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# Arbeitspapiere/ Working Papers

Christian Müller

## Monopolistic Competition in Switzerland and Mark-up Pricing Over the Business Cycle



# Monopolistic Competition in Switzerland and Mark-up Pricing Over the Business Cycle

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## Abstract

We investigate how firms' market power affects the price level. In our small macro-model we show, that firms - in addition to hypothesised structural mark-up pricing power - may take advantage of favourable business cycle fluctuations. The paper provides empirical evidence for both these propositions to hold. To show this, we estimate the model in a multivariate time series framework with double integrated variables. We can derive a model based business cycle indicator which compares very well with exogenous survey data information.

*JEL classification:* C32, D40, E31, E32

*Keywords:* mark-up pricing, monopolistic competition, business cycle indicators, I(2) cointegration, multivariate time series analysis

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## 1 Introduction

The Swiss economy is sometimes considered as an agglomeration of companies contending in a monopolistic competition. This is equivalent to saying that firms can pursue mark-up



pricing where the mark-up is added to the marginal costs and depends on the elasticity of the demand curve.

In this paper we extend this framework by suggesting that the stance of the business cycle may equip firms with additional or reduced pricing power, depending on whether the economy experiences a boom or a recession. In order to do so, we derive a small partial macro-model which describes price setting behaviour of firms, show that the potency to set prices can be derived from this model, estimate a corresponding system of equations, and finally test whether or not the derived pricing power indicator corresponds to an observable empirical counterpart. It turns out that a significant share of the otherwise unexplained price changes can be attributed to business cycle fluctuations.

The remainder of the paper is as follows. First, the theoretical model is briefly sketched, second, the data for the empirical application will be described and the empirical model will be set up. Then, the implied business cycle indicator is calculated and compared to a measure based on survey data.

## 2 The Model Economy and Firm's Prices Setting

The technology in the model economy is described by its principal input which is labour. Likewise, for simplicity, we assume that the cost of production is a function of labour input. With stable and low real interest rates this does seem to be a reasonable restriction.

We assume that the representative firm has some market power and thus can maximise income by equating marginal revenue and marginal costs. However, since revenues also depend on the demand for the final good, the price firms can set will depend on demand and this will affect the choice of labour input.

Thus, the economy is described by

production	$Q_t = Q(L_t)$	$\frac{\partial Q}{\partial L_t} > 0$
costs	$C_t = C(L_t)$	$\frac{\partial C}{\partial L_t} = a_1 W_t^{a_2}$
demand	$P_t = P(Q(L_t))$	$\frac{\partial P}{\partial L_t} = \frac{\partial P}{\partial Q_t} \frac{\partial Q}{\partial L_t}$
demand elasticity	$\eta_t = \eta(Q_t)$	$\eta_t^{-1} = \frac{\partial P}{\partial Q_t} \frac{Q_t}{P_t}$

where  $Q_t$  is the quantity of goods produced and sold at the market,  $L_t$  stands for labour input which is paid the wage  $W_t$ , and  $P_t$  is the price per unit of output.

The firms maximise

$$\max_{L_t} P_t Q_t - C_t$$

and the first order condition can be given as

$$\frac{\partial Q}{\partial L_t} \left[ \frac{\partial P}{\partial Q_t} Q_t + P_t \right] = \frac{\partial C}{\partial L_t}. \quad (1)$$

After expanding the first term in brackets, and substituting for the definitions given above we obtain

$$\frac{\partial Q}{\partial L_t} P_t (1 + \eta_t^{-1}) = a_1 W_t^{a_2}. \quad (2)$$

According to (2) firms' mark-up on marginal costs is  $(1 + \eta_t^{-1})$ . The factor  $\frac{\partial Q}{\partial L_t}$  is given by the production technology and can be interpreted as labour productivity. Prices will principally be ruled by the evolution of wages, however we do not restrict the relationship to be strictly linear. Linearity would be obtained if we set  $a_2 = 1$ .

