Is Aggregate Labour Demand Asymmetric? A VAR-model-based empirical investigation

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Abstract

This paper investigates the presence of asymmetry in the adjustment to equilibrium in the Italian labour market. Labour demand in the industrial sector is estimated with an asymmetric error correction model.

As firms can adjust labour demand by changing both the number of employees and the degree of utilization of labour force (worked hours), we estimate two different models. There is no evidence of asymmetry both when employment is measured in standard labour units, which take worked hours into account, and when labour input is measured in terms of employees, although in this latter case, adjustment costs and the difference between hiring and firing costs, underlying the asymmetric adjustment, should emerge more clearly.

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JEL classification: C32, E24, E32.

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1 Introduction

This paper investigates some issues of labour demand behaviour in order to assess the presence of asymmetries in employment fluctuations. It is motivated by a revival of interest in nonlinear dynamics in general, including the issue of asymmetric cycles (Hamilton 1989, Potter 1995, Sichel 1993, among others), and by recent studies on nonlinear adjustment costs in factor demand (Hamermesh and Pfann 1996a, Pfann and Palm 1993, Palm and Pfann 1997).

Asymmetry in labour fluctuations may be attributed to the changing behaviour of economy over the different phases of the business cycle and/or to the presence of asymmetric adjustment costs of the labour factor to its long-run equilibrium. According to the first hypothesis, different types of shocks may operate at different phases of the cycle (e.g. recessions may be caused by adverse supply shocks and expansions by demand shocks) and the propagation mechanism may change over the cycle (Acemoglu and Scott 1994, 1995; Burgess 1992a).

Within the framework set up by Sargent (1978), who models labour demand with quadratic adjustment costs, another strand of the literature has tried to explain the asymmetric behaviour of employment across the cycle by introducing non-smooth or asymmetric adjustment costs in the basic model, rejecting the idea that negative shocks are larger and less persistent than positive ones.[1] According to this line of inquiry, input dynamics out of equilibrium are asymmetric owing to the presence of linear costs, asymmetries in hiring and firing costs, fixed adjustment costs or lumpiness due to (S,s) rules (Hamermesh 1989, Pfann and Palm 1993, Palm and Pfann 1997, Bentolila and Bertola 1990, Caballero, Engel and Haltiwanger 1997).

This paper follows this latter approach and models an asymmetric labour demand using an asymmetric vector error correction model (AVECM), strictly related to the first-order conditions, stemming from the solution of a dynamic labour demand moldel under the constraint of asymmetric adjustment costs.[2]

[1] If this explanation were correct we would observe the same degree of asymmetry in the paths of output and employment. However, De Long and Summer (1986) find much less asymmetry in aggregate output than in production inputs (labour, capital) in the United States.

[2] Most papers investigate the particular dynamics of labour demand by directly estimating the equations resulting from the solution of some maximization equations, with GMM

The VAR approach can be useful to obtain a *statistically adequate* description of data, while cointegration and error correction representation allow us to deal with non-stationary data, retaining the relevant information about long-run equilibrium and the adjustment to it (Juselius 1993). Short-term adjustment is determined freely.[3]

We work with quarterly data and Italian industrial sector variables. Quarterly data are a natural choice for investigating cyclical behaviour. Moreover, as Hamermesh (1993) notes, annual data might produce biased estimates because lags in employment adjustment are fairly short. The paper is organised as follows. Section 2 outlines the basic labour demand model, investigates the possible causes of asymmetric adjustment of labour input, and discusses the problem of modelling net costs of adjustment and working with aggregate data. Sections 3 introduce cointegration and the asymmetric error correction model, the statistical tools of our empirical analysis. Section 4 reports our findings using two measures of labour input: standard labour units (the official measure of labour input in the national accounts) and the number of workers employed. Section 5 concludes.

2 Labour Demand

When hiring or firing is a costly procedure, the quantity and quality of employment are intertemporal decisions. In this case the "investment" in employment is in some degree irreversible and labour demand will be considerably affected by uncertainty.

When it takes time and is costly to adjust the actual level of employment to the desired level, employment is a medium-term investment. In this respect, dynamic labour demand treats labour as one of the production factors and most of the dynamic approach used in investment theory is applied to labour demand (Hamermesh 1993, Pfann and Palm 1997).

By and large, the recent literature provides a partial equilibrium analysis

applied to Euler's first-order conditions (Pfann and Palm 1993, Pfann 1996). Others, such as Bentolilla and Bertola (1990) and Burgess (1992a), use the calibration approach to carry out simulations. However, Hamermesh (1995) stresses that GMM and other nonlinear estimation methods are very unsatisfactory when applied to short time series.

[3]Economic theory is often not informative enough about dynamics. Morover, generally, aggregation does not preserve microdynamics (Lee and Pesaran and Pierce 1990).

of the labour demand in a dynamic intertemporal setting. Usually, the model is a description of the demand side of the labour market and is conditioned on some exogenous variables. From the marginal condition, one obtains Euler's equations describing the optimal adjustment of the labour factor, away from the optimum.

In the absence of adjustment costs, the first-order condition amounts to making marginal revenue equal to marginal cost and the dynamic problem yields the same solution as the static labour demand specification. Away from the static optimum, however, the costs associated with changing output drive a wedge between price and marginal cost. This gives rise to a less elastic supply response in the short run than in the long run, as introducing adjustment costs makes it no longer optimal to adjust labour input to the equilibrium level in a single time period. The representative firm may find it optimal to spread the adjustment process out over several time periods, and thus reduce current adjustment costs even though this means a less efficient level of production.

In the standard case of quadratic adjustment costs (Sargent 1978, Nickell 1986), labour demand N_t, will be generated by resolving the following problem:

$$\min_N E_t \sum_{j=0}^{\infty} \beta^j (N_{t+j} - N^*_{t+j})^2 + w(\Delta N_t)^2 \tag{2.1}$$

where N^* is the stationary equilibrium level of N, satisfying some steady state first-order condition (Nickell 1986), whereas $w(\cdot)$ is the cost of adjusting the stock in the unit of time.

The first-order condition at time t is:

$$\beta E[w\Delta N_{t+1}] = w(\Delta N_t) + (N_t - N^*_t) \tag{2.2}$$

which yields the following linear autoregressive solution:

$$(1 - \lambda L)N_t = (1 - \lambda)(1 - \beta\lambda) \sum_{j=0}^{\infty} (\beta\lambda)^j E(N^*_{t+j}) \tag{2.3}$$

where L is the *lag operator* $LX_t = X_{t-1}$ and λ, the adjustment coefficient, is the stable root from the second -order polynomial in the Euler equation.

