Monopolistic price setting and supply rigidities in a disequilibrium framework

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Published on: 18 Jan 1998 - Economic Theory (Springer-Verlag)

Topics: Reservation price, Price level, Mid price, Limit price and Price elasticity of supply

Smolny, Werner

Working Paper

Monopolistic price setting and supply rigidities in a disequilibrium framework

Diskussionspapier, No. 12

Provided in Cooperation with:
Department of Economics, University of Konstanz

Forschungsschwerpunkt
"Internationale Arbeitsmarktforschung"

Center for International Labor Economics
(CILE)

Fakultät für Wirtschaftswissenschaften und Statistik
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Diskussionspapier
12 – 1994

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Diskussionspapier

Nr. 12

März 1994

Abstract:

In the paper, a model of the firm with a delayed adjustment of prices and supply is analyzed. Prices and supply are determined under uncertainty about the location of the demand curve. Three models are distinguished: a price setting with predetermined supply, supply determination with predetermined prices, and a simultaneous price and supply determination. It is shown that many of the results of the deterministic case can be transferred to this stochastic model set-up. The deterministic model is included as a special case of the presented model. However, the model here allows for supply rigidities and labour hoarding and permits the analysis of price adjustment and rationing situations.

Keywords: monopolistic price setting, adjustment delays.

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1 Introduction

Underutilization of capacities and labour hoarding during recessions are stylized facts of the business cycle. They indicate an excess supply and a rationing situation for firms in the short run. On the one hand, this can be interpreted as an indication for a slow adjustment of quantities, i.e. employment and the capital stock. On the other hand, the same stylized facts indicate price rigidities. In this paper, it is tried to develop a unified approach for the analysis of the slow adjustment observed for many economic variables. The analysis of price and quantity adjustment is carried out within a framework of monopolistic competition.[1] It is known that monopolistic competition, by itself, cannot account for price rigidities. However, monopolistic competition combined with some other imperfection can explain price rigidities.[2] The imperfection which is studied here is a *delayed* adjustment of prices and quantities.[3] This approach has been proven to be useful for the analysis of quantity adjustment[4] and appears to be even more useful for the analysis of price adjustment. In most cases, a dynamic adjustment is analyzed under the assumption of adjustment costs. However, it is difficult to find examples for adjustment costs which can account for the observed slow adjustment of many economic variables, especially for prices. On the other hand, changing decision variables necessarily takes time, and even a short time delay between a decision and the realization of an exogenous variable can introduce considerable uncertainty.

The analysis of dynamic adjustment in terms of adjustment delays has a further advantage. It allows to reduce the dynamic decision problem of the firm to a sequence of static problems which can be solved stepwise. Adjustment delays for prices and quantities lead to case differentiations which can be expressed by minimum conditions at the micro level. An explicit aggregation procedure then allows an easy derivation of approximate relations at the macro level.[5] The model presented here builds on previous work of the author on a delayed adjustment of quantities, i.e. employment, investment, and capital-labour substitution,[6] and extends it by introducing an endogenous price setting of firms. This appears to provide a suitable framework for the analysis of the relation between price rigidities and the slow adjustment of quantities. It is related to the work of Maccini (1981), Sneessens (1987), and de la Croix (1992) who also analyze delayed price adjustment, but under different assumptions about the flexibility of quantity adjustment.

[1] See e.g. Arrow (1959) and Dixit, Stiglitz (1977).
[2] See Blanchard, Kiyotaki (1987).
[3] For the analysis of adjustment delays, see e.g. Kydland, Prescott (1982).
[4] See Smolny (1993).
[5] See Lambert (1988) and Smolny (1993).
[6] Smolny (1993).

2 The model of the firm

In the model, it is assumed that the firm faces a loglinear demand curve with an error term which is not known at the time of the price and supply decision:[7]

$$\ln YD = \ln \overline{YD} + \ln m + \eta \ln \frac{p}{\overline{p}} + \varepsilon \tag{1}$$

with: YD: demand
$\overline{YD}$: aggregate demand
p: price
$\overline{p}$: aggregate price
m: market share parameter
η: price elasticity of demand, $\eta < -1$
ε: error term, $\mathrm{E}(\varepsilon) = 0, \mathrm{Var}(\varepsilon) = \sigma^2$

Loglinear demand curves can be derived from CES utility functions and have several advantages for the analysis.[8] Apart from simplicity for the analysis, they allow a clear differentiation between: aggregate demand shifts $\overline{YD}$, firm specific product quality changes reflected by m, relative price effects, and market structure parameters (η, σ). σ^2 is the variance of the logarithm of demand, i.e. it measures the uncertainty about demand at the time of the price and supply decision. The value of σ is an indicator for the degree of price rigidity: instantaneous price adjustment in case of demand changes would imply $\sigma = 0$, while a slow adjustment of prices with respect to shocks results in long delays and a large uncertainty about the location of the demand curve. Eq. (1) can be simplified as:

$$\ln YD = \ln \tilde{YD} + \eta \cdot \ln \dot{p} + \varepsilon \tag{2}$$

The most important aspect for the analysis is the idea of the delayed adjustment of prices and supply. The firm has to decide on price and supply before the realization of demand, i.e. there is uncertainty about ε. Thus, in the short run output is determined as the minimum of demand and supply:[9]

$$YT = \min(YS, YD) \tag{3}$$

with: YT: output
YS: supply

Supply, in turn is determined by a short-run limitational production function with capital and labour as inputs:

$$YS = \min(\pi_l \cdot LT, \pi_k \cdot K) = \min(Y_{LT}, YC) \tag{4}$$

[7] The time index is omitted for convenience.
[8] See Deaton, Muellbauer (1980).
[9] Overtime working and inventory adjustment is omitted.