Because the main focus of this paper is the relationship between the business cycle and the mark-up, we will take a closer look at the mark-up measure  $(1 + \eta_t^{-1})$ . Conventionally, it might be assumed that the mark-up is constant because it could be argued, that the demand for goods is a relatively stable function of prices and quantity. Defining  $\eta_t^* = 1 + \eta_t^{-1}$  this assumption can be reflected in the following decomposition of  $\eta_t^*$ :

$$\eta_t^* = b_0 + b_1 \epsilon_t \quad (3)$$

where  $b_0$  represents the time invariant part of the elasticity. If  $b_0 \neq 0$  we can regard this as the *structural* mark-up which is given by the *market structure*.

The interpretation of  $b_1$  is not as straightforward. One could for example think of the demand function for goods to be dependent on some exogenous circumstances as for example the business cycle conditions. This however, would imply a number of complications for the model like time varying partial derivatives. Instead of doing so, we assume the shape of the demand curve to be stable and consider the possibility that firms do not always supply at the optimal point of the demand curve. The reason for this could be the unavoidable uncertainty when drawing up production plans. Occasionally this may result

in too high or too low output relativ to the demand for goods which will be known only at a later stage.

It appears reasonable to assume that these fluctuation are more pronounced during upturns or downturns over the business cycle. Apart from these swings, the variations should be largely random and zero on average. Furthermore, if economic activity follows a stable growth path with only temporary deviations then  $\eta_t^*$  should follow a process with finite variance.

### 3 Empirical Analysis

The theoretical model links wages, prices, income, labour productivity and demand elasticity. Following (2) only prices, wages, labour productivity are needed to obtain an estimate for  $\eta_t^*$ . Avoiding the difficulties in measuring labour productivity correctly we will approximate this variable by a time trend. In a next step, we take the logarithm of (2) and write

$$p_t + \delta t + c_0 + c_1 \varepsilon_t = a_2 w_t, \quad (4)$$

where we apply the convention that lower case letters indicate the logarithms of the variable defined in upper case letters. In (4) the coefficient  $c_0$  is a composite of the mean of  $\log(\eta_t^*)$  and  $a_1$ . In the more likely case that  $a_1 \geq 1$ , positive values of  $c_0$  imply that a structural mark-up exists, i.e. firms have structural market power. The impact of the variation in  $\log(\eta_t)$  is measured by  $c_1$ .

Re-arranging the terms in (4) we find

$$p_t - a_2 w_t + \delta t + c_0 = c_1 \varepsilon_t. \quad (5)$$

In this representation,  $c_1$  can now be regarded as a scaling factor for  $\varepsilon_t$ . We now turn to the estimation of the coefficients in (5).



### 3.1 Data and Data Properties

Prior to running a straightforward regression of (5) equation we report the choice of the data and investigate their time series properties. The prices will be represented by the seasonally adjusted chain index deflator of the gross domestic product at factor costs. Wages are paid to workers and white collar employees excluding the self-employed. For both variables we use indexes. The deflator is calculated on a quarterly basis while wages are reported once a year by the Federal Office of Statistics. In order to obtain quarterly figures the Institute for Business Cycle Research (KOF) at the Federal Technical University in Zurich (ETHZ) uses a linear interpolation. A graphical impression of  $w_t$  and  $p_t$  is provided in figure 1 at the end of the paper.

Table 1 lists the result of the augmented Dickey-Fuller (Dickey and Fuller, 1979) unit root tests. We use  $\Delta^i$  as the difference operator with  $i = 1$  if not indicated otherwise.

The tests point to the fact that nominal wages and the price level are integrated of order 2, denoted  $I(2)$ . It should be recalled that the business cycle fluctuation of the mark-up should have finite variance, i.e. they should be  $I(0)$ . That's why we conclude from (5) that  $p_t$ ,  $w_t$ , and a time trend should form a cointegration relationship whose residual,  $c_1 \varepsilon_t^*$ , has to be stationary for the theory to hold. Moreover, estimating and identifying the coefficients of the cointegration relationship will enable us to obtain parameter estimates for  $a_2$ ,  $c_0$ , and  $\delta$ .

### 3.2 System Cointegration Analysis

The estimation of (5) will now be set in a multivariate time series model. We follow Rahbek, Kongstedt and Jørgensen (1999) who provide an asymptotic theory for the Johansen (1992) two-step approach with trending variables.

