PRICE EXPECTATIONS AND INVESTMENTS : DISTRIBUTED LAG ESTIMATES

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1. Introduction

The role of price expectations in investment decisions has been examined mainly within the framework of several investment functions; in three of them, the methodology followed is common. These functions are : (a) the standard neoclassical one, hereafter SNC (see [5, 8, 9]); (b) the Federal Reserve-MIT-Pennsylvania model, hereafter FMP (see [2,5]); and (c) the one proposed by Ando, Modigliani, Rasche, and Turnovsky, hereafter AMRT (see [1]). The unifying theme is the decomposition of the «required» or «target» rate of return on capital in two components : the real rate of return (or interest) and the expected rate of price changes. Estimates of future expected prices are then used to generate real rates of interest which are included in the rental price of capital (c) :

$$c = \frac{q(d + r)(1 - k - uz + uzk')}{(1 - u)} \tag{1.1}$$

where r = appropriate rate of interest

q = price index of investment goods

d = rate of replacement

k = effective rate of tax credit

k′ = rate of tax credit deducted from depreciation base

u = rate of taxation of corporate income

z = present value of the depreciation deduction

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Investment models which include a measure of the real cost of capital are subsequently compared with those based on a nominal interest rate. Such a comparison cannot be made, however, in the context of the AMRT model because this model is claimed to have been designed so as to be appropriate for a real rate of interest. It should be noted that the real rate of interest is measured in terms of capital goods by those employing the SNC model and in terms of output prices by those using the FMP model[1]. The present paper is intended to : (a) provide further empirical evidence on the role of price expectations in investment decisions; (b) point out the limitations of the methodology employed in the above studies; and (c) remove a usually made assumption; namely, that nominal interest rates are fully adjusted for the expected rate of commodity price changes.

2. The Data

2.1 The Expected Price Variables.

In order to hedge against the possibility of using an unreliable series of expected prices, six distinct price models, covering a variety of expectation-generating mechanisms, were employed.

The Yohe-Karnosky Model

Estimates of expected prices are derived by regressing a nominal interest rate on concurrent and past rates of price changes in line with the work of Yohe and Karnosky (see [14]) and are denoted by YOH. The variables used are a high-grade corporate bond rate (constructed by the First National City Bank of New York and published in *Business Conditions Digest*) and the deflator for personal consumption expenditures, and the estimation technique employed is an Almon polynomial lag coupled with the Cochrane-Orcutt autoregressive adjustment.

The Feldstein-Chamberlain Model

The expected rates of price changes are derived from the Feldstein-Chamberlain model (see [3]) in which market interest rates are regressed on their «fundamental determinants» and multimarket expectations. The coefficient of adjustment for price expectations was estimated to be 0.80 in their study and the resulting series is indicated by FEL.

The Hendershott-Van Horne Model

Expected prices are derived from the Hendershott-Van Horne model (see [7]) in which the spread between bond rates and dividend yields depends on the

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[1] In the former, the expected appreciation of capital goods is subtracted from the nominal cost of capital, whereas, in the latter, the expected change of output prices is subtracted.

expected rate of price change, real growth of dividends, and a risk factor. Price expectations for 1973(I) - 1974(IV) are obtained from the distributed lag on the period 1960(I) - 1967(I) and are denoted by HEN.

Observed Price Expectations

There are two types : one is derived from survey data gathered by Livingston from academic and business economists on six— and twelve-month price expectations, indicated by L6 and L12, respectively (see *Philadelphia Bulletin* and for more information [6]); the other is derived from survey data collected by the Institute for Social Research at The University of Michigan from a random sample of 1,500 households, and they are denoted by MI.

2.2 The Specification of the Cost of Capital and the Investment Function.

Among the most frequently used formulations of the *after - tax* nominal cost of capital are the following :

$$RN^{1}_{t} = (1 - U_t)\, RN_t \qquad (2.1)$$

$$RN^{2}_{t} = (1 - \lambda U_t)\, RN_t \qquad (2.2)$$

$$RN^{3}_{t} = (1 - U_t)\ 0.20 \qquad (2.3)$$

where U stands for the corporate income tax and λ for the desired ratio of debt to total capital. The nominal cost of capital was taken to be either the high-grade corporate bond rate (the same as in YOH) or 0.20; the latter was chosen following the recent work by Hall and Jorgenson (see [5]). The term (1 - U_t) allows for the deduction of interest payments and the target leverage (λ) was taken to be 0.2 on the basis of the Modigliani-Miller empirical work (see [10]).

