, we estimated relationships (19) and (20) simultaneously, by a full information maximum likelihood (FIML) procedure for implicit nonlinear functions. We use the Davidon-Fletcher-Powell minimization technique. Since first order autocorrelation of the error terms may occur, we decided to correct for this autocorrelation in relationship (19) by estimating $y_{1,t} = f_1(x_t, y_{2t}) + \rho_1 u_{1,t-1} + \varepsilon_{1,t}$ (or : $y_{1,t} = \rho_1 y_{1,t-1}$

Table 5 : Estimation results of equations (14) and (15) simultaneously, by non linear least squares (standard error between brackets); dependent variable = $\Delta \ln L_t$

	CHEMICALS	PAPER	TEXTILES	FOOD	METALS
β_o	3.95(20.57)	0.07 (2.86)	0.33(1.75)	-6.10(7.61)	2.47(0.90)
β_1	-0.24 (0.56)	0.08 (0.22)	0.25(0.27)	1.23(1.42)	0.51(0.21)
β_3	0.44 (0.12)	0.02 (0.03)	0.02(0.03)	0.05(0.02)	0.03(0.01)
α_o	-10.00 (0.00)	-10.00 (0.00)	5.00(0.00)	5.00(0.00)	-5.00(0.00)
α_1	0.18 (1.59)	1.54 (4.54)	-2.25(3.48)	0.23(0.49)	1.28(0.43)
α_2	0.13 (0.05)	0.11 (0.34)	0.38(0.38)	0.11(0.12)	0.01(0.08)
α_3	-0.01 (0.006)	0.01 (0.13)	-0.11(0.05)	-0.02(0.004)	-0.05(0.01)
α_4	0.11 (0.20)	-3.89(12.99)	3.34(3.43)	0.39(0.65)	1.55(0.90)
R^2, $\bar{R}^2$	0.78; 0.67	0.25; -0.10	0.45; 0.19	0.50; 0.27	0.71; 0.57
DW	2.40	1.07	1.86	1.78	1.95
£	74.78	101.32	103.93	124.04	119.281

Sample 1962-'84

Table 6 : Estimation results of equation (16) by OLS and AR_1
(standard error between brackets)
dependent variable : ln H

	OLS	AR_1, max. likelihood	OLS	AR_1, max. likelihood
	CHEMICALS		PAPER	
constant	-246.88 (111.35)	-156.55 (68.33)	-1.72 (6.20)	-0.97 (7.23)
$\ln Q_t$	6.02 (2.95)	6.42 (2.73)	-0.15 (0.37)	-0.08 (0.33)
$\ln Q_{t-1}$	4.02 (2.89)	0.00 (0.00)	0.18 (0.28)	0.12 (0.29)
$\ln K_t$	-0.31 (0.17)	-0.18 (0.14)	0.03 (0.48)	-0.06 (0.44)
$\ln K_{t-1}$	0.10 (0.15)	0.04 (0.13)	-0.03 (0.29)	0.03 (0.27)
$\ln \bar{H}_t$	0.39 (0.24)	0.86 (0.25)	0.13 (0.63)	0.39 (0.58)
$\ln \bar{H}_{t-1}$	0.21 (0.23)	-0.26 (0.26)	0.98 (0.49)	0.68 (0.46)
R^2; $\bar{R}^2$	0.96; 0.95	1.00; 1.00	0.98; 0.97	1.00; 1.00
DW	2.25	2.16	1.63	2.02
£	52.58	51.78	64.92	65.72
U	0.003	0.005	0.002	0.002
	TEXTILES		FOOD	
constant	-13.88 (7.70)	-10.50 (8.87)	14.22 (25.78)	11.07 (23.59)
$\ln Q_t$	-0.24 (0.28)	-0.31 (0.27)	-0.14 (0.50)	0.07 (0.46)
$\ln Q_{t-1}$	0.09 (0.32)	0.21 (0.31)	-0.53 (0.48)	-0.61 (0.44)
$\ln K_t$	0.74 (0.68)	0.38 (0.75)	0.07 (0.57)	0.10 (0.54)
$\ln K_{t-1}$	-0.46 (0.45)	-0.22 (0.50)	-0.04 (0.35)	-0.07 (0.33)
$\ln \bar{H}_t$	0.92 (1.40)	1.19 (1.23)	0.25 (0.77)	-0.31 (0.74)
$\ln \bar{H}_{t-1}$	1.47 (1.06)	0.95 (0.90)	1.05 (0.60)	1.58 (0.59)
R^2; $\bar{R}^2$	0.94; 0.92	0.99; 0.99	0.96; 0.95	1.00; 1.00
DW	1.62	2.02	2.24	1.94
£	44.80	45.48	59.96	60.50
U	0.05	0.005	0.002	0.002
	METALS			
constant	-20.30 (5.71)	-14.33 (7.31)		
$\ln Q_t$	0.37 (0.18)	0.22 (0.17)		
$\ln Q_{t-1}$	-0.20 (0.17)	-0.05 (0.16)		
$\ln K_t$	0.50 (0.39)	0.17 (0.39)		
$\ln K_{t-1}$	-0.28 (0.24)	-0.08 (0.24)		
$\ln \bar{H}_t$	0.37 (0.57)	0.37 (0.53)		
$\ln \bar{H}_{t-1}$	1.93 (0.49)	1.61 (0.48)		
R^2; $\bar{R}^2$	0.98; 0.97	1.00; 1.00		
DW	1.75	2.03		
£	60.71	61.20		
U	0.002	0.004		

Sample : 1962-'84

$+ (f_1(x_t, y_{2,t}) - \rho_1 f_1 (x_{t-1}, y_{2,t-1})) + \varepsilon_{1,t})$, instead of $y_{1,t} = f_1(x_t, y_{2,t}) + u_{1,t}$. For the implicit function, relationship (20), we estimated $f_2 (x_t, y_t) - \rho_2 f (x_{t-1}, y_{t-1}) = \varepsilon_{2,t}$, with $y_t := (y_{1,t}, y_{2,t})'$ and x_t being the vector of exogenous variables at period t. The autocorrelation correction is carried out for both relationships; as a consequence we have two extra parameters to be estimated, i.e., ρ_1 and ρ_2. Because of the complex form of the equations, we decided to estimate the constant term as a whole, i.e., we estimated c_1 and c_2 instead of $-\frac{1}{\theta} \ln \frac{\eta}{\nu\beta} - \frac{1}{\nu} \ln B$ and $\frac{\nu}{\eta} \beta B^{-\frac{\theta}{\nu}}$ respectively. Since the effects of substitution, returns to scale and technological progress are difficult to distinguish, we have fixed one of these parameters, namely the returns to scale parameter ν. The largest value of the log of likelihood was, after a lot of trials, obtained by fixing ν at 1, implying constant returns to scale between capital K and employment L, but not necessarily between the capital and labour inputs. A small deviation from 1 already resulted in much smaller values of the log of likelihood. The estimation results are in table 7.