This model requires the specification of the determinants of the optimal level N^*_t. In general, N^* depends on the revenue function, the technology and the other economic variables of the firm's environment. A set of exogenous variables, assumed to be known by the economist, the empirical specification of technology and market conditions allow us to determine a long-run relation such as $N_t^* = f(X_t)$. Once we know N_t^*, we can estimate (2.3).

If we suppose that the target level N_t^* is linearly related to the firms non-deterministic forcing variables:

$$N_t^* = \alpha X_t + u_t \tag{2.4}$$

then the closed form solution for this model can be written as:

$$(1 - \lambda L)N_t = \alpha(1 - \lambda)\theta(L)X_t + (1 - \lambda)(1 - \beta\lambda)v_t \tag{2.5}$$

where $\theta(L)$ is a polynomial dependent on the process which generates X_t.

This closed final form stems from the hypothesis of quadratic adjustment costs and can be easily estimated.

In the following section, we briefly introduce the determinants of N^*. In the context of a VAR model, they also constitute the variables to be modelled.

2.1 Long-Run Determinants

In this section we review the problems involved in selecting the variables determining N^*, the static equilibrium level or long-run steady-state level of employment.

The neoclassical scheme holds that real wages are the only determinant of employment, generally adding a trend to account for technical progress and the "missing" capital stock.

1) Capital stock. Capital stock is predetermined in the short run, although in the long run all factors can be adjusted and the capital stock will have a role. Normally, capital adjustment is ignored because of the absence of high-frequency data on capital. Hamermesh (1993) shows that estimates of dynamic labour functions are not biased if the adjustment of capital is ignored. Bentolilla and Bertola (1990) and Pfann and Palm (1993) neglect the existence of capital. Peeters (1993) is a rare exception.

2) *Production.* In the neoclassical framework with price-taker firms in both labour and good markets, the production level is endogenously determined as a consequence of profit maximization and should therefore not enter the set of determinants of employment.

Nevertheless, if firms work along the production frontier, capital can be expressed in terms of levels of activity (in monopolistic competition or perfect competition, firms always fulfill demand), so output may be added as a scale parameter.[4]

Thus, output and capital stock should not be taken as variables accounting for employment, unless a regime of disequilibrium is assumed so that the output/demand variables allow for demand-side constraints.

3) *Wages.* Although the neoclassical approach is based on relative prices of factors, including intermediate goods and raw materials, if labour demand is separable in value added and materials prices we can specify the equation using wages deflated by the value-added deflator, without including material prices. Since we are working with national accounts data, we follow this approach.[5]

Choosing a measure of the price of labour is more difficult (see Hamermesh 1993). We simply use a labour cost variable taken from national accounts, i.e. compensation of employees. This amounts to wages plus social security contributions.

4) *Employment.* Finally, for labour input, the literature normally uses two measures: the total number of worked hours and the number of employees, depending on the availability of data and the aim of the study. Clearly, if workers are homogeneous and work the same number of hours per period, the choice is irrelevant. On the other hand, if they differ in terms of hours worked, using the number of employees to represent the quantity of labour will be inappropriate: if hours per worker are correlated with factor prices or output, estimations will be affected by an omitted variable *bias*. The problem is more relevant in cross-sectional studies where working hours may vary substantially across plants and firms.

Using total hours instead of the number of employees amounts to assuming that employees and hours are perfect substitutes and have the same adjustment costs.

Hamermesh and Pfann (1996b), Wulfsberg (1996), Burgess (1988, 1992a, 1992b,) use the number of workers.

In this study we assume a homogeneous workforce, measured by the two

[4]Burgess (1988) uses capital instead of output as scale variable, whereas Leoni *et al.* (2000) use industrial production.

[5]Other price variables may be used to normalize wages. For instance, in Burgess (1988) labour costs are deflated by wholesale output prices.

official measures of labour input: standard labour units and the number of employees (fig. 1).[6] The former measure is the official variable in the European System of Accounts[7] and is consistent with the other national accounts aggregates. Since we work with Italian national accounts aggregate data, standard labour units are the natural measure of labour input. This measure allows for the different amount of hours worked by each worker and weights the different labour positions with the ratio of hours worked to the average hours established by contract.[8]

The other measure, the number of workers, represents the number of persons at work, regardless of hours worked by each. It is based on the Istat quarterly labour force survey, which, through a sample of 75,000 households, provides the main indicators of the Italian labour market.

HERE ABOUT FIGURE 1

2.2 Asymmetric Adjustment

In discussing asymmetries most of the literature relies on partial equilibrium models, skipping the difficulty of distinguishing variations in demand and, therefore, the nature of adjustment costs, from variations in labour supply. However, unless supply is explicitly modelled, employment asymmetries may appear, although they are not related with the asymmetries generated by the adjustment costs.[9] Although we are not carrying out a structural model, this caveat applies to our analysis because of the set of variables concerning the labour demand side we pick up.

[6]The word "employment" in this paper refers to labour input in general.

[7]See ESA (1995).

[8]Introducing the concept of "full-time equivalence", a measure of hours worked by a full-time worker, according to contractual hours, Istat is able to estimate the labour force in terms of the total hours worked, although official statistics in Italy do not include total hours actually worked per worker. The theoretical relation between total hours (THL) actually worked and standard labour units (LU) is

$$LU = \frac{THL}{HC}$$

where HC is the average hours worked in a full-time position (Leoni *et al.* 2000).

[9]See Hamermesh (1993). Bentolila and Bertola (1990) emphasize the limits of the partial equilibrium model, but they do not mention the "identification" problem.

To face this problem, Hamermesh (1993) specifies the asymmetries explicitly by allowing changes in employment (in hours or number of workers) to respond differently to changes in each of the forcing variables, depending on whether this change is positive or negative. Since the hypothesis of a symmetric quadratic function implies that the costs a firm faces when hiring are equal to those when firing, Hamermesh suggests introducing non-convex costs or using convex cost functions which take into account asymmetries between hiring and firing costs.

Nickell (1986) and Hamermesh and Pfann (1996) discuss several forms of adjustment cost functions and their implications for dynamic labour demand theory. For instance, the linear adjustment cost model is found to be consistent with instantaneous hiring and firing, that is, with a static rather than dynamic demand model. In this paper we are going to use Pfann and Verspagen's (1989) cost function, who, in order to extend the basic dynamic model, introduce an asymmetric but convex specification that encompasses the quadratic form as a special case:

$$C(\Delta N_t) = w(\Delta N_t)^2 + 2\exp(b\Delta N_t) - (1 + b\Delta N_t) \tag{2.6}$$

where ΔN_t is the net variation in the workforce.

For $b \neq 0$ costs are not symmetric: $b > 0$ implies that hiring costs are marginally higher than firing costs, and viceversa in the case of $b < 0$[10].