with: LT: employment
K: capital stock
π_l: labour productivity
π_k: capital productivity
Y_{LT}: employment constraint
YC: capacities

In the medium run, the firm fixes prices and employment. Wages are assumed to be exogenous or predetermined. The capital stock and the factor productivities are set in the long run, therefore they are predetermined for the price and employment decision. The optimization problem can be formalized as

$$\max_{\rightarrow LT,p} p \cdot \mathrm{E}(YT) - w \cdot LT - c \cdot K \tag{5}$$

with w: wages
c: user costs of capital

subject to the constraints given by eqs. (2)–(4) above. Three models are distinguished. First, a price setting model with predetermined supply is analyzed. This refers to a case with rather flexible prices and more constraints on the quantity adjustment. In a second model, prices are assumed to be more rigid than employment, and employment determination is analyzed. In the final model, the simultaneous determination of the price and employment is analyzed.

3 Price setting with fixed supply

This represents a short-run approach for the price setting. Consider for instance constraints on the adjustment of employment due to legal or contractual periods of notice, or delays for finding, sreening, and qualifying workers. The price is set after the determination of supply, but before the realization of demand, i.e. the firm sets price tags. The first order condition of the optimization problem, eq. (5), with respect to prices is given by:

$$p \cdot \frac{\partial \mathrm{E}(YT)}{\partial p} + \mathrm{E}(YT) \stackrel{!}{=} 0 \tag{6}$$

Expected output can be written as

$$\mathrm{E}(YT) = \int_0^{YS} YD \cdot f_{YD} dYD + \int_{YS}^{\infty} YS \cdot f_{YD} dYD \tag{7}$$

where f_{YD} is the probability distribution function (p.d.f.) of demand. Changing integration variables yields

$$\mathrm{E}(YT) = \int_{-\infty}^{\bar{\varepsilon}} YD \cdot f_{\varepsilon} d\varepsilon + \int_{\bar{\varepsilon}}^{\infty} YS \cdot f_{\varepsilon} d\varepsilon \tag{8}$$

with: $\bar{\varepsilon} = \ln YS - \ln \tilde{YD} - \eta \cdot \ln p$

f_ε is the p.d.f. of the error term of the demand function. Partial differentiation of expected output with respect to p yields:

$$\begin{aligned}\frac{\partial \mathrm{E}(YT)}{\partial p} &= YD(\varepsilon=\bar{\varepsilon})\cdot f_\varepsilon(\varepsilon=\bar{\varepsilon})\cdot\frac{\partial\bar{\varepsilon}}{\partial p}+\int_{-\infty}^{\bar{\varepsilon}}\frac{\partial YD}{\partial p}\cdot f_\varepsilon d\varepsilon - YS\cdot f_\varepsilon(\varepsilon=\bar{\varepsilon})\cdot\frac{\partial\bar{\varepsilon}}{\partial p}\\ &= \eta\cdot\int_{-\infty}^{\bar{\varepsilon}}\frac{YD}{p}\cdot f_\varepsilon d\varepsilon \qquad (9)\end{aligned}$$

Inserting eq. (8) and (9) into the first order condition yields

$$(1+\eta)\cdot\int_{-\infty}^{\bar{\varepsilon}} YD\cdot f_\varepsilon d\varepsilon+\int_{\bar{\varepsilon}}^{\infty} YS\cdot f_\varepsilon d\varepsilon = 0 \qquad (10)$$

which can be reformulated as:

$$(1+\eta)\cdot \mathrm{e}^{-\bar{\varepsilon}}\cdot\int_{-\infty}^{\bar{\varepsilon}} \mathrm{e}^{\varepsilon}\cdot f_\varepsilon d\varepsilon+\int_{\bar{\varepsilon}}^{-\infty} f_\varepsilon d\varepsilon = 0 \qquad (11)$$

This implies that the optimal value of $\bar{\varepsilon}$ depends only on η and on the parameters of the p.d.f. of ε. Assuming a p.d.f. of ε which is completely characterized by its expected value and its variance, it can be written as

$$\bar{\varepsilon} = h(\eta,\sigma) \qquad (12)$$

and the optimal price can be determined from:

$$\ln p = \frac{1}{\eta}\cdot\left[\ln YS - \ln \tilde{YD} - h(\eta,\sigma)\right] \qquad (13)$$

