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SOURCES OF PERSISTENCE IN EMPLOYMENT ADJUSTMENT - DENMARK 1974-1993

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Abstract
This paper aims at identifying and quantifying different sources of persistency in employment adjustment. Based on a dynamic labour market model an explicit distinction is made between real and nominal (prices and wages) propagation mechanisms. The theoretical analysis provides the basis for an empirical analysis of nominal wages, nominal prices and employment for the manufacturing sector in Denmark 1974.1 to 1993.4. We find that nominal rigidities prevail in the short run and that nominal propagation mechanisms play a larger role than real propagation mechanisms. The persistency mechanisms identified here are substantial from a business cycle perspective, but not in relation to the span of time over which unemployment has persisted at a high level.

Keywords: Wage and price formation, nominal and real shocks, propagation mechanisms
JEL classification: E20, J3, L60

We gratefully acknowledge comments and suggestions from participants at the conference on "Unemployment Persistence and the Long Run: Re-evaluating the Natural Rate, Vigo, 30 November/1 December 1997as well as from Dennis Snower and an anonymous referee. All the computations are done using PcGive 9, see Hendry and Doornik (1996). The data applied can be downloaded from http://www.econ.au.dk/vip-htm/shylleberg.

1. Introduction

Many western European countries have for a prolonged period of time experienced historically high unemployment rates. This development has fostered two competing class of theories. One holds that various structural shifts (including more generous welfare policies, technological changes or changes in morale) have deteriorated labour market performance and caused an increase in the "equilibrium" or long-run rate of unemployment. According to this interpretation, there will be no automatic tendency for unemployment to fall and no role for traditional demand management policies in reducing unemployment. Structural policies are called for. Another interpretation is that a sequence of bad shocks in combination with strong inertia in the adjustment process have implied that the unemployment rate has been kept at a high level. Eventually the unemployment rate will come down due to endogenous adjustment mechanism provided that the system is not hit by further adverse shocks. Moreover, traditional demand management policies including monetary policy may be designed so as to speed up the adjustment towards lower unemployment.

It is difficult to discriminate between these two explanations by simply considering the time series properties of key variables like employment and unemployment, since they both claim to explain why strong persistency is observed. Moreover, the small samples available for such analysis it makes it very difficult to distinguish between a unit root (random walk) and a root close to but below one. This paper takes another and more structural route in trying to discriminate empirically between the two explanations of persistent unemployment by considering how different shocks can generate persistency through various propagation mechanisms. This allows us to evaluate how far a combination of adverse shocks and inertia in adjustment can bring us in accounting for the observed changes in employment and unemployment.

The issue of the quantitative importance of the various sources of inertia in adjustment or so-called propagation mechanisms is of course central to business cycle theory. There is a recurrent controversy over both the type of shocks[1] and the sources of propagation which are quantitatively most important.

According to real business cycle models, it is possible to account for observed persistency in output within a perfectly competitive economy which is driven by (persistent) real shocks (see

[1] There is a large literature attempting to identify the most important shocks driving the cycle, see e.g. Hartley and Whitt (1997) for a recent example and references. While this type of analysis yields useful insights, the present paper aims at going one stop further in trying to identify the main channels generating inertia in adjustment.

eg Kydland and Prescott (1982)). Although output displays strong persistency, this is not so for employment because the propagation mechanism is primarily driven by capital accumulation [2]. In the present context two major deficiencies of this model are that the internal propagation mechanism turns out to be very weak (Cogley and Nason (1995)), and that it has difficulties in accounting for a number stylized business cycle facts relating to the labour market (see eg Stadler (1994)).

Taylor (1979,1980) suggested that sluggishness in nominal wage and/or price adjustment may be a very strong propagation mechanism implying that it is possible to account simultaneously for persistency in output and employment (unemployment) and the role changes in aggregate demand have for changes in aggregate activity[3]. This view has recently been challenged by Chari, Kehoe and McGrattan (1996) who points out that the basic Taylor-model only produces significant persistency in the adjustment process under the assumption of implausible large labour supply elasticities. However, this turns out to be a model specific finding and it is in general possible to generate strong persistency effects from sluggishness in nominal price and wage adjustment even if individual labour supply is inelastical to wage changes (see eg Jeanne (1996), Taylor (1998) and Andersen (1998)). Hence, the adjustment process in the labour market may not only be important for accounting for specific labour market observations but also more generally for observed business cycle regularities.

These contesting business cycle models make it essential to distinguish between real and nominal sources of propagation. This is the starting point for the present analysis which aims at identifying and quantifying various shocks and propagation mechanisms which work through labour demand and nominal price and wage formation to determine the path for employment. This is of relevance for evaluating both the explanatory power of different business cycle theories and the competing hypotheses explaining the persistent rise in unemployment.

Since the aim is to explicitly analyse the interaction between employment, prices, and wages, there is an important strategic decision to be made concerning the level of aggregation for which the empirical analysis will be made. We have chosen to work with data for the manufacturing sector in Denmark. In Denmark the share of public consumption in GDP is very high (1993: about 55%). Accordingly, it is not possible in a meaningful way to analyse the inter-

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[2] This is reflected in the fact that the basic mechanism can be captured despite a constant employment (see eg Stadler1994). Obviously unemployment has no role in a setting with a competitive labour market.

[3] See also Phaneuf (1990),Ambler and Phaneuf (1992) and West(1988)

action between price and wage setting at the aggregate level since price setting is not well-defined for a large fraction of the economy. This rules out the use of aggregate data. We have chosen to apply data for the manufacturing sector as this is the highest aggregation level for which we think it is appropriate to analyse the interaction between wages, prices and employment without having to construct a complicated disaggregate model allowing for sectoral interdependencies. The manufacturing sector also comprises a large fraction of firms in direct competition with foreign firms leaving a role of foreign shocks both to the demand and the supply side. While this choice of data produces a more coherent model, it has the disadvantage that it precludes a direct analysis of the overall employment performance in the Danish economy. However, manufacturing employment gives a fair representation of private employment, and a full account of Danish employment has moreover to raise political economy aspects since both registered unemployment figures and public employment are strongly af-fected by various (passive) labour market measures, and the tendency of the public sector to be either the employer or income supported of last resort in an extended welfare state like the Danish. Working at this sectoral level further has the advantage that we reasonably can take economy wide variables like aggregate demand, exchange rates etc. as exogenous.

The aim of this paper is to try to identify and quantify the sources of sluggishness in the adjustment processes of the labour market. In particular, we are interested in the role of sluggish nominal price and wage adjustment relative to other sources of persistency which may arise on the real side of the economy. As a benchmark for the empirical analysis, we develop in section 2 a stylized dynamic labour market model which allows a distinction between real and nominal propagation mechanisms. In section 3 we confront this model with data from the Danish manufacturing sector over the period 1974.1 to 1993.4. Section 4 summarizes and concludes the paper.

2. A Dynamic Labour Market Model

The purpose of the empirical analysis is to quantify possible sources of inertia in the adjustment process for employment. To set the scene, we present in this section an illustrative model. While this model takes a short-cut to problems which should ideally be analysed in an explicit dynamic context, it has the virtue that it in a very simple way brings forward the empirical relevant sources of inertia and their interdependencies.[4] It is worth stressing that the qualitative re-

[4] Dynamic general equilibrium models tend to be very stylized despite their technical complexity, and therefore they do not lend themselves to a straightforward formulation of an operational econometric model. A method much in vogue is to use calibrations as a way to yield insight on the empirical relevance of the model, to the present authors this is an imperfect substitute for an econometric analysis.

sults presented here on adjustment dynamics have support in explicit dynamic models. The specific purpose of the model is to clarify the distinction between real and nominal propagation mechanisms and their interdependencies.

Consider an open economy with a fixed exchange rate and fully liberalized international capital movements[5]. Output markets have a specialized production structure yielding market power to domestic firms. Labour markets are also imperfectly competitive, and specifically it is assumed that unions that determine wages subject to a right to manage structure. The sequential structure is such that wages are determined prior to the price and employment decision of firms[6].

Firms produce subject to a traditional production technology linking output (Y) to the production factor labour (L), i.e.

$$Y_t = F(L_t) \qquad F' > 0 \quad F'' < 0$$

and face a demand function depending on relative prices and other real factors captured by the variable (vector) Z_t, ie

$$D_t = D\left(\frac{P_t^f}{P_t}, Z_t\right) \quad D'_{P^f/P} > 0$$

where P_t is the price of domestically produced goods and P^f is the price of foreign produced goods measured in domestic currency. A nominal shock in the present context of a fixed exchange rate regime is a change in the exchange rate which via a change in the price of foreign goods in domestic currency is transmitted to the real side of the economy.

Solving for the profit-maximizing price, we find that the optimal price can be written

$$P_t = P\left(P_t^f, WN_t, Z_t\right) \tag{1}$$

and it fulfils the homogeneity property

$$\lambda P_t = P\left(\lambda P_t^f, \lambda WN_t, Z_t\right) \qquad \forall \lambda > 0$$

The implied labour demand function can now be written

5 This allows us to use the basic insight of the Mundell-Fleming model that money market variables are determined recursively to the real side of the economy.

6 For a more detailed outline of the micro structure of the model, see Andersen (1997).

$$L_t = L\left(\frac{P_t^f}{P_t}, Z_t\right) \qquad L_{P_t^f/P_t} > 0 \tag{2}$$

or by use of the price equation

$$L_t = \hat{L}\left(\frac{P_t^f}{P(P_f^t, WN_t, Z_t)}, Z_t\right) \qquad \hat{L}_{WN} < 0 \tag{3}$$

The union has a pay-off function depending on the consumer real wage (the nominal wage deflated by the consumer price index Q), employment and other exogenous variables, ie

$$V\left(\frac{WN_t}{Q_t}, L_t, Z_t\right)$$

where the consumer price index is defined as

$$Q_t = Q(P_t, P_t^f); \qquad \lambda Q_t = Q(\lambda P_t, \lambda P_t^f) \qquad \forall \lambda > 0$$

Maximizing this subject to the labour demand function (2) yields a wage function of the form

$$WN_t = WN(P_t, P_t^f, Z_t) \tag{4}$$

which is homogenous of degree 1 in all nominal variables.

$$\lambda WN_t = WN(\lambda P_t, \lambda P_t^f, Z_t) \qquad \forall \lambda > 0$$

Note that the labour demand function is imbedded in the wage function.

Next we have to introduce various sources of inertia in the labour market. These may be either real or nominal in origin. Real sources of inertia can in general arise from a variety of mechanisms including capital accumulation, various forms of intertemporal substitution and costs of adjusting quantities and relative prices (see e.g. Romer (1996) for an introduction and references). Nominal sources of inertia relate to adjustment problems associated with nominal variables, here nominal output prices and wages (see e.g. Andersen (1998) for an introduction and references). Presence of nominal inertia is a necessary condition for nominal shocks to have real effects. Accordingly, it is important to be able to distinguish between real and nominal sources of inertia in adjustment. This is also of importance for evaluating the explanatory power of leading business cycle models since real business cycle models focus on real shocks and real inertia as driving the business cycle, while Keynesian type business cycle theory stresses the importance of nominal shocks and rigidities.

The most simple way to illustrate the various forms of inertia is to assume that decision variables are adjusted in accordance with the partial adjustment model, that is, if we let x_t (measured in logs) denote the decision variable, and x_t^* the optimal value of the decisions variable in period t, then

$$x_t = \lambda \ln x_{t-1} + (1-\lambda) \ln x_t^* \qquad 0 < \lambda < 1 \tag{5}$$

where x_t^* is the optimal value of the decision variable in period t[7].

An important question is the extent to which the partial adjustment model adequately captures the various forms of inertia which are important for the present analysis. It turns out that this model in some cases may give an exact representation of the adjustment pattern. This applies in the case of costs of adjusting either employment (real inertia), see e.g. Sargent (1979) or in adjusting nominal prices or wages (nominal inertia) see e.g. Rotemberg (1982). It also applies if adjustment problems are caused by the information problem of disentangling permanent from transitory changes see e.g. Andersen (1985). Clearly, the partial adjustment model is an exact representation of adjustment inertia only under specific assumptions concerning functional forms, stochastic process etc., and therefore the more general question is the extent to which it represents a reasonable approximation in the sense that it captures the qualitative implications of more generally formulated adjustment problems. The answer to this is confirmative in the sense that the partial adjustment model essentially introduces an autoregressive element in the process for the relevant decision variable, and autoregressive elements are essential to all forms of endogenously generated propagation mechanisms [8](see e.g. Romer (1996), Blanchard and Fischer (1989)). Obviously, the specific auto-regressive structure is model-specific and often involves complicated dynamic structures, but this has more a quantitative than a qualitative importance. Hence, we conclude that the partial adjustment model is useful to illustrate some basic dynamic results.[9] In the empirical analysis we allow for a broader formulation of the adjustment process.

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[7] We specify the partial adjustment equation in a logarithmic form because we will work with a log-linearized version of the model.

[8] Some important examples: Consumption smoothing implies autoregressive elements in consumption as captured most strongly in the random walk model for consumption; installation costs for real capital or employment implies autoregressive elements in output and employment, staggered price or wage contracts imply autoregressive elements in wages and prices and so on.

[9] The model is not in general useful to illustrate the effects of anticipated changes, like announced future policy shifts

Considering a log-linearized version of the model combined with the adjustment equation (5) we find from (4) that the dynamic employment equation can be written as

$$l_t = \alpha_0 + \alpha_1 \left(p_t^f - p_t\right) + \alpha_2 l_{t-1} + \alpha_3 z_t \qquad 0 < \alpha_2 < 1$$

where all lower case letters denote the log-value of the variable in question ($x_t \equiv \ln X_t$). The co-efficient α_2 captures the adjustment inertia arising from real propagation mechanisms.

A dynamic nominal price equation is found from (1) and (5) to read

$$p_t = \beta_0 + \beta_1 p_t^f + \beta_2 wn_t + \beta_3 p_{t-1} + \beta_4 z_t \qquad 0 < \beta_3 < 1$$

where the homogeneity property implies

$$\beta_1 + \beta_2 + \beta_3 = 1$$

The coefficient β_3 captures inertia in the adjustment of the nominal price.

The price equation can be rewritten

$$p_t - p_t^f = \beta_0 + \beta_2 \left(wn_t - p_t^f\right) + \beta_3 \left(p_{t-1} - p_{t-1}^f\right) + \beta_3 \left(p_{t-1}^f - p_t^f\right) + \beta_4 z_t$$

Showing that nominal inertia implies inertia in the adjustment of relative prices.

Similarly a dynamic nominal wage equation is found from (3) and (5) to read[10]

$$wn_t = \gamma_0 + \gamma_1 p_t^f + \gamma_2 p_t + \gamma_3 wn_{t-1} + \gamma_4 z_t$$

where

$$\gamma_1 + \gamma_2 + \gamma_3 = 1$$

Inertia in nominal wage adjustment is captured by γ_3.

The wage equation can be rewritten

$$wn_t - p_t^f = \gamma_0 + \gamma_2 \left(p_t - p_t^f\right) + \gamma_3 \left(wn_{t-1} - p_{t-1}^f\right) + \gamma_3 \left(p_{t-1}^f - p_t^f\right) + \gamma_4 z_t$$

The model presented here captures real propagation via the coefficient α_2. The larger α_2, the more inertia there is in the real part of the economy to changes in relative prices. The price-wage part of the model allows for nominal inertia in both prices ($\beta_3 > 0$) and wages ($\gamma_3 > 0$)

[10] Note that the effect on wages of changes in the labour market situation affecting the level of employment and thus unemployment (assuming exogenous labour supply) is embedded in the equation and that the dynamic adjustment towards the "equilibrium" wage is captured by γ_3. Adding the unemployment rate as a separate argument is thus meaningless and would add multi-collinearity problems to the empirical analysis and make the interpretation of the wage equation difficult as this variable should then catch up the effects and adjustment dynamics not already captured by the other variables in the equation.

which therefore also imply inertia in relative prices. It follows that nominal changes like a change in foreign prices in domestic currency will have real effects in the short run, but not in the long run.

The dynamic labour market model can in a more compact form be written

$$Ay_t = By_{t-1} + Cx_t \tag{6}$$

where

$$y_t \equiv \begin{bmatrix} l_t \\ p_t - p_t^f \\ wn_t - p_t^f \end{bmatrix} \qquad x_t \equiv \begin{bmatrix} p_{t-1}^f - p_t^f \\ z_t \end{bmatrix}$$

$$A \equiv \begin{bmatrix} 1 & \alpha_1 & 0 \\ 0 & 1 & -\beta_2 \\ 0 & -\gamma_2 & 1 \end{bmatrix} \qquad B \equiv \begin{bmatrix} \alpha_2 & 0 & 0 \\ 0 & \beta_3 & 0 \\ 0 & 0 & \gamma_3 \end{bmatrix}$$

$$C \equiv \begin{bmatrix} 0 & \alpha_3 \\ \beta_3 & \beta_4 \\ \gamma_3 & \gamma_4 \end{bmatrix}$$

The dynamic system (6) can be rewritten

$$y_t = Fy_{t-1} + Gx_t \tag{7}$$

where $F \equiv A^{-1}B$ and $G = A^{-1} C$.

Let λ_1 λ_2 and λ_3 be the characteristic roots of F, that is, the roots of

$$|F - \lambda I| = 0$$

and denote the corresponding matrix of eigenvectors by C, it follows that (see Anderson (1971))

$$F = C\Lambda C^{-1}$$

where

$$\Lambda = \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix}$$

The solution to (7) can now be written

$$y_t = C \sum_{i=0}^{\infty} \Lambda^i C^{-1} x_{t-i} \tag{8}$$

This process converges if and only if $|\lambda_j| < 1$ j = 1,2,3.

Solving for the characteristic roots, we find

$$\lambda_1 = \alpha_2$$

$$\lambda_2 = \frac{\beta_3 + \gamma_3 - \sqrt{(\beta_3 + \gamma_3)^2 - 4\beta_3(1-\beta_2\gamma_2)\gamma_3}}{2(1-\beta_2\gamma_2)}$$

$$\lambda_3 = \frac{\beta_3 + \gamma_3 + \sqrt{(\beta_3 + \gamma_3)^2 - 4\beta_3(1-\beta_2\gamma_2)\gamma_3}}{2(1-\beta_2\gamma_2)}$$

It is easily verified that $0 < \lambda_j < 1$ for j = 1, 2, 3. This proves that the system is stable and moreover that it displays monotone damping.

Considering the dynamic multiplier, we find

$$\frac{\partial y_t}{\partial x_{t-1}} = C\Lambda^i C^{-1}$$

where

$$\Lambda^i = \begin{bmatrix} \lambda_1^i & 0 & 0 \\ 0 & \lambda_2^i & 0 \\ 0 & 0 & \lambda_3^i \end{bmatrix}$$

Showing that temporary shocks and therefore also nominal shocks will have persistent real effects. It follows that the larger the eigenvalues λ_j (j = 1, 2, 3), the more persistent is the adjustment process.

It is seen that the size of the characteristic roots is related to the underlying inertia in employment (α_2) prices (β_3) and wages (γ_3) as reflected by the fact that

$$\mathrm{Tr}(\Lambda) = \lambda_1 + \lambda_2 + \lambda_3 = \alpha_2 + \frac{\beta_3 + \gamma_3}{1 - \beta_2\gamma_2}$$

It is noted that inertia in adjustment adds up in the sense that the dynamics of equilibrium employment, prices and wages depend mutually on the inertia in the adjustment of each single variable. The first term captures the inertia arising from employment adjustment (α_2) and the two other the inertia arising from nominal price and wage adjustment. The latter is seen most clearly by solving the price-wage system to read

$$p_t = \frac{1}{1 - \beta_2\gamma_2}\left[(\beta_1 + \beta_2\gamma_1)p_t^f + \beta_2\gamma_3 wn_{t-1} + \beta_3 p_{t-1} + \beta_4 z_t\right]$$

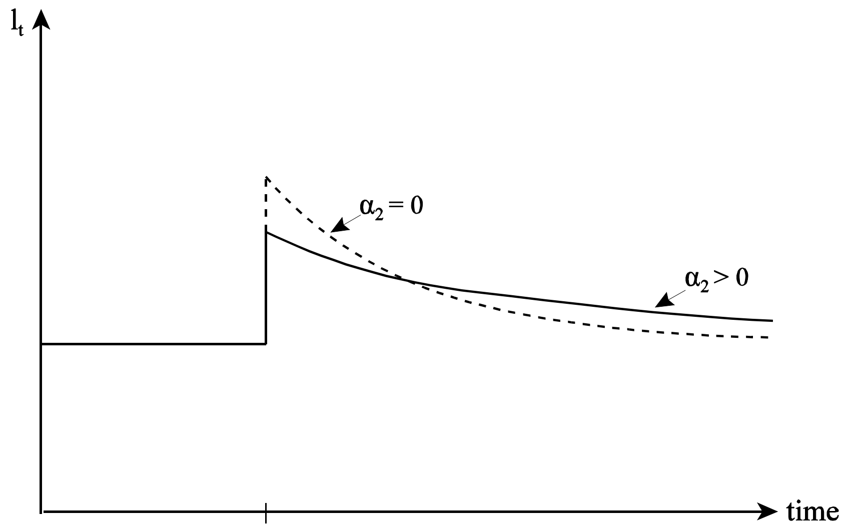
$$wn_t = \frac{1}{1 - \beta_2\gamma_2}\left[(\gamma_1 + \gamma_2\beta_1)p_t^f + \gamma_2\beta_3 p_{t-1} + \gamma_3 wn_{t-1} + \gamma_4 z_t\right]$$

The coefficient $\frac{\beta_3}{1 - \beta_2\gamma_2}$ measures thus inertia in price adjustment and $\frac{\gamma_3}{1 - \beta_2\gamma_2}$ inertia in wage adjustment. Note that $(1-\beta_2\gamma_2)^{-1}$ is a price-wage multiplier arising from the mutual dependence between prices and wages.

To see the interplay between the different types of inertia more clearly, consider the following example. A nominal change (a change in p_t^f) has real effects due to inertia in nominal price and wage adjustment ($\beta_3 > 0$ and/or $\gamma_3 > 0$). An increase in p^f will thus cause an employment increase because it takes time until domestic prices and wages have fully adjusted to this change (classic neutrality prevails only in the long run). Figure 1 illustrates the adjustment path with ($\alpha_2 > 0$) and without ($\alpha_2 = 0$) real adjustment inertia. In comparing the two cases, it is seen that inertia in real adjustment lowers the impact effect of the shock[11], but the adjustment process is stretched out which makes the effect of the shock more persistent.

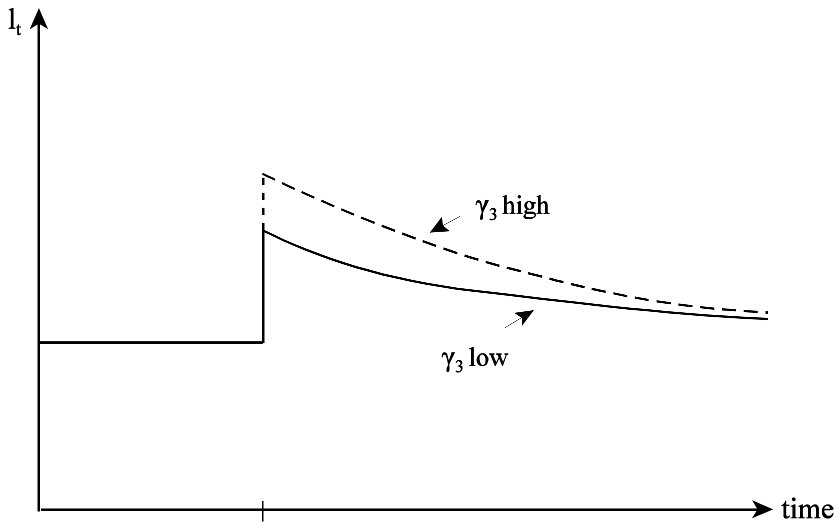
[11] In the present setting this follows directly from the partial adjustment model.

Figure 1. Employment Effects of Nominal Shocks with and without Real Inertia.



The situation is somewhat different for nominal inertia. The reason being that nominal inertia is necessary for nominal shocks to have a real impact effect. Hence, the more inertia, the larger the impact effect, and the more sluggish the adjustment to nominal shocks. This is illustrated in Figure 2 for the case of small and large nominal inertia in wage adjustment.