2.3 Net Costs and Asymmetry

Analysis of the adjustment costs comprises the distinction between gross and net costs. Since in this study we consider a homogeneous labour input, we model the growth rate of employment, measuring the net costs of adjustment. We can only measure the net changes in employment. If we were able to measure gross flows (hiring, firing and quits) separately, we would have a more precise estimation of adjustment costs in terms of gross costs, because net costs are zero when the stock is unchanged ($\Delta N = 0$) whereas gross costs are positive. Morover, rather than using (2.6) for estimating asymmetry, we could model each flow separately.

[10]They estimate the cost of adjusting the workforce in Dutch manufacturing industry at the firm level, measuring the net changes in number of workers and find evidence of asymmetry (namely, hiring costs exceed firing costs).

Although these data are not available either at the aggregate level or at quarterly frequency, we show that an investigation is still possible.

A useful way to think about these costs is the relationship between the amount of the labour input and its flow. The net variation in the workforce ΔN can be expressed as:

$$\Delta N = H - (F + Q) \tag{2.7}$$

where H, F and Q are, respectively, the number of workers per period who are hired and fired and the voluntary quits.

Hamermesh (1995) investigates the importance of the distinction between gross adjustment costs (hiring costs) and net costs (the cost of changing the level of employment). He evaluates the weight of these costs with the following cost function:

$$C_t = b_1(\Delta N_t)^2 + b_2(H_t)^2 \tag{2.8}$$

where the first term reflects the cost of changing the level of employment (net cost) and H_t denotes the number of hires (gross costs). Notice that the cost function is symmetric and quits are exogenous.

If both costs matter ($b_1 = b_2 > 0$), it is possible to observe asymmetric labour fluctuations, even when net costs are symmetric.

Taking quits into account might affect the size of asymmetry in labour demand, but it does not eliminate it. Quits do not generate a direct cost, but an indirect replacement cost.

Normally quits are assumed at a constant rate (Jaramillo *et al.* 1993, Pfann and Palm 1993), but Hamermesh and Pfann (1996b) stress that quits are more numerous during economic expansions. According to a search approach to labour market, during expansionary phases workers may find more job openings.

Actually, voluntary turnover is more strongly procyclical than employment. During booms quits rise rapidly, so that both net costs and gross costs of new hiring are generated, whereas in recessions quits are few and the costs of the slowdown in demand consist nearly entirely in those of changing the employment level. Even if the net costs are symmetric, the procyclicality of quits and the presence of gross costs guarantee asymmetry in the path of aggregate employment.

In conclusion, working with net flows should not affect the possibility of testing asymmetry in employment adjustment.

2.4 Working on aggregated data

A further interesting question is what kind of costs we should observe at the aggregate level. Using nonlinear (but convex) adjustment cost functions may not turn out to be the right approach to modelling firm's behaviour. The continuous and smooth adjustment supposedly stemming from convex cost functions has been called into question by Bertola and Caballero (1990), who suggest that adjustment costs at firm level are non-convex, non-differentiable and also discontinuous.

There might be fixed or "lumpy" adjustment costs, regardless of the size of the adjustment. Moreover, Hamermesh (1989), who models an adjustment cost function with fixed cost, notices that even at very low levels of aggregation the fixed cost component becomes non-significant and the convex component prevails.

Lumpy adjustment costs can be identified only using firm-level data, whereas in sectoral models lumpy costs appear in the constant term of the first-order conditions, which varies across different regimes (Pfann 1996).

From a theoretical point of view, Bertola and Caballero show that a kinked adjustment function may result at the aggregate level when aggregate shocks are large relative to firm-specific shocks.[11]

In this study we propose neither to characterise and test microeconomic behaviour nor to aggregate that behaviour up to the level of a sector. We test whether at the aggregate level a simple model of (homogeneous) labour demand, with firms facing identical adjustment costs, can add information to track and understand the fluctuations in aggregate employment (see also Hamermesh and Pfann 1996a).

In order to avoid misinterpretation of the analysis undertaken in this paper, we stress that aggregation may hide differences in adjustments at the firm or sectoral level. In the light of the accumulating evidence for nonlinearity in macroeconomic time series and the fundamental asymmetry existing

[11] The role of common shocks in preserving nonlinearity under aggregation has been investigated by Granger and Lee (1999): if common factors are present at the micro level, the same nonlinearity is likely to be present at the aggregate level.

between expansions and recessions of economic activity, we aim to understand if the aggregate cyclical fluctuations are still explained by nonlinear-quadratic approximations. Therefore, we interpret the kinds of asymmetries / nonlinearities by means of an economic model rather than simply finding them with statistical tests.

3 Cointegration and Asymmetric ECM

Cointegration theory is invoked to model economic relations among non-stationary variables. A set of K integrated non-stationary variables $y_t \sim I(1)$, described by the autoregressive representation:

$$y_t = v + \sum_{i=1}^{p} A_i y_{t-i} + u_t \tag{3.1}$$

is a cointegrated process, if there is some linear combination $c\prime y_t$ which is stationary, that is $I(0)$. If variables are K, there may be up to $K-1$ stationary relations.

Strictly linked to this definition is the concept of Error Correction Model (ECM): a cointegration relation can be equivalently expressed as an error correction model (Engle and Granger 1987):

$$\Delta y_t = v + \sum D_i \Delta y_{t-i} + \Pi y_{t-p} + \varepsilon_t \tag{3.2}$$

subtracting y_{t-1} from both members and rearranging, where $D_i = -I_k - \sum_{J=1}^{i} A_j$ and $D_i = -I_k - \sum_{J=1}^{i} A_j$; $\Pi = I_k - \sum_{J=1}^{p} A_j$.

Written in this form the model is stationary, given that the differenced variables are $I(0)$ and Πy_{t-p} is stationary as well, because the matrix associated with the variables in levels Π indicates the number of stationary cointegrated relations linearly independent.

This matrix can be decomposed in $\Pi = \alpha\beta'$, a matrix of dimension $K \times r$ and rank r: α represents the matrix of adjustment coefficients of the system to the stationary relations $\beta' y_t$. These stationary relations are commonly interpreted as long-run relations of the system.

In what follows we determine long-run equilibrium relations of labourdemand, using the multivariate maximum likelihood procedure introduced by Johansen (1988, 1995).