After-tax real rates of interest are constructed by subtracting the expected rate of price change from the above nominal rates :

$$RR^{I}_{t} = (1 - U_t)\, RN^{t} - \mathring{P}^{e}_{t} \qquad (2.4)$$

$$RR^{2}_{t} = (1 - \lambda U_t)\ RN_t - \mathring{P}^{e}_{t} \qquad (2.5)$$

$$RR^{3}_{t} = (1 - U_t)\ 0.20 - \mathring{P}^{e}_{t} \qquad (2.6)$$

After-tax real rates of return were substituted for r in (1) in the context of the SNC and FMP model. One should note, however, that these real rates are not freely applicable to the SNC model because they are based on expected prices of output rather than of capital goods. Since expectations on capital gains are not available, I used expected output prices as proxies for expectations of capital goods prices. One can rely on the results obtained with the SNC model only to the extent that the former expectations move in similar patterns with the unobservable expectations of capital goods prices. Accordingly, the empirical results on the SNC model should be examined with caution. Two specifications of each model were tested; the first specification for both models is a «general» one used by Bischoff in [2] :

$$\text{SNC}: \quad I_t = b_0 + \sum_{i=1}^{n} b_i \left(\frac{PQ}{c}\right)_{t-1} + b_{n+1} K_{t-1} + e_t \tag{2.7}$$

$$\text{FMP}: \quad I_t = \beta_0 + \sum_{i=2}^{n} \beta_{i,\,i-1} \left(\frac{P}{c}\right)_{t-1} Q_{t-i+1}$$

$$+ \sum_{i=1}^{n} \beta_{i,\,i} \left(\frac{P}{c}\right)_{t-i} Q_{i-1} + \beta_{n+1} K_{t-1} + \varepsilon_t \tag{2.8}$$

I indicates expenditures for producers' durable equipment; Q stands for private business gross product (both I and Q are in billions of 1958 dollars and in seasonally adjusted annual rates); P is the implicit price deflator for business gross product; and K is a measure of the capital stock derived from the following recursive relationship :

$$K_t = 0.25\ I_t + (1 - \delta')\ K_{t-1} \tag{2.9}$$

with δ' being a quarterly depreciation rate, equal to 0.04265 (corresponding to an annual rate of 0.16).

A specification that satisfies some of the criticisms made on (2.7), mainly by Hall, is [2] :

$$I_t = \sum_{i=1}^{n} b_i \left(\frac{P_{t-i}\ Q_{t-i}}{c_{t-i}} - \frac{P_{t-i-1}\ Q_{t-i-1}}{c_{t-i-1}}\right) + \delta K_{t-1} + e_t \tag{2.10}$$

To estimate (2.10), replacement investment (δK) was generated - taking the depreciation rate to be 0.16 - and subtracted from I to produce net investment ($I - \delta k$) as the dependent variable. Preliminary regressions of (2.10), nevertheless, did not produce satisfactory distributed lags in terms of expected sign and statistical significance of the b_i coefficients. The distributed lag was improved (in terms of shape and statistical significance) when estimation was carried out on gross rather than net investment, with replacement investment as a right-hand side variable. Accordingly, (2.10) was replaced by :

$$I_t = \sum_{i=1}^{n} b_i \left(\frac{P_{t-i}\ Q_{t-i}}{c_{t-i}} - \frac{P_{t-i-1}\ Q_{t-i-1}}{c_{t-i-1}}\right) + \gamma(\delta K_{t-1}) + e_t \tag{2.11}$$

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[2] Hall has criticized (2.7) on the following grounds : (a) it has a constant term that theoretically does not belong there; (b) changes in the conglomerate term should replace its level; and (c) the coefficient of the capital stock variable ought to be equal to the depreciation rate (see «Comments and Discussion» following [2], pp. 61 - 2).

The FMP model was also estimated with an alternative specification suggested by Bischoff (see [5]), in which the constant term and the capital stock variable were dropped[3]:

$$I_t = \sum_{i=2}^{n} \beta_{i,\,i-1} \left(\frac{P}{c}\right)_{t-1} Q_{t-i+1} + \sum_{i=2}^{n} \beta_{i\,,\,i} \left(\frac{P}{c}\right)_{t-i} Q_{t-i} + \varepsilon_t \quad (2.12)$$

3. Estimation of the models

The investment models (2.7), (2.8), (2.11), and (2.12) were estimated with the Almon polynomial lag and the Cochrane-Orcutt autoregressive adjustment for the period 1956 (I) - 1974(III)[4]. To achieve sample homogeneity, the third quarter of 1952 and the fourth quarter of 1970 were omitted in an effort to insulate the estimation from the effects of the steel and automobile strike, respectively[5]. The criterion of the minimum standard error of estimate was used in deciding : (i) when to terminate the lag period; (ii) the degree of the polynomial; and (iii) whether the weights had to taper off to zero in the last lagged period (hereafter referred to as «far» zero restriction)[6]. However, if a minimum-error equation yielded insignificant coefficients and/or coefficients with the wrong sign, it was deemed inferior to an equation with *slightly* larger error but statistically significant coefficients having the expected sign[7].

Estimates of (2.7) are presented in Table 1; the static expectations model is represented by (2.3); that is, by a constant pre-tax rate of return adjusted only

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[3] The capital stock variable was dropped because it added almost nothing to the explanatory power of (2.8).

[4] The performance of the SNC equations for this particular period was disappointing (half of the lagged coefficients were insignificant). However, satisfactory estimates for the SNC model were obtained if the three quarters of 1974 were omitted. This prompted me to terminate the sample period, as far as the SNC equations were concerned, with the fourth quarter of 1973. