Inflation and the Formation of Expectations: Some Empirical Results

By John A. Leventakis*, Athens

I. Introduction

The role of expectations and their treatment is perhaps the most important issue concerning the process of inflation. Since inflationary expectations are not an observable variable, in estimating the effects of price expectations on actual inflation various proxies have generally been used for the unobservable expected rate of inflation (see e.g., *Turnovsky* and *Wachter,* 1972; *Lahiri,* 1976; *Mullineaux,* 1980). One procedure for modelling price expectations is the rational expectations approach, in which the expression for the expected rate of inflation is derived from the general rational expectations solution of the structural model for the process generating inflation. An alternative procedure is to use independent measures of inflationary expectations which are employed for estimating price equations.

In this paper we follow the second approach. In particular, we develop and estimate a model of price determination using alternative expectations hypotheses, all taking into account the role of money growth in the formation of inflationary expectations. The model is estimated with quarterly data from the small open economy of Greece over the period 1975.I - 1983.IV.

The plan of the paper is as follows: section II sets up the model of price formation. In section III we discuss various hypotheses on the formation of expectations. Empirical results are presented in section IV and concluding remarks are given in section V.

II. The Model

The model presented in this section is a variant of a general model developed by *Tobin* (1972) and is representative of much of the recent empir-

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ical work on price and wage behaviour (see *Eckstein* and *Girola,* 1978; *Spitäller,* 1978). The model contains five equations – an identity for the general price level, a price adjustment equation, a wage adjustment equation, an equation relating the unemployment rate to the output gap, and an equation for price expectations with alternative hypotheses as to how inflationary expectations are formed.

The overall rate of inflation is expressed as a weighted average of the rate of change of the price level of domestically produced goods and the rate of change of price of imported goods

$$\Delta p_t = \mu \Delta p_t^h + (1 - \mu) \Delta p_t^m \tag{1}$$

where p is the log of the general price level, p^h is the log of price of domestically produced goods, p^m is the log of the domestic price of imported goods, μ and $(1 - \mu)$ are the weights of domestically produced and imported goods respectively and Δ is the first difference operator; ΔX is rate of change on an annual basis.

The prices of domestic goods are assumed to respond to both domestic and foreign factors

$$\Delta p_t^h = a_0 + a_1 \Delta w_t + a_2 \Delta q_t + a_3 \Delta p_t^h + a_4 (y - \overline{y})_t \tag{2}$$

$$a_1, a_3, a_4 > 0; \quad a_2 < 0$$

where w is the log of the money wage rate, q is the log of productivity (output per man-hour), y is the log of real output and $\overline{y}$ is the log of normal production capacity proxied by the trend level of actual output.

The first term in eq. (2) gives the influence of the rate of change of wage rate on inflation, while the second term represents that of the rate of change of productivity. The third term captures the influence of foreign inflation (in domestic currency) on domestic inflation. The fourth term represents the extent to which prices adjust to a gap between actual and the normal level of output. When actual output is above its capacity level, inflationary pressure is present in the goods market.

The wage equation is the well known expectations augmented *Phillips* hypothesis where the rate of change of money wages is positively related to the expected rate of inflation and to the rate of change of productivity, and negatively related to the unemployment rate.

$$\Delta w_t = b_0 + \mathrm{b}_1 \Delta p_t^e + b_2 \Delta q_t + b_3 U_t \tag{3}$$

$$b_1, b_2 > 0 : b_3 < 0$$

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where p_t^e is the log of the expected price level in period t and U is the unemployment rate. The expected rate of inflation enters equation (3) to allow wage earners to protect their purchasing power against inflation.

Assuming *Okun*'s law (1962), in which the output gap is related to the unemployment rate, we have

$$U_t = \gamma_0 + \gamma_1 \ (y-\overline{y})_t \qquad (4)$$

$$\gamma_0 > 0; \ \gamma_1 < 0$$

where the constant term, γ_o, represents some frictional unemployment which it is assumed that does not respond systematically to the variations in the demand pressure in the market for goods. The above formulation involves the restrictive assumption that all changes in the output gap necessarily cause changes in unemployment rate in the opposite direction.