Conditioned on the long-run linear relations, we model the short-run fluctuations of employment with an asymmetric error correction model. Conditioning a nonlinear model on a cointegration linear space is quite common (Hall *et al.* 1997, Holly and Jones 1997), but analyses using a multivariate model are rare.[12]

When the speed of employment adjustments towards the long-run level depends on whether employment is above or below its equilibrium level, the reaction to a shock is asymmetric and linear error correction is therefore not suitable to describe dynamics. Escribano and Pfann (1998) suggest a nonlinear or asymmetric error correction model as a reasonable approximation to the dynamic optimization problem under asymmetric adjustment costs. This model is described below and various types of asymmetric adjustment mechanisms are illustrated.

This way of modelling asymmetry was introduced by Granger and Lee (1989) and developed in Granger and Swanson (1996) and has been used in several applications. Cover (1992) uses it to describe the effect of expansive or restrictive monetary policies, Kandil (1999) to analyze economic fluctuations in response to demand and supply shocks. Cook, Holly and Turner (1999b) use the Escribano and Pfann method to extend a life-cycle model with an asymmetric consumption response, while Holly and Jones (1997) study housing price dynamics in UK with this adjustment mechanism.

Let us consider the relationship between a pair of variables (Y, X), where X is assumed to be weakly exogenous for Y :

$$\phi(L)Y_t + \theta(L)X_t = -g\left(Y_{t-1} - \alpha X_{t-1}\right) + e_t \qquad (3.3)$$

where $\phi(L)$ and $\theta(L)$ are usual polynomials of lags and $g()$ stands for a generic nonlinear term. If Y_t e X_t are non-stationary series, Engle and Granger (1987) show that the autoregressive representation in levels possesses an equivalent representation in terms of an error correction model. Let us consider the following decomposition of the two polynomials of lags (Johansen 1995):

$$\begin{aligned}\phi(L) &= \phi(1) + \phi^{**}(L)(1-L) \\ \theta(L) &= \theta(1) + \theta^{**}(L)(1-L)\end{aligned}$$

[12]See, for istance, Pfann and Palm (1993), Pfann (1996) and Palm and Pfann (1997).

which substituted in (3.3) yields the nonlinear representation of the ECM:

$$\phi^{**}(L)(1-L)Y_t+\theta^{**}(L)(1-L)X_t=-\phi(1)Y_{t-1}-\theta(1)X_{t-1}-g\left(Y_{t-1}-\alpha X_{t-1}\right)+e_t \tag{3.4}$$

Decomposing the long-run terms $\phi(1)=\Gamma_1\alpha_1$; $\theta(1)=\Gamma_2\alpha_1$ and dividing by α_1, we have:

$$\phi_\alpha^{**}(L)(1-L)Y_t+\theta_\alpha^{**}(L)(1-L)X_t=-\Gamma_1(Y_{t-1}-\alpha X_{t-1})-g_\alpha\left(Y_{t-1}-\alpha X_{t-1}\right)+e_t \tag{3.5}$$

where the subscript α indicates that functions in (3.4) are divided by α.

As the first member of the equality is the traditional linear symmetric error correction term, this general representation embodies the linear model ($g_\alpha=0$). Since the error correction term is supposed to be stationary, (1, $-\alpha$) is a cointegration vector.

Nickell (1985, 1986) shows that the linear-quadratic problem of labour demand (2.1) has a solution in error correction form reparameterization.Yet, when the traditional problem is extended by introducing asymmetric adjustment costs (AAC) in the form suggested by Pfann and Verspagen (1989):

$$AAC=w(\Delta Y_t)^2+2(\exp b\Delta Y_t))-(1+b\Delta Y_t) \tag{3.6}$$

Escribano and Pfann (1998) show that the solution of the maximization problem is nonlinear, but it may be approximated by a piecewise linear error correction representation. In fact, when we substitute the cost function (3.6) in the problem (2.1), first-order conditions are:

$$E[w\Delta Y_{t+1}+\exp b\Delta Y_{t+1}-1]=w(\Delta Y_t)+(Y_t-Y_t^*)+b(\exp b(\Delta Y_t)-1) \tag{3.7}$$

Euler's equation (3.7) doens't have a closed form and traditionally has been estimated by GMM, which allows a consistent estimation, given that ΔY_t and $(Y_t-Y_t^*)$ are stationary (Pfann and Palm 1993, Pfann 1996).

The alternative solution suggested by Escribano and Pfann (1998) is to approximate nonlinearity by piecewise linearity:

$$\phi_\alpha(L)(1-L)Y_t=-(1-\lambda_1)(Y_{t-1}-\alpha X_{t-1})^- -(1-\lambda_2)(Y_{t-1}-\alpha X_{t-1})^+$$

$$+\alpha(1-\lambda)\theta_{\alpha}(L)X_t(1-L)X_t+v_t \qquad (3.8)$$

The precise parameterization of this nonlinear error correction model depends upon its particular applications. Granger and Lee (1989) utilise:

$$\begin{array}{|lcl|}\hline (Y_{t-1}-\alpha X_{t-1})^- &=& (Y_{t-1}-\alpha X_{t-1}) \textit{ if } (Y_{t-1}-\alpha X_{t-1})<0 \\ (Y_{t-1}-\alpha X_{t-1})^- &=& 0 \text{ otherwise} \\ (Y_{t-1}-\alpha X_{t-1})^+ &=& (Y_{t-1}-\alpha X_{t-1}) \textit{ if } (Y_{t-1}-\alpha X_{t-1})>0 \\ (Y_{t-1}-\alpha X_{t-1})^+ &=& 0 \text{ otherwise} \\ \hline \end{array}$$

Escribano and Pfann (1998) suggest instead:

$$\begin{array}{|lcl|}\hline (Y_{t-1}-\alpha X_{t-1})^- &=& (Y_{t-1}-\alpha X_{t-1}) \textit{ if } \Delta(Y_{t-1}-\alpha X_{t-1})<0 \\ (Y_{t-1}-\alpha X_{t-1})^- &=& 0 \text{ otherwise} \\ (Y_{t-1}-\alpha X_{t-1})^+ &=& (Y_{t-1}-\alpha X_{t-1}) \textit{ if } \Delta(Y_{t-1}-\alpha X_{t-1})>0 \\ (Y_{t-1}-\alpha X_{t-1})^+ &=& 0 \text{ otherwise} \\ \hline \end{array}$$

In the first case the ECM term is partitioned into positive or negative deviations above or below its mean. By contrast, in Escribano and Pfann's definition the ECM term is split according to whether the difference of the ECM term is positive or negative. In the context of our model, these two forms allow us to evaluate the path of employment out of equilibrium depending on whether it is above or below the equilibrium level and on whether it is decreasing or increasing respectively.[13]

The asymmetric ECM can be easily estimated applying the two-stage procedure introduced by Engle and Granger (1987). In the multivariate framework, it amounts to modelling short-run dynamics, conditioned on the cointegration space, spanned by the estimated cointegration relationships.

