

Smolny, Werner

Working Paper

Non-linear models of employment adjustment

Diskussionspapier, No. 8

Provided in Cooperation with:

Department of Economics, University of Konstanz

Suggested Citation: Smolny, Werner (1993) : Non-linear models of employment adjustment, Diskussionspapier, No. 8, Universität Konstanz, Forschungsschwerpunkt Internationale Arbeitsmarktforschung, Konstanz

This Version is available at:

<https://hdl.handle.net/10419/92418>

Standard-Nutzungsbedingungen:

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

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

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

Terms of use:

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

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

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

Forschungsschwerpunkt
“Internationale Arbeitsmarktforschung”

Center for International Labor Economics
(CILE)

Fakultät für Wirtschaftswissenschaften und Statistik
Universität Konstanz

Werner Smolny

**Non-linear Models of Employment
Adjustment**

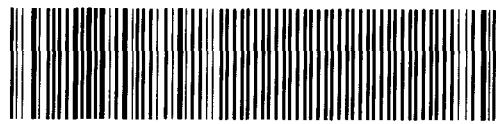
Postfach 5560 D 139
78 434 Konstanz
Deutschland / Germany

Diskussionspapier
8 – 1993

Non-linear Models of Employment Adjustment

Werner Smolny

W 752 (8)



50 7215

Diskussionspapier

Nr. 8

November 1993

Abstract: The paper deals with causes and consequences of constraints on the adjustment of employment. First, a model of a delayed adjustment of employment and capital is worked out. This model is augmented with linear constraints on the adjustment speed of labour supply and demand. The aggregate model is estimated for the Federal Republic of Germany. The results confirm the importance of adjustment barriers for the employment situation in the FRG, especially for the persistence of unemployment in the second half of the eighties. Final estimates of a non-linear error correction model give a hint on non-linearities of observed employment adjustments.

Contents

1	Introduction	1
2	The basic model	3
3	Dynamic employment adjustment	12
4	Estimation results	13
5	Conclusion	20
	References	21

List of Figures

1	Labour hoarding	8
2	Annual changes in labour productivity and utilization	8
3	Employment series I: LT , L_{YC} , LS	10
4	Employment series II: LT , L_{YD}	10
5	Employment series III: LT , LT^*	16
6	Residual histogram	19
7	Adjustment coefficient	19

List of Tables

1	Employment dynamics: CES-specification	15
2	Employment dynamics: error correction specification	17

“Workers who walk out of the factory gate on a Friday afternoon will typically return through the same gate on a Monday morning, if not before.”

Stephen J. Nickell

1 Introduction

In many theoretical factor demand models, employment is still treated as the flexible factor, while analyzing the inflexibility of the demand for capital. On the other hand, the quasi-fixity of labour and the efficiency of long-run worker-employer relationships has long been recognized by economic theory.¹ In addition, it is argued that the slow adjustment of employment was one reason for the persistence of high unemployment in Germany in the eighties.² The paper here deals with the dynamic adjustment of employment within the context of a rationing model. It is assumed that wages and prices do not adjust instantaneously to clear the market at every moment of time. Labour supply can differ from labour demand, and the dynamics of matching, i.e. employment determination is the key issue of the study.

There are different themes which are connected to the dynamics of employment adjustment and which appear under several headlines in the literature.³ First, the detailed studies of Becker and Oi derive the efficiency of long-term worker-employer relationships on the base of investments in firm specific human capital.⁴ Fixed employment costs arise from investments of firms in hiring and training activities which implies that labour cannot be treated as a flexible factor of production. Similar arguments for the quasi-fixity of the employment relation were derived within the theory of implicit “full employment” contracts on the base of reputation losses for firms in case of frequent dismissals.⁵ A third argument is based on legal or explicit contractual clauses on periods of notice for employees. All three arguments are in favour of a cautious hiring policy to avoid hiring and/or firing costs, and they favour “natural” fluctuation, i.e. quits and retirement, as a tool to achieve downward adjustments of the labour force.

Another strand of the literature on employment dynamics analyzes interrelated factor demand functions and macroeconomic consequences of the quasi-fixity of the employment decision.⁶ Usually, any constraints on the adjustment of one factor lead to an overshooting of the demand for a more flexible factor, at least if substitution is possible. This caused serious problems for the first models of dynamic factor demand which were based on the assumptions of a quasi-fixed capital demand and flexible labour. These models imply an overshooting of employment and an anticyclical behaviour of the productivity of labour. This contrasts sharply with the observed slow adjustment of employment and the procyclical development of labour productivity.

¹See Oi (1962) and Becker (1962).

²Another reason is probably the slow creation of capacities and working places especially at the end of the eighties. See Smolny (1993b).

³For an overview, see Nickell (1986).

⁴See Becker (1962) and Oi (1962).

⁵See Okun (1981).

⁶See Nadiri, Rosen (1969), Pindyck, Rotemberg (1983), Palm, Pfann (1990).

These shortcomings were removed with the introduction of a putty-clay technology, adjustment costs for labour, and other flexible “factor inputs” such as the working time and the utilization of labour and capital.

A third theme of adjustment models of labour demand is related to the shape of the adjustment cost function. This issue was already discussed in detail within the context of distributed lag models of investment behaviour.⁷ More recently, it is introduced also into the discussion of labour demand models. Most traditional models of dynamic factor demand rely on the approximation of the adjustment cost function by a linear-quadratic polynomial in net or gross adjustment. This assumption, together with some further restrictive simplifications such as absence of uncertainty, static expectations, and linear homogeneity of the model, allows to derive a simple partial adjustment model for the demand of the quasi-fixed factor. However, the above mentioned causes for the slow adjustment of employment such as partial irreversibility and fixed costs of screening and training fit only badly into the quadratic cost approach. This argument is important, because fixed costs of adjustment imply a quite different behaviour of the labour demand at the firm level: convex adjustment cost imply a slow adjustment with respect to equilibrium values, fixed costs lead to a lumpy adjustment.⁸ On the other hand, the aggregate consequences of both models have some similarities. Suppose a shock in the target level of employment: with fixed adjustment costs, some firms adjust completely while others stay with the previous employment level. The aggregate outcome in both models is a partial adjustment of employment. However, for large shocks, the adjustment in the fixed-cost model is faster; the hazard is increasing in the distance between the actual and the target employment level. A related issue is the symmetry of adjustment costs and the adjustment of employment. Hiring is quite different from firing and one may think, for example, of linear adjustment costs for hiring and fixed or linear costs of firing.⁹

Finally, there is the literature about the Beveridge-curve and the matching function.¹⁰ These models introduce some interesting aspects into the discussion of dynamic employment adjustment. The first is that employment dynamics cannot be understood solely in terms of labour demand. Labour supply and unemployment are also important. A second is the idea that matching takes time. For instance, it can be argued that it takes less time to find one worker when looking for two than to find 50 worker when looking for 100. In this case, the adjustment hazard is decreasing in the size of the desired adjustment. This is just the opposite as compared with the fixed-cost model. Third, the matching function literature is concerned with gross flows which are usually much larger than net employment changes.

The dynamic model of employment adjustment which is derived here is mostly related to the matching function literature. In the basic model, the idea of a delayed adjustment is introduced. This allows for a simple derivation of decision rules. Interdependent factor demand is taken into account by assuming larger delays for the capital adjustment and a putty-clay technology. In section 3, the matching function is augmented by linear constraints on the adjustment speed. The estimation results

⁷See Rothschild (1971) and Nickell (1978).

⁸See Hamermesh (1989,1990a,b,1993), and Caballero, Engel (1992a,b).

⁹See Bertola, Caballero (1990), Bentolila, Bertola (1990), Bertola (1991), Pfann, Palm (1993), and Pfann (1993).

¹⁰See Blanchard, Diamond (1989,1992).

reveal that even this extended model is a too simple approximation of the observed adjustment processes for employment, and final estimates of a non-linear error correction model give some rough idea about the adjustment processes found in the data.

2 The basic model

The macroeconomic structure of the model relies on the concept of micro-markets. The aggregate goods and labour market can be divided into a number of micro-markets with homogeneous labour and output on each micro-market, but limited mobility between micro-markets. This allows for a straightforward introduction of structural imbalances between supply and demand at the aggregate level, while preserving homogeneity at the microeconomic level. A micro-market is defined by a single firm operating on it. Each firm is engaged on one market for its output, one labour market, and one market for capital goods. Aggregate wages and prices are assumed to adjust sluggishly with respect to demand. At the micro level, they are treated as exogenous.