Figure 2. Employment Effects of Nominal Shocks with Weak and Strong Nominal Inertia



he important implication is that the different sources of inertia add up and reinforces each other. Even though the adjustment inertia in each separate decision variable may be low, it is possible that the variable in question displays substantial inertia due to the interplay between inertia in different parts of the system[12].

The following empirical analysis aims at identifying and quantifying these three basic sources of inertia. The purpose is both to clarify the adjustment problem to different types of shocks and to try to separate out how different sources of inertia contribute to the adjustment process.

3. Empirical Analysis

We estimate our model for the manufacturing sector in Denmark using quarterly data 1974.1 to 1993.4. Before proceeding to model estimation, we shall consider the properties of the data employed in the analysis. The data applied are all i logs, and they are labour productivity, lp_t, employment, l_t, a demand indicator, d_t, consisting of government expenditures plus export in fixed prices, the producer price of manufacturing goods, p_t, the producer price of foreign goods in Danish currency, pf_t, the real product wage, w_t, the nominal wage, wn_t, the real raw material price, r_t, the nominal raw material price, rn_t, and the relation between the foreign and domestic producer prices, pfp_t.

The data are depicted in Figure 3 together with their first and fourth differences.

From Figure 3 it is seen that all the variables have strong persistence as well as strong and in some cases varying seasonal patterns. As a prelude to estimation of the model, we therefore report the results of a series of unit root tests in Table 1.

[12] See Andersen (1998) for a demonstration of this finding in a fully specified intertemporal macromodel.

Figure 3. The data series, the first differences and the fourth differences 1974.1-1993.4

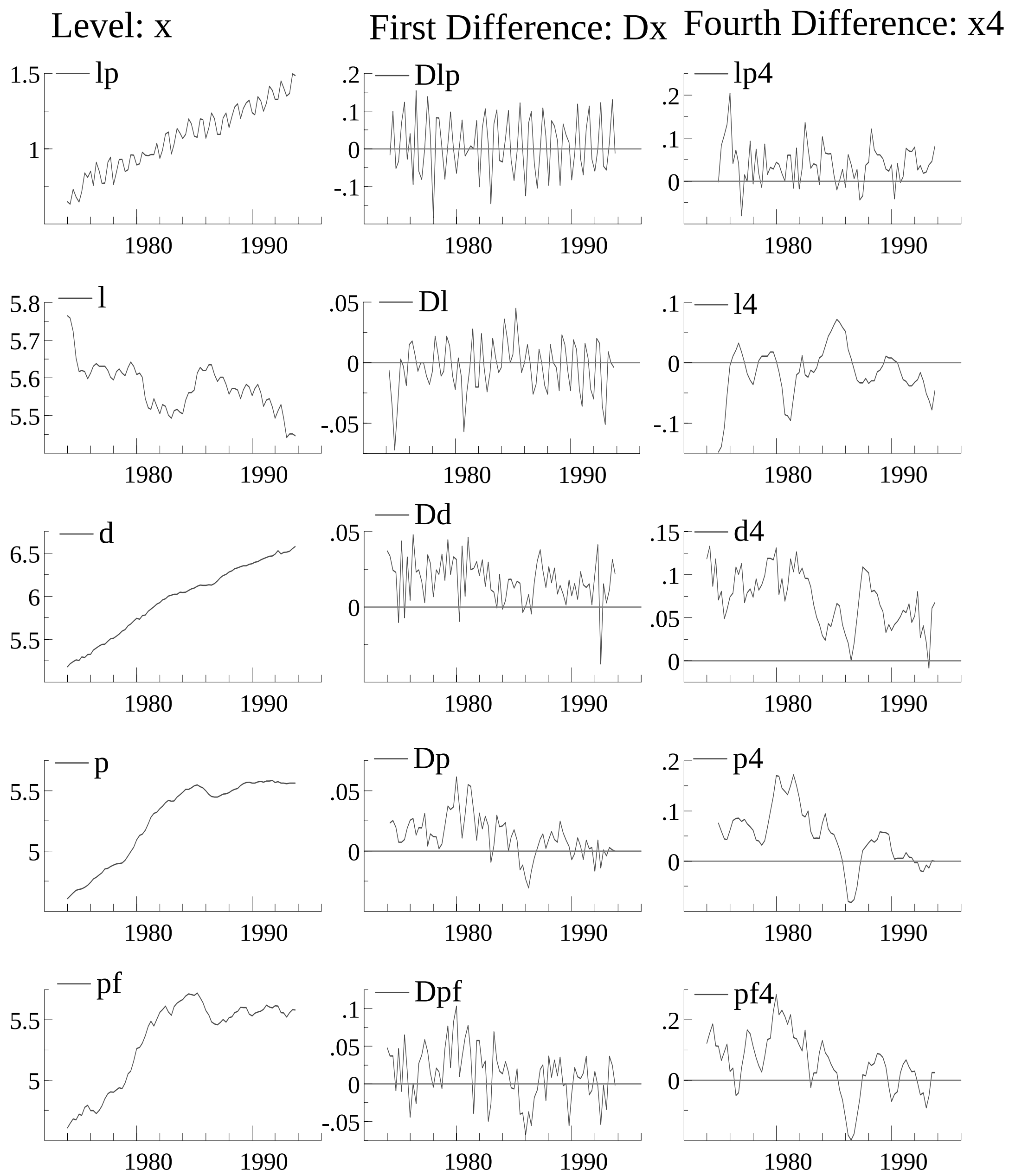
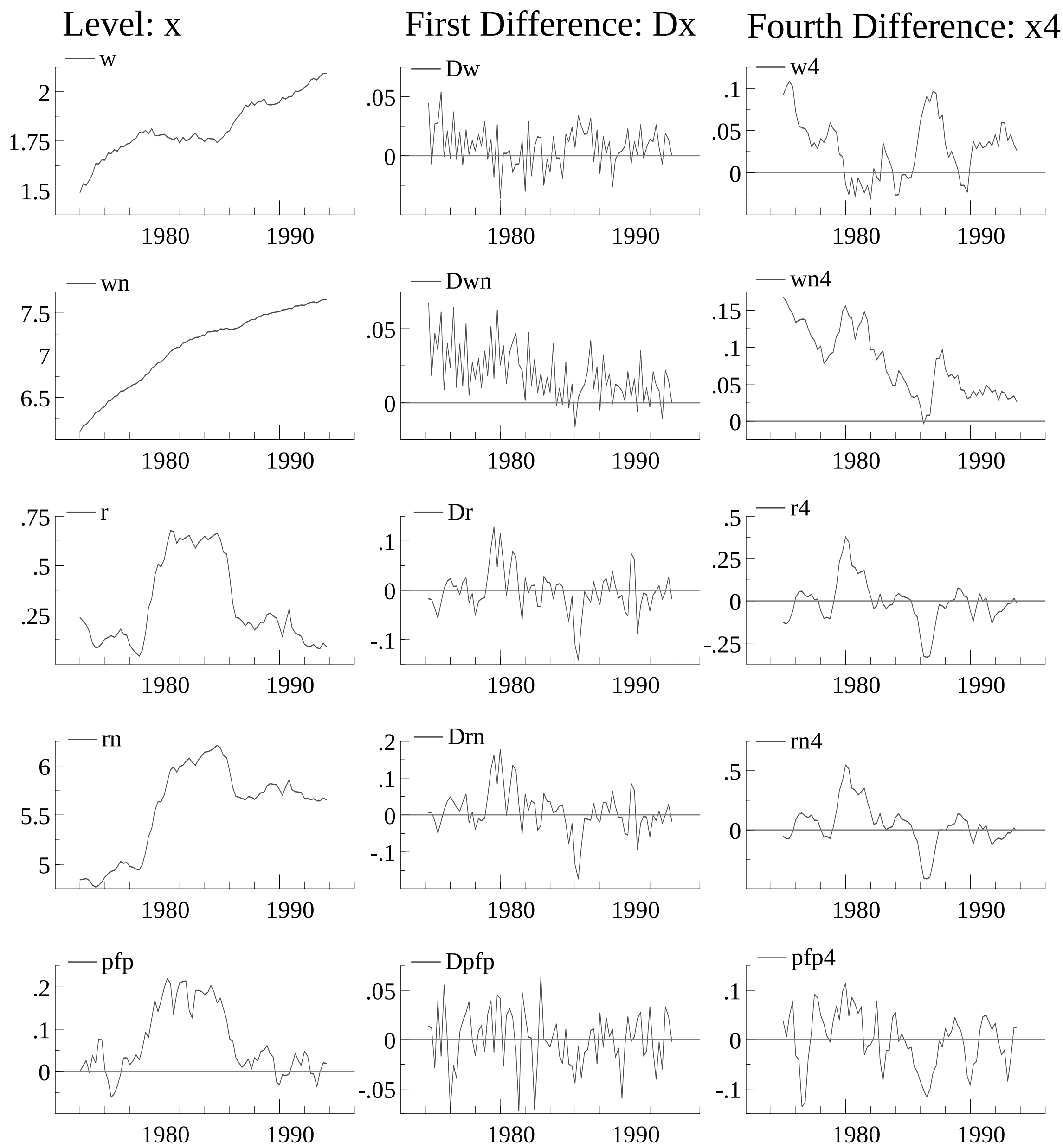