4 Empirical Findings

This work is inspired by previous analyses that use the methodology of cointegrated VAR: Chiarini (1997), who estimates Italian labour demand using a standard linear vector error correction model, and Krolzig and Toro

[13]Normally, both asymmetric ECMs are allowed for (Cook *et al.* 1999b, Escribano and Granger 1998).

(1999), who investigate output and employment fluctuations with a Markov-switching VAR.

A multivariate approach is rather unusual in labour demand models (see Hamermesh and Pfann 1996a), although a problem of simultaneity of employment, real wage and output (value added or production) arises. As a matter of fact, i the usual univariate analysis of labour demand endogeneity of output is often overlooked in empirical studies (e.g. Hamermesh and Pfann 1993, 1996a).

In a single equation estimation, endogeneity can be mitigated by excluding the current value of that variable, making it predetermined, but bias may still occur, if disturbances are serially correlated.

In the following, we deal with this problem by modelling a system, an unrestricted reduced form VAR, where all variables are endogenous and residuals are innovations (uncorrelated white noise errors) against the available information set. Before conditioning on some non-modelled X_t exogenous variable, we test for X_t to be weakly exogenous for the parameters of interest.

Gorter *et al.* (1997) show that when output exogeneity cannot be rejected, the speed of adjustment of employment and the elasticity of employment with respect to output are seriously affected.[14]

The model presented here is less stylised than Krolzig and Toro's and it allows for Chiarini's findings on the enlargement of the set of variables.

Chiarini, in the work cited above, sets out a VAR with employment, value added, labour cost, total hours worked and turnover.[15] With this set of variables for the Italian industrial sector, he reaches two findings that are going to be relevant for our analysis:

a) there is no cointegration relationship between output and employment unless a labour cost variable is introduced;

b) employment turns out to be weakly exogenous for the cointegration vector, when the model is extended with turnover and hours worked. In accordance with Chiarini's results then, we do not include hours in our model, because they affect cointegration relations,[16] while we include labour costs.

[14]This kind of analysis is likely to be model-specific, but dynamic labour demand specifications are often very similar.

[15]Available only for the large firms, used as a *proxy* for the whole sector.

[16]In addition, Leoni *et al.* (2000) note that hours worked per employee, when labour is measured in terms of standard labour units, might be correlated with the dependent

The latter are also a key variable in both neoclassical and new-Keynesian models of labour demand, being the price of factor to be modelled, but they are surprisingly neglected in Krolzig and Toro's model.

We model the industrial sector's labour demand, using logs of quarterly data over the period 1970: 1998:3 of the sector's value added (VA), employment measured in standard labour units (LU) and labour costs (CL). Value added and labour costs are expressed in real terms, deflated by the value-added implicit deflator. A trend is added to allow for technical progress. Raw materials are assumed separable from the other factors; firms are price-takers and, therefore, output is endogenous.

In contrast with the principle of *general to specific* in the general VAR model, it seems more useful to follow the principle of specific to general in the choice of information set (Juselius 1993). In other VAR specifications, several variables are left out, such as strikes, unemployment benefits and capital stock (see Tyrvainen 1995 and Chiarini 1997). Provided that labour demand analysis produces a large set of different results, due to the different sets of relevant variables involved in the estimations, in order to assess the robustness of our findings, we have carried out our analysis starting from different sets of variables. As a result, capital and its price were then added, using the investment deflator as a *proxy*. Moreover, several employment aggregates were taken into account: industry, industry excluding constructions, manufacturing, the business sector. Different cointegration relations were obtained, but the findings, in terms of cyclical behaviour, do not change: the model discussed below is only one of the possible models.

Our empirical analysis starts from an unrestricted VAR model in levels of our variables of interests. According to the usual ADF test[17], all variables are I(1), although CL is more probably trend stationary (Table 1)

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variable itself, thus entailing inconsistency of the estimation.

[17] ADF(5) test is provided by the t-statistic on $\hat{b}$

$$\Delta x_t = a + bx_{t-1} + \sum_{i=1}^{5} c_t \, \Delta x_{t-i} + u_t$$

Rejection of $b = 0$ implies that $\Delta x_t \sim I(0)$. $a \neq 0$ implies a trend in the series, suggested unless the data is known to have a zero mean in differences (Doornik and Hendry 1997).

Table 1. Unit Root Tests					
	EM	OD	VA	CL	Crit. values
ADF(5)	-1.325	-2.025*	2.884	2.716	$-1.943(5\%)$ / $-2.585(1\%)$
ADF(5) + const.	-0.776	0.336	-1.809	-4.676**	$-2.888(5\%)$ / $-3.192(1\%)$

The unrestricted VAR model constitutes the statistical system against which all hypotheses are tested. Its main requirement is that it must be a *congruent*[18] representation of the data, which implies that $\widehat{u_t}$ in (3.1) is an innovation process against $Y_{t-1} = (y_{t-1}, y_{t-2}, ...y_{t-p})$. This crucially depends on adequate specification of the lag structure and on the selected variables. The number of lags p is chosen in order to achieve white noise, homoskedastic residuals. It is important to avoid too many lags, since the number of parameters increase rapidly with the lag length. Since Johansen's method is based on the time independence of residuals, an important criterion for the choice of lag length is that the residuals should be uncorrelated.

On the basis of these considerations, a VAR(2) is selected[19] where few lags are necessary even though we are working with quarterly data, a result that could be related to the selection of an appropriate set of variables of the model. As our analysis implicitly assumes that the data-generating process is nonlinear, we recall that, for instance, in the MSVECM case the initial linear VAR with finite lags is only an approximation. Thus, we also modelled an unrestricted VAR(3) on our data, but our results are unchanged in terms both of cointegration space and of short-run dynamics.

The estimation is carried out using the Gaussian maximum likelihood procedure proposed by Johansen (1988). The cointegration rank is estimated as the number of stationary independent relations between the levels of variables. The r eigenvalues in a system of n variables are taken into account. The magnitude of an eigenvalue λ_i indicates how strongly the cointegrated relation is correlated with the stationary part of the process. The test for a specific value of r concerns the hypothesis that $\lambda_{r+1}, ...\lambda_n = 0$ and $\lambda_1, ...\lambda_r \neq 0$.

In the model a constant term not restricted in the cointegration space is added, which implies a linear trend in the cointegration space; as a result, a

[18]See, for instance, Hendry and Richard (1982).