In the basic model, it is assumed that adjustment costs depend solely on the delay between the decision to change a factor input and the completion of adjustment. It is further assumed that adjustment costs are negligible if firms take account of a factor-specific adjustment delay τ_j , and prohibitive if firms try to adjust faster. This results in constant adjustment delays for labour and capital. Adjustment delays are probably smaller for labour than for capital, and the production technology is approximated by a putty-clay production function. Finally, it is assumed that output can be adjusted rather quickly with respect to demand changes in the presence of sufficient capacity and labour. These assumptions allow to reduce the dynamic decision problem of the firm to three static problems which can be solved sequentially:

1. Short-run adjustment of output YT_i with predetermined employment LT_i , capital stock K_i , and capital-labour ratio. Output is given by the minimum of goods supply YS_i and demand YD_i :

$$YT_i = \min(YS_i, YD_i) \quad (1)$$

The index i refers to micro-markets. Output supply is given by a short-run limitational production function:

$$YS_i = \min \left[\left(\frac{Y}{L} \right)_i \cdot LT_i, \left(\frac{Y}{K} \right)_i \cdot K_i \right] = \min(Y_{LT_i}, Y_{C_i}) \quad (2)$$

Y_{LT_i} : employment constraint

Y_{C_i} : capacities

$\left(\frac{Y}{L} \right)_i$: technical productivity of labour

$\left(\frac{Y}{K} \right)_i$: technical productivity of capital

The factor productivities are predetermined by the capital-labour ratio and the production function.

2. Medium-run adjustment of employment with uncertain output and still predetermined capital stock and capital-labour ratio. Employment is determined by the minimum of labour supply LS_i and demand LD_i .

$$LT_i = \min(LD_i, LS_i) \quad (3)$$

3. Long-run adjustment of the capital stock and the capital-labour ratio with uncertain output and employment.

Neglecting overtime work and inventory adjustment, the optimal output of the firm is given by eq. (1) and (2). The employment decision for time t has to be made at time $t - \tau_L$, i.e. τ_L periods before demand realization, thus under uncertainty of goods demand. Labour supply for time t is known in advance and assumed to be exogenous for the firm. The capital stock at time t and the capital-labour ratio have to be chosen *before* the employment decision, therefore capacities and labour productivity are also fixed. Optimal employment is derived from:

$$\max_{LT_i} p_i \cdot {}_{t-\tau_L}E(YT_i) - w_i \cdot LT_i - c_i \cdot K_i + \lambda_{LS_i} \cdot (LS_i - LT_i) \quad (4)$$

p_i is the output price, w_i are wages, and c_i are the user costs of capital. ${}_{t-\tau_L}E(YT_i)$ is the expected value of output in t , with expectations formed at $t - \tau_L$. For the determination of employment, three cases can be distinguished:

1. **No constraints:** If the firm is neither constrained by the available labour supply nor by the existing capital stock, the first order condition is given by:¹¹

$$p_i \cdot \text{prob}(YD_i > Y_{LT_i}^*) \cdot \left(\frac{Y}{L}\right)_i \stackrel{!}{=} w_i \quad (5)$$

expected marginal returns marginal costs

The firm chooses employment as to equalize expected marginal returns to marginal wage costs. Marginal returns are given by the price, multiplied with the probability of the supply constrained regime on the goods market, and labour productivity. In the optimum, the probability of the supply constrained regime is equal to the full employment labour share sl_i^* . Optimal employment is determined from:

$$LT_i^* = L_i^* = F_{YD_i}^{-1}(1 - sl_i^*) / \left(\frac{Y}{L}\right)_i \quad \text{with} \quad sl_i^* = \frac{w_i}{p_i} / \left(\frac{Y}{L}\right)_i \quad (6)$$

$F_{YD_i}^{-1}$ denotes the inverse of the cumulative distribution function of demand YD_i . Optimal employment is determined by the productivity of labour, the share of labour costs in nominal full employment output, and the parameters of the distribution function of goods demand. The partial derivative of L_i^* with respect to the real wage is negative. The effect of a higher productivity of labour on optimal employment is ambiguous: there is an employment increasing effect on profitability sl_i^* , but there is also a decreasing effect, because less labour is needed to produce a given output. The effect of a higher expected demand on

¹¹For the derivation of this result, see Smolny (1993b).

employment is positive, while increased uncertainty, i.e. a higher variance of demand may increase or decrease employment, depending on the value of sl_i^* and depending on the particular form of the distribution function of demand. For example, if the distribution function is symmetric around the expected value, the critical value of sl_i^* is 0.5. For $sl_i^* > 0.5$ optimal employment will decrease with higher uncertainty and vice versa. However, this property cannot be generalized for skewed distributions.

2. **Capacity constraint:** If the firm is constrained by the existing capital stock, no more workers will be demanded than can be employed with the (predetermined) capital stock. Optimal employment is determined according to:

$$LT_i^* = LYC_i = YC_i / \left(\frac{Y}{L}\right)_i = \left(\frac{Y}{K}\right)_i \cdot K_i / \left(\frac{Y}{L}\right)_i \quad (7)$$

Employment is given by the available number of working places. This implies that the employment constraint is also binding for goods supply YS_i .

3. **Labour supply constraint:** In the final case of insufficient labour supply, the firm has not enough applicants to fill all vacancies. Employment cannot exceed this constraint, optimal employment is equal to the labour supply:

$$LT_i^* = LS_i \quad (8)$$

The three cases can be summarized by a minimum condition for optimal employment:

$$LT_i^* = \min(L_i^*, LYC_i, LS_i) \quad (9)$$

In the model, the utilization of labour varies procyclically, with higher utilization in the presence of positive (unexpected) demand shocks and, hence, a *procyclically* varying measured productivity of labour. This property is in accordance with observed stylized facts and stands in contrast to conventional models of dynamic factor input adjustment, which allow for immediate adjustment of employment and short-run substitution of capital and labour, thus implying an *anticyclical* movement of the productivity of labour. On the other hand, optimal labour hoarding will decrease with less uncertainty of demand and less labour hoarding will be observed in the presence of labour supply or capacity constraints.

The investment decision has to be made τ_K periods before demand realization with uncertainty about labour supply and goods demand. It fixes capacities as well as the capital-labour ratio. Optimal capacities depend on profitability and the possible constraints on the goods and labour market. The optimal factor productivities are determined by real factor costs, weighted by the utilization of the factors and the shadow price of the labour supply constraint.¹²

The aggregation procedure of micro-markets in different regimes rests on a derivation put forward by Lambert.¹³ For lognormally distributed micro-marketes, a very simple analytical expression for aggregate employment LT can be derived. If the

¹²For a complete description of the model, see Smolny (1993b).

¹³Lambert (1988), appendix A.

weighted probabilities of the regimes are approximated by a logistic curve, it can be shown to yield the following CES-type function for aggregate employment:

$$LT = \{LD^{-\rho_m} + LS^{-\rho_m}\}^{-1/\rho_m} \quad (10)$$

Variables without the index i refer to aggregate values. ρ_m serves as a mismatch parameter with:

$$\frac{\partial LT}{\partial \rho_m} > 0, \quad \lim_{\rho_m \rightarrow \infty} LT = \min(LD, LS)$$

Aggregate employment can be determined from aggregate supply and demand, and a mismatch parameter ρ_m depending on the variance of the logarithmic difference of both variables on the micro level. Labour demand, in turn, is given by the minimum of the capacity constraint and demand determined employment. For this case, the CES-property can be applied as well. The distribution of the minimum of two lognormally distributed variables can again closely be approximated by a lognormal distribution and aggregate employment can be determined from:¹⁴

$$LT = \{LS^{-\rho_m} + [L^{*- \rho_f} + L_{YC}^{-\rho_f}]^{\rho_m/\rho_f}\}^{-1/\rho_m} \quad (11)$$

This example shows that the aggregation procedure, which was originally designed to capture the case of *micro-markets* in disequilibrium situations, can also be applied to those kind of firm's (or household's) behaviour, which can be expressed by minimum conditions. Two CES-functions can be stated, one for the labour market and one for the labour demand of the firm, which can be nested to determine aggregate employment in terms of labour supply, capacity employment, and demand determined employment.