Figure 3 (cont). The data series, the first differences and the fourth differences 1974.1-1993.4



The Dickey-Pantula test is based on the Dickey Fuller test or DF test, see Dickey and Fuller (1979). The DF test is a test for a unit root at the zero frequency (the long run). The test is based on a auxiliary regression where the first difference of the series is regressed on the level lagged one period, deterministic terms like an intercept and a trend plus an augmentation of lagged first differences of the series just sufficient in numbers to make the errors white noise. The t-value on the lagged level has a non standard, so called DF distribution.

The Dickey-Pantula test (see Dickey and Pantula (1987)) sets up a testing sequence where the first test is a Dickey Fuller test using the first difference of the series instead of the level. In case a unit root in the first difference is rejected i.e. the null of an I(2) series is rejected, the hypothesis of I(1) against I(0) is tested. The latter in a regression of the second difference on the first difference and on the level, both lagged one period as well as the usual augmentation of lagged second differences and deterministic terms. The test statistic i.e. the t-value on the lagged level in the second regression has a non standard Dickey Fuller distribution.

The HEGY (see Hylleberg, Engle, Granger, Yoo (1990)) test is a test for unit roots at the zero frequency, and at the seasonal frequencies, which in quarterly data are the frequencies 1/4 (annual) and ½ (semi-annual). The test is based on an auxiliary regression where the fourth difference is regressed on transformations of the levels lagged one and two periods. The transformations are created to isolate the different possible unit roots. The regression is augmented with lags of the dependent variable and deterministic terms such as an intercept, seasonal dummies and a trend. The t-values on the coefficients to the transformations isolating the zero frequency unit root and the semi-annual frequency unit roots have a nonstandard DF distribution, while the F-value on the coefficients to the transformation isolating the annual unit root, lagged 1 and 2 periods have a non standard distribution tabulated in Hylleberg et al.(1990).

The results of the tests given in table 1 indicate that all the variables except possible lp_t where the evidence is mixed are integrated of order one at the zero (long run) frequency, i.e. $I_0(1)$, and integrated of order zero, stationary, at the seasonal frequencies ½ and 1/4 , i.e. $I_{1/2}(0)$ and $I_{1/4}(0)$. In addition, none of the variables are integrated of order 2 at the zero frequency, i.e. none are $I_0(2)$. Hence, the proper way to proceed is through an ordinary cointegration analysis.

Next we start searching for cointegration relations. We exploit previous work on the manufacturing sector in Denmark reported in Andersen and Hylleberg (1998) where basically the same real version of the model is analysed and two cointegration relations are found. Redoing this analysis applying both the Johansen Maximum Likelihood analysis (see Johansen (1991)) and the Engle-Granger analysis (see Engle and Granger (1987)) indicates that the following two cointegrating relations cannot be rejected.

Table 1. Unit Root Tests 1974.1-1993.4.

	HEGY test					Dickey-Pantula test			
Variable	H_0:$I_0(1)$	H_0:$I_{1/2}(1)$	H_0:$I_{1/4}(1)$	Augmentation		H_0: $I_0(2)$	H_0: $I_0(1)$	Augmentation	
				Lags	Deter-ministic			Lags	Deter-ministic
lp_t	-4.52**	-4.26**	26.73**	0	I, SD,Tr	-7,19**	-3.16	1,28	I,SD,Tr
l_t	-2.07	4.40**	39.25**	0	I,SD,Tr	-5.83**	-1.73	1	I,SD,Tr
d_t	-1.24	-4.57**	49.78**	0	I,SD,Tr	-10.48**	-0.88	0	I,SD,Tr
p_t	-0.85	-6.19**	25.76**	0	I,SD,Tr	-4.39**	-0.84	4,6	I,SD,Tr
pf_t	-1.14	-5.41**	40.63**	0	I,SD,Tr	-6.35**	-0.91	0	I,SD,Tr
wn_t	-2.32	-4.46**	41.78**	3,6,7	I,SD,Tr	-7.91**	-0.92	3,4,5,6,7	I,SD,Tr
wn_t	-1.05	-3.51*	48.28**	5,6	I,SD,Tr	-6.94**	-1.02	2,5,8	I,SD,Tr
rn_t	-2.05	-7.96**	21.15**	0	I,SD,Tr	-5.22**	-1.62	0	I,SD,Tr
rn_t	-1.52	-7.18**	19.28**	0	I,SD,Tr	-4.65**	-1.15	0	I,SD,Tr
pfp_t	-1.75	–5.26**	29.15**	0	I,SD,Tr	-8.12**	-1.78	0	I,SD,Tr

Note: DF - HEGY test for a unit root at the zero frequency, and at the seasonal frequencies, see Hylleberg et al (1990). - Dickey-Pantula test for two unit roots at the zero frequency followed by a test for a single unit root. Dickey and Pantula (1987). * significant at the 5% level. ** significant at the 1% level.

$$l_t = 6.19 - 0.0151\, S1_t + 0.0100\, S2_t + 0.0134\, S3_t - 0.606\, w_t - 0.178\, r_t + 0.0907\, d_t + zl_t \quad (9)$$

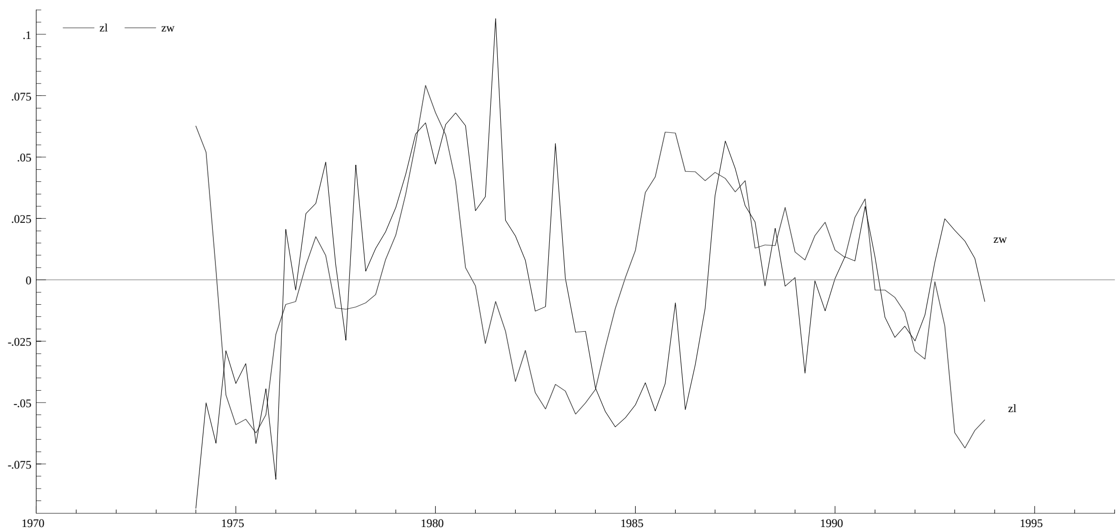
$$w_t = 1.20 + 0.0364\, S1_t + 0.0389\, S2_t - 0.0207\, S3_t - 0.243\, r_t + 0.291 pfp_t + 0.614\, lp_t + zw_t \quad (10)$$

where Si_t denotes seasonal (quarterly) dummies, zl_t and zw_t are the cointegrating errors (relations).