Combining equations (1) - (4), we obtain

$$\Delta p_t = c_0 + c_1 \Delta p_t^m + c_2 (\gamma-\overline{\gamma})_t + c_3 \Delta q_t + c_4 \Delta p_t^e \qquad (5)$$

$$c_1, \ c_2, \ c_4 > 0; \ c_3 \gtrless 0.$$

The sign of the coefficient c_3 can be either positive or negative depending on the relative magnitudes of the coefficients a_2 and $b_2^{'} = b_2 a_1$. The expected value of a_2 is between minus one and zero while that of $b_2^{'}$ lies between zero and one. Thus, two opposing forces are present in the effect of the rate of change of productivity on the rate of inflation.

III. Alternative Hypotheses for the Formation of Inflationary Expectations

To complete the model we need to specify how expectations are formed. Since the primary purpose of the study is to test alternative hypotheses of inflationary expectations which take account of the role of monetary changes in the formation of expectations, the selected hypotheses include monetary changes as one variable affecting inflationary expectations. One hypothesis that omits monetary changes has been considered but only as a basis of comparison for the set of hypotheses containing monetary changes. Thus, in estimating the price equation (5) the following hypotheses for the expectational variable are considered:

(i) The first hypothesis we consider is the standard adaptive expectations learning model (see *Cagan,* 1956; *Frenkel,* 1975)

(6) $$\Delta p_t^e - \Delta p_{t-1}^e = \lambda(\Delta p_{t-1} - \Delta p_{t-1}^e)$$

where λ is the error adjustment coefficient. Recursive substitution of the expected rate of inflation in the above equation allows us to express the expected rate of inflation as the weighted sum of past (actual) inflation rates

(7) $$\Delta p_t^e = \sum_{i=0}^{\infty} a_i p_{t-i-1}$$

where $a_i = \lambda(1 - \lambda)^i$

(ii) The second model of expectations formation considered is called monetary model, which refers to the hypothesis that price expectations are formed as a weighted average of current and past rates of growth of the money supply

(8) $$\Delta p_t^e = \sum_{i=0}^{\infty} b_i \Delta m_{t-i}$$

where m is the log of the money supply. This type of hypothesis was suggested by *Flemming* (1976, p. 58) who writes that "on this basis a monetarist is required to assume that other people's price expectations are based on recent changes in the money supply"[1].

(iii) The third model of expectations formation is the model that combines both adaptive and monetary hypotheses

(9) $$\Delta p_t^e = \sum_{i=0}^{\infty} a_i \Delta p_{t-i-1} + \sum_{i=0}^{\infty} b_i \Delta m_{t-i}$$

The basic idea underlying the above hypothesis, which has been formulated by *Rutledge* (1974), is that inflation expectations are formed on the basis not only of past values of the variable itself, but also of the information contained in the history of the rate of growth of the money supply[2].

Substituting equations (7), (8) and (9) into (5) we obtain the alternative price equations:

(10) $$\Delta p_t = c_0 + c_1 \Delta p_t^m + c_2 (y - \bar{y})_t + c_3 \Delta q_t + \sum_{i=0}^{\infty} a_i \Delta p_{t-i-1}$$

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[1] *McGuire* (1976) and *Holden* and *Peel* (1977), among others, provide support for this hypothesis by explaining the expected rate of inflation in terms of monetary changes.

[2] Recent support for this hypothesis is provided by *Mullineaux* (1980) who shows that inflation forecasts are systematically influenced by past inflation rates and past rates of money growth.