Comparing the sum of squared residuals (SSR) of the H equation to the mean of H does not make sense; since we do not estimate the H time series in the implicit form (20).

Some autocorrelation of the error terms remains, even after the correction for first order autocorrelation, especially for chemicals and metals.

The substitution elasticity, $\sigma = \frac{1}{1+\theta}$, is in the range of 0.25 to 0.54; a small value is obtained in the metals sector. The parameter of technological progress, γ, is between 2 and 3 percent a year; the largest growth can be found in the chemical sector; this is not surprising. The technological progress is the smallest in the metals sector, which is indeed a sector without much progress : the existing big machines are used during a very long period. For the other sectors, the innovation parameter is about 2.4 to 3.0 % per year. The phenomenon of labour hoarding

Table 7 : Simultaneous estimations of equations (19) and (20) by FIML (method : DFP)
(standard error between brackets)
dependent variables : L and H

	CHEMICALS	PAPER	TEXTILES	FOOD	METALS
ν	1.0(-)	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
θ	1.26(0.01)	1.96(0.01)	1.86(0.04)	0.85(0.12)	2.93(0.00)
=> σ	0.44	0.34	0.35	0.54	0.25
γ	0.03(0.01)	0.025(0.01)	0.024(0.00)	0.03(0.01)	0.02(0.002)
η	0.80(0.03)	0.49(0.04)	0.41(0.03)	1.26(0.38)	0.34(0.02)
c_1	0.60(0.16)	1.07(0.46)	0.82(0.05)	0.51(0.38)	0.40(0.41)
c_2	2.03(0.36)	13.68(3.04)	4.83(0.42)	3.56(1.20)	0.10(0.01)
ρ_1	0.90(0.05)	0.92(0.14)	0.23(0.09)	0.44(0.29)	0.99(0.12)
ρ_2	0.96(0.11)	0.91(0.11)	0.23(0.13)	0.93(0.33)	1.00(0.12)
£	207.61	198.93	147.90	143.52	196.74
L-eq.(19)					
SSR	0.03	0.02	0.15	0.07	0.09
SER	0.03	0.03	0.08	0.06	0.06
DW	2.66	1.62	1.55	1.01	2.68
h	2.17	1.28	1.23	-	-2.06
H-eq.(20)					
SSR	0.93	0.76	3.15	2.03	7.37
SER	0.20	0.18	0.36	0.29	0.55
DW	2.48	1.59	1.64	1.20	2.73
h	-1.40	1.19	1.14	-	-2.21

Sample : 1960-'84

is no longer reflected by the parameter η : all η's are significantly positive. The smallest value is again located in the metals sector (0.34). The parameter is larger than one for food.

The relationship between employment and total labour costs is described by $\frac{-1}{\theta}$; this coefficient is -0.34 for metals, -0.51 for paper, -0.54 for textiles, -0.79 for chemicals and -1.18 for food. A negative value for $\frac{-1}{\theta}$ implies that an increase in total labour costs results in a decrease in employment. The coefficient is - in absolute value - smaller than one for four sectors, which means that an increase (decrease) in labour costs leads to a smaller decrease (increase) in employment. The relation between the overtime wage rate and employment is a reverse one : an increase in the overtime wage rate is leading to a growth (although mostly smaller than one) in employment. In that case, the expensive overtime hour is partially replaced by a cheaper working hour of an outsider, i.e., of a new employee. This is less followed in the metals sector.

The employment elasticity of hours of work is approximated by the coefficient $-\left(\frac{\eta\theta-\nu}{\nu\theta}\right)$ (see footnote on p. 16). This coefficient is the expression of the effect of a reduction of actual working time on employment. This effect is very small but positive in metals (0.001), paper (0.02) and textiles (0.13), while it is negative for chemicals (-0.006) and food (-0.08), which is consistent to our long run findings (certainly w.r.t. chemicals).

However, as noted before, the effect of a reduction of actual working time on employment cannot be identified with the employment elasticity of working hours. Firstly, the effect plays also through the labour costs variable, where H is appearing too. Secondly, while regression parameters include both, ups and downs, the implication of a policy cannot be detected completely from the elasticity.
As the employment elasticity of working hours is only an approximation to the effect of a reduction of working time, we decided to simulate some employment policies with the help of estimated equations (19) and (20).
We simulated the impact of a policy carried through in 1984 and sustained in 1985; we only simulated the short run impact of the policy, i.e., the effects for 1984 and 1985; hence, we were able to use exact known values for the exogenous variables. To make simulation results comparable to those in section 4.4, where we use the model of Bayar a.o. (1986), we wanted to simulate the effects of three different employment policies.
The policies are 1) a decrease of the hourly wage rate by 5 %, 2) a contractual working time reduction by 5 % with wage compensation (i.e., an increase of the hourly wage rate) and 3) a contractual working time reduction by 5 % without any wage compensation.
However, due to the lack of data about the variable z, we estimated equation (19) in corrected form for autocorrelation with z:= 0, so that the hourly

wage rate, w, appears in both, the nominator and the denominator of the first parameter θ^{-1} As a consequence, the impact of the change of hourly wage rate on employment cannot be detected, similarly for the equation (20). As a consequence, we can only carry through the policy of a 5 % reduction of conventional working time without any assumption concerning the wage rate. The simulation is compared to a base simulation where no employment policy is considered. Because of the implicit form of equation (20), and the resulting impossibility of estimating the actual hours of work series, we had to work in two successive steps for the simulation of H. First, we approximated the impact of the different levels of contractual working time on actual working time by a Gauss-Seidel iterative procedure. Secondly, we used the obtained values for H as exogenous variable in estimating the policy impact on employment. Hence, actual working time is firstly considered as endogenous (whilst employment is exogenous) and afterwards as exogenous (employment becomes endogenous). The impact on employment is found out by a SIML-procedure in TSP.
The results are in table 8.