The optimal price depends through a loglinear function on the demand shift parameter $\tilde{YD}$, supply, and a third term determined by the degree of uncertainty about demand and the price elasticity of demand. The elasticity of the optimal price with respect to supply and the demand shift is equal to $1/\eta$, and prices are independent of costs. Without uncertainty about demand, i.e. for $\sigma = 0$, the firm would choose a price for which supply is equal to demand, $YS = YD$. In this case, $\bar{\varepsilon} = h(\eta,\sigma) = 0$ and the optimal price can be directly derived from eq. (13). For the optimal solution, the following properties can be derived. The probability that demand is less than supply is given by:

$$\mathrm{prob}(YD < YS) = \int_{-\infty}^{\bar{\varepsilon}} f_\varepsilon d\varepsilon \qquad (14)$$

This probability depends only on σ and η and is independent of supply and the demand shift parameter $\tilde{YD}$! From eq. (10), one can determine the *weighted* probability of the demand constrained regime. It is equal to the inverse of the absolute value of the price elasticity of demand and it is also independent of supply and the demand shift.

$$\mathrm{prob}_w(YD < YS) := \frac{\int_{-\infty}^{\bar{\varepsilon}} YD\cdot f_\varepsilon d\varepsilon}{\int_{-\infty}^{\bar{\varepsilon}} YD\cdot f_\varepsilon d\varepsilon+\int_{\bar{\varepsilon}}^{\infty} YS\cdot f_\varepsilon d\varepsilon} = \frac{1}{-\eta} \qquad (15)$$

This expression describes the expected share of output in the demand constrained regime. The intuition behind this result is that the firm simply maximizes nominal sales, which implies that the elasticity of output with respect to the price is chosen equal to one: in case of a price increase, demand decreases with an elasticity of η; expected output decreases with an elasticity of η, *times the weighted probability that demand is less than supply.* One can also determine the expected utilization of supply. From eq. (10) and (14) one can derive:

$$\mathrm{U} := \frac{\mathrm{E}(YT)}{YS} = \frac{\eta}{1+\eta} \cdot [1 - \mathrm{prob}(YD < YS)] \tag{16}$$

The utilization of supply is also completely determined by the variance and the price elasticity of demand, and it is independent from supply. However, it is impossible to determine p in terms of σ and η without referring to an explicit assumption about the distribution of ε. It is even impossible to prove the uniqueness of the solution. Therefore, the characteristics of the solution are analyzed for the case of a normal distribution of ε. Even for this case an explicit analytical solution is not possible, but all characteristics can be explored by numerical methods. Eq. (11) can be reformulated as:

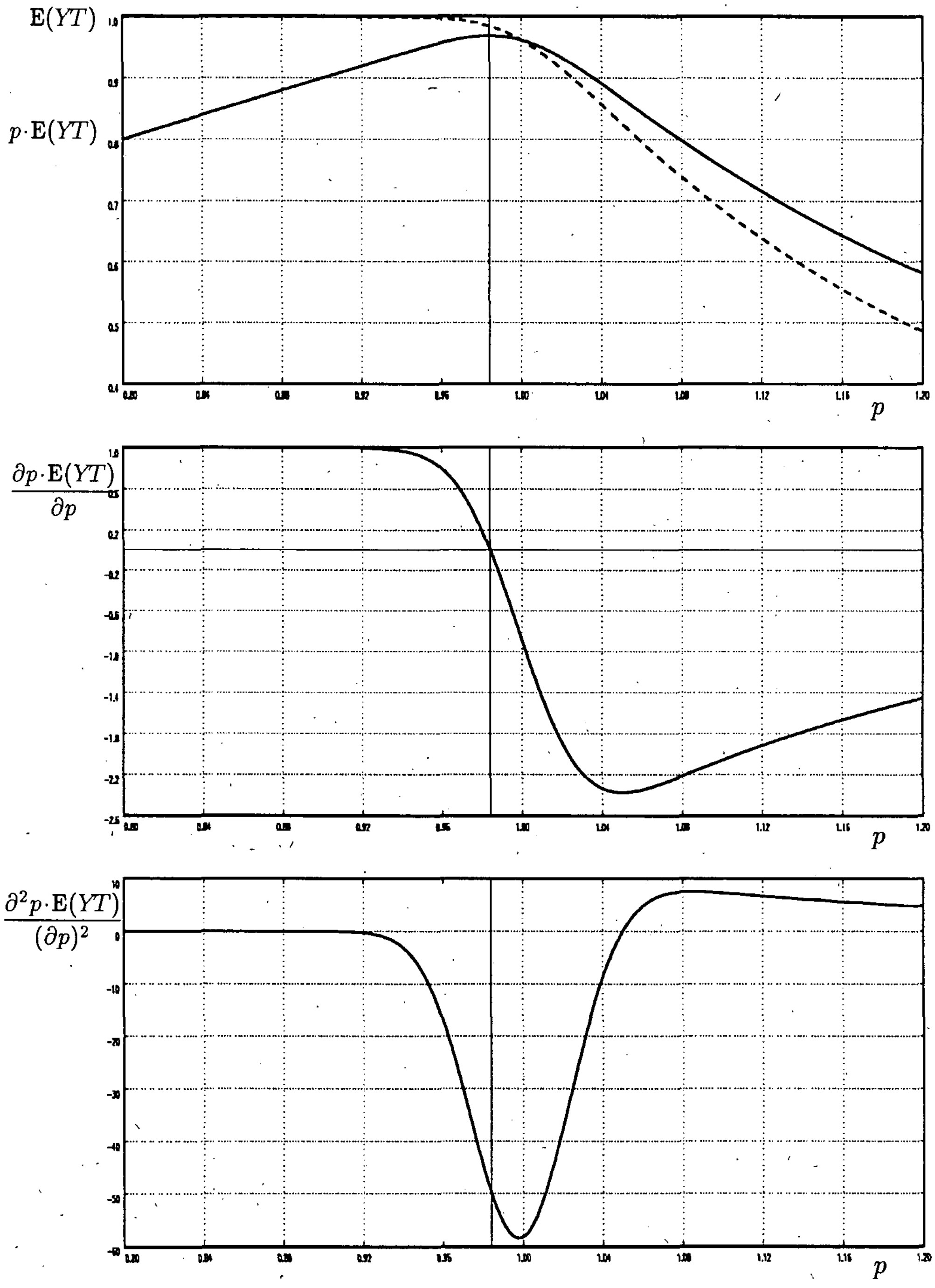
$$(1+\eta) \cdot \mathrm{e}^{-\bar{\varepsilon}+\sigma^2/2} \cdot \int_{-\infty}^{\bar{\varepsilon}/\sigma-\sigma} f_z dz + \int_{\bar{\varepsilon}/\sigma}^{-\infty} f_z dz = 0 \tag{17}$$