$$\Delta p_t = c_0 + c_1 \Delta p_t^m + c_2 (y - \bar{y})_t + c_3 \Delta q_t + \sum_{i=0}^{\infty} b_i \Delta m_{t-i} \tag{11}$$

$$\Delta p_t = c_0 + c_1 \Delta p_t^m + c_2 (y - \bar{y})_t + c_3 \Delta q_t + \sum_{i=0}^{\infty} a_i \Delta p_{t-i-1} + \sum_{i=0}^{\infty} b_i \Delta m_{t-i} \tag{12}$$

which are all in terms of observable variables and can be directly estimated. As is immediately obvious, equations (10) to (12) are a set of nested models. Equation (12) comprises the complete set of explanatory variables contained in the other models. Proceeding in terms of the conceptual framework expounded by *Courakis*[3], we can examine the validity of alternative hypotheses regarding the formation of price expectations. In particular, comparison of (12) with (10) can throw light on the validity of the monetary expectations hypothesis. The null hypothesis that $\sum b_i = 0$ can be tested by using an F-Test on the nested models. If the hypothesis is rejected, it can be argued that monetary changes acting as a proxy for inflationary expectations affect actual inflation. On the other hand, comparison of (12) with (11) enables us to examine the validity of the adaptive expectations hypothesis.

IV. Empirical Results

It will be noticed that the above relationships do not commit us to any particular lag configuration. On the other hand, the general tendency has been to proceed in terms of specific lagged structures. Typical of the latter type of study are relationships that employ *Almon* lags. In what follows the results derived from relationships constrained to conform to Almon structures are presented while subsequently the pertinence of such constraints is examined.

The results of estimation are presented in Table 1. All coefficients have the correct signs and, with the exception of the intercept, are significant at the 5 percent level. The estimates indicate that expectations play an important role in the determination of actual inflation. In equation (10′) the expected rate of inflation is represented by a distributed lag in past rates of inflation. It is interesting to notice that the sum of the coefficients on lagged inflation is significantly less than unity (0.153), implying that the long-run *Phillips* curve is not vertical. Moreover, lagged values of the rate of inflation, except the first lag, are insignificant, a finding indicating that in forming their expectations people attach great significance to the most recent history of the

[3] See for example *Courakis* (1978, 1981).

Table 1: **Estimates of Price Equations Using Implicit Expectational Variables**

Dependent variable	Constant term	Coefficient of Δp^m_{t-1}	$(y-\bar{y})_{t-1}$	Δq_t	$\sum_{i=0}^{3} \Delta p_{t-i-1}$	$\sum_{i=0}^{4} \Delta m_{t-i}$	ϱ	R^2	DW	SE
10′. Δp	−0.082 (0.919)	0.144 (2.962)	0.001 (2.292)	−0.162 (2.522)	0.153	—	0.715 (6.464)	0.912	2.211	0.016
	$\Sigma a i = 0.153$,		$a_0 = 0.301$ (2.133)	$a_1 = 0.001$ (0.010)	$a_2 = -0.149$ (1.297)					
11′. Δp	−0.151 (1.197)	0.180 (4.211)	0.002 (2.224)	−0.157 (2.775)	—	0.112	0.790 (8.141)	0.908	1.755	0.017
	$\Sigma \beta i = 0.112$,		$\beta_0 = -0.024$, (0.512)	$\beta_1 = -0.002$, (0.050)	$\beta_2 = 0.039$, (0.914)	$\beta_3 = 0.099$ (2.060)				
12′. Δp	−0.123 (1.475)	0.148 (3.001)	0.001 (2.634)	−0.143 (2.153)	0.212	0.183	0.667 (5.666)	0.921	2.208	0.016
	$\Sigma a i = 0.212$,		$a_0 = 0.276$, (1.815)	$a_1 = 0.103$, (0.639)	$a_2 = -0.170$, (1.327)					
	$\Sigma \beta i = 0.183$,		$\beta_0 = 0.033$, (0.595)	$\beta_1 = 0.021$, (0.494)	$\beta_2 = 0.040$, (0.934)	$\beta_3 = 0.089$, (1.211)				

Note: R^2 is the coefficient of determination; DW is the *Durbin-Watson* statistic; a second-degree *Almon* polyonomial was used unconstrained; all equations were run using the *Cochrane-Orcutt* technique to adjust for serial correlation; ϱ is the estimated value of the first-order autoregression coefficient; SE is the standard error of the regression; the numbers in parentheses are t-ratios.

variable itself. The significant effects of the other variables deserve special mention. The magnitude of the foreign inflation on domestic inflation is smaller than that one might expect in the small open economy of Greece, which imports more than one-fifth of its final goods. Excess demand, as measured by deviations of actual output from its normal capacity level[4] (of the previous period), appears to have a rather weak effect, while the influence of the rate of change of productivity is strong and negative.