The empirical model is defined as

$$\begin{aligned} y_t &= (p_t w_t)' \\ y_t^* &= (y_t' t)' \\ \Delta^2 y_t &= \Pi y_{t-1}^* + \Gamma \Delta y_{t-1} + \sum_{i=1}^{p-2} \Gamma_i \Delta^2 y_{t-i} + D + u_t \end{aligned} \tag{6}$$

**Table 1:** Univariate Properties of the Data

Variable	lag order			specification and test statistics*			
	AIC	FPE	HQ	spec.	D.F.	c. v.	decision
$w_t$	6	6	6	$t, 6$	-2.93	-3.41	$I(2)$
$\Delta w_t$	10	10	5	5	-2.80	-2.86	$I(1)$
$\Delta\Delta w_t$	9	9	4	4	-3.283		$I(0)$
$p_t$	3	3	3	$t, 3$	-1.11	-3.41	$I(2)$
$\Delta p_t$	2	2	2	2	-2.48	-2.86	$I(1)$
$\Delta\Delta p_t$	2	2	2	2	-9.01		$I(0)$
$\pi_{z,t}$	3	3	0	3	-2.83	-2.86	$I(0)$
$\Delta\pi_{z,t}$	0	0	0	2	-4.3	-2.86	$I(0)$

\* D.F. is short for the augmented Dickey-Fuller test, the column spec. reports if in addition to an intercept a time trend ( $t$ ) entered the regression, and the number of lagged endogenous variables used for the D.F., c.v. abbreviates critical value (at the 5% level of significance). The columns headed by AIC, FPE, HQ give the optimal lag lengths according to the commonly used model selection criteria Akaike information criterion, Final Prediction Error, and Hannon-Quinn criteria respectively.

**Table 2:** Hypotheses About the Cointegration Rank

Model (6) with $p = 6$ .				
$n - r - s$				
		0	1	2
r	0	59.92	36.31	32.33
		47.60	34.36	25.43
	1	-	<b>18.10</b>	10.83
			19.87	12.49

$$\Pi = \alpha\beta'$$

$$\alpha'_{\perp}\Gamma\beta_{\perp} = \xi\nu'$$

where  $\alpha$  and  $\beta$  are  $(n \times r)$ ,  $r \leq p$  matrices of full column rank, with  $n$  denoting the dimension of the process. Likewise  $\xi$  and  $\nu$  are  $((n - r) \times s)$  matrices of full column rank with  $s < n - r$ . We define the  $(n \times m)$  matrix  $\gamma_{\perp}$  as the orthogonal complement to  $\gamma$   $(n \times m)$  with  $\gamma'_{\perp}\gamma = 0_{m \times m}$ . Finally,  $\Gamma_i$  are coefficient matrices,  $D$  is a  $n \times 1$  vector with constant terms, and  $u_t$  is the vector of innovations.

The matrix  $\beta'$  defines those linear relationships between the endogenous variables which are  $I(0)$ . Therefore, they should be informative about the coefficients of (5). In particular, if the theory outlined above holds, the the rank of  $\Pi$  would be one and the rank of  $\xi\nu'$  would be zero, i.e.  $\xi\nu' = 0$ . This can be tested in the framework of Rahbek et al. (1999). Table 2 reports the results.

The test procedure is a sequential one which can be read from left to right and top to bottom. Each of the entries represents a hypothesis about the process (6). For example, in the top left corner it is assumed that  $r = 0$  and  $n - r - s = 0$  which is a more general model than the one defined by the hypothesis next to the right:  $r = 0$  and  $n - r - s = 1$ , and so on. The sequence of tests stops when the hypothesis cannot be rejected for the first time. The .05 critical value for each hypothesis can be found below the test statistics. According to table 2 this is the case for the hypothesis  $H_0^4$ :  $r = 1$  and  $n - r - s = 1$ . Therefore, we consider (6) with  $r = 1$  and  $s = 0$  to be an acceptable description of the data generating process.

Under  $H_0^4$  we estimate (estimates of coefficients and variables are indicated by  $\hat{\cdot}$ )

$$\hat{\delta} = .00309$$

$$\hat{a}_2 = 1.172$$

$$\hat{c}_0 = .56.$$

We can now put forth further hypothesis about the coefficients and thereby confirm their statistical significance. For example,  $H_0^6 : a_2 = 1$  (linear marginal costs) and  $H_0^7 : \delta = 0$  (zero log-linear productivity growth) have been tested to the effect that both hypotheses had to be rejected at the .00 level of significance. Therefore, we can conclude that for  $c_1 \hat{\varepsilon}_t$  we have

$$c_1 \hat{\varepsilon}_t = p_t - 1.172w_t + .00309t + .56. \quad (7)$$

It is noteworthy that the constant term in (7) is positive and significant (standard error: .007) implying that firms have structural mark-up power.