f_z is the p.d.f. of the standard normal distribution, and eq. (17) can be solved by standard numerical algorithms. For each (σ, η) combination, there exists an optimal $\bar{\varepsilon}$, and p can be determined from eq. (13). Figure 1 gives a visual impression of the decision problem. The upper figure displays output and nominal sales dependent on the price. For small values of p, the elasticity of nominal sales with respect to the price is greater than 1. However, for higher prices the probability of the demand constrained regime increases until nominal sales decrease. The pictures below depict the development of the first and second derivative of nominal sales with respect to the price. For the assumed parameter values ($\tilde{YD} = YS = 1, \sigma = 0.1, \eta = -4$), the optimal price is equal to 0.984, the probability of the demand constrained regime is equal to 0.261, the weighted probability of the demand constrained regime is equal to 0.25 (see eq. (15)), and the utilization of supply is equal to 0.985.

Figure 2 shows the effects of the uncertainty about demand σ and the price elasticity of demand η on the optimal values of $\bar{\varepsilon}$ and the price. $\bar{\varepsilon}$ decreases with the absolute value of η. A higher price elasticity of demand makes it easier for the firm to achieve a higher utilization of supply, and a higher probability of supply constraints is chosen. The optimal price also decreases for most of the depicted range with the absolute value of η, but may also increase for large values according to eq. (13). Small values of the uncertainty about demand imply that $\bar{\varepsilon}$ converges to 0 and the optimal price approaches 1. Note that the case without uncertainty is included as a special case of the model above with:

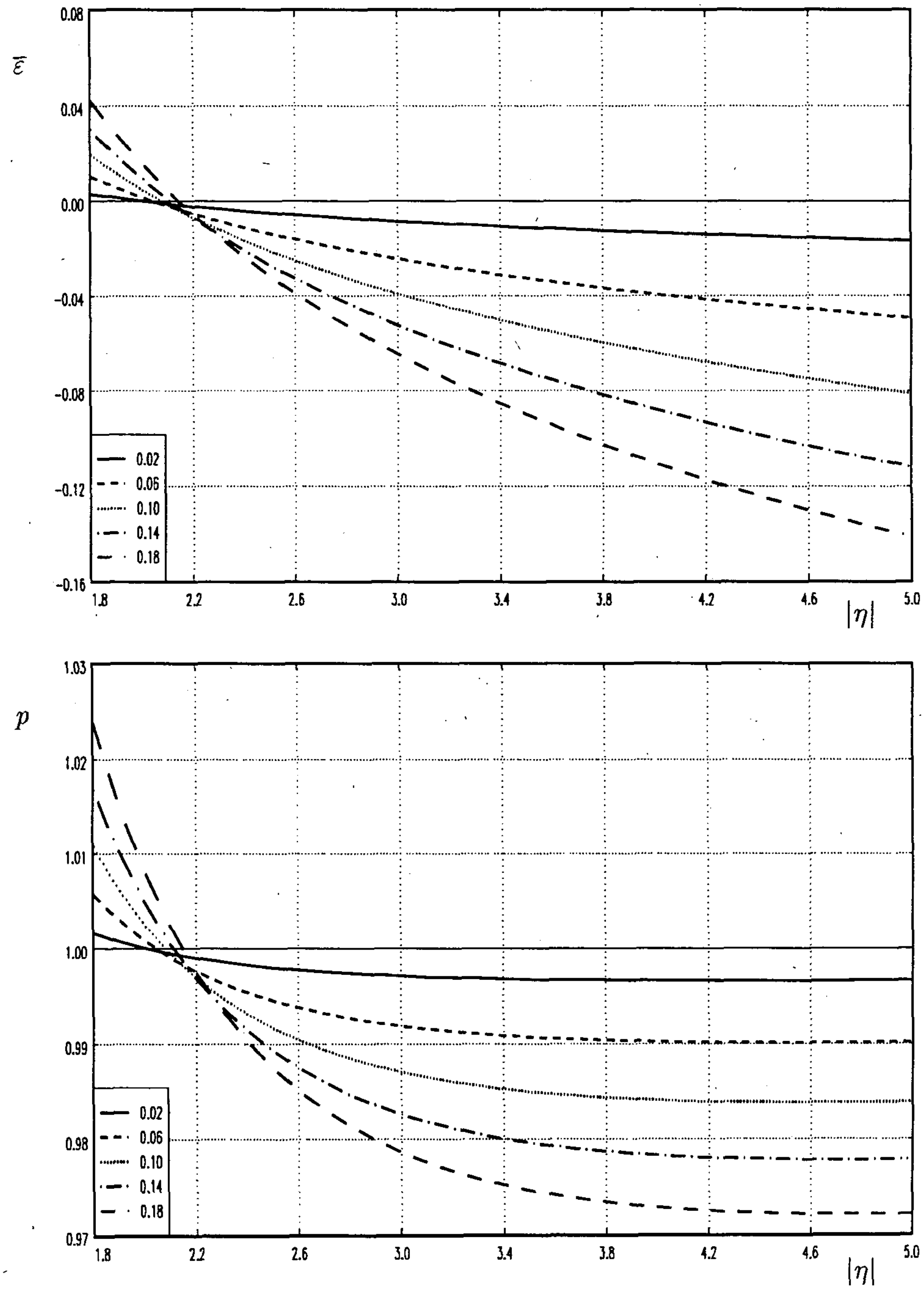
$$\lim_{\sigma\to 0} p = 1, \quad \lim_{\sigma\to 0} \bar{\varepsilon} = 0, \quad \lim_{\sigma\to 0} U = 1$$