The effects are very diverging between the different sectors. In two sectors, food and metals, the 5 % reduction of contractual working time does not lead to any reduction of actual working time at all. In textiles, the reduction of actual working time is delayed, i.e., only appearing during the second year, but it is larger than the decrease in contractual working time, i.e., 7.2 %. For chemicals, the decrease in contractual working time is dashed past by the reduction in actual working time. This can be explained by the labour hoarding existing in this sector. For the paper sector, the decrease in actual working time is very extreme in the first year but becomes smaller than the 5 % reduction of contractual working time in the second year.
The effects on employment vary also very much among the sectors. Again, food and metals behave in the same way : the employment decreases due to a decrease in contractual working time (although the decrease in employment is smaller than the contractual RWT). The combination of the stagnating actual hours of work and the decrease in employment, suggest an excess supply of labour. In the textiles sector, the delay in adjustment of actual hours of work is accompanied by a delay in adjustment in employment. In this sector, the normal effect is playing : the reduction of contractual working

Table 8 : The effects of a 5 % reduction of contractual working time in 1984, by simulating equations (19) and (20).

	CHEMICALS		PAPER		TEXTILES		FOOD		METALS	
	'84	'85	'84	'85	'84	'85	'84	'85	'84	'85
actual working time										
base	1486	1386	1611	1611	1390	1340	1584	1584	1499	1499
sim	-250	-200	-450	-50	-0	-97	-0	-0	-0	-0
	(-16.8%)	(-14.4%)	(-39.8%)	(-3.2%)	(-0.0%)	(-7.2%)	(-0.0%)	(-0.0%)	(-0.0%)	(-0.0%)
employment										
base	79804	82190	47975	48859	95795	93726	92792	89589	370903	357645
sim	+2922	-3909	+10501	-8289	+0	+2069	-2498	-1359	-2031	-237
	(+3.7%)	(-4.8%)	(+21.9%)	(-17.0%)	(+0.0%)	(+2.2%)	(-2.7%)	(-1.5%)	(-0.5%)	(-0.0%)

time by 5 % is accompanied by an increase of employment, although in the second year only and by 2.2 % only. For chemicals and paper, an opposite effect appears : the sustained reduction of contractual working time is leading to an increase of employment only in the first year. In the second year, the employment reduces again, not only compared to the base simulation but even in comparison with the absolute 1984 level in the simulation. However, there are considerable differences between these two sectors, chemicals and paper. In chemicals, the increase of employment is 3.7 % in the first year, while the decrease in the second year is 4.8 %. For paper, the percentages are much larger : + 21.9 % in the first year and - 17.0 % in the second, always compared to the base simulation. The fact that the policy has positive effects only in the first year, explains the delay in the adjustment of the production process.

The simulation results do not only vary among the different sectors, but are also different from the obtained result in our macro economic simulation study with the Maribel model (PLASMANS, J. and A. VANROELEN (1986)). However, we will not compare the results yet at this moment. First, we will have a look at another model on the sectoral level existing in Belgium, i.e., the model of Bayar e.a. (86). This model, its estimation results and the simulation results, are described in sector 4.4. At the end of section 4.4, a brief comparison between the results we obtained by the Bayar e.a.-model, our own micro model and the Maribel macro model is performed.

4.4. A comparison with an alternative sectoral model for Belgium

Bayar, Deimezis, Guillaume and Meulders estimated a macro-sectoral model for employment and hours of work (Bayar A. a.o. (1986)).
They started from a Leontief production function, i.e.,

$$Q^p = A \cdot K \qquad (21a)$$

$$Q^p = B \cdot LA^{f*} \qquad (21b)$$

where LA^{f*} = 'efficient' (or 'desired') labour activity at full capacity utilization,
A = capital productivity,
B = labour activity productivity.

This means that

$$LA^{f*} = \frac{A}{B} \cdot K = C \cdot K \qquad (22),$$

where the ratio between capital productivity and labour productivity, $\frac{A}{B} = C$, the complementarity index, is assumed to satisfy :

$$C = C_o \; e^{c_1 \; Kr/K} \; e^{c_2 \; CS} \; e^{c_3 (1/t)} \qquad (23),$$

where Kr = recent capital stock
$\equiv K_t - K_{t-5}$
CS = wage part in total output
$\equiv (L \cdot H \cdot w) / (p \cdot Q)$
1/t $\equiv$ trend, implying a progressive deceleration of exogenous productivity growth.

The labour and the productive capacity utilization are assumed to be interrelated as follows :

$$\frac{LA^f}{LA^{f*}} = \left(\frac{Q}{Q^p}\right)^d = DUC^d \qquad (24).$$

This means that an underutilization of labour is a function of the underutilization of the production capacity.
Labour activity is defined as a non linear relationship between employment and actual working hours :

$$LA = LH^{g}, \tag{25}$$

where g is the effect of a reduction of actual working time on labour activity.

The partial adjustment parameter of labour activity is $(1-\delta)$, while

$$\frac{LA_t}{LA_{t-1}} = \left(\frac{LA_t^f}{LA_{t-1}}\right)^{\delta} \tag{26}$$

with $0 < \delta < 1$.

From equations (22), (23), (25) and (26), the log linear relationship (27) can be derived :

$$\ln\left(\frac{L_t}{L_{t-1}}\right) = \delta \cdot \ln c_o + \delta \cdot c_1 \cdot \left(\frac{Kr}{K}\right) + \delta \cdot c_2 \cdot CS$$

$$+ \delta \cdot c_3 \cdot \left(\frac{1}{t}\right) + \delta \cdot \ln\left(\frac{K_t}{L_{t-1}}\right) + \delta \cdot d \cdot \ln DUC$$

$$- g \cdot \ln H_t + g(1-\delta)\ln H_{t-1} \tag{27}$$

Bayar a.o. also present an (ad hoc) equation relating actual to contractual working time, to the degree of capacity utilization and to the (inverse of) technological progress :

$$H = h_1 \cdot \bar{H}^{h2} \cdot DUC^{h3} \cdot e^{h4(1/t)} \tag{28a}$$

They estimated equations (27) and (28) for some subsectors of the Belgian manufacturing sector. As their subdivision is slightly different from ours (especially for metals and chemicals, the composition is different) and as they use weekly instead of yearly working hours, we reestimated the equations (27) and (28) with our own data, to make the results comparable to those found in sections 4.2. and 4.3.