The cointegrating relations are depicted in Figure 4.

The next step is to use these long run relations between the real variables in the model and superimpose them upon a dynamic model for employment, nominal wages and nominal prices specified in first differences. Notice, that the model is specified such that price homogeneity is imposed on the long-run relation while this is not so for the short-run/dynamic model.

Figure 4.The cointegrating relations.



Specifically, we estimate a model allowing for a more rich dynamic structure than the illustrative model from section 2. The general form of the model is a ten equation model with the first differences of employment, l_t, nominal prices, p_t, and nominal wages, wn_t, as the endogenous variables determined in stochastic equations, and lagged values of these as explanatory variables together with lagged and unlagged values of the first differences of demand, d_t, nominal raw material prices, rn_t, labour productivity, lp_t, and foreign producer prices, pf_t. The lagged value of the two error cointegrating correction terms zl_t and zw_t determined in (9) and (10) are included as explanatory variables as well as seasonal dummies and an intercept. In addition, to the these stochastic equations and the two cointegrating relations the model contains 5 identities determining the relative producer prices, pfp_t, the real wage, w_t, the producer price, p_t, the level of the nominal wage, wn_t, and the level of unemployment, l_t.

By applying a general to specific approach, we have then constructed an empirical version of the model. The estimated version of the stochastic equation applying a Full Information Maximum Likelihood procedure is shown below.

It is assumed that all other variables than the employment, the domestic producer price, the nominal wage, and the two variables defines by the identities are weakly exogenous for the parameters of interest. Following, the general to specific approach we have specified a parsimonious model which is not over-parameterized. This implies that we have removed insignificant terms and imposed coefficient restrictions in order to obtain parsimony. However, care should be exercised when interpreting such coefficients as they may capture several effects between which the data cannot separate. Instead one should concentrate on the general dynamic properties of the model. Also notice that labour productivity enters the model only through the long-run cointegration relationship, and that the use of second differences is an effect of the estimation results and not an constraint imposed on the model.

The total model estimated by Full Information Maximum Likelihood for the period 1974.1 to 1993.4 contains the two cointegrating relations defining the equilibrium corrections zl_t and zw_t (see (9) and (10)), five identities defining pfp_t as $pf_t - p_t$, w_t as $wn_t - p_t$, p_t as $\Delta p_t + p_{t-1}$, wn_t as $\Delta wn_t + wn_{t-1}$, and l_t as $\Delta l_t + l_{t-1}$ and the three stochastic equations determining Δl_t, Δwn_t and Δp_t shown below.

Equation 1 for Δl_t

Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
Δl_{t-1}	0.435	0.095	4.58	0.000	0.093
$\Delta\Delta pfp_{t-2}$	0.062	0.032	1.97	0.053	0.036
$\Delta\Delta d_{t-2}$	0.105	0.057	1.85	0.069	0.078
zl_{t-1}	-0.078	0.037	-2.09	0.041	0.029
zw_{t-1}	-0.061	0.037	-1.66	0.102	0.031
Constant	-0.020	0.003	-7.93	0.000	0.003
$S1_t$	0.014	0.004	3.23	0.002	0.005
$S2_t$	0.044	0.004	10.80	0.000	0.005
$S3_t$	0.019	0.004	5.15	0.000	0.004

$\sigma_1 = 0.011$

Equation 2 for Δwn_t

Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
Δp_t	0.430	0.093	4.60	0.0000	0.069
$\Delta\Delta d_{t-2}$	0.142	0.054	2.63	0.011	0.050
Δwn_{t-2}	0.285	0.097	2.93	0.005	0.100
zw_{t-1}	-0.035	0.035	-1.02	0.314	0.037
Constant	0.007	0.004	1.89	0.063	0.004
$S1_t$	-0.006	0.004	-1.32	0.193	0.005
$S2_t$	0.013	0.004	3.80	0.000	0.004
$S3_t$	-0.004	0.004	-0.88	0.380	0.004

σ_2 = 0.010

Equation 3 for Δp_t

Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
Δp_{t-1}	0.514	0.085	6.04	0.000	0.091
Δpf_t	0.113	0.028	4.04	0.000	0.029
Δr_t	0.210	0.025	8.42	0.000	0.024
Δr_{t-1}	-0.080	0.033	-2.44	0.017	0.031
Constant	0.0049	0.002	2.68	0.009	0.002
$S3_t$	-0.0065	0.003	-2.52	0.014	0.003
$S1_t$	0.0021	0.0025	0.84	0.405	0.002
$S2_t$	0.0023	0.0026	0.88	0.384	0.0019

σ_3 = 0.007

loglik = 1079.6875 log|\Omega| = -28.4128 |\Omega| = 4.57578e-013 T = 76
LR test of over-identifying restrictions:
Chi^2(38) = 84.0383 [0.0000] **

Vector portmanteau 9 lags=   79.023   [Autocorrelation test]
Vector AR 1-5 F(45,152) = 1.1785 [0.2309] [Autocorrelation test]
Vector normality Chi^2(6)= 5.9553 [0.4282]   [Normality test]
Vector Xi^2 F(222,156) = 1.1096[0.2445][Heteroskedasticity test]

Although the LR test for over-identifying restriction rejects the model, the fit is quite impressive, see below, and the design criteria are otherwise fulfilled.
Our primary interest here is inertia. We find the error-correction term to be correctly signed in the employment and nominal wage equations (it is not significant in the price equation), but also that the adjustment towards the long run works slowly. The empirical estimates confirm that both real and nominal sources of inertia play a role.

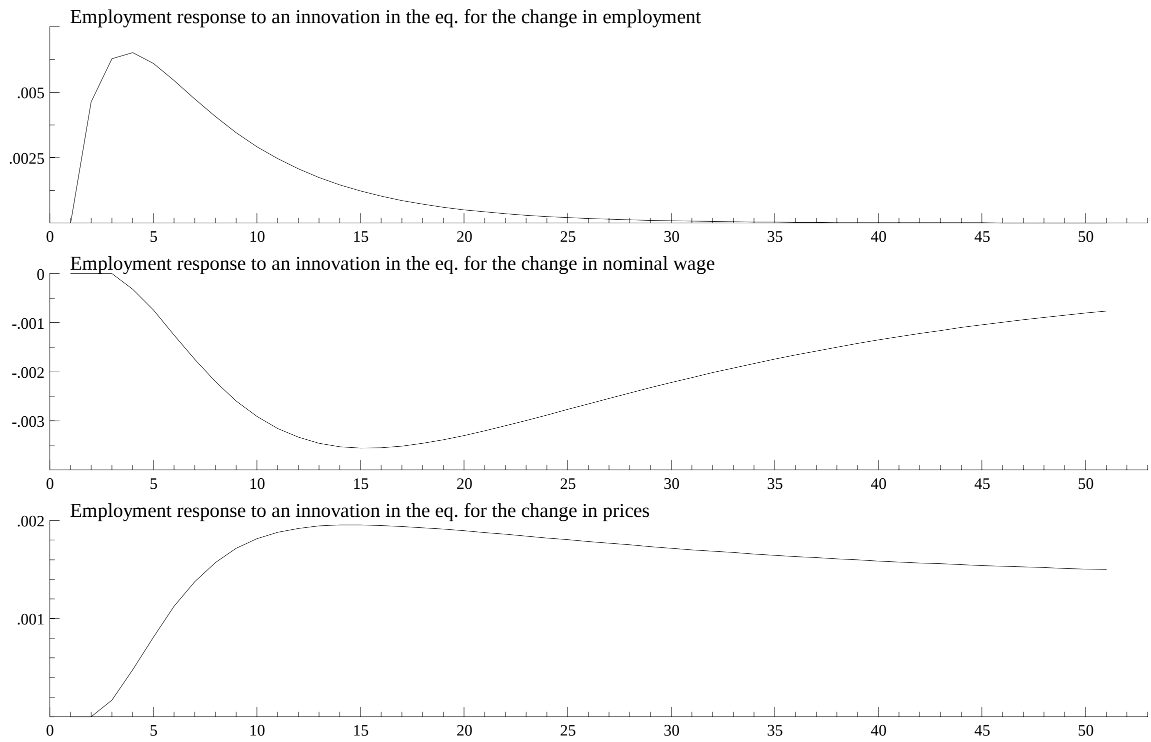
To gain more insight on the inertia implied by the estimated model, we report in Figure 6 the impulse response functions of employment to innovations to each of the dynamic stochastic equations of the model, that is, innovations to employment, nominal wages and nominal prices.