### 3.3 The Business Cycle and the Power of Mark-up Pricing

In (7) we derived an estimate for the time varying part of the mark-up on marginal costs. It has been argued before, that this measure should follow business cycle fluctuations. Of course, if one is ready to accept that the theory used to motivate this interpretation, one could stop at this point and apply  $c_1 \hat{\varepsilon}_t$  as a business cycle indicator for further analysis. In our case however, we suggest to compare this endogenous indicator with an exogenous measure aiming at representing the stance of the business cycle.

For Switzerland, the KOF conducts a large number of surveys which attempt to give a reliable picture of the current situation of the economy. One of them investigates if the firm in question experiences capacity constraints, i.e. if capacities are too low, just right, or too high if compared to (expected) demand. The difference between firms reporting too high and too low capacities can then be used to indicate the state of the business cycle. This variable, denoted  $\pi_t$ , will be compared to  $c_1 \varepsilon_t$  in the following.

First, a unit root analysis is conducted for  $\pi_t$  (see table 1). If  $\pi_t$  and  $c_1 \hat{\varepsilon}_t$  are ought to be similar, they both should feature mean reverting behaviour and finite variance. This

seems indeed to be the case. Second, plotting these two variables adjusted for their means and variances, reveals that they both are strikingly similar in their evolution over time. This can be confirmed from figure 2.

A statistical analysis shows that the correlation between these variables is .6 while Granger-causality tests indicate that the hypotheses  $H_0^8$  : " $\pi_t$  does not Granger cause  $c_1\hat{\varepsilon}_t$ " cannot be rejected at the 10 percent level of significance at lags 1, 2, 4, 5. At lag 3 the p-value is .05. The corresponding hypothesis  $H_0^9$  : " $c_1\hat{\varepsilon}_t$  does not Granger cause  $\pi_t$ " can be rejected at all lags at the one percent level of significance. Therefore, it can be argued that the  $c_1\hat{\varepsilon}_t$  is a leading indicator for  $\pi_t$ .

Furthermore, due to the very high correlation between  $c_1\hat{\varepsilon}_t$  and  $\pi_t$ , a formal OLS regression shows a very significant linear relationship between these two variables. That is why one can conclude that there is not enough evidence to reject the hypothesis that  $c_1\hat{\varepsilon}_t$  and  $\pi_t$  to a large extent represent the same information. In the model we argued that the variation in the mark-up over time is a result of changing market power of firms due to business cycle fluctuations. The close link between  $c_1\hat{\varepsilon}_t$  and  $\pi_t$  implies that this suggestion is actually true.

### 3.4 Business Cycle Pricing Power and Pricing

So far, it had been shown that there is a linear relationship between prices, wages, and time that is following business cycle fluctuations. What is left though, is to show that this indicator indeed equips firms with additional or reduced power to raise prices. This however, can easily be confirmed by checking that the coefficients of  $\hat{a}$  corresponding to the price equation are significant and have the correct sign.

#### 3.4.1 Restricted Reduced Form Estimation

In order to show this, we specify a subset model with a reduced number of coefficients, yet extended set of regressors to improve the regression fit. The restricted reduced form

regression results in (heteroscedasticity adjusted standard errors in parentheses):<sup>1</sup>

$$\begin{aligned}\Delta^2 p_t = & -\frac{0.28}{(0.07)} \hat{\varepsilon}_{t-1} - \frac{0.64}{(0.07)} \Delta^2 p_{t-1} - \frac{0.41}{(0.06)} \Delta^2 p_{t-2} + \frac{1.24}{(0.28)} \Delta^2 w_{t-2} \\ & + \frac{0.008}{(0.002)} \pi_t + \frac{0.014}{(0.001)} \text{DUM99q3}_t + \frac{0.016}{(0.001)} \text{DUM91q1}_t \\ & + \frac{0.021}{(0.002)} \text{DUM83q3}_t - \frac{0.15}{(0.04)} + u_{1,t}\end{aligned}\quad (8)$$