The complete model of the firm consists of five behavioural relations. Output is given by the minimum of goods supply and demand, and supply, in turn, is determined by employment. Employment depends on expected demand, the labour supply and capacities. Optimal capacities depend on profitability and possible constraints on the goods and labour market, and the optimal factor productivities are determined by real factor costs, weighted by the utilization of the factors and the shadow price of the labour supply constraint. The estimation is carried out in two steps. The first step consists of the determination of the technical productivities of labour and capital. Observed productivities deviate from the technical ones by the respective degree of utilization of the factor in question. This implies a relation between actual productivities, factor costs, the shadow price of the labour supply constraint, and the utilization of the factors:

$$\frac{YT}{LT} = \left(\frac{Y}{L}\right) \cdot DUL \quad (12)$$

$$\frac{YT}{K} = \left(\frac{Y}{K}\right) \cdot DUC \quad (13)$$

By using indicators for the degrees of utilization of labour DUL and capital DUC , the productivity equations can be expressed completely in terms of observable variables.

¹⁴See Smolny (1993a).

For the utilization of capital an indicator is given by the business survey series on capacity utilization q for industry published by the ifo-institute. The indicator for utilization of labour within the firm is based on the correlation of the utilizations of labour and capital: the most important source of underutilization are unexpected demand shocks, with employment adjusting faster to those shocks, which is captured by a dynamic specification of q .

The significance of this indicator provides also a test of the assumptions applied for the derivation of the model. Significant underutilization of labour stresses the role of a delayed adjustment of employment as well as of a delayed adjustment of the capital-labour ratio. With an immediate adjustment of employment and a putty-clay technology, the productivity of labour should not be cyclical at all. An immediate adjustment of employment together with short-run substitution possibilities between labour and capital would imply an *anticyclical* productivity of labour. A procyclical productivity of labour within the firm can occur only in case of a slow adjustment of employment and the capital-labour ratio. The underutilization of labour and capital is also an indicator of price rigidities. In a model with perfectly flexible prices, firms can always lower prices in case of a negative demand shock. This should increase utilization, and if instead of this firms prefer underutilizations of labour and capital, there is some form of price rigidity. The estimated degree of utilization of labour is given by:¹⁵

$$\ln DUL_t = \underset{(0.06)}{0.444} \cdot (\ln q_t - \underset{(0.10)}{0.408} \cdot \ln q_{t-1}) - const. \quad (14)$$

Standard errors are reported in parentheses. The constant stands for the observed maximum of the variable. Very significant coefficients were found for the utilization indicator. The short-run correlation between labour productivity and utilization can be seen in [figure 2](#). The estimated coefficients imply an average utilization of labour of about 97 percent. This corresponds to an average amount of labour hoarding of about 600,000 workers, and in recession periods, labour hoarding exceeds 1,000,000 workers. The implied amount of labour hoarding can be seen from [figure 1](#).¹⁶ IT is actual employment and L_{YT} is the number of workers which are necessary to produce output:

$$L_{YT} = YT / \left(\frac{Y}{L} \right) \quad (15)$$

This result accentuates the importance of labour hoarding and the dynamic adjustment of employment. It also gives a hint for understanding business cycle asymmetries: the reaction of output with respect to demand is bounded upwards by supply, but has no similar bound in case of negative demand shocks.

The optimal productivities are necessary ingredients for the calculation of capacity employment. Capacities are calculated from capital productivity and the stock of capital, and capacity employment is given by:

$$L_{YC} = YC / \left(\frac{Y}{L} \right) = \left(\frac{Y}{K} \right) \cdot K / \left(\frac{Y}{L} \right) \quad (16)$$

¹⁵The estimation is based on quarterly data of the private sector of the West German economy. The data sample is 1960.1 1989.4.

¹⁶The data depicted in the figures are seasonally adjusted by constant seasonal factors.

Figure 1: Labour hoarding

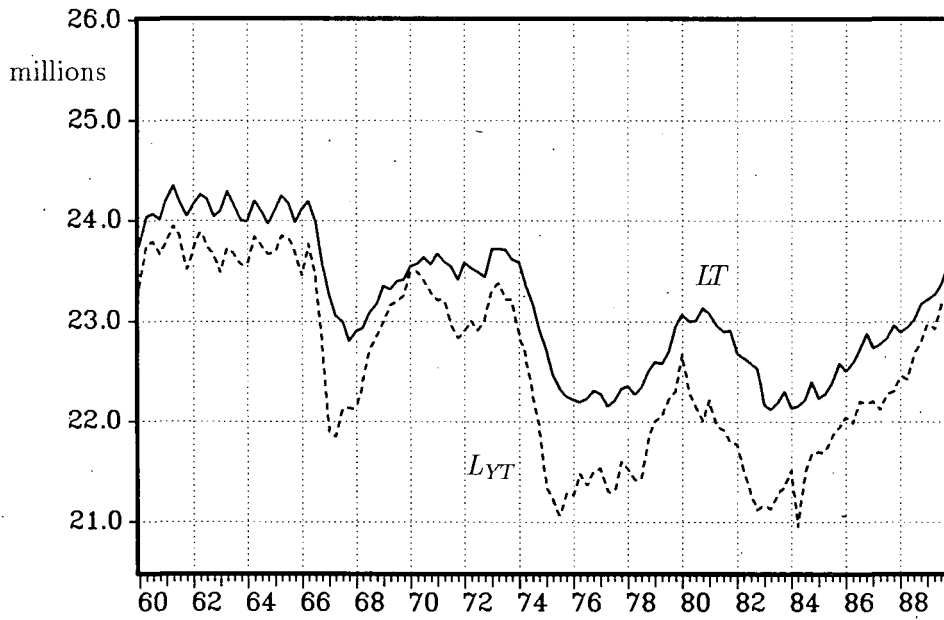
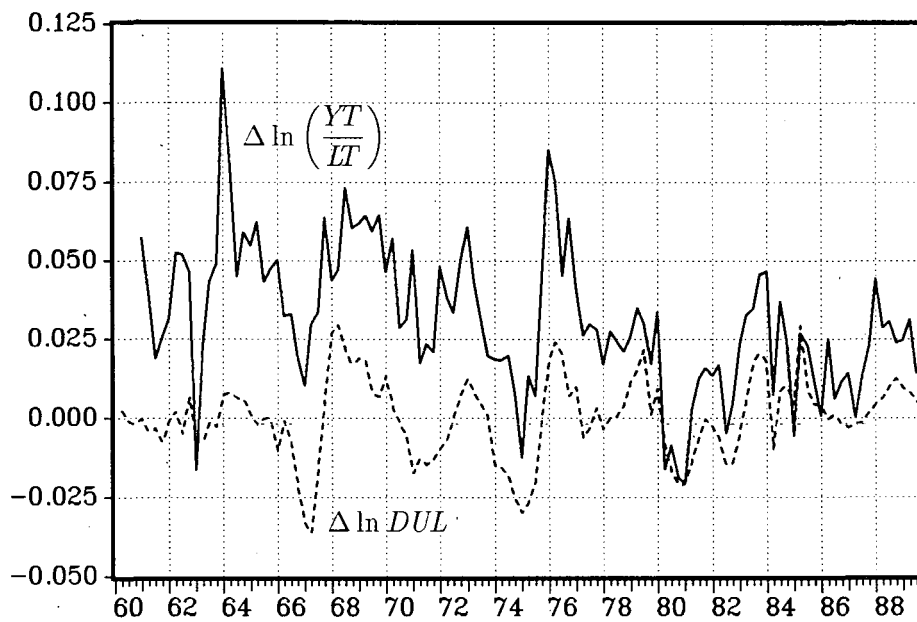


Figure 2: Annual changes in labour productivity and utilization



For the determination of excess demand, it is assumed that domestic demand can always be realized by switching to the foreign markets in case of supply constraints on the domestic market. This gives an instruction for the calculation of demand: the excess demand for domestic products is given by those imports, which are caused by supply constraints on the domestic market plus those part of exports, which are *not* carried out due to supply constraints of domestic firms. Trade equations are estimated with the most important determinants of exports and imports included, and containing also an indicator for supply constraints on the domestic market.¹⁷ This yields an estimate for the excess demand. Aggregate demand is calculated according to

$$YD = YT + \text{excess demand} \quad (17)$$

and demand determined employment follows from:

$$L_{YD} = YD / \left(\frac{Y}{L} \right) \quad (18)$$

The supply of labour is given by employment plus the number of unemployed.

$$\overline{LS} = LT + U \quad (19)$$

These series are seen as an important outcome of the approach. In [figures 3](#) and [4](#) they are depicted together with actual employment LT .