We used non linear least squares (LSQ) for equation (27) and ordinary least squares (OLS) for the log linearized form of equation (28). The results are in tables 9 and 10.

The sample period is 1966-'84, which is shorter than in the previous section, because we have a lag of five years by computing the recent capital stock Kr.

The parameter δ can be considered as an indictor for the rigidities on the labour market. It is directly seen that $(1-\delta)$ is the coefficient of $\ln LA_{t-1}$, i.e., the partial adjustment parameter. For the chemical sector, the results were very bad if we let all the parameters vary : all the coefficients became insignificant. After some trials, we found the most significant results by fixing δ at a value of 0.5; this means that the average adjustment delay is one year in the chemical industry. The coefficient δ is significantly positive in the 4 other sectors and smaller than one in textiles, food and metals. The average adjustment delay is 5.7 years in textiles, 2.45 years in food and 0.92 years in metals, which is a larger delay than in our own model of the previous paragraph. The parameter δ is also the employment elasticity of the capital stock : an increase of the capital stock results in an inelastic increase of employment in textiles, food and metals, while it leads to an elastic growth of employment in the paper industry.
The effect of the relationship between capital productivity and labour activity productivity, i.e., complementarity, measured by the C-coefficient, is subdivided into the effects of new investments (the coefficient δc_1), of the wage part (δc_2) and of the inverse time trend (δc_3).

The coefficient of the wage part, δc_2, is negative (but insignificant) for four of the five sectors, i.e., chemicals, textiles, food and metals. The negative relationship between the wage part in total output and employment

Table 9. : Estimation results of equation (27), by LSQ (standard error between brackets); dependent variable : $\ln(\frac{L_t}{L_{t-1}})$

	CHEMICALS	PAPER	TEXTILES	FOOD	METALS
$\delta \ln C_o$	-7.52(0.65)	-18.22(2.92)	-11.74(1.58)	-10.99(3.72)	-5.50(1.14)
δ	0.50(-)	1.03(0.21)	0.85(0.10)	0.71(0.24)	0.48(0.11)
δc_1	-0.13(0.09)	-0.95(0.86)	-0.73(0.44)	-0.12(0.68)	-0.60(0.45)
δc_2	-0.63(0.25)	0.25(0.37)	-0.10(0.15)	-0.11(0.21)	-0.46(0.15)
δc_3	5.93(0.70)	12.26(7.88)	14.07(3.66)	6.20(6.34)	7.75(3.94)
δd	-0.20(0.33)	1.81(0.36)	1.50(0.20)	0.63(0.19)	1.78(0.33)
c_1	-0.27(0.17)	-0.92(0.69)	-0.85(0.48)	-0.17(0.91)	-1.27(0.84)
c_2	-1.27(0.49)	0.25(0.33)	-0.12(0.19)	-0.16(0.31)	-0.98(0.43)
c_3	11.85(1.40)	11.96(5.77)	16.53(3.26)	8.73(6.65)	16.32(6.53)
d	-0.40(0.66)	1.76(0.35)	1.76(0.08)	0.88(0.15)	3.74(0.47)
g	0.03(0.18)	-0.44(0.32)	-0.09(0.11)	-0.14(0.14)	0.27(0.23)
$R^2;\bar{R}^2$	-----	0.86; 0.78	0.93; 0.89	0.66; 0.49	0.90; 0.85
DW	1.94	2.59	2.22	2.15	2.35
£;U	50.13	54.65;	58.03;	60.28;	61.19;

Sample period : 1966-'84

Table 10 : Estimation results of equation (28), by OLS (standard error between brackets) ; dependent variable : ln H

	CHEMICALS	PAPER	TEXTILES	FOOD	METALS
constant	1.65(2.26)	-1.94(3.21)	-5.00(7.78)	-2.17(4.02)	-4.74(4.42)
$\ln \bar{H}$	0.77(0.30)	1.26(0.43)	1.65(1.05)	1.29(0.54)	1.62(0.59)
ln DUC	-0.66(0.74)	0.29(0.13)	0.24(0.13)	0.37(0.13)	0.38(0.31)
$\frac{1}{t}$	0.71(0.74)	-0.77(0.90)	-0.68(2.19)	-0.89(1.12)	-0.01(0.96)
$R^2;\ \bar{R}^2$	0.93; 0.92	0.96; 0.95	0.91; 0.89	0.95; 0.94	0.95; 0.94
DW	2.17	1.68	1.47	2.26	0.99
£; U	39.45; 0.004	52.36; 0.002	35.34; 0.005	48.27; 0.003	44.89; 0.003

Sample : 1966-'84

is logical : an increase in total labour costs due to an increase in the average actual hours of work or to an increase in the hourly wage rate, yields a decrease in employment. A positive sign of δc_2 can be explained if the increase in the wage part is due to an increase in employment; this is however not the case for paper over the sample period. If the degree of capacity utilization is increasing, labour activity will increase more than proportionally (d>1) in 3 sectors, i.e., paper, textiles and metals. The negative value of d for chemicals is due to a bad functioning of the labour market as previously remarked : an increase in the utilization rate of the production capacity results in a decrease in the utilization rate of labour.

The effect of a reduction of actual working time on employment is equal to the parameter g. A negative g, as can be found in the sectors paper, textiles and food, refers to labour hoarding. For paper and textiles, the results are in the same direction as by estimating equation (19). For food and metals, the effects are in the opposite way. In chemicals, g is positive, i.e., there should be no labour hoarding; this result is opposite to what we previously found (see later in this section).

We estimated equation (28), the actual hours of work equation, by ordinary least squares in its log linearized form, i.e.,

$$\ln H = \ln h_1 + h_2 \ln \bar{H} + h_3 \ln DUC + h_4(\frac{1}{t}) \qquad (28b)$$

The results are in table 10. We used the same sample period as for equation (27), i.e., 1966-'84. The Durbin-Watson test statistic shows that there is no autocorrelation of the error terms in chemicals and food, while the test is indecisive concerning positive autocorrelation for the other sectors.