Equation (11′) incorporates the hypothesis that price expectations are proxied by changes in money supply. It appears that only the third lag of money growth is significant. The sum of the coefficients of current and lagged values of money growth is considerably less than unity (0.112), a finding indicating the weak influence of money growth on actual inflation. Thus there is little evidence of systematic changes in prices in response to changes in money supply. As to the effects of the other variables, it can be seen that on the whole there are no substantial differences between the estimates of eq. (11′) and those of eq. (10′).

Equation (12′) embodies the hypothesis that past rates of inflation as well as current and past values of money growth act as a proxy for inflationary expectations. Inspection of Table 1 reveals that inflation is explained a little better by this model than by the other two models. The F-tests indicate, however, that money growth does not contribute to the explanation of actual inflation, given the effect of past inflation. The hypothesis that money growth coefficients all equal zero cannot be rejected (see Table 2 for the F-statistics). In addition, the evidence does not enable us to reject the hypothesis that all the past inflation coefficients equal zero. The results therefore do not yield conclusive evidence as regards the selection of the appropriate expectational variable.

Table 2: **A Comparison of Alternative Hypotheses: General Form (12)**

Compared equations	Hypothesis	F-statistic	Critical F (0.05)
(12) – (10)	$\Sigma\beta i = 0$	1.15	2.92
(12) – (11)	$\Sigma\alpha i = 0$	1.63	2.92
(12a) – (10a)	$\Sigma\beta i = 0$	0.71	2.92
(12a) – (11a)	$\Sigma\alpha i = 0$	0.92	2.92

Note: The letter a denotes a variant including the unit labour cost variable.

[4] Capacity output is measured by its trend value, which is given by
$\overline{Y} = 4.911 + 0.009t \qquad R^2 = 0.753 \qquad DW = 0.436.$

Table 3: **Estimates of Price Equations Using Implicit Expectational Variables**

Dependent variable	Constant term	Coefficient of Δp^m_{t-1}	$(y-\bar{y})_{t-1}$	Δulc	$\sum_{i=0}^{3} \Delta p_{t-i-1}$	$\sum_{i=0}^{4} \Delta m_{t-i}$	ϱ	R^2	DW	SE
10″. Δp	−0.148 (1.662)	0.183 (4.002)	0.001 (2.760)	0.179 (3.881)	0.031	—	0.741 (6.980)	0.927	2.226	0.015
	$\Sigma a i = 0.031$,		$a_0 =$ 0.144, (1.130)	$a_1 =$ 0.049, (0.392)	$a_2 =$ −0.162 (1.562)					
11″. Δp	−0.185 (1.826)	0.198 (5.154)	0.002 (2.807)	0.180 (4.209)		0.067	0.762 (7.449)	0.926	2.001	0.015
	$\Sigma \beta i = 0.067$,		$\beta_0 =$ −0.031, (0.725),	$\beta_1 =$ 0.003, (0.085)	$\beta_2 =$ 0.031 (0.811)	$\beta_3 =$ 0.071 (1.603)				
12″. Δp	−0.168 (1.925)	0.182 (3.841)	0.001 (2.920)	0.161 (3.304)	0.083	0.121	0.712 (6.416)	0.932	2.194	0.015
	$\Sigma a i = 0.083$,		$a_0 =$ 0.126, (0.909)	$a_1 =$ 0.118, (0.863)	$a_2 =$ −0.161 (1.362)					
	$\Sigma \beta i = 0.121$,		$\beta_0 =$ 0.012, (0.228)	$\beta_1 =$ 0.010, (0.261)	$\beta_2 =$ 0.030, (0.742)	$\beta_3 =$ 0.069 (1.441)				

Note: See Table 1.