The labour supply was treated as an exogenous variable for the derivation of the basic model, but the endogeneity of the labour supply will be taken into account for the derivation of the dynamic adjustment of employment below. From [figure 3](#), it can be seen that the labour supply is an endogenous variable also on the aggregate level. It decreased during recessions and increased during boom periods. Factors accounting for this are the dependence of international factor mobility on the employment situation in the FRG and the inverse relation between the unemployment rate and the participation rates of workers in Germany.¹⁸ From the figure one can also see the distinct development of unemployment. There was virtually no unemployment in the sixties until 1973, apart from the short recession in 1966/67. Then the number of unemployed people increased to about one million. Despite the partial recovery of the employment level in the late seventies, the unemployment rate remained high due to the sharply increasing labour supply. The mild decrease of the unemployment rate was terminated abruptly by the recession at the beginning of the eighties, and the number of unemployed people increased to more than two millions. Since then, it remained rather stable and decreased only slowly since 1986 despite the enormous increase in employment since 1983.

The most striking characteristic of demand determined employment is the high variance over the business cycle. During recession periods, it lies far beyond the employment level, while in boom periods it increases faster than employment. This points again towards labour hoarding. The employment level that is necessary to produce output is always less than or equal to L_{YD} and $L_{YD} < LT$ implies labour hoarding. On the other hand, during boom periods, demand determined employment

¹⁷The estimation results are contained in Smolny (1993b).

¹⁸The endogeneity of the aggregate labour supply is not analyzed in this work. Some determinants of the labour supply in the FRG are analyzed by Franz, Smolny (1990), and Smolny (1992).

Figure 3: Employment series I: LT , L_{YC} , LS

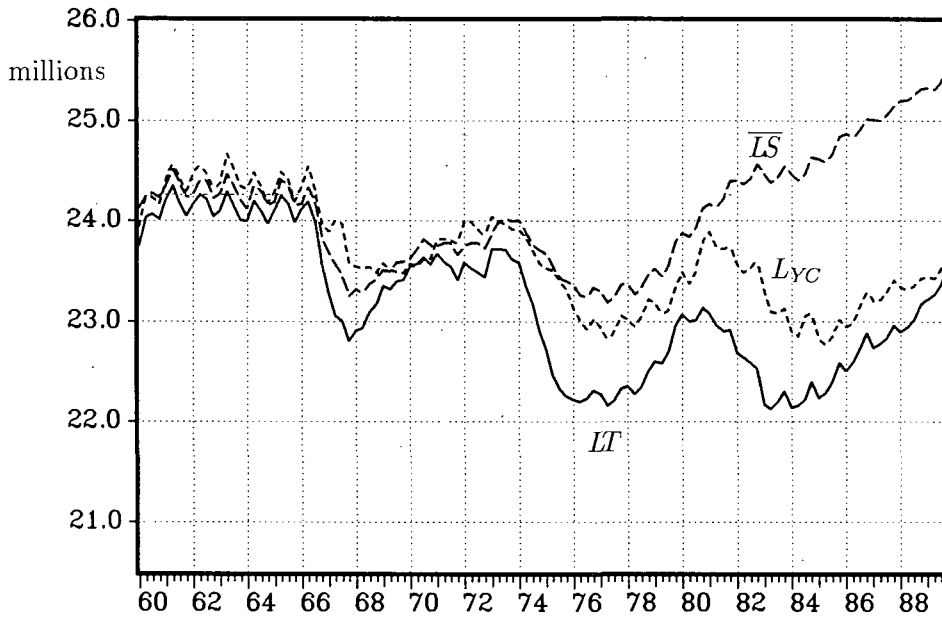
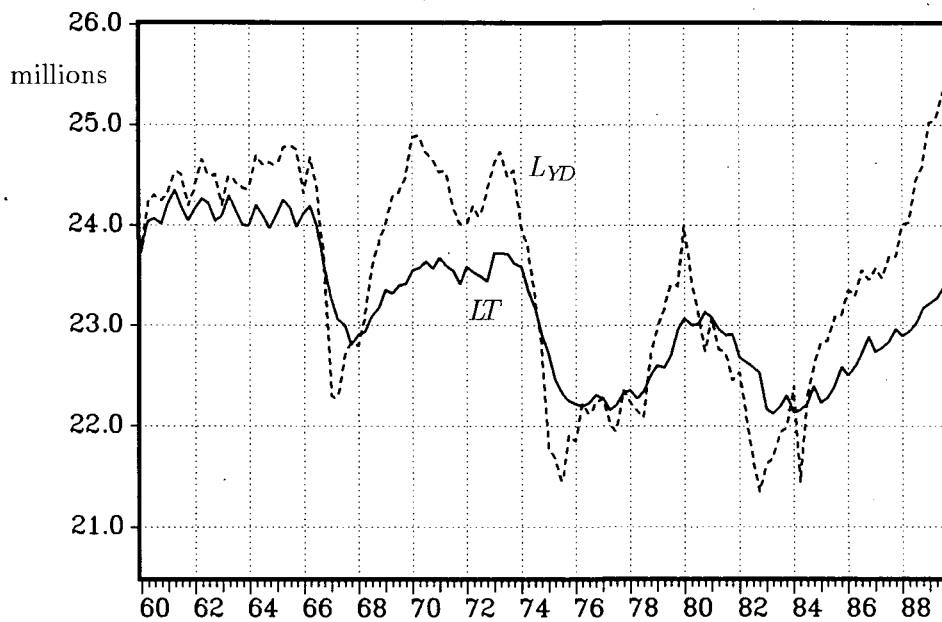


Figure 4: Employment series II: LT , L_{YD}



increases faster than employment. These distinct developments again indicate the importance of adjustment constraints for employment. Referring solely to this figure, employment adjusts only slowly with respect to demand during the upswing and during the downswing. On the other hand, the development of capacity employment is smoother than actual employment. The recessions 1966/67 and 1974 are less pronounced in LYC than in employment. In addition, LYC lags behind employment, indicating the slower adjustment of capacities with respect to demand.

Taken together, these figures already draw a rather detailed picture of the economic situation in the FRG. Until 1966, an equilibrium situation can be stated. The labour supply was slightly below capacity employment, goods demand about equals capacities, and the unemployment rate stays at about one percent. Employment and the degrees of utilization of labour and capital remain fairly stable. This picture changes sharply with the recession in 1966. Demand determined employment decreased and the unemployment figures increased to above 500,000 people, despite the remigration of many guest workers. Capacities adjusted downward and in the first quarter in 1967, gross investment was nearly 20 percent below the corresponding level of the preceding year. However, the recession was only short-termed and demand increased again until 1970, brought about mainly by higher exports caused by the undervaluation of the Deutsche Mark and high growth rates of the world economy. The labour supply and capacities adjusted only slowly, and in 1970, the shortages of capital and labour supply are the main factors restraining a higher growth rate of the economy. The following slowdown of demand in 1971 had hardly consequences for employment and investment, and the economy boomed when the first oil price shock hit the German economy. High inflation rates at the beginning of the seventies caused by an enormous wage push in 1970 and increases in the monetary growth in course of the breakdown of the Bretton-Woods exchange rate system induced the Deutsche Bundesbank to switch to a restrictive policy, and short-run interest rates exceeded 14 percent. These high interest rates reduced investment and consumption demand, and exports declined in consequence of the slowdown of world demand. In 1975, the unemployment figure exceeded one million and the utilizations of labour and capital decreased to very low levels. The partial recovery since then was terminated with the second oil price shock. Again high inflation rates induced a restrictive monetary policy.¹⁹ Between 1979 and 1981, the money supply remained below the minimum of the target set by the Deutsche Bundesbank and interest rates were high. In consequence, investment and consumption decreased in real terms. Furthermore, the fiscal authorities changed to a restrictive course and in 1983 the unemployment figure exceeded two millions. Since then, the economy switched on a path of sustained growth. The figures indicate that one reason that prevents a higher employment growth are probably adjustment constraints of employment, i.e. the persistence of unemployment in the eighties can partly be attributed to the dynamics of employment adjustment. Only at the end of the eighties, the slow adjustment of capacities became the dominant constraint for employment.