$$\begin{aligned}\Delta^2 w_t = & \frac{0.11}{(0.02)} \hat{\varepsilon}_{t-1} - \frac{0.10}{(0.06)} \Delta^2 w_{t-2} - \frac{0.3}{(0.07)} \Delta^2 w_{t-3} \\ & + \frac{0.0052}{(0.002)} \text{DUM82q1}_t - \frac{0.004}{(0.0002)} \text{DUM89q1}_t \\ & + \frac{0.004}{(0.0002)} \text{DUM91q1q2}_t + \frac{0.06}{(0.01)} + u_{2,t}\end{aligned}\quad (9)$$

The overall model fit appears satisfactory, although there remains some autocorrelation especially in the wage equation. This could be a phenomenon which might be due to the interpolation of this data series.

Diagnostic analysis ( $p$ -values in brackets)

Standard error( $u_{1,t}$ )		$4.37 * 10^{-3}$
Standard error( $u_{2,t}$ )		$1.29 * 10^{-3}$
Vector Portmanteau(9)		7.08
Vector $\chi^2_{\text{normality}}$	$\chi^2(4) =$	9.22 [0.6]
Vector F <sub>EGE-AR(1-5)</sub>	$F(20, 130) =$	.68 [0.83]
Vector F <sub>hetero</sub>	$F(111, 108) =$	1.59 [0.01]

Having pointed out the similarity between  $\pi_t$  and  $\hat{\varepsilon}_t$  one might wonder if the information provided by  $\pi_t$  suffices to model the impact of the time varying mark-up. This too can easily be answered in the current framework. We simply split the information of  $\hat{\varepsilon}_t$  into two linearly independent parts by regression, and replace  $\hat{\varepsilon}_{t-1}$  by  $\pi_{t-1}$  and the residuals of the auxiliary regression. Doing so does not increase the information set but helps to distinguish the effects stemming from the survey data and the endogenous business cycle measure.

The result of this exercise (not reported) is that in both equations  $\pi_{t-1}$  is highly significant and has the the correct sign. The residual information however, is only significant in the price equation. We conclude once again that the interpretation of  $\hat{\varepsilon}_t$  as a business cycle measure is confirmed if we use the exogenous data as the point of reference.

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<sup>1</sup>We use dummy variables do account for outliers. They are abbreviated DUM followed by a code for the year (83 for 1983 and so on), the letter  $q$  and an integer indicating the quarter of the aforementioned year.

### 3.4.2 Interpretation

From (8) and (9) it can be confirmed that  $\hat{\varepsilon}_{t-1}$  indeed enters the equations for the independent variables significantly. At a first glance the sign might come as a surprise because it had been said before that the  $\hat{\varepsilon}_t$  is an indicator for market power. Large values of it will lead to a slowdown in inflation, however. What is important though, is the timing. While  $\hat{\varepsilon}_t$  measures current market power,  $\hat{\varepsilon}_{t-1}$  can also be interpreted as the extent to which the level of  $p_{t-1}$  is in excess of its long-run equilibrium value given by the realisation of  $w_{t-1}$ . Because the extra mark-up pricing power is finite, an adjustment back to equilibrium has to take place. Therefore, the coefficient on the once lagged value of  $\hat{\varepsilon}_t$  measure the adjustment taking place in the period following the one with excess market power.

A further reassurance that the reasoning above is correct is provided by the coefficient estimates on  $\pi_t$ . They show that in the very period in which extra market power is at the hands of the firms this is associated with additional inflationary pressure on wages and factor costs.

The fact that the core equation (5) represents a cointegration relationship implies that deviations from the long-run mark-up pricing power are not only short lived, but also that they do not have lasting impacts. That means even if firms take advantage of temporary extra market power due to business cycle fluctuations, these efforts will be reversed and the price level does not change in the long-run.

## 4 Summary and Outlook

In a small macroeconomic model we showed that firms might have time varying power to conduct mark-up pricing. This opportunity was attributed to the possibility of unexpected changes in the strategic position of firms for optimal price setting. For example, firms could be faced with a shift of the demand curve due to unpredicted events.

Under fairly weak assumptions with respect to the marginal costs of production function it could be shown that firms in Switzerland on average have the possibility to conduct mark-up pricing. Therefore, the view of monopolistic competition within the Swiss econ-

omy finds support.