[19]All calculations and tests concerning linear VARs are based on PC-FIML 9.0, by Doornik and Hendry (1997).

trend is imposed in the long run (Johansen 1995):[20]

$$y_t = v_t + A_1 y_{t-1} + A_2 y_{t-2} - \alpha\gamma t + u_t \tag{4.1}$$

where $y_t = (VA, CL, LU)$. The corresponding error correction representation is:

$$\Delta y_t = v_t + \Gamma_1 \Delta y_{t-1} + \alpha(\beta' y_{t-1} - \gamma t) + \varepsilon_t \tag{4.2}$$

Johansen's test suggests the presence of a cointegration vector only.

Table 2. Cointegration Rank						
LR-test[21]	max eigenvalue			trace		
H_0: rank=r	-Tlog(1-λ)	T-Kp[22]	95%	-Tlog(1-λ)	T-Kp	95%
$r = 0$	34.9**	33.01**	25.5	60.89*	57.6**	42.4
$r \leq 1$	17.12	16.19	19.0	25.99*	24.58	25.3
$r \leq 2$	8.87	8.39	12.2	8.87	8.39	12.2

The eigenvalues for this cointegration analysis are 0.27, 0.14, 0.08 and 0.0001, and the magnitude of the first eigenvalue confirms the existence of only a cointegration vector.[23]

The cointegration relationship shows the expected signs and coefficients are extremely significant (standard errors in brackets). We choose to normalise in terms of the employment variable[24]:

$$\begin{array}{lllll} LU = & 1.5VA & -0.48CL & -0.009TREND & -\mu \\ (0.015) & (0.007) & (0.0252) & (0.0001) & \end{array} \tag{4.3}$$

[20] A constant in the short run means that differences of the data have a drift. As a result, their levels possess a linear trend.

[21] The trace test is $Qr = -T\sum_{r+1}^{k}(1-\lambda_i)$, whereas the maximum eigenvalue is $Qr = -T\log(1-\lambda_{r+1})$. Distributions are non-standard and tabulated in Johansen (1995).

[22] T-Kp is a correction of degrees of freedom in small samples, due to Reimers (Doornik and Hendry 1997).

[23] We also checked the roots of the companion matrix (Johansen 1995). Moreover, graphic analisys confirms that only a cointegration relationship is stable.

[24] This relationship is quite robust, even when other variables are added. For istance, when the price of capital is taken into account in terms of the investment deflator (PI), we obtain $LU = 1.8VA - 0.25CL - 0.01TREND - 0.06PI - \mu$.

Employment is positively related to demand (expressed by value added), while it is reduced by an increase of the cost of labour. A technological improvement also reduces employment if technological progress is labour-saving (see also Krolzig and Toro 1999). It is worth noting the explicit presence of the constant μ, the equilibrium mean. This implies that the cointegration relationship is zero mean.

In order to obtain a more efficient estimation and to reduce the dimension of the model, we can test the weak exogeneity of each variable, i.e. whether some of the variables do not react to a disequilibrium in the long run. This is equivalent to testing that the $\alpha_i's$, the adjustment coefficients, are zero in the equation for that variable. Owing to the stationarity of cointegration relations, this test is standard and asymptotically χ^2 distributed.

Conditioned on the cointegration space, labour costs are weakly exogenous to the long-run equilibrium. The adjustment coefficient of this variable is actually not different from zero, according to the Wald test $\chi^2(1) = 0.019[0.89]$. Consequently, we model a bivariate VECM of employment and output, conditioned on the cointegration space and on the labour cost variable. Given that the uniequational model of labour demand is rejected, value added is endogenous ($\chi^2(2) = 18.129[0.0001]$).

Table 3: Error-Correction Model. OLS 1970:4-1998:1								
Linear VECM(1)				VECM(1) G-L			VECM(1) E-P	
Dep. var. ΔLU	coeff.	t-stat		coeff.	t-stat		coeff.	t-stat
$\Delta LU(-1)$	0.35	4.02		0.36	4.02		0.41	3.92
$\Delta VA(-1)$	0.11	4.10		0.11	3.09		0.07	1.32
ECM(-1)	-0.04	-2.05						
ECM(-1)$^+$				-0.02	-0.71		-0.03	-1.23
ECM(-1)$^-$				-0.05	-1.81		-0.04	-1.85
ΔCL	0.05	1.55		0.05	1.56		0.04	1.24
Const.	-0.01	-3.90		-0.01	-3.14		-0.01	-1.98
Dep. var. ΔVA	coeff.	t-stat		coeff.	t-stat		coeff.	t-stat
$\Delta LU(-1)$	0.70	3.29		0.70	3.28		0.62	2.51
$\Delta VA(-1)$	0.45	5.16		0.45	5.22		0.50	3.72
ECM(-1)	0.23	5.04						
ECM(-1)$^+$				0.17	2.18		0.27	4.38
ECM(-1)$^-$				0.27	3.81		0.18	3.35
ΔCL	0.23	3.39		0.25	3.54		0.26	3.55
Const.	0.01	2.13		0.01	2.12		0.01	4.95

Table 4. Linear VECM(1): Vector Specification Tests (p-value)		
AR-(1-5)	F(20,188)	1.17 (0.28)
Normality	$\chi^2(4)$	9.19 (0.06)
Hetero	F(42,261)	1.03 (0.42)

4.1 The Asymmetric VECM

We construct the VECM model in both the linear form and the asymmetric form, conditioning the model on the cointegration space.

Table 4 shows that the linear model is well-specified and the fit appears to be satisfactory ($R^2 = 0.61$ for the entire system[25]). The ECM term is significant and with the expected sign in both the equations (Table 3). It is important to recall that the cointegration vector is normalised in terms of employment and has a negative sign in the first equation. By contrast,

[25] See Doornik and Hendry 1997, chap. 14 about this measure of goodness of fit in a system).

in the second equation the adjustment coefficient has a positive sign, since value added appears with the negative sign in the cointegration vector.

As already found in Chiarini (1997), labour factor adjustment to the long-run level is very slow (-0.04); it is also slow with respect to the adjustment of value added (0.23).

Labour costs have a positive significant coefficient in the employment equation. We anticipate here that in all estimated models this coefficient is positive or not different from zero. This finding is only partially surprising and has been obtained in other Italian studies (Chiarini 1998 for instance). However, there are many explanations for real wages to increase with employment or output (see the survey by Brandolini 1995).

Perfectly competitive models with a standard neoclassical product technology as well as new-Keynesian models imply that a demand shock increases output and employment, reducing real wages. Thus, a negative coefficient of the cost of labour should be expected.

This effect might be obstructed by high adjustment costs, which induce a lagged response of labour demand, reducing the meaning of a positive contemporaneous[26] correlation between real wages and employment (Sargent 1978). Thus, a positive coefficient of labour cost term in the short run, associated with a negative coefficient in long-run labour demand, further supports the general framework of this paper.