The coefficient of $\ln \bar{H}$ is significantly positive in all sectors. This means that a percentage reduction of contractual working time is leading to a percentage decrease in actual working time. The coefficient is larger than one in all sectors, except in the chemical one. In the chemical sector, the decrease in actual working time is smaller than the reduction in contractual working time. By estimating equation (16), we found however that the coefficient representing the relation between contractual and actual working time was everywhere positive but smaller than one, although most coefficients were insignificant (see table 7). The coefficient h_3, representing the hours of work elasticity of the degree of capacity utilization, is significantly between zero and one, except for the chemical sector.

Reestimating equations (27) and (28) simultaneously, by a full information maximum likelihood procedure, gives approximately the same results. The parameter g does change into a small positive value for textiles and food (0.08 and 0.03 respectively), implying a positive result of a reduction of working time.

Following Bayar a.o., we have simulated some employment policies. As base simulation, we have taken the situation without any employment policy. We simulated only one year, i.e., 1985, while we did not want to use prospects for the exogenous variables but real values. The policy simulations carried through are threefold : a decrease of the wage rate, a decrease in contractual working time with wage compensation, and a reduction of contractual working time without wage compensation. The first simulation is to suppose a 5 % decrease of the nominal wage rate in 1984 in comparison with the base simulation, sustained in 1985. Simulations 2 and 3 start from a 5 % reduction of contractual working time in 1984, while the variable remains at the same lower level in 1985. In simulation 2, the hourly wage rate increases by 5 % in comparison with the base simulation, to keep the average annual personal income constant; this scenario is called working time reduction with wage compensation. In simulation 3, we also did carry through a 5 % reduction of contractual working time but without any wage compensation : the hourly wage rate remains at the base simulation level and, as a consequence, the annual wage decreases.
In table 11, the impact of those employment policies on the endogenous variables, i.e., employment and actual hours of work, always compared to the base simulation, can be found.

Table 11 : The effects of some employment policies in 1984 on employment and actual hours of work; by simulating the model of equations (27) and (28).

	CHEMICALS		PAPER		TEXTILES		FOOD		METALS	
	'84	'85	'84	'85	'84	'85	'84	'85	'84	'85
employment										
base	67595	66701	44434	50742	107875	112896	104941	106033	368876	257278
sim 1[a/]	+478	+668	-184	-343	+438	+729	+202	+260	+2595	+10767
	(+0.7%)	(+1.0%)	(-0.4%)	(-0.7%)	(+0.4%)	(+0.6%)	(+0.2%)	(+0.2%)	(+0.7%)	(+4.2%)
sim 2[b/]	-395	-162	-80	-208	-349	-81	+14	+100	+6888	+4752
	(-0.6%)	(-0.2%)	(-0.2%)	(-0.4%)	(-0.3%)	(-0.07%)	(+0.01%)	(+0.09%)	(+1.9%)	(+1.8%)
sim 3[c/]	+80	+292	-263	-425	+88	+369	+215	+288	+9531	+11145
	(+1.0%)	(-0.5%)	(-0.6%)	(-0.8%)	(+0.08%)	(+0.3%)	(+0.2%)	(+0.3%)	(+2.6%)	(+4.3%)
actual working time										
base	1489	1474	1633	1169	1317	1329	1576	1587	1461	1467
sim 1	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)	(-0%)
sim 2	-58	-57	-104	-137	-108	-109	-104	-104	-141	-142
	(-3.9%)	(-3.9%)	(-6.4%)	(-8.1%)	(-8.2%)	(-8.2%)	(-6.6%)	(-6.6%)	(-9.7%)	(-9.7%)
sim 3	-58	-57	-104	-137	-108	-109	-104	-104	-141	-142
	(-3.9%)	(-3.9%)	(-6.4%)	(-8.1%)	(-8.2%)	(-8.2%)	(-6.6%)	(-6.6%)	(-9.7%)	(-9.7%)

a/ sim 1 = 5 % reduction of hourly wage rate

b/ sim 2 = 5 % increase of hourly wage rate + 5 % reduction of contractual working time

c/ sim 3 = hourly wage rate constant + 5 % reduction of contractual working time

A 5 % sustained decrease in the nominal hourly wage rate (this is in this model equal to the real wage rate) does not result in a 5 % increase in employment : the effect is always much smaller. Except for the metal sector, where the 5 % decrease in the wage rate results in a 4.2 % increase in 1985, the effect is everywhere smaller than one percent. The negative value for paper is surprising, it must be due to a bad functioning of the labour market or to structural sector characteristics. The effects are in all the sectors larger in the second than in the first year of the wage rate reduction policy. This policy does not have any effect on the actual hours of work, while this variable does not depend on the labour costs in this model.

The effects of a sustained reduction of contractual working time with wage compensation are very differing.
Only in the sectors food and metals, the employment increases slightly (less than 1 % in food, in the range of 1 % to 2 % in metals). In the other sectors, we even note a decrease in employment, due to the increasing labour costs. The effects are smaller in 1985 than in 1984, which is the opposite of the result of the wage decrease in simulation 1. The actual hours of work decrease with more than 5 %, except for chemicals. This is in contrast with the results previously found in our macro economic simulation study with the Maribel model, where a 10 % reduction of contractual working time resulted in approximately 5 % reduction of actual working time.
A reduction of contractual working time with 5 % without wage compensation, i.e., with a constant hourly wage rate and, as a consequence, a decrease in the annual income (simulation 3), results in a positive effect on employment for all the sectors, except for the paper industry. The effect is always less than 5 %; the increase in employment is in the range of 0.1 % to 4.0 %. The largest effect can again be found in the metals sector, in the second year. The effects are in all the sectors larger in 1985, so we can conclude that there is always a delay in the adjustment process. The effects are always larger in this simulation without wage compensation than in simulation 2 with a wage compensation, which was also our conclusion in our macro economic approach.

Simulations 2 and 3 result in the same decrease in the actual hours of work. According to this model, a reduction of contractual working time with or without wage compensation does not affect the actual hours of work but only plays by way of employment.
Which policies are to be preferred to reduce unemployment in the different sectors ? It is dangerous to conclude this out of this small model simulation, because of the limitation of the model and the lack of the knowledge of the effects in the medium and the long run. We can only say that, according to this model, the reduction of the wage rate is the most efficient employment policy for chemicals and textiles.
For the food and the metals sector, the policy of reduction of working time without wage compensation gives the best results, while all policies are inefficient for the paper industry. Except for this sector, a decrease in the hourly wage rate results everywhere in an increase in employment, but this is not the best scenario for food and metals. In these 2 sectors, all policies are labour-creating, although the increase in employment is always less than the sacrifice in income. However, in the food and metals sector, even a reduction of working time without income loss is efficient. In the other sectors, this policy leads to more unemployment.