The figures give also a hint for the understanding of asymmetric behaviour of employment during the business cycle. In case of positive demand shocks, there is an upper bound of the target level of employment given by capacities and the labour

¹⁹ Another reason for the restrictive monetary policy was a deficit in the trade balance and a devaluation of the Deutsche Mark.

supply. No similar bound prevents the reduction of employment in case of negative demand shocks.

3 Dynamic employment adjustment

Employment cannot exceed the labour supply. However, the labour supply consists of those already employed in the firm and job applicants. Therefore it seems sensible to allow for a dependence of the current labour supply on the past employment level. A similar dependence on past employment can be stated for the demand for labour. Investments in firm specific human capital, implicit “full employment” contracts, and reputation losses give rise to costs of dismissing workers and tend to restrict the downward adjustment of employment to normal fluctuations, i.e. quits and retirement. In addition, the capacity of training entrants may prevent a too rapid growth of employment. One way to introduce these aspects into the employment decision is to assume a constraint on the adjustment *speed* of employment. For labour demand, this can be formalized as:

$$LD_{t,i} = \min \left\{ (1 + \delta_i^c) \cdot LT_{t-1,i}, \max [LD_{t,i}^*, (1 - \delta_i^s) \cdot LT_{t-1,i}] \right\} \quad (20)$$

t is the time index and $LD_{t,i}^*$ is the target level of labour demand to which the firm wants to adjust. The parameter δ_i^c is determined by the capacity of training entrants, and the minimum condition in eq. (20) restricts the maximum amount of adjustment of employment within one period to δ_i^c percent of the past employment level. The maximum condition implies a limit on the downward adjustment, and δ_i^s is the maximum rate of downward adjustment of employment.²⁰ If the costs of dismissing are prohibitive, δ_i^s can be identified with the rate of normal separations, i.e. quits and retirement. A similar model can be applied to the supply of labour:

$$LS_{t,i} = \min [(1 + \delta_i^a) \cdot LT_{t-1,i}, \overline{LS}_{t,i}] \quad (21)$$

Eq. (21) reflects a constraint on the absolute level of labour supply \overline{LS} as well as on the maximum rate of applications. It implies that the labour supply increases if the firm increases employment, but only until it reaches an exogenous level constraint $\overline{LS}_{t,i}$. It seems important to allow for both kinds of constraints. In the short run and during recessions the number of *applications within a time period* restricts employment growth, while in the long run and during boom periods it is plausible that a low *level* of labour supply prevents a higher employment.

Now there are four restrictions causing employment to differ from the target level of labour demand $LD_{t,i}^*$: first, the level of employment is restricted by the exogenous level constraint on labour supply $\overline{LS}_{t,i}$; second, the decrease of employment cannot exceed maximum (optimal) separations; third, employment increases must be carried out with limited training capacities; finally the number of job applicants within a time period can be binding. The last two restrictions can be combined. Defining $\delta_i^h = \min(\delta_i^a, \delta_i^c)$, optimal employment is determined by:

$$LT_{t,i} = \min \left\{ \overline{LS}_{t,i}, (1 + \delta_i^h) \cdot LT_{t-1,i}, \max [LD_{t,i}^*, (1 - \delta_i^s) \cdot LT_{t-1,i}] \right\} \quad (22)$$

²⁰ δ_i^s can also be interpreted as the optimal rate of downward adjustment, and a dependence of δ_i^s on the expected persistence of a low labour demand, for instance, is plausible.

An interesting property of this kind of introduction of adjustment constraints is the simple way to allow for different restrictions for upward and downward adjustments of employment. For $\delta_i^s < \delta_i^h$, for instance, the downward adjustment is more impeded than the upward adjustment; as a special case, $\delta_i^h = \infty$ ($\delta_i^s = 1$) implies an unconstrained upward (downward) adjustment.

However, in the dynamic model here, the optimal target level of employment differs from those derived in the static context. $LD_{i,i}^*$ again depends on the number of workers that can be employed with the capital stock, L_{YC_i} . However, it may be profitable to employ more workers than L_{YC_i} . If for instance the firm is installing capacities at time t_1 , it can start earlier with employment adjustment in face of difficulties of finding applicants. The additional wage costs incurred by an earlier hiring may be more than compensated by the earlier use of the machine. The expected demand for goods is also a determinant for $LD_{i,i}^*$, but once again, the strong minimum condition derived above, eq. (9), need not hold. In the face of an expected temporary demand shock, for instance, the employment level may only adjust partially. Employment depends not only on current constraints on adjustment, but also on expected employment changes and expected future constraints on employment adjustment.

This model of employment adjustment has in some respect features just opposite than those of the fixed-costs model mentioned above. In the model here, firms adjust completely, if the desired adjustment is *within* some small range given by the δ -parameters. In the fixed-cost model, firms adjust only, if the desired adjustment is *outside* some range determined by the extent of those costs. Both model imply a partial adjustment of aggregate employment with respect to shocks, but with increasing hazards in the fixed-cost model and decreasing hazards in the model here.

The aggregation procedure of micro-markets in disequilibrium situations can also be applied to capture these extensions of the model. Eq. (22) contains a *maximum* condition but it can be shown in a procedure analogous to those applied for the aggregation of the minimum condition that the aggregate maximum of two lognormally distributed variables can equally be approximated by a CES-function.²¹ The only modification is given by a change in the sign of the mismatch parameter. It should be noted that the δ parameters must not be equal for all firms, the only requirement is the close approximation of the distribution of all variables by a lognormal distribution.

4 Estimation results

In the empirical application of the model, three mechanisms for the dynamic adjustment of labour demand and supply with respect to equilibrium values are tested. The first corresponds to the aggregate version of eq. (22) and implies a lower and upper bound on the adjustment speed of actual employment with respect to its target level. Alternatively, a more standard specification of the dynamic adjustment of employment is tested, which relies on convex adjustment costs instead of adjustment constraints. The adjustment path implied by convex adjustment costs is approximated by a partial adjustment mechanism for labour demand. Actual

²¹See Smolny (1993a).

employment is again determined by supply and demand, and the target level of employment is determined by the available number of working places and expected goods demand. This combination of minimum conditions and a partial adjustment mechanism seems to be another promising basis for the specification of dynamic adjustment processes for employment. Compared with a standard partial adjustment mechanism for employment, it has the advantage that the restriction $LT \leq \overline{LS}$ is implied, compared with a sole specification in terms of constraints, it has the advantage of less non-linearities, and fewer coefficients must be estimated. Finally, the dynamic adjustment of employment is estimated by a linear and a non-linear error correction model. This procedure is not derived within the context of the theoretical model, but it can give some hints to non-linearities and asymmetries of the observed employment adjustment.

In table 1, the estimation results of the CES-employment equations are reported. The first rows depict the results from a static CES-employment function. The fitted values of this equation will be used later for the estimation of the error correction model. Else, these results should be seen only as a reference point for the dynamic employment functions displayed below. In the next version displayed, the dynamic adjustment of employment is specified solely in terms of minimum and maximum conditions. The estimated coefficient for the constraint on the speed of the upward adjustment δ^h is about 0.006 which implies that the firms, on average, cannot increase their labour force by more than 0.6 percent per quarter. The coefficient is rather low but stable in the different specifications tested. The result seems to be plausible: it can be seen from figures 3 and 4 that the maximum observed employment increases are about in this dimension.²² The estimated coefficient δ^s implies that the downward adjustment is slightly less impeded. The maximum downward adjustment is estimated with about 1 percent per quarter. However, the difference between these coefficients is not significant. In the last rows, the results obtained from a partial adjustment specification of labour demand are depicted.²³ The results achieved with this combination of minimum conditions and the usual partial adjustment mechanism are encouraging. Only two coefficients are estimated and the standard error of the equation is below 0.5 percent. The estimated dynamic adjustment is similar to those obtained from the pure CES-specification, the adjustment coefficient λ is about 0.2.