We now introduce the asymmetry factor, according to Granger and Lee's (G-L) specification and according to Escribano and Pfann's (E-P), by splitting the error correction term, already normalised to have zero mean.

$$\text{G-L}\begin{cases} ECM^- = ECM \; if \; ECM < 0 \\ ECM^- = 0 \qquad otherwise \\ \\ ECM^+ = ECM \; if \; ECM > 0 \\ ECM^+ = 0 \qquad otherwise \end{cases} \quad \text{E-P}\begin{cases} ECM^- = ECM \; if \; \Delta ECM < 0 \\ ECM^- = 0 \qquad otherwise \\ \\ ECM^+ = ECM \; if \; \Delta ECM > 0 \\ ECM^+ = 0 \qquad otherwise \end{cases}$$

In the G-L model (table 5), asymmetry is rejected by the Wald test. Moreover, as far as labour demand is concerned, the ECM^+ term is now not significant. In the value added equation, the ECM term is highly significant, but even in this case, asymmetry is rejected. However, as recently proved by Cook *et al.* (1999a), the conventional F-Wald test of linear restrictions is

[26] In this respect, it is worth noting that labour costs are introduced without lags.

not powerful enough to reject symmetry when G-L asymmetry is the actual hypothesis[27].

Table 5. Wald test (p-values in parentheses)			
equation		G-L Asymmetry	E-P Asymmetry
ΔLU	$\chi(1)$	0.33 [0.60]	0.13 [0.72]
ΔVA	$\chi(1)$	0.76 [0.38]	1.14 [0.28]
Model	$\chi(2)$	1.56 [0.45]	1.14 [0.56]

Notwithstanding, the E-P model also yields a similar finding. Thus, the Wald test suggests that the response to the long-run equilibrium is symmetric in both the equations $\chi(2) = 1.14[0.56]$.

4.2 Focusing on the number of workers

An interesting question that should be posed is if a different dependent variable might affect our results or possibly make them more conclusive. The endogenous variable used in the previous model is standard labour unit (LU in the text). This variable is the reference variable in the European System of Accounts, and it is consistent with the other series used in our analysis. Moreover, this measure of the labour input is the one most frequently used in Italian quarterly models. However, it implicitly assumes that effective labour input is multiplicative in employment and hours, masking any differences in the prices of these two possible ways of altering the input of labour.

Firms can adjust labour demand by changing both the number of employees and the degree of utilization of labour force (hours worked). These two components of the total amount of labour are not perfect substitutes and are characterised by different cyclical behaviour. Changing the number of employees is costly, so firms facing cyclical variations in demand find it easier to adjust their degree of utilization of the workforce in order to keep it at optimal level. As a result, total hours and, consequently, standard labour units will be smoother than the number of employees over the cycle. This

[27]These authors prove that the power of the test is very low even in the case of very large asymmetry, $(\theta_1 - \theta_2) = 0.5$ in a sample of 100 observation.

smoothness is likely to hide the real cost of adjusting labour input, which is mainly linked to the variation of the number of workers, regardless of the amount of worked hours.

In conclusion, when the labour input is measured in terms of employees, adjustment costs and the difference between hiring and firing costs underlying the asymmetric adjustment should come out more clearly.

In Figure 2, the growth rate of the two labour measures (standard units, LU, and employees, EM) are compared: the coefficient of variation (standard deviation/mean) of the former is about half that of latter (2.7 against 6.0).

HERE ABOUT FIGURE 2

Below, we set out a model, using the number of workers as the dependent variable in an asymmetric ECM model. A VAR(3) approximating the data-generation process (tests on residuals are depicted in Table 6) is estimated and cointegration analysis is performed (Table 7).

Table 6. VAR(3): Vector Specification Tests (p-value)		
AR-(1-5)	F(45,244)	1.02 (0.52)
Normality	$\chi^2(6)$	10.87 (0.09)
Hetero	F(120,429)	1.22 (0.07)

Table 7. Cointegration Rank						
LR-test	max eigenvalue			trace		
Ho:rank=r	-Tlog(1-λ)	T-Kp	95%	-Tlog(1-λ)	T-Kp	95%
p=0	34.9**	33.01**	25.5	60.89*	57.6**	42.4
r$\leq$ 1	17.12	16.19	19.0	25.99*	24.58	25.3
r$\leq$ 2	8.87	8.39	12.2	8.87	8.39	12.2

Now the eigenvalues are 0.30, 0.12, 0.05 and 0.0001. Again, the cointegration analysis shows only one stationary relationship, confirmed by the size of the first eigenvalue. When the cointegrating vector is normalised on labour positions, coefficients are again extremely significant and signs are as expected:

$$\begin{array}{lllll} EM = & 3.88VA & -2.31CL & -0.014TREND & -\mu \\ (0.0516) & (0.2017) & (0.1191) & (0.0008) & \end{array} \quad (4.4)$$

Although the coefficients in (4.4) are greater than those reported in the long-run equation (4.3), the specification of long-run labour demand seems to be stable even when expressed in terms of the number of workers. This may be due to a long-run perfect substitutability between hours worked and employees, so that the way of measuring labour does not really matter in the long run. However, this conclusion does not hold in the short run.

Table 8: Error-Correction Model. OLS 1970:4-1998:1								
VECM(2) linear				VECM(2) G-L			VECM(2) E-P	
Dep. Var. ΔEM	coeff.	t-stat		coeff.	t-stat		coeff.	t-stat
$\Delta EM(-1)$	-0.21	-2.29		-0.22	-2.29		0.27	3.92
$\Delta EM(-2)$	-0.09	1.04		-0.10	-1.05		-0.05	4.93
$\Delta VA(-1)$	0.09	1.70		0.09	1.59		0.07	1.32
$\Delta VA(-2)$	0.22	0.35		0.02	0.36		0.01	0.40
ECM(-1)	-0.04	-2.96						
ECM(-1)$^+$				-0.03	-1.42		-0.03	-1.73
ECM(-1)$^-$				-0.05	-2.10		-0.04	-2.75
ΔCL	0.09	1.87		0.09	1.84		0.10	2.12
Const.	-0.01	-3.19		-0.01	-2.53		-0.01	-3.26
Dep. Var.ΔVA	coeff.	t-stat		coeff.	t-stat		coeff.	t-stat
$\Delta EM(-1)$	0.21	1.48		0.70	3.28		0.16	1.13
$\Delta EM(-2)$	0.23	1.67		0.25	1.82		0.27	1.92
$\Delta VA(-1)$	0.43	5.13		0.43	5.19		0.54	5.20
$\Delta VA(-2)$	0.12	1.38		0.12	1.35		0.10	1.20
ECM(-1)	0.09	5.01						
ECM(-1)$^+$				0.06	2.01		0.08	3.49
ECM(-1)$^-$				0.13	4.01		0.10	4.07
ΔCL	0.30	4.26		0.31	4.34		0.31	4.39
Const.	0.00	0.87		0.01	1.65		0.00	0.92

Table 9.Linear VECM(2): Vector Specification Tests (p-value)		
AR-(1-5)	F(20,184)	1.56 (0.06)
Normality	$\chi^2(4)$	2.73 (0.60)
Hetero	F(36,260)	1.44 (0.06)

The specification is satisfactory (table 9); the ECMs are statistically significant (table 8), and the cost of labour turns to be weakly exogenous. The magnitude of the adjustment coefficient (-0.04) is the same as the previous model, but value added adjusts much more slowly, thus making the whole adjustment slower.