A comparison of the results obtained here with the simulation results of our own short run model of equations (19) and (20) is not so easy. Firstly, in the Bayar a.o. (1986) model, the hourly wage rate is an important variable with respect to the level of employment. In our own theoretical model, the wage rate is also important, but in the empirical application it looses its importance : according to the model, a lack of data on non-wage labour costs "shrinkens" the influence of the hourly wage rate. Secondly, in our own model, actual working time is only implicitely defined related to contractual working time; there exists however an explicit (although ad hoc) relationship between both variables in the model of Bayar e.a. Thirdly, employment does not rely on the capital stock in the model of equations (19) and (20), while it does in the model of equations (27) and (28).
So, all results are that much related to the respective models, that a meaningful comparison is nearly impossible. We only venture some general

remarks. We compare the simulation of our own model to the third simulation of the Bayar a.o. model, because in both simulations, the hourly wage rate is not influenced. In the model of equations (27) and (28), contractual working time reduction always influences the actual working time, which is declining in the range of 3.9 % to 9.7 %. The effects are mostly the same in both years, except for paper, where the second year effect is larger. In the model of equations (19) and (20), there are two sectors without any impact of a contractual RWT on actual WT, i.e. food and metals. In any other sector, the effect is equal in both years; in textiles the reduction is larger in the second year while it declines in chemicals and paper. According to the Maribel model simulations, carried through in our 1986 paper, a 10 % contractual working time leads to a 5.6 % reduction of actual working time.

Concerning the effects on employment, the differences are rather considerable. Except for the paper industry, the contractual reduction of working time is labour creating in all sectors in both years in the Bayar a.o. model, although the increase is always smaller than the decrease in contractual and actual working time. In our own model simulation, there are negative effects in food an metals for both years, and for the second year in chemicals and paper (profit maximizing behaviour). The RWT only leads temporaly to a increase in chemicals and paper. A comparison with the results of the simulation of the 10 % contractual RWT for the entire private sector with Maribel, together with a sustained wage rate, makes clear that according to that model, there is always a labour creating effect which is always smaller than the RWT.

5. Concluding remarks

In this paper, we have investigated the relationship existing between working time, employment and production, by estimating a short run and a long run micro economic labour time model. We have done this for five subsectors of the Belgian manufacturing sector, i.e., chemicals, paper, textiles, food and metals, for the sample period 1960-'84.

The long run model is defined for a profit maximizing firm, being constrained by a constant elasticity of substitution production function, allowing for substitution between labour and capital. An employment function and a capital stock function can be derived by solving the profit maximization problem (see equation (9)).

In the short run, we assume a production technology with limited substitution possibilities. The optimization problem is now a cost minimization one, under the constraint of the production function. The total costs comprise not only fixed costs and normal labour costs, but also overtime work costs and non wage labour costs, i.e., costs related to the number of people employed instead of to the hours worked. This short run optimization program can be solved w.r.t. the number of employees and w.r.t. the average number of actual working hours per employee (see equations (19) and (20)).

We estimated both models,but with some constraints due to the lack of data,at the sectoral level. We were not able to introduce the number of shifts because this is strongly varying over the different firms and even over the different plants within a firm. We could not introduce the non wage labour costs either since sector-aggregated data of these costs are not available. This leads to a large underestimation of total labour costs, since non wage labour costs reach a high level nowadays (see Hart (1984)). This makes it impossible to introduce the insider-outsider problem into our model (see Lindbeck and Snower (1986)). Labour turnover costs (i.e., hiring, firing and training costs) make that firms prefer to keep insiders on the job instead of hiring and firing new employees. This phenomenon of labour hoarding, i.e., a distinction between actual and efficient employment, will be underestimated because of the lack of data on the non wage labour costs.

Our first interest is to detect the relationship between labour time and employment, but we also analyze the effects on employment of a growth in production, of technological progress and returns to scale, and of labour costs and capital costs.
We do not only estimate our own long run and short run model, but do either reestimate the models proposed by Bodo and Giannini (1985) and by Bayar, Deimezis, Guillaume and Meulders (1986) (see equations 14 to 16 for Bodo a.o. and 27-28 for Bayar a.o.). The model of Bodo a.o. starts from a Cobb Douglas production function; Bayar a.o. suppose a Leontief production technology.

Comparing the regression results, we may conclude that a reduction of contractual working time leads only very partially to a hiring of new employees in the long run, and that in the chemical sector even less employment emerges owing to the bad functioning of its labour market (with a considerable amount of labour hoarding). In the short run, negative employment effects of a reduction of actual working time occur for the chemical, textiles and metals sectors, may be also due to depressive labour demand effects.

Also taking account of the wage rate evolution, we may observe that the reduction of the wage rate is the most efficient employment creating policy for chemicals and textiles. For the food and metals sector, the policy of reduction of working time without any wage compensation yields the best employment results, while all wage rate policies are inefficient for the paper industry.

APPENDIX A

LIST OF VARIABLES

$\bar{H}$ = the average contractual working time per employee per year in hours including holiday time (Source : Planning Bureau, 1986, note)

H = the average effective working time per employee per year in hours (Source : Planning Bureau, 1986, note)

H_h = number of hours not worked but paid, (i.e., holidays, public holidays, ...) per employee per year (Source : generated from paid holidays)

$H.s$ = time capital is used, in hours per year, where s = number of shifts (s = supposed to be 1 in these empirical applications).