From these versions of the employment function, the following conclusions can be drawn. First, the dynamic adjustment of employment is very pronounced. Allowing for a dynamic adjustment yielded a remarkable better explanation of actual employment as compared with a static equation. The estimated adjustment is rather slow: the partial adjustment model yielded an estimate of 20 percent adjustment of labour demand per quarter,²⁴ the CES-approach yielded a maximum adjustment per quarter not above one percent of the previous employment level. This is in accordance with the model and can explain the considerable amount of labour hoarding during reces-

²²It should be noted that seasonal dummies were included in the estimated equation. The data for the figures are also seasonal adjusted with constant seasonal factors. It should be noted that the observed seasonal changes are larger than the estimated coefficients.

²³A similar combination of the CES-function and the partial adjustment mechanism was used by Sneessens, Drèze (1986).

²⁴It should be noted that the adjustment of employment is lower in case of labour supply constraints.

Table 1: Employment dynamics: CES-specification

(1) Static CES-function	
$LT_t = \{LS_t^{-\rho} + LD_t^{-\rho}\}^{-1/\rho}$	
$1/\rho = 0.0127$ (0.002)	
SEE: 0.0143	DW: 0.538
(2) CES-adjustment	
$LT_t = \{LS_t^{-\rho} + LD_t^{-\rho}\}^{-1/\rho}$	
$LS_t = \{\overline{LS}_t^{-\rho} + [(1 + 0.0062) \cdot LT_{t-1}]^{-\rho}\}^{-1/\rho}$ (0.001)	
$LD_t = \{LD_t^{*\rho'} + [(1 - 0.0101) \cdot LT_{t-1}]^{\rho'}\}^{1/\rho'}$ (0.003)	
$LD_t^* = \{L_{YD,t}^{-\rho} + L_{YC,t}^{-\rho}\}^{-1/\rho}$	
$1/\rho = 0.0080$, (0.001)	$1/\rho' = 0.0194$ (0.005)
SEE: 0.0045	BP(8): 82.2
(3) Partial adjustment	
$LT_t = \{LS_t^{-\rho} + LD_t^{-\rho}\}^{-1/\rho}$	
$LS_t = \overline{LS}_t$	
$LD_t = 0.204 \cdot LD_t^* + (1 - 0.204) \cdot LT_{t-1}$ (0.023) (*)	
$LD_t^* = \{L_{YD,t}^{-\rho} + L_{YC,t}^{-\rho}\}^{-1/\rho}$	
$1/\rho = 0.0057$ (0.001)	
SEE: 0.0043	BP(8): 85.9

DW: Durbin-Watson statistic.

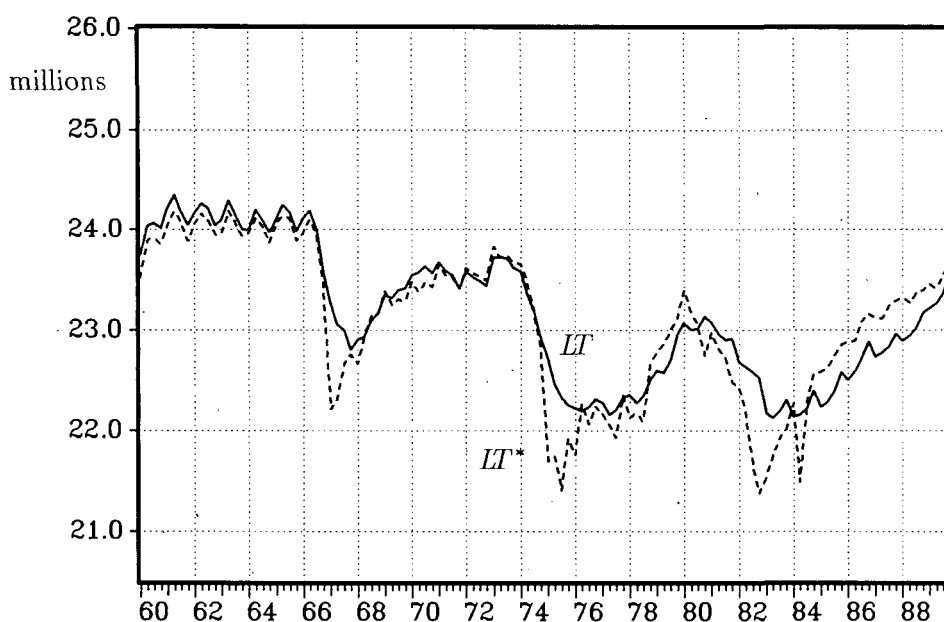
BP(8): Box-Pierce Q-statistic, 8 lags.

Data sample 1960.1 1989.4. The estimation sample is shortened to allow for lags.

Standard errors in parentheses. The estimation is carried out in logs.

All equations include seasonal dummies, but no constant.

Figure 5: Employment series III: LT , LT^*



sion periods. The results indicate that it is difficult to discriminate between these approaches despite their different implications: recall that the CES-specification of employment dynamics implies a slower adjustment in case of large deviations of actual employment from the target level, i.e. the adjustment hazard is decreasing in the desired adjustment. In addition, both employment equations are plagued by enormous serial correlation. Therefore, it was tried to achieve some further information about employment dynamics by estimating a more general error correction model.

The results from the error correction specification of employment adjustment are displayed in [table 2](#). The target level of employment LT^* is taken from the fitted values of the static CES-employment function in [table 1](#) and is depicted together with actual employment in [figure 5](#). It was shown above that the target level derived from this equation is always below its arguments, i.e. demand determined employment, capacity employment, and the labour supply. The bad fit of this equation is therefore not surprising.²⁵ In addition, one can see an asymmetry of the differences between actual employment and the target level: in case of negative demand shocks, the target level of employment falls much below actual employment, in case of a positive demand shock, insufficient capacities prevent a quick increase of the target level. One can also see that actual employment is below the target level in the second half of the eighties which points towards the importance of adjustment constraints for the explanation of the persistence of unemployment during this period.

In the first two versions displayed in [table 2](#), a linear error correction model is estimated. In version (1), employment changes are explained by changes in the target

²⁵One may even question the stationarity of the residuals of this equation. The t -statistic of an augmented Dickey/Fuller test is 2.76. However, the residuals are significant in the dynamic error correction model. See below.

Table 2: Employment dynamics: error correction specification

dependent variable: $\Delta \ln LF_t$				
explanatory variables	(1)	(2)	(3)	(4)
$\Delta \ln LF_t^*$	0.194 (0.03)	0.182 (0.02)	0.015 (0.04)	0.060 (0.03)
$\ln LF_{t-1} - \ln LF_{t-1}^*$	-0.143 (0.03)	-0.090 (0.03)		
$\ln LF_{t-2} - \ln LF_t^*$			-0.179 (0.05)	-0.150 (0.04)
$(\ln LF_{t-2} - \ln LF_t^*)^2$			0.527 (0.62)	1.473 (0.69)
$(\ln LF_{t-2} - \ln LF_t^*)^3$			28.36 (26.3)	25.79 (27.6)
$(\ln LF_{t-2} - \ln LF_t^*)^4$			-432.2 (282.)	-468.7 (267.)
$\Delta \ln LF_{t-1}$	0.320 (0.07)	0.384 (0.08)	0.154 (0.09)	0.256 (0.10)
$\Delta \ln LF_{t-2}$	-0.118 (0.06)		-0.158 (0.06)	
$\Delta \ln LF_{t-3}$	-0.177 (0.05)		-0.163 (0.05)	
$\Delta \ln LF_{t-4}$	0.600 (0.06)		0.611 (0.06)	
$\Delta \ln LF_{t-5}$	-0.492 (0.06)		-0.493 (0.06)	
AR(4)		0.788 (0.06)		0.800 (0.06)
SEE	0.00288	0.00311	0.00286	0.00301
serial correlation: χ^2	9.95 [0.27]	13.1 [0.11]	12.8 [0.12]	9.1 [0.33]
Wald χ^2			4.7 [0.20]	9.6 [0.02]

The constant and the seasonal dummies are not reported

AR(4): coefficient of autocorrelation, 8 lags

The test for autocorrelation is the Breusch/Godfrey-Lagrange Multiplier test with 8 lags.