We estimated as an alternative equations (10) - (12) by replacing the rate of change of productivity with the rate of change of unit labour cost (Δulc), measured as the ratio of wage rate to productivity. The results of estimation are presented in Table 3 and show an improvement in comparison to those exhibited in Table 1. The explanatory power of the regressions and the influence of foreign prices is slightly increased, but the coefficients of past inflation are insignificant. This result may be taken to imply that past inflation may be reflecting price expectations captured by changes in unit labour cost. Again, in the specification of price equation which includes the unit labour cost variable we are unable to decide whether past inflation rates, money growth rates or both are better proxies for price expectations (see Table 2 for F-statistics).

As mentioned earlier, equation (10) to (12) were estimated constraining the lag coefficients on past inflation and/or on money growth terms to lie along a polynomial. The estimation of these equations freely[5] (unconstrained) permits us to test the validity of imposing the Almon weights by using an F-test. The results indicate that in three cases we cannot reject the hypothesis that the coefficients of all the expectational variables lie on a polynomial (see Table 4 for F-statistics). In case of equation (11), however, the hypothesis can be rejected.

Table 4: **F-Test Values from Comparisons of Unrestricted and Almon Weights**

Unconstrained Variants of (12)			Constrained/Almon variants of (12)		
Variant	Sum of quared residuals	Degrees of freedom	Variant	Sum of squared residuals	Degrees of freedom
(u10)	0.0086	33	(10)	0.0086	33
(u10a)	0.0071	33	(10a)	0.0071	33
(u11)	0.0079	32	(11)	0.0090	33
(u11a)	0.0065	32	(11a)	0.0072	33
(u12)	0.0068	29	(12)	0.0077	30
(u12a)	0.0059	29	(12a)	0.0067	30

Compared equations		F-statistic	Critical F(0.05)
(u10) – (10)	The α's lie on a polynomial	—	—
(u10a) – (10a)	The α's lie on a polynomial	—	—
(u11) – (11)	The β's lie on a polynomial	4.55	4.15
(u11a) – (11a)	The β's lie on a polynomial	3.77	4.15
(u12) – (12)	The α's and β's lie on a polynomial	3.90	4.16
(u12a) – (12a)	The α's and β's lie on a polynomial	2.84	4.16

Note: The letter a denotes a variant including the unit labour variable.

[5] The estimation results from the unconstrained forms were not included in the paper but are available on request.

V. Summary and Conclusions

The purpose of this paper has been to develope and estimate a model of price determination using alternative hypotheses of the formation of expectations. In particular, adaptive, monetary and the expectations hypothesis which combines both adaptive and monetarist elements were assumed in the estimation of the model.

The results indicate that the major determinants of actual inflation in Greece are foreign prices (in domestic currency), excess demand, unit labour cost and the expected rate of inflation. The evidence does not enable us to identify whether inflationary expectations are proxied better by past inflation or by current and past rates of money growth or by both. The size of the response of actual inflation to the expectations variable is not invariant to the specification of price equation. The sum of the coefficients on past inflation rates or on money growth terms is considerably less than unity. Finally, the evidence concerning the hypothesis that the coefficients of all the expectational variables lie on a polynomial was ambiguous.

Data Appendix

The data used in this study are quarterly, seasonally unadjusted data for the period 1975 I - 1983 IV. The sources of data are (1) Bank of Greece, Monthly Statistical Bulletin and (2) National Statistical Service of Greece, Monthly Statistical Bulletin.

The definitions of the variables used are:

P : consumer price index (1974 = 100) (source 1);
P^m : import prices in domestic currency (1975. I = 100) (source 1);
Y : industrial production (1975 = 100) (source 2);
Q : output per man-hour, i.e. industrial production divided by industrial employment. Data for industrial employment were obtained by the National Statistical Service of Greece (source 2);
ULC : unit labour cost, i.e. wage rate (W) divided by productivity;
W : hourly earnings of workers employed in industry and handicraft (source 2);
M : money supply narrowly defined, i.e. currency plus private sight deposits (average of monthly data) (source 1).

Note: Small letters in the text denote natural logarithms of the variables.