On top of their structural mark-up pricing power firms exploit further opportunities to change prices if during the business cycle they experience capacity constraints with respect to demand for their goods.

These results could be used for further research into - among others - the following directions. The assumption that the exogenous information  $\pi_t$  is a complete representation of business cycle fluctuations provides the possibility to interpret the remaining impact of  $\hat{\varepsilon}_t$  in various other ways. The simplest of these could be that this residual information is related to planning mistakes due to other sources than imbalances between expected demand and capacity.

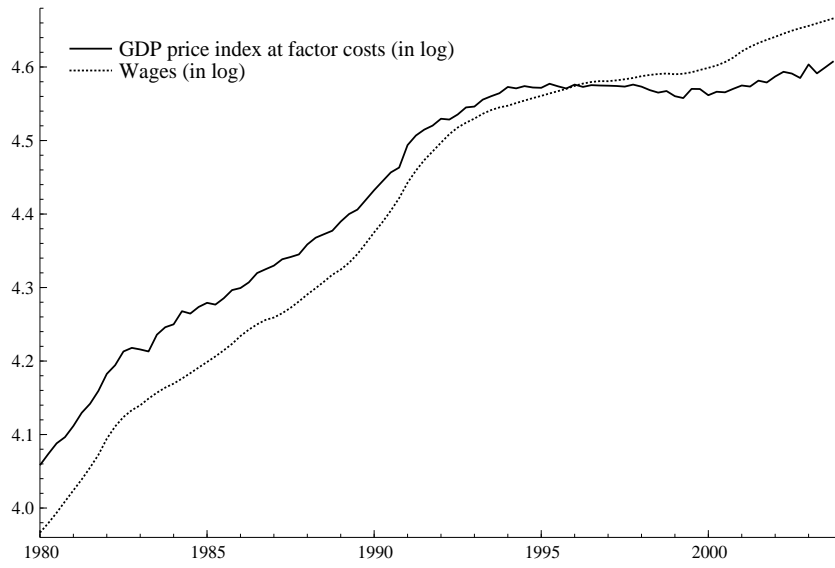
Second, under the assumption that the principal source for variations in  $\hat{\varepsilon}_t$  are shifts of the demand curve while the shape of the curve remains constant, one could engage in estimating the demand curve in the price - quantity space. This would e.g. require to extend the model in order to incorporate GDP income.

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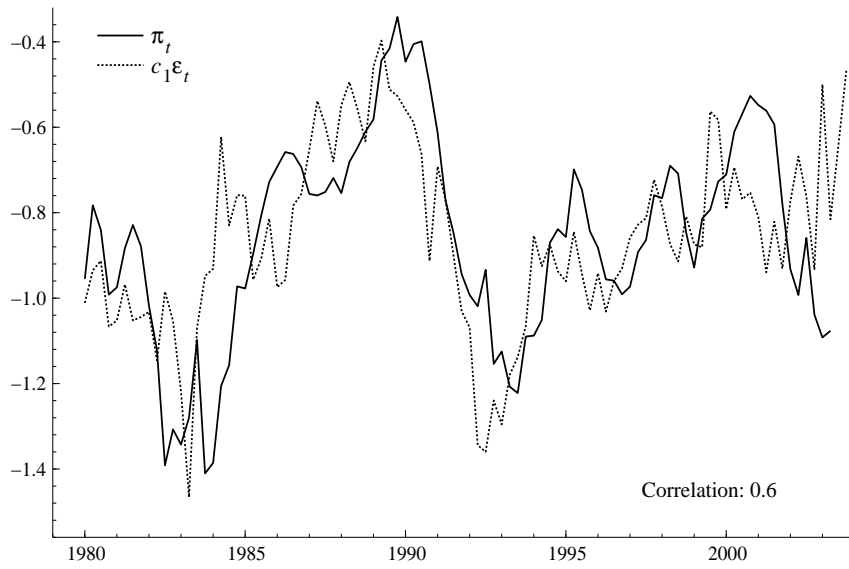
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## 4.1 Figures



**Figure 1:** Wages and the GDP deflator at factor costs



**Figure 2:** Long-run Disequilibrium between Wages and Prices according to (6), and capacity constraints