The coefficient restriction of the Wald test concerns the exclusion of the 3 nonlinear error correction terms. The significance levels are reported in brackets.

level of employment, the lagged residuals of the static CES-equation, and additional lags of the endogenous variable. The short-term impact of a change in the target level is about 0.2, the error correction coefficient is about -0.15 , and a rather strong effect is found for the first lagged endogenous variable. In addition, the seasonal lags account for fourth order autocorrelation. The adjustment speed is similar compared to the dynamic CES-equations above, but the error correction model also accounts for the positive autocorrelation of employment changes. This gives a further hint to the argument that adjustment takes time, i.e. an intended change of employment takes more than one period. The large seasonal changes of employment correspond to the large gross flows emphasized in the matching function literature, as compared with the rather low net annual changes of employment. In version (2), the seasonal autocorrelation is captured by an AR(4)-process for the residuals instead of lagged endogenous variables, which gives about the same results.

In versions (3) and (4) in table 2, it is tested for additional non-linearities in the adjustment process of employment. More specifically, the adjustment coefficient is approximated by a higher order polynomial of the difference between the target level of employment and lagged employment. This should give some information whether adjustment hazards are asymmetric and/or increasing or decreasing in the size of the desired adjustment. Taking the about equal importance of the actual change in the target, the lagged equilibrium error, and the lagged change of the endogenous variable, it is tested for a non-linearity in the coefficient of $(\ln LL_{t-2} - \ln LL_t^*)$. The non-linearity was also specified in terms of $(\ln LL_{t-1} - \ln LL_t^*)$ and $(\ln LL_{t-1} - \ln LL_{t-1}^*)$, these versions yield the same qualitative results (not reported). In the displayed versions, up to fourth order polynomial terms of this difference are used as regressors, higher order polynomials of this difference did not contribute significantly to the explanation. The versions correspond to the linear error correction models (1) and (2), i.e. in version (3) seasonal autocorrelation is specified in terms of the endogenous variable, while in version (4) an autoregressive model for the residuals is employed. Both versions include as special cases the corresponding linear error correction models, therefore it can be tested for the significance of these terms. In version (4) the non-linearity contributes significantly to the explanation of employment changes. The implied adjustment coefficient λ , defined as

$$\lambda = \frac{\partial(\Delta \ln LL_t)}{\partial(\ln LL_{t-2} - \ln LL_t^*)}$$

is displayed in [figure 7](#). A histogram of the frequency of the observations is given in [figure 6](#). It can be seen that the absolute value of the adjustment coefficient has a relative maximum for small negative differences between lagged employment and the target level. The estimated adjustment is fastest, if the target level is slightly higher than lagged employment, i.e. for small increases of employment. The adjustment coefficient is lower (in absolute value) for larger increases of employment and has a relative minimum for medium-size downward adjustments of the labour force. For large decreases of employment, i.e. recessions, the estimated coefficients imply an increase of the adjustment speed. However, it should be noted that this estimation result is based on only two observations within this range and should be viewed with care. Version (3) reveals about the same conclusions for the adjustment coefficient. The significance of the non-linearity of the adjustment coefficient is lower, which

Figure 6: Residual histogram

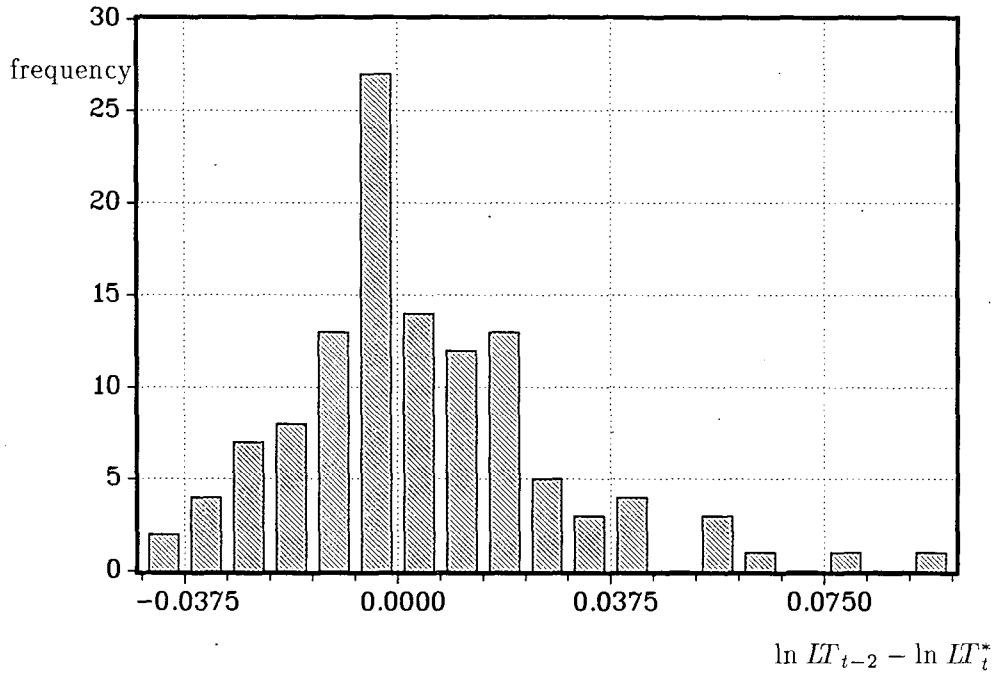
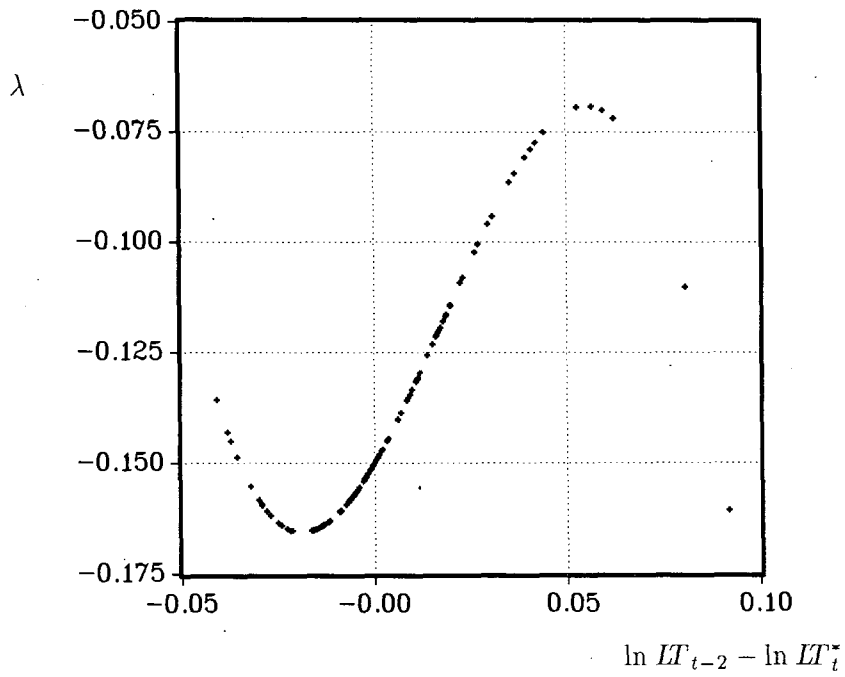


Figure 7: Adjustment coefficient



may partly be caused by multicollinearity of lagged employment changes and the non-linear error correction terms.

What can be learned from these estimation results? First, less than 20 percent of a desired change of employment is carried out within the first quarter. This accounts for the considerable amount of labour hoarding during recession periods. It accentuates also the importance of supply constraints on the goods market in case of demand increases. Second, the observed adjustment appears to be more complicated than a simple partial adjustment scheme. The estimated adjustment is asymmetric as well as decreasing in the size of the desired change of employment. This result is in accordance with matching function models and stands in contrast to the model with fixed costs of adjustment. One interpretation of this result is that adjustment takes time, and a larger adjustment takes a longer time. Only in deep recessions, the adjustment speed seems to increase. Third, there is considerable seasonal variation of employment changes. This corresponds to the observed large gross employment flows and stands in contrast to the estimated slow seasonal adjusted changes of aggregate employment. One interpretation is that a different mechanism drives the adjustment of employment in those parts of the economy with strong seasonal changes in labour demand.