The adjustment of employment to all these types of shocks displays inertia. While the effects of employment on shocks to employment have evaporated after 4 years, shocks to nominal wages and prices have real effects on employment lasting much longer. The very long period is an effect of inclusion or non inclusion of the error correction term in the three stochastic equations. If
zw_{t-1},which is only slightly significant in the equation for Δwn_t, is removed from that equation,

the impulse response of employment to an innovation in that equation is even more persistent. The opposite effect arise if the error correction terms zl_{t-1} and zw_{t-1} are imposed on all stochastic equations although not significant in these equations. However, the persistence of the innovations is quite evident in all cases. This confirms that nominal inertia plays an important role for the adjustment process in the labour market.

To analyse the role of nominal shocks more directly, we consider the adjustment path to a (unanticipated) permanent nominal shock which effects employment, wages and prices simultaneously. The relevant nominal variable in the model is a change in the exchange rate and it is transmitted into the real side of the economy via a change in the price of foreign products in domestic currency (pf) and a change in the raw material prices (rn)[13].

Figure 6. Impulse responses of the log of employment, l_t, to a one standard deviation increase in the innovation of each of the stochastic equations for t = 1, 2,...................., 50 quarters.



[13] The calculation is performed imposing homogeneity on the dynamic wage and price equation, to eliminate possible effects of non-neutralities of nominal shocks.

Figure 7 displays the employment response to a nominal (exchange rate) shock. Nominal rigidities in both prices and wages imply that the shock has real effects. Specifically, we find that it takes some time for the effect to reach its peak level and also that the adjustment process displays some
sluggishness. It is seen that the peak effect is reached after more than a year, and after two years more than half the peak effect is still present. Hence, nominal shocks have persistent real effects The adjustment of nominal prices and wags are illustrated in figure 8 showing the relation of foreign prices in domestic currency to prices (terms of trade) and wages. The half-life of the effects of the nominal shock on the real exchange rate is about 4-5 quarters or 2 years based on annual data. This is somewhat lower than the usually found half-life of PPP-deviation which is 4-5 years (see eg Rogoff (1996)). Nominal wages are seen to adjust with more inertia than nominal prices. While the model does display inertia, it is the case that it does not produce any persistency pattern beyond the usual short term business cycle horizon. Hence, these findings do not support the hypothesis that very substantial inertia in adjustment can explain the deterioration in employment performance.

Figure 7. Employment effects of a nominal shock (1%).

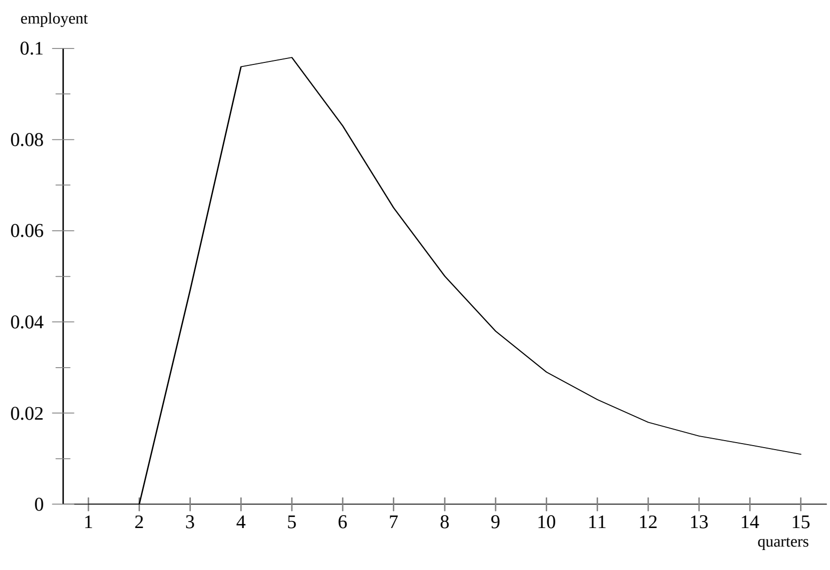
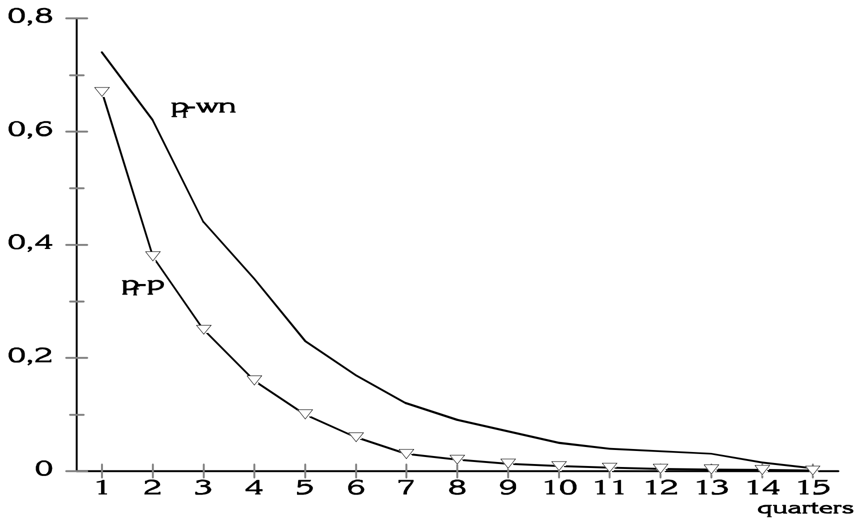


Figure 8. Adjustment of the terms of trade (pfp=pf-p) and foreign prices relative to wages (p_f-wn) to a nominal shock (1%)



In order to shed more light on the quantitative importance of the various sources of inertia for employment[14], we have used our 2 long-run relations e.g the cointegrating relations, which are in real terms to calculate the forecast i.e the fitted valued of the employment series[15] L_t. The fitted variable is denoted $LHATL_t$ and is interpreted as the prediction from the long run real part of the model. The fitted value of the employment computed from the total model including both the long run part and the short run part is denoted $LHAT_t$. The difference between $LHAT_t$ and $LHATL_t$ is denoted $LHATS_t$ and it can be interpreted as the prediction of employment based on the short term part of the total model.

The 4 series are depicted in Figure 9.

Figure 9 indicates that the model fits employment very well, and moreover that the long run real part of the model fits the long run falling trend of the employment series quite well. However, from the graph of the short run part, $LHATS_t$, it is clear that a lot of dynamics and persistence

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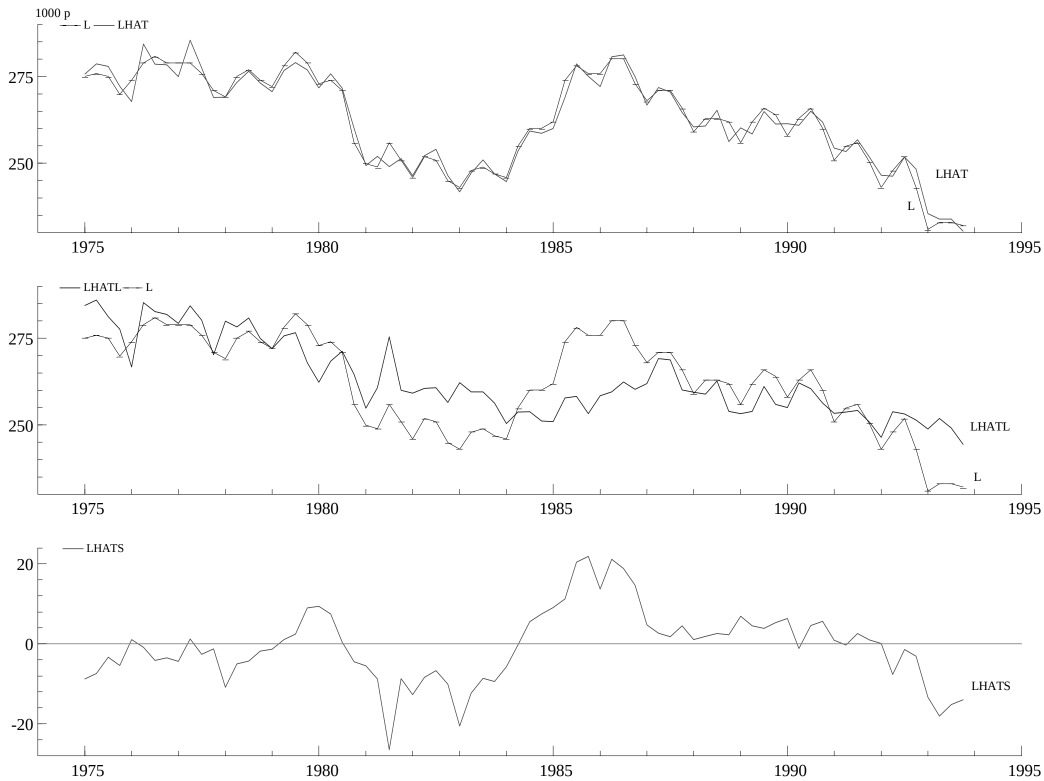
[14] Notice that since the model is estimated using sectorial data, it is not meaningful to try to calculate a structural or equilibrium unemployment level. This would require a well-defined series for labour supply which is not available at the sectorial level.