Figure 1: The decision problem of the firm



$\tilde{YD} = YS = 1, \sigma = 0.1, \eta = -4$

Figure 2: The optimal price with supply rigidities



$\tilde{YD} = YS = 1, \sigma = 0.02, 0.06, 0.10, 0.14, 0.18$

Of course, in the short run prices react with respect to demand shifts and supply according to eq. (13) above.

4 Price rigidities

This model represents the rationing approach for the determination of supply.[10] Prices are more rigid than quantities. One can think in terms of large adjustment costs for prices, or prices determined by some kind of an oligopolistic price setting process with strong price rigidities. In terms of model building, it represents the other extreme case which is studied before analyzing a simultaneous price and supply setting. The first order condition of the optimization problem, eq. (5) above, with respect to employment for this model is given by

$$p \cdot \frac{\partial \mathrm{E}(YT)}{\partial YS} \cdot \frac{\partial YS}{\partial Y_{LT}} \cdot \frac{\partial Y_{LT}}{\partial LT} - w \stackrel{!}{=} 0 \quad (18)$$

or

$$p \cdot \int_{\bar{\varepsilon}}^{\infty} f_\varepsilon d\varepsilon \cdot (1 - \lambda_{YC}) \cdot \pi_l - w = 0 \quad (19)$$

The marginal increase of expected output with respect to supply is equal to the probability of the supply constrained regime. The marginal increase of supply with respect to the employment constraint can take only the values 0 or 1:

$$\lambda_{YC} = \begin{cases} 0 \text{ for } YC > Y_{LT} \\ 1 \text{ for } YC < Y_{LT} \end{cases}$$

λ_{YC} is the shadow value of capacity constraints. In case of sufficient capacities, λ_{YC} is equal to 0, i.e. an increase of the employment constraint increases supply. For $YC < Y_{LT}$, capacities limit supply, and optimal employment is determined by capacities and the productivity of labour.[11] The last term is equal to the productivity of labour (see eq. (4)). For $\lambda_{YC} = 0$, the optimal probability of a supply constraint is equal to the share of labour costs in full employment nominal output

$$\mathrm{prob}(Y_{LT} < YD) = \frac{w}{p \cdot \pi_l} \quad (20)$$

or

$$F_\varepsilon(\varepsilon = \bar{\varepsilon}) = 1 - \frac{w}{p \cdot \pi_l} \quad (21)$$

F_ε is the cumulative distribution function (c.d.f.) of ε. The economic interpretation of this result is quite easy. The marginal cost of an additional unit

[10] See Smolny (93).

[11] This implies that output supply is always equal to the employment constraint of the production function. One can also introduce the possibility of labour supply constraints, in which case optimal employment will be equal to the minimum of labour supply, capacity employment and the demand determined employment level derived below. See Smolny (1993).

of employment is equal to the wage rate w. Marginal returns are determined as the price, mulitiplied with the productivity of labour, and multiplied with the probability that the additional unit of output can be sold. This results holds irrespective of the distribution of the ε. For a normal distribution of ε, employment can be determined as:

$$\ln LT = -\ln \pi_l + \ln \tilde{YD} + \eta \cdot \ln p + \sigma \cdot F_z^{-1}\left(z = 1 - \frac{w}{p \cdot \pi_l}\right) \tag{22}$$

where F_z^{-1} is the inverse of the c.d.f. of the standard normal distribution. Optimal employment is determined via a loglinear relation in terms of the demand shift $\tilde{YD}$, the uncertainty about demand σ, and the price elasticity of demand η. It depends in a nonlinear way on wages, prices and the productivity of labour.[12] A visual impression of the result is given in figure 3. The upper figure depicts the p.d.f. of demand. In the lower figure, the marginal product of employment is depicted. For small values of LT, the marginal product of employment is equal to $p \cdot \pi_l$. For larger values, the probability of demand constraints increases, a unique optimum is therefore assured. For $w = 0.5$, the firm would choose a probability of the supply constraint also equal to 0.5 which implies for the assumed parameter values that $LT = 1$. The special case without uncertainty about demand is included in eq. (22) for $\sigma = 0$. In this case, the firm chooses $YS = YD$.