L = average number of employees per year (L^p = potential employment) (Source : Planning Bureau, 1986, note)

w = average gross hourly wage rate (per unit cost of labour) (Source : National Institute of Statistics, Statistical Yearbook)

ϕw_o = average mark-up for overtime work on the unit cost of labour (e.g. : = 1 if no overtime, = 1.5 if overtime work)

z = non-wage labour costs per employee per year (not used in estimations)

A,B = constant term in the firm's production function = efficiency parameter

α = long run labour distribution parameter

β = short run labour distribution parameter

γ = Hicks' neutral technical progress parameter

γ_1 = labour-augmenting technological progress parameter in the long run production function

γ_2 = capital-augmenting technological progress parameter in the long run production function

σ = $\frac{1}{1+\rho}$ $(= \frac{1}{1+\theta})$ = LR(SR) elasticity of substitution

μ, ν, η = returns to scale parameters

Q.q = output per year, value added, current prices (Source : National Institute of Statistics, National Accounts)

Y.p = turnover per year, current prices (not used in estimations)

q = average (weighted) production price per unit (Source : National Institute of Statistics, National Accounts)

p = average (weighted) turnover price of selled products, per unit (not used in estimations)

Q = output per year, constant prices (Q^p = potential output) (Source : derived from Qq and q)

Y = turnover per year, constant prices

Π^g = gross profits per year

Π^n = net profits per year

X = exports per year

I = gross investments per year (Source : National Institute of Statistics, National Accounts)

K = level of capital goods, i.e., the book value of the working-stock, at the end of each year (Source : generated from I and δ)

c = average per unit user's cost of capital per year = $g \times (r+\delta)$ (see Jorgenson, 1986)

g = average per unit purchase value for investments per year (Source : National Institute of Statistics, National Accounts)

r = average per unit costs of maintenance of capital goods per year (Source : Planning Bureau, Mirabel databank)

δ = average per unit depreciation rate of capital stock per year (Source : Planning Bureau, Mirabel databank)

APPENDIX B

A SECOND ORDER APPROXIMATION FOR THE LR-CES MODEL

To perform a second order truncated Taylor expansion about $\rho = 0$ (Cobb-Douglas case) for the logarithm of the term between [ ] in reduced form relationship (8), for z:=0 (see relationship (8'), p. 19), we denote this expression as :

$$f(\rho) = \ell n[\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}}] , \qquad (B.1)$$

with $\underline{w} = (w\bar{H}+z)$

so that its first order derivative can be evaluated as

$$f'(\rho) = \frac{1}{\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} + (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}}} . [\alpha^{\frac{1}{\rho+1}} (\ell n\alpha) e^{\frac{-\gamma_1 \rho t}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} .$$

$$. \frac{-1}{(\rho+1)^2} - \gamma_1 e^{\frac{-\gamma_1 \rho t}{\rho+1}} \alpha^{\frac{1}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} \frac{1}{(\rho+1)^2} t + \underline{w}^{\frac{\rho}{\rho+1}} (\ell n\ \underline{w}) \alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}}$$

$$. \frac{1}{(\rho+1)^2} + (1-\alpha)^{\frac{1}{\rho+1}} (\ell n(1-\alpha)) e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}} \frac{-1}{(\rho+1)^2}$$

$$- \gamma_2 e^{\frac{-\gamma_2 \rho t}{\rho+1}} (1-\alpha)^{\frac{1}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}} \frac{1}{(\rho+1)^2} t - (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} (\ell n(\bar{s}\bar{H}))(1-\alpha)^{\frac{1}{\rho+1}} .$$

$$. e^{\frac{-\gamma_2 \rho t}{\rho+1}} c^{\frac{\rho}{\rho+1}} \frac{1}{(\rho+1)^2} + c^{\frac{\rho}{\rho+1}} (\ell n\ c)(1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} . \frac{1}{(\rho+1)^2}]$$

$$= \frac{\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} (\ell n\ \underline{w} - \ell n\ \alpha - \gamma_1 t) + }{(\rho+1)^2 (\alpha^{\frac{1}{\rho+1}} e^{\frac{-\gamma_1 \rho t}{\rho+1}} \underline{w}^{\frac{\rho}{\rho+1}} + }$$

$$\frac{+ (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}} (\ell n\ c - \ell n(1-\alpha) - \gamma_2 t - \ell n(\bar{s}\bar{H}))}{+ (1-\alpha)^{\frac{1}{\rho+1}} e^{\frac{-\gamma_2 \rho t}{\rho+1}} (\bar{s}\bar{H})^{\frac{-\rho}{\rho+1}} c^{\frac{\rho}{\rho+1}})} \qquad (B.2),$$

or, replacing $\rho = 0$, the first derivative becomes :

$$f'(0) = \alpha(\ell n\ \underline{w} - \ell n\ \alpha - \gamma_1 t) + (1-\alpha)(\ell n\ c - \ell n(1-\alpha) - \gamma_2 t - \ell n(\bar{s}\bar{H})). \qquad (B.3)$$

The second order derivative of $f(\rho)$ can similarly be computed for $\rho = 0$ as :

$$\begin{aligned} f''(0) = {} & \alpha(\ell n\ \underline{w} - \ell n\ \alpha - \gamma_1 t)^2 + (1-\alpha)\ (\ell n\ c - \ell n(1-\alpha) - \gamma_2 t - \ell n(\bar{s}\bar{H}))^2 \\ & - \alpha^2(\ell n\ \underline{w} - \ell n\ \alpha - \gamma_1 t)^2 - (1-\alpha)^2\ (\ell n\ c - \ell n(1-\alpha) - \gamma_2 t - \ell n(\bar{s}\bar{H}))^2 \\ & - 2\ \alpha(1-\alpha)\ (\ell n\ \underline{w} - \ell n\ \alpha - \gamma_1 t)\ (\ell n\ c - \ell n(1-\alpha) - \gamma_2 t - \ell n(\bar{s}\bar{H})). \end{aligned} \qquad (B.4)$$