[15] L_t is the employment series while l_t is the log of the employment series.

is present in this series. Notice, that the increase in the employment from 1983 to 19986/87 is "explained" by the short run part of the model. The inertia is also documented in Figure 10, where the

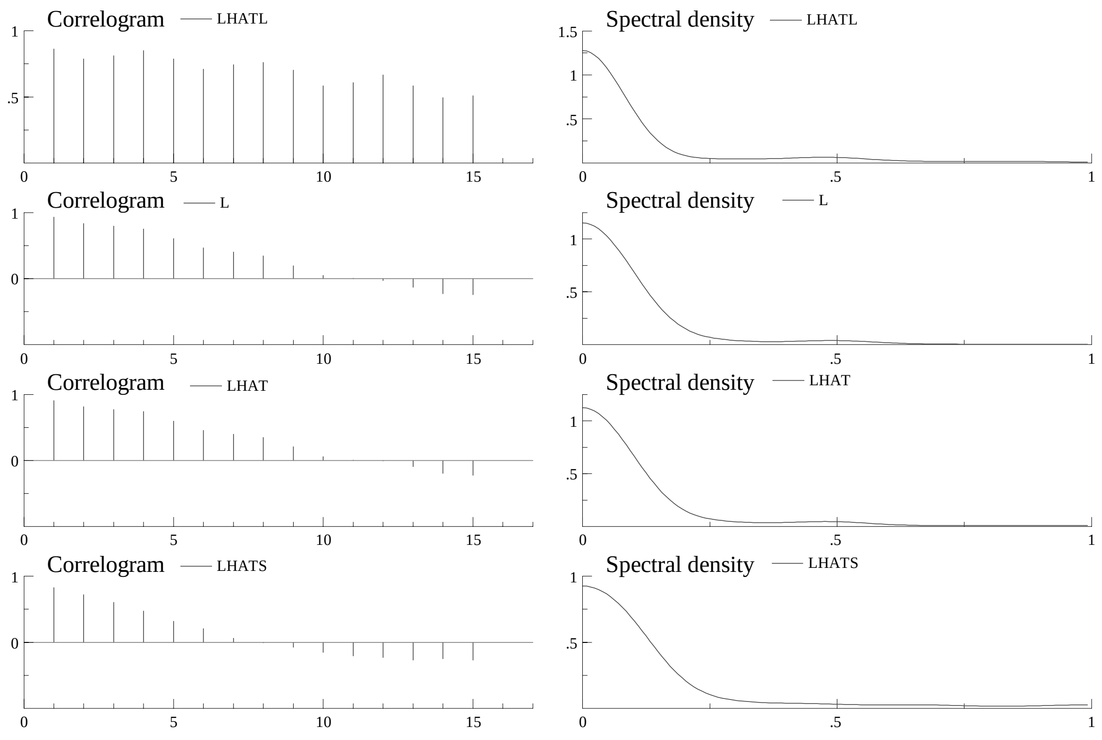
Figure 9. Employment, L_t , and fitted values from the total model, $LHAT_t$, the long run real model, $LHATL_t$, and the short run nominal model, $LHATS_t$.



correlograms and spectra of the series are shown. The correlogramme of the fitted value of the long run model is very slowly falling off with an increasing lag length, as could be expected, but even the correlogram for the short run part has significant contributions after 1½ year

Another way of decomposing the short and long run effects on employment can be based on table 2 showing the results of a series of regressions of L_t on $LHAT_t$, $LHATL_t$, and $LHATS_t$ are shown. The first regression of L_t on $LHAT_t$ indicates that the model fits the employment series quite well since the constant is not significantly different from zero and the slope not significantly different from one. The R^2 of 0.96 can then be used as a measure of the fit. The second regression of L_t on the components of $LHAT_t$ i.e. $LHATL_t$ and $LHATS_t$ gives a similar information, but in addition the very high partial squared correlation coefficients of 0.94 and 0.92, respectively, indicate that the short run and long run parts of the total model complements each other, and that one of the two components to a great extents explain the variation in L_t which is not explained by the other component. The two remaining regressions of L_t on each of the components of $LHAT_t$, indicate as should be expected that the long run model is able to explain approximately 1½ times as much of the total variation in L_t as the short run part of the model.

Figure 10. Correlogrammes and spectra of employment, L_t , and fitted values from the total model, $LHAT_t$, the long run real model, $LHATL_t$, and the short run nominal model, $LHATS_t$. The correlogrammes are depicted for lags 1 to 15 and.



From these regressions it can be concluded that both the long-run part and the short-run part are very important in explaining the variation in employment. In addition the two components are to a great extent orthogonal complements. The short run part of the model shows that there is substantial inertia in the adjustment process.

Table 2. Auxiliary Regressions of L_t on $LHAT_t$, on $LHTAL_t$ and $LHATS_t$, on $LHATL_t$, and on $LHATS_t$

	L_t on $LHAT_t$			L_t on $LHATL_t$ & $LHATS_t$			L_t on $LHATL_t$			L_t on $LHATS_t$		
	coef.	st. dev.	Partial R^2	coef.	st. dev.	Partial R^2	coef.	st. dev.	Partial R^2	coef.	st. dev.	Partial R^2
$LHAT_t$	1.00	0.02	0.96									
$LHATL_t$				1.00	0.03	0.94	0.88	0.10	0.51			
$LHATS_t$				1.01	0.03	0.92				0.85	0.14	0.33
Constant	-0.50	6.10		0.64	7.55		30.04	26.74	0.02	263.0	1.29	
R^2	0.96			0.96			0.51			0.33		

4. Concluding remarks

The present study has documented that there is substantial inertia in the adjustment process in the Danish labour market. Both real and nominal sources of inertia are present, but nominal adjustment failures in prices and wages are quantitatively important. This finding has several important implications.

First, it may be misleading to base measures of the structural unemployment rate on recently observed unemployment rates. The latter may show substantial persistence without this necessarily reflecting a shift in the underlying structural unemployment rate.

Second, policies directed towards making the labour market more flexible so as to reduce inertia in the adjustment process should focus more on the incentives underlying wage and price formation rather than on employment determination.

Finally, given the substantial inertia and in particular the nominal inertia, there is not only a role for general demand management policies in smoothing employment, but also for monetary policies in contributing to speeding up the adjustment process.

However, even though we have identified substantial sources of both real and nominal inertia, it is the case that the adjustment failures are not strong enough to support the interpretation that deteriorating labour market performance is due to a sequence of adverse shocks and substantial inertia. The inertia identified here is substantial from a business cycle perspective, but not in relation to the time span over which unemployment has persisted at a high level. This is also reflected in the finding that the long-run version of the model without any inertia captures the long-run trend in employment quite well. This indicates that structural problems may be important for observed unemployment persistency, but the framework applied here is not constructed with the aim of identifying these.

This study used data for the manufacturing sector. This has the advantage that is becomes more meaningful to model the different adjustment processes in a fairly detailed way. However, it has the disadvantage that it does not allow an evaluation of the overall performance of the labour market. Since the sector considered here is very central for the general economic performance of the Danish economy, it may be conjectured that the findings of the present study can be generalized.

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