5 Simultaneous price and supply setting

This model represents the medium-run approach to price and employment setting. The analysis can be short, because this model just combines the two models above. The solution is achieved by deriving the optimal value of $\bar{\varepsilon}$ for given σ, η from eq. (12) above. Then the optimal price results by inserting eq. (12) into eq. (21) and solving for p:

$$\ln p = \ln w - \ln \pi_l - \ln\left[1 - F_\varepsilon(\varepsilon = \bar{\varepsilon})\right] \quad \text{with} \quad \bar{\varepsilon} = h(\eta, \sigma) \tag{23}$$

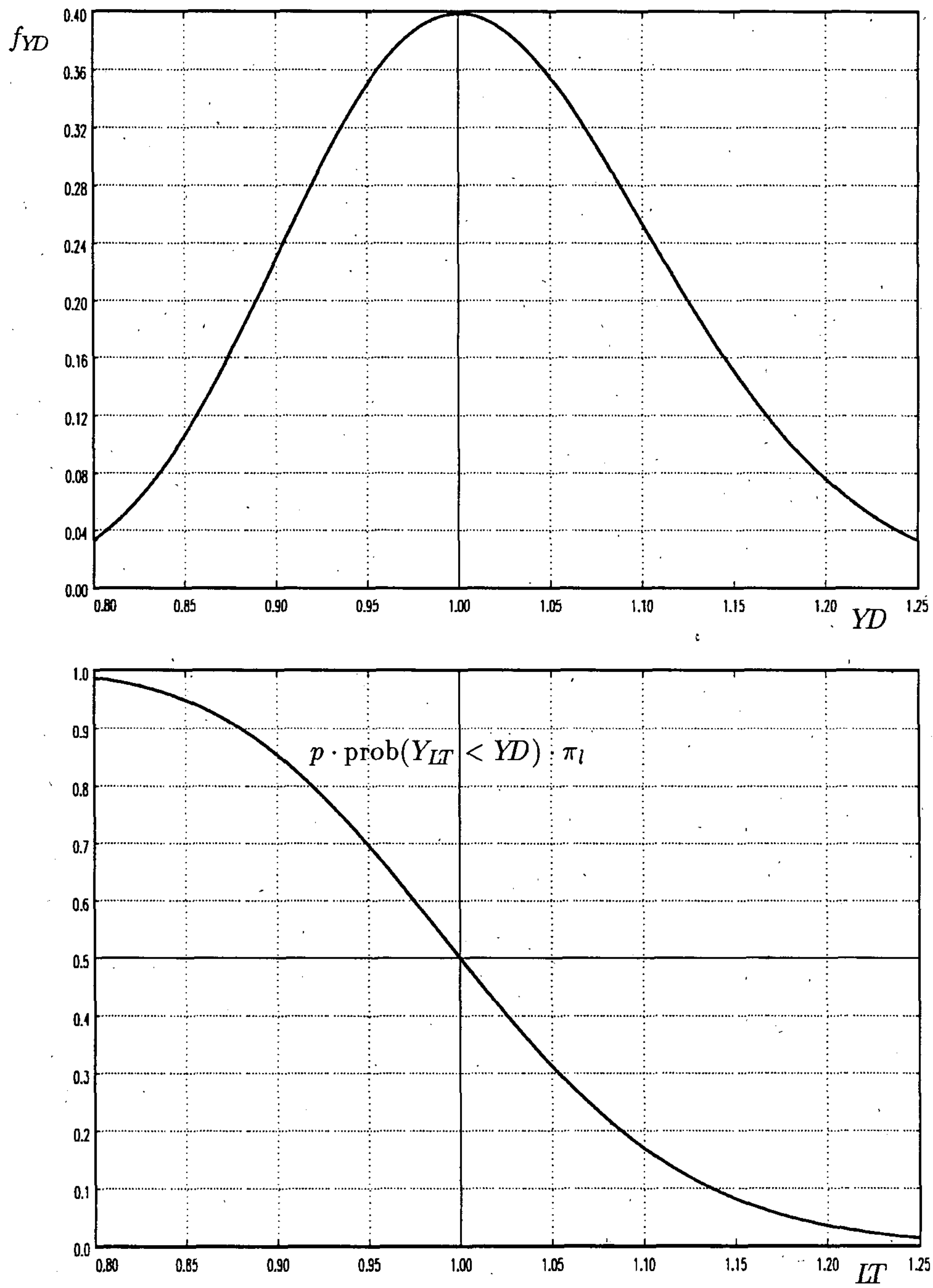
Prices are determined by a loglinear function in terms of unit labour costs, and the mark-up depends on the probability of the supply constrained regime, which in turn is determined by the price elasticity of demand and the variance of demand shocks. In addition, prices are independent of demand shifts. The optimal supply can be determined by inserting eq. (23) into eq. (13) and solving for YS.

$$\ln YS = \ln \tilde{YD} + h(\eta, \sigma) + \eta \cdot \left(\ln w - \ln \pi_l - \ln\left[1 - F_\varepsilon(\varepsilon = \bar{\varepsilon})\right]\right) \tag{24}$$

The unconstrained optimal supply is determined via a loglinear function in terms of $\tilde{YD}$. In addition, it is loglinear with elasticity η on costs. In case of

[12] For a detailed discussion, see Smolny (1993).