Linearity is confirmed against both the nonlinear specifications (table 11).

Table 11. Wald test (p-values in parentheses)			
equation		G-L Asymmetry	E-P Asymmetry
ΔLU	$\chi(1)$	0.29 [0.58]	0.65 [0.42]
ΔVA	$\chi(1)$	2.08 [0.15]	0.24 [0.62]
Model	$\chi(2)$	2.45 [0.29]	0.92 [0.62]

5 Conclusion

In this paper we estimate labour demand for the Italian industrial sector using a nonlinear multivariate model, namely the asymmetric vector error correction model (AVECM). The aim is to investigate the presence of asymmetry in the aggregate dynamics of employment. With long-run labour demand defined by a cointegration relation, the model allows us to test an hypothesis of asymmetry in employment adjustment due to different hiring and firing costs. We do not study the presence of asymmetry or nonlinearity in economic time series; rather, we describe the characteristics of a specific and economically relevant phenomenon, labour demand, within a well-defined stylized macroeconomic model.

A cointegrated VAR model, to specify both short-run dynamics and long-run relations, does not require a priori structural restrictions. The model embodies the hypothesis of linearity as a nested hypothesis, so that asymmetry is explicitly and formally tested.

Our findings show that macro adjustment in the Italian labour market over the cycle can still be explained from a linear data generating process. Moreover, aggregate behaviour of employment is symmetric, regardless of the way of measuring labour input.

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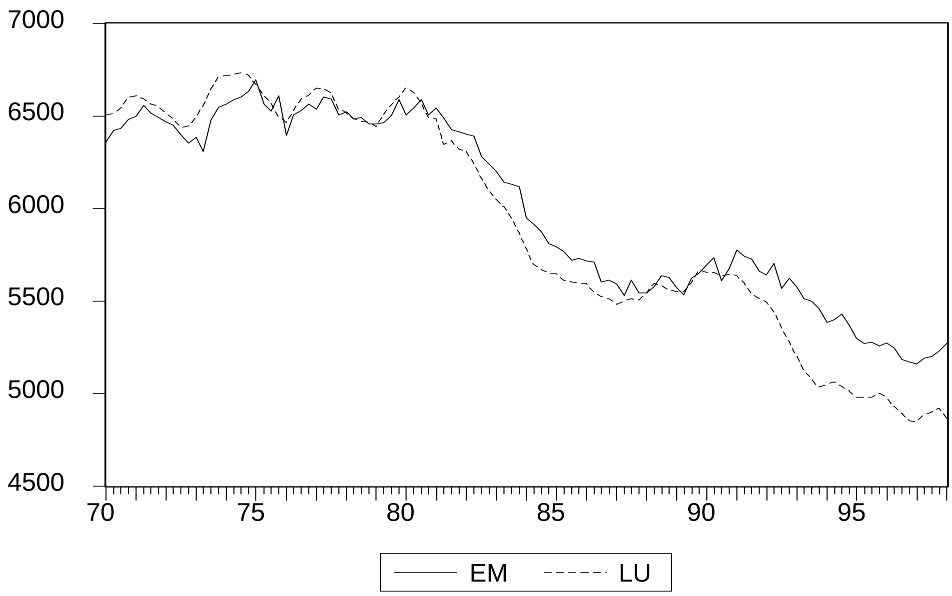

Figure 1: Employment (thousands) in the industrial sector: standard labour units (LU) and number of workers (EM).

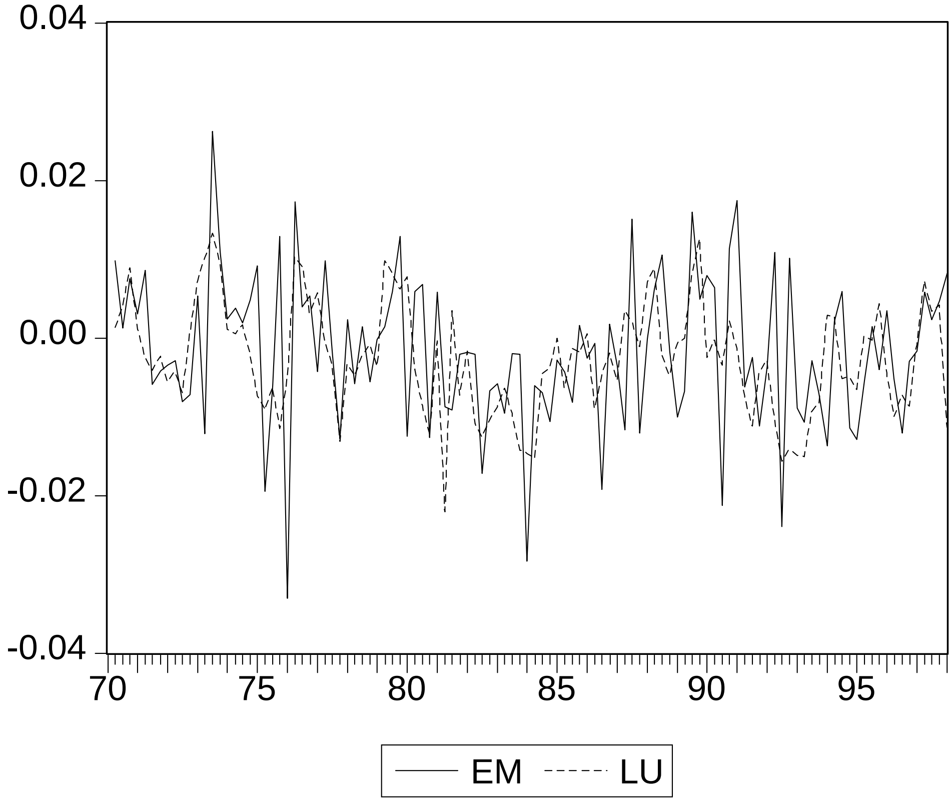

Figure 2: LU vs EM in the industrial sector; growth rates.