References

Cagan, P. H. (1956): "The Monetary Dynamics of Hyperinflation" in M. *Friedman* (ed.), Studies in the Quantity Theory of Money, Chicago, pp. 23 - 117. – *Courakis,* A. S. (1978): "Serial Correlation and a Bank of England Study of the Demand for Money: An Exercise in Measurement without Theory", Economic Journal, 88, pp. 537 - 548. – *Courakis,* A. S. (1980): "In Search of Commercial Bank Short-Run Portfolio Selection", Oxford Bulletin of Economics and Statistics, Vol. 42, pp. 306 - 335. – *Eckstein,* O. and *Girola,* J. A. (1978): "Long-Term Properties of the Price-Wage Mechanism", The Review of Economics and Statistics, Vol. 60, pp. 323 - 333. – *Flemming,* J. (1976): Inflation. Oxford University Press. – *Frenkel,* J. A. (1975): "Inflation and the Formation of Expectations", Journal of Monetary Economics, Vol. I., pp. 403 - 421. – *Holden,* K. and *Peel,* D. A. (1977): "An Empirical Investigation of Inflationary Expectations". Oxford Bulletin of Economics and Statistics, Vol. 39, pp. 291 - 299. – *Lahiri,* K. (1976): "Inflationary Expectations: Their Formation and Interest Rate Effects", American Economic Review, Vol. 66, pp. 124 - 131. – *McGuire,* T. W. (1976): "On Estimating the Effects of Controls" in the Economics of Price and Wage Controls. (ed.) K. Brunner and A. H. Meltzer. North-Holland. Amsterdam. – *Mullineaux,* D. J. (1980): "Inflation Expectations and Money Growth in the United States", American Economic Review, Vol. 70, pp. 149 - 161. – *Okun,* A. (1962): "Potential GNP: Its Measure and Significance", in Proceedings of the Business and Economic Statistics Section of the American Statistical Association, Washington, D.C. – *Rutledge,* J. A. (1974): A Monetarist Model of Inflationary Expectations, Lexington. – *Spitäller,* E. (1978): "An Analysis of Inflation in the Seven Main Industrial Countries, 1958 - 1976", International Monetary Fund, Staff Papers, Vol. 25, pp. 254 - 277. – *Tobin,* J. (1972): "The Wage-Price Mechanism: Overview of the Conference", in O. Eckstein (ed.). The Econometrics of Price Determination, Washington, pp. 1 - 15. – *Turnovsky,* S. J. and *Wachter,* M. L. (1972): Expectations Hypothesis Using Directly Observed Wage and Price Expectations", Review of Economics and Statistics, Vol. 54, pp. 47 - 54.

Zusammenfassung

Inflation und Erwartungsbildung: Einige empirische Ergebnisse

In diesem Aufsatz wird ein Modell für die Bestimmung des Preisniveaus entwickelt und geschätzt. Das Modell enthält sowohl ausländische als auch inländische Faktoren. Bei der Schätzung des Modells verwenden wir alternative Hypothesen darüber, wie Inflationserwartungen gebildet werden. Sie berücksichtigen die Rolle des Geldmengenwachstums. Das Modell wurde mit vierteljährlichen Daten der Periode I/1975 bis IV/1983 für die kleine offene Volkswirtschaft Griechenland geschätzt.

Summary

Inflation and the Formation of Expectations: Some Empirical Results

The purpose of this paper is to develop and estimate a model of price determination which includes both foreign and domestic factors. In the estimation of the model we use alternative hypotheses of inflationary expectations which take account of the role of money growth in the formation of expectations. The model is estimated with quarterly data from the small open economy of Greece over the period 1975.I - 1983.IV.

Résumé

L'inflation et la formation d'attentes: Quelques résultats empiriques

Ce travail vise à développer et à apprécier un modèle de détermination des prix qui inclut à la fois des facteurs étrangers et nationaux. L'estimation du modèle se base sur des hypothèse alternatives d'attentes inflationnistes qui tiennent compte du rôle de la croissance monétaire dans la formation d'attentes. Le modèle est estimé avec des donnés trimestrielles de la petite économie ouverte de la Grèce pour la période s'étendant de 1975.I à 1983.IV.