Figure 3: Optimal employment



$\tilde{YD} = 1, p = 1, \pi_l = 1, \sigma = 0.1$

labour supply or capacity constraints this optimal value cannot be achieved. In this case, supply is given by the constrained level and the optimal price is determined as in the first model presented above, i.e. eq. (13). The optimal regime probabilities and the utilization of supply U can also be determined as above, eq. (14–16), i.e. they are completely determined by σ and η and are independent of supply constraints.

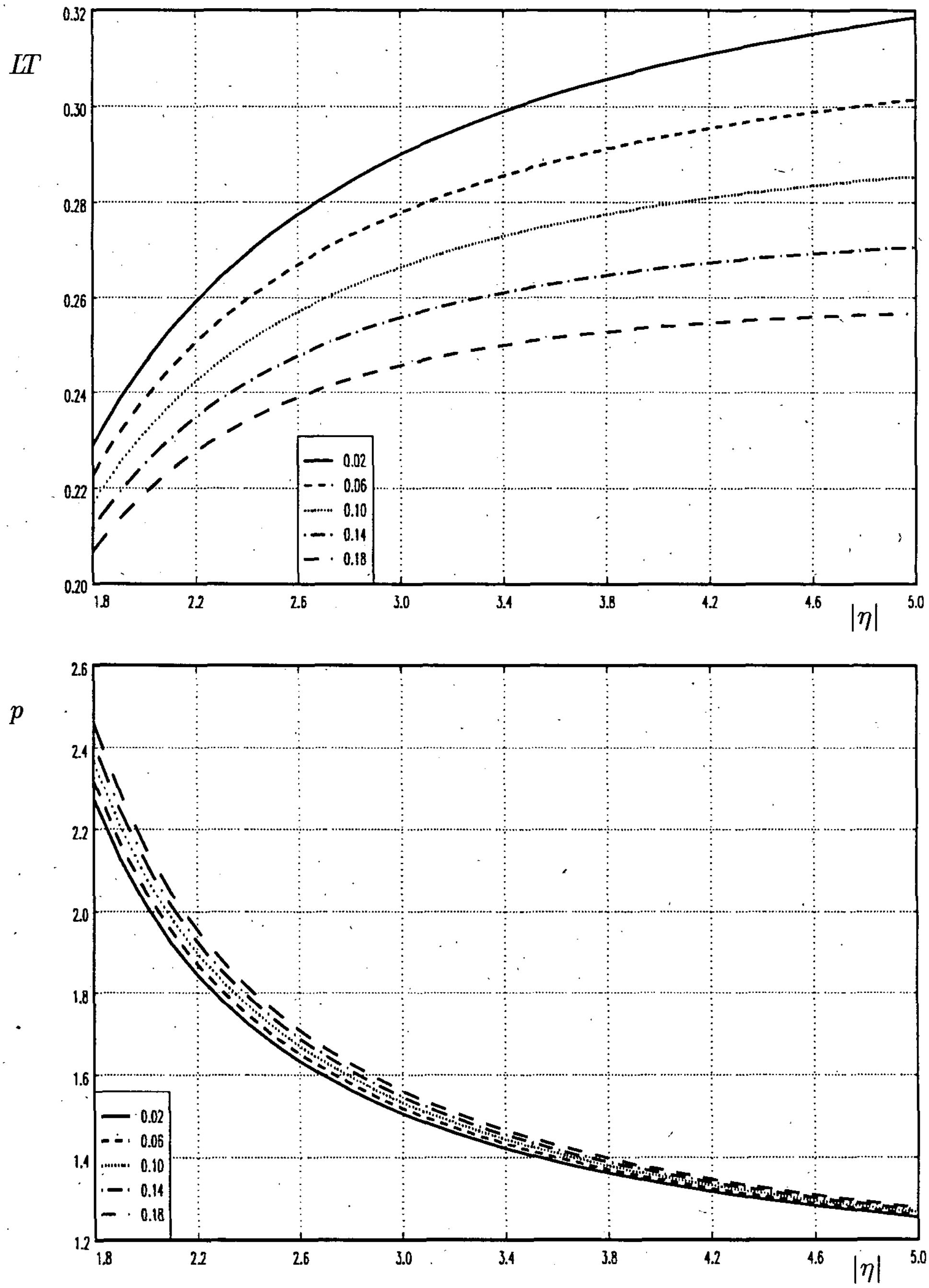
The optimal price can also be expressed in terms of the price elasticity of demand, costs, and the utilization of supply. Rearrangements yield:

$$p = \frac{\eta}{\eta + 1} \cdot \frac{1}{U} \cdot \frac{w}{\pi_l} \tag{25}$$

This equation shows again that the model without uncertainty is included as a special case in the model above. For $\sigma \rightarrow 0$ the firm can achieve full utilization of supply and $U \rightarrow 1$. Introducing uncertainty lowers the expected (average) utilization of supply, and has the same effect as higher costs. The optimal prices and employment levels for different values of σ and η are depicted in figure 4. The optimal price decreases and employment increases for increasing $|\eta|$. A lower uncertainty about demand at the time of the price and employment decision reduces inefficiencies, lowers the optimal price, and increases employment.