Hence, substituting (B.3) and (B.4) into a second order expansion of (B.1) at $\rho = 0$:

$$f(\rho) \stackrel{\sim}{=} f(0) + \rho\, f'(0) + \frac{\rho^2}{2} f''(0)$$

$$= 0 + \rho\,\alpha\,\ln \underline{w} - \rho\,\alpha\,\ln\alpha - \rho\,\alpha\,\gamma_1 t + \rho(1-\alpha)\ln c$$

$$- \rho(1-\alpha)\ln(1-\alpha) - \rho(1-\alpha)\gamma_2 t - \rho(1-\alpha)\ln(\bar{s}\bar{H})$$

$$+ \frac{\rho^2}{2}\{\alpha(\ln \underline{w})^2 - \alpha^2(\ln \underline{w})^2 - 2\,\alpha\ln \underline{w}\ln\alpha + 2\,\alpha^2\ln \underline{w}\ln\alpha + \alpha(\ln\alpha)^2$$

$$- \alpha^2(\ln\alpha)^2 + \alpha\,\gamma_1^2 t^2 - \alpha^2\gamma_1^2 t^2 - 2\,\alpha\gamma_1 t\ln \underline{w} + 2\,\alpha\,\gamma_1 t\ln\alpha$$

$$+ 2\,\alpha^2\gamma_1 t\ \ln \underline{w} - 2\,\alpha^2\gamma_1 t\ln\alpha + (1-\alpha)(\ln c)^2 - (1-\alpha)^2(\ln c)^2$$

$$- 2(1-\alpha)\ln c\ln(1-\alpha) + 2(1-\alpha)^2\ln c\ln(1-\alpha) + (1-\alpha)(\ln(1-\alpha))^2$$

$$-(1-\alpha)^2(\ln(1-\alpha))^2 + (1-\alpha)\gamma_2^2 t^2 - (1-\alpha)^2\gamma_2^2 t^2 + (1-\alpha)(\ln(\bar{s}\bar{H}))^2 - (1-\alpha)^2(\ln(\bar{s}\bar{H}))^2$$

$$-2(1-\alpha)\gamma_2 t\ln c - 2(1-\alpha)\ln c\ln(\bar{s}\bar{H}) + 2(1-\alpha)\gamma_2 t\ln(1-\alpha) + 2(1-\alpha).$$

$$\ln(1-\alpha)\ln(\bar{s}\bar{H}) + 2(1-\alpha)\gamma_2 t\ln(\bar{s}\bar{H})$$

$$+ 2(1-\alpha)^2\gamma_2 t\ln c + 2(1-\alpha)^2\ln c\ln(\bar{s}\bar{H}) - 2(1-\alpha)^2\gamma_2 t\ln(1-\alpha)$$

$$- 2(1-\alpha)^2\gamma_2 t\ln(\bar{s}\bar{H}) - 2(1-\alpha)^2\ln(1-\alpha)\ln(\bar{s}\bar{H})$$

$$- 2\,\alpha(1-\alpha)\ln \underline{w}\ln c + 2\,\alpha(1-\alpha)\ln \underline{w}\ln(1-\alpha) + 2\,\alpha(1-\alpha)\gamma_2 t\ln \underline{w}$$

$$+ 2\,\alpha(1-\alpha)\ln \underline{w}\ln(\bar{s}\bar{H}) + 2\,\alpha(1-\alpha)\ln\alpha\ln c - 2\,\alpha(1-\alpha)\ln\alpha\ln(1-\alpha)$$

$$- 2\,\alpha(1-\alpha)\gamma_2 t\ln\alpha - 2\,\alpha(1-\alpha)\ln\alpha\ln(\bar{s}\bar{H}) + 2\,\alpha(1-\alpha)\gamma_1 t\ln c$$

$$- 2\,\alpha(1-\alpha)\gamma_1 t\ln(1-\alpha) - 2\,\alpha(1-\alpha)\gamma_1 t\,\gamma_2 t - 2\,\alpha(1-\alpha)\gamma_1 t\ln(\bar{s}\bar{H})\} \quad (B.5)$$

or

$$f(\rho) = \rho\ \alpha\ \ell n\ \underline{w} - \rho\ \alpha\ \ell n\ \alpha - \rho\ \alpha\ \gamma_1 t + \rho(1-\alpha)\ell n\ c - \rho(1-\alpha)\ \ell n(1-\alpha)$$

$$- \rho(1-\alpha)\gamma_2 t - \rho(1-\alpha)\ \ell n(\bar{s}\bar{H}) + \frac{\rho^2}{2}\{\alpha(1-\alpha)\ [(\ell n\ \underline{w})^2 + (\ell n\ c)^2]$$

$$+ \alpha(1-\alpha)\ [(\ell n\ \alpha)^2 + (\ell n(1-\alpha))^2] + \alpha(1-\alpha)\ (\gamma_1^2\ t^2 + \gamma_2^2\ t^2)$$

$$+ \alpha(1-\alpha)\ (\ell n(\bar{s}\bar{H}))^2 - 2\ \alpha(1-\alpha)\ [\ell n\ \underline{w}\ \ell n\ \alpha + \gamma_1 t \ell n\ \underline{w}$$

$$- \gamma_1\ t\ \ell n\ \alpha + \ell n\ c\ \ell n(1-\alpha) + \gamma_2 t\ \ell n\ c + \ell n\ c\ \ell n(\bar{s}\bar{H}) - \gamma_2 t\ \ell n(1-\alpha)$$

$$- \ell n(1-\alpha)\ \ell n(\bar{s}\bar{H}) - \gamma_2 t\ \ell n(\bar{s}\bar{H}) - \ell n\ \underline{w}\ \ell n(1-\alpha) - \gamma_2 t\ \ell n\ \underline{w}$$

$$- \ell n\ \underline{w}\ \ell n(\bar{s}\bar{H}) - \ell n\ \alpha\ \ell n\ c + \ell n\ \alpha\ \ell n(1-\alpha) + \gamma_2 t\ \ell n\ \alpha + \ell n\ \alpha\ \ell n(\bar{s}\bar{H})$$

$$- \gamma_1 t\ \ell n\ c + \gamma_1 t\ \ell n(1-\alpha) + \gamma_1 t\ \gamma_2 t + \gamma_1 t\ \ell n(\bar{s}\bar{H})] - 2\ \alpha(1-\alpha)\ell n\ \underline{w}\ \ell n\ c\}$$

$$= \rho\ \alpha\ \ell n\ \underline{w} - \rho\ \alpha\ \ell n\ \alpha - \rho\ \alpha\ \gamma_1 t + \rho(1-\alpha)\ell n\ c - \rho(1-\alpha)\ \ell n(1-\alpha)$$

$$- \rho(1-\alpha)\gamma_2 t - \rho(1-\alpha)\ \ell n(\bar{s}\bar{H}) + \frac{\rho^2}{2}\ \alpha(1-\alpha)\ [\ell n\ \underline{w} - \ell n\ c - \gamma_1 t$$

$$+ \gamma_2 t + \ell n(\bar{s}\bar{H}) - \ell n\ \alpha + \ell n(1-\alpha)]^2, \qquad \text{(B.6)}$$

which can be substituted into reduced form expressions(8) and (9).

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