5 Conclusion

The main objects of the paper are the investigation of the dynamic adjustment of employment, and the analysis of the resulting inefficiencies. An excess supply on the goods market, which is not immediately removed by price or quantity adjustments implies underutilization of labour, and excess supply on the labour market is unemployment. The slow adjustment of quantities increases the persistence of these disequilibria and is seen as an important component for an explanation of the business cycle. A dynamic model of the firm is derived and supplemented by an aggregation procedure for firms in disequilibrium situations. At any moment of time, different firms face different constraints on the goods and labour market. The aggregate transacted quantity can be approximated by an explicit functional relation depending on aggregate supply, aggregate demand, and a mismatch parameter. The aggregation procedure allows an easy transformation of the firm-specific variables into aggregate quantities, and the model can be tested solely by using aggregate data.

The results of the estimation of the model generally confirm the assumptions applied for the derivation of the model. Significant underutilizations of labour were found, which indicates a slow adjustment of employment and the production technology. They indicate also a downward rigidity of prices. For employment, it takes more than two quarters before half of the adjustment is carried out. The adjustment appears to be asymmetric, and the adjustment speed appears to be decreasing in the size of the desired adjustment. One outcome of the approach are the different measures of disequilibrium on the goods and labour market. A measure of the short-run excess supply or demand on the goods market is provided by the utilization of labour. On the labour market, "Keynesian" labour demand and capacity employment can be determined in addition to the labour supply. The employment series reveal the

importance of demand for the medium-run determination of employment. Demand is the driving force for employment changes.

In the short run, employment growth can be limited by adjustment constraints for employment. These aspects provide a partial explanation for the persistence of the high unemployment in Germany in the eighties. At the beginning of the eighties, the demand breakdown in course of the second oil price shock reduced employment. After the recovery of demand in 1984, the employment growth was mainly impeded by adjustment constraints for employment. Only at the end of the eighties, the slow adjustment of capacities constrained employment.

References

- [1] **Becker, G.S.**, (1962). Investment in human capital: a theoretical analysis. *Journal of Political Economy*, 70:9–49.
- [2] **Bentolila, S. and G. Bertola**, (1990). Firing costs and labour demand: how bad is eurosclerosis ? *Review of Economic Studies*, 57:381–402.
- [3] **Bertola, G.**, (1991). Labor turnover and average labor demand. *National Bureau of Economic Research, Working Paper*, 3866.
- [4] **Bertola, L. and J. Caballero**, (1990). Kinked adjustment costs and aggregate dynamics. *NBER, Macroeconomics Annual*, pages 237–295.
- [5] **Blanchard, O.J. and P. Diamond**, (1989). The Beveridge curve. *Brookings Papers on Economic Activity*, 1:1–76.
- [6] **Blanchard, O.J. and P. Diamond**, (1992). The flow approach to labor markets. *American Economic Association, Papers and Proceedings*, 82/2:354–59.
- [7] **Caballero, R.J. and E.M.R.A. Engel**, (1992a). Beyond the partial-adjustment model. *American Economic Association, Papers and Proceedings*, 82/2:360–64.
- [8] **Caballero, R.J. and E.M.R.A. Engel**, (1992b). Microeconomic adjustment hazards and aggregate dynamics. *National Bureau of Economic Research, Working Paper*, 4090.
- [9] **Drèze, J.H. and C. Bean**, (1990). *Europe's Unemployment Problem*. MIT-Press.
- [10] **Entorf, H., W. Franz, H. König, and W. Smolny**, (1990). The development of German employment and unemployment: estimation and simulation of a disequilibrium macro model. In J. H. Drèze and C. Bean, editors, *Europe's Unemployment Problem*, pages 239–287. MIT-Press.
- [11] **Franz, W. and W. Smolny**, (1990). Internationale Migration und wirtschaftliche Entwicklung: Eine theoretische und empirische Analyse mit Hilfe eines Mengenerationierungsmodells. In B. Felderer, editor, *Bevölkerung und Wirtschaft*, pages 195–209. Duncker & Humblodt, Berlin.

- [12] **Franz, W. and W. Smolny**, (1993). The measurement and interpretation of vacancy data and the dynamics of the Beveridge-curve—The German case. *Center for International Labor Economics, Universität Konstanz, Diskussionspapier*, 3.
- [13] **Hamermesh, D.S.**, (1989). Labor demand and the structure of adjustment costs. *American Economic Review*, 79:647–89.
- [14] **Hamermesh, D.S.**, (1990a). Aggregate employment dynamics and lumpy adjustment costs. *Carnegie-Rochester Conference Series on Public Policy, Supplement to the Journal of Monetary Economics*, 33:93–130.
- [15] **Hamermesh, D.S.**, (1990b). A general model of dynamic labor demand. *National Bureau of Economic Research, Working Paper*, No. 3356.
- [16] **Hamermesh, D.S.**, (1993). Spatial and temporal aggregation in the dynamics of labor demand. In J.C.van Ours, G.A. Pfann, and G. Ridder, editors, *Labor Demand and Equilibrium Wage Formation*, pages 91–108. Elsevier.
- [17] **Lambert, J.-P.**, (1988). *Disequilibrium Macroeconomic Models – Theory and Estimation of Rationing Models using Business Survey Data*. Cambridge University Press, Cambridge.
- [18] **Nadiri, M.I. and S. Rosen**, (1969). Interrelated factor demand functions. *American Economic Review*, 59/4:457–71.
- [19] **Nickell, S.J.**, (1978). *The Investment Decision of Firms*. Cambridge University Press.
- [20] **Nickell, S.J.**, (1986). Dynamic models of labour demand: In O. Ashenfelter and R. Layard, editors, *Handbook of Labor Economics, Volume I*, pages 473–522. Elsevier Science Publishers BV.
- [21] **Oi, W.Y.**, (1962). Labor as a quasi-fixed factor. *Journal of Political Economy*, 70:555–88.
- [22] **Okun, A.M.**, (1981). *Prices and Quantities: A Macroeconomic Analysis*. Basil Blackwell, Oxford.
- [23] **Palm, F.C. and G.A. Pfann**, (1990). Interrelated demand rational expectations models for two types of labour. *Oxford Bulletin of Economics and Statistics*, 52.1:45–68.
- [24] **Pfann, G.A.**, (1993). The thin end of the wedge: non-linearity in stochastic labor market dynamics. In J.C.van Ours, G.A. Pfann, and G. Ridder, editors, *Labor Demand and Equilibrium Wage Formation*, pages 23–48. Elsevier.
- [25] **Pfann, G.A. and F.C. Palm**, (1993). Asymmetric adjustment costs in non-linear labour demand models for the Netherlands and UK manufacturing sectors. *Review of Economic Studies*, 60:397–412.

- [26] **Pindyck, R.S. and J.I. Rotemberg**, (1983). Dynamic factor demands under rational expectations. *Scandinavian Journal of Economics*, 85/2:223–238.
- [27] **Pissarides, C.**, (1992). Search theory at twenty-one. *Center for Economic Performance, Discussion Paper*, 90.
- [28] **Rothschild, M.**, (1971). On the costs of adjustment. *Quarterly Journal of Economics*, 85:605–22.
- [29] **Smolny, W.**, (1992). Macroeconomic consequences of international labour migration. In H.-J. Vosgerau, editor, *European Integration in the World Economy*, pages 376–408. Springer, Berlin, Heidelberg, New York.
- [30] **Smolny, W.**, (1993a). Die Aggregation von Mikromärkten in Ungleichgewichtssituationen. In B. Gahlen, H. Hesse, and H.-J. Ramser, editors, *Makroökonomik unvollständiger Märkte*, pages 137–67. Mohr, Tübingen.
- [31] **Smolny, W.**, (1993b). *Dynamic Factor Demand in a Rationing Context: Theory and Estimation of a Macroeconomic Disequilibrium Model for the Federal Republic of Germany*. Physica, Heidelberg.
- [32] **Sneessens, H.R. and J.H. Drèze**, (1986). A discussion of Belgian unemployment, combining traditional concepts and disequilibrium econometrics. *Economica*, 53:S89–S119.