The models as presented above extends the standard deterministic model by introducing uncertainty, and allows to analyze the resulting inefficiencies. Prices usually differ from market clearing prices, supply differs from demand, and labor hoarding can occur. In addition, the model provides a framework to analyze certain features of the prices setting process during the business cycle. Consider, for instance, the case when the stochastic process generating the demand shocks ε is autocorrelated. Then a positive demand shock increases the utilization of supply today. The response of the firm depends on the presence of supply rigidities: in case of supply rigidities, the firm will increase the price; in case of supply flexibility, the price will remain constant, and supply will be increased. Therefore, the model predicts a different price adjustment with respect to demand shocks during the business cycle. In recession periods with sufficient capacities and easy availability of labour, demand shocks result in higher supply without increasing the price. In boom periods, more and more firms attain full utilization and the price increases. The relevant variable for the price setting from a macroeconomic viewpoint is the share of firms experiencing full utilization of supply. A similar response results in case of cost shocks. If the firm experiences supply rigidities, prices (and supply) will remain unchanged. On the other hand, with flexible supply, the firm increases the price and reduces supply.

Figure 4: Optimal prices and employment



$w = \pi_l = 1$, $\tilde{YD} = 1$, $\sigma = 0.02, 0.06, 0.10, 0.14, 0.18$

6 Conclusions

The model as presented above is incomplete and should be extended in a number of directions. First, it should be supplemented with an analysis of the long-run determination of capacities, capital-labour substitution, and technical change. This appears possible, adjustment delays can be analyzed with a rather simple stepwise optimization procedure as shown in a different set-up in Smolny (1993). Second, the short-run optimization should be further elaborated to allow for more flexibility of supply, for instance a flexibility of the working time by overtime working. Third, the model of the firm should be complemented by an explicite aggregation procedure. This aggregation can be done analoguos to the procedure developed by Lambert (1988):[13] in case of a lognormal distribution of demand and supply of the firms, the aggregate relations will have the same structure as microeconomic relations. In addition, it can be shown that the minimum conditions on the goods and labour market at the micro level can be approximated accurately by simple CES-type functions on the macro level. The weighted regime probabilities at the micro level then have their counterparts in the share of firms in the respective regime at the macro level.

Probably more difficult to analyze are extentions which place more emphasis on the adjustment constraints for prices. One may introduce, for instance, costs of stock-outs, or costs of price changes. A firm will probably loose demand, if customers cannot be served or observe price increases. One can argue that costs of stock-outs lead to higher prices, and costs of price changes lead to a smoother price policy. However, an explicit analysis would require a dynamic analysis of the decision of the firm and is postponed to future work.

[13] See also Smolny (1993).

References

[1] **Arrow, K.J.**, (1959). Toward a theory of price adjustment. In M. Abramowitz, editor, *The Allocation of Economic Ressources*, pages 41-51. Stanford University Press, Stanford.

[2] **Blanchard, O.J. and N. Kiyotaki**, (1987). Monopolistic competition and the effects of aggregate demand. *American Economic Review*, 77:647-666.

[3] **de la Croix, D.**, (1992). *Union-Firm Bargaining and Equilibrium Unemployment in Quantity Rationing Models.* PhD-Thesis, Louvain-la-Neuve.

[4] **Deaton, A. and J. Muellbauer**, (1980). An almost ideal demand system. *American Economic Review*, 70/3:312-26.

[5] **Dixit, A.K. and J.E. Stiglitz**, (1977). Monopolistic competition and optimum product diversity. *American Economic Review*, 67:297-308.

[6] **Kydland, F.E. and E.C. Prescott**, (1982). Time to build and aggregate fluctuations. *Econometrica*, 50/6:1345-70.

[7] **Lambert, J.-P.**, (1988). *Disequilibrium Macroeconomic Models – Theory and Estimation of Rationing Models using Business Survey Data.* Cambridge University Press, Cambridge.

[8] **Maccini, L.J.**, (1981). On the theory of the firm underlying empirical models of aggregate price behavior. *International Economic Review*, 22/3:609-624.

[9] **Smolny, W.**, (1993). *Dynamic Factor Demand in a Rationing Context: Theory and Estimation of a Macroeconomic Disequilibrium Model for the Federal Republic of Germany.* Physica, Heidelberg.

[10] **Sneessens, H.R.**, (1987). Investment and the inflation-unemployment tradeoff in a macroeconomic rationing model with monopolistic competition. *European Economic Review*, 31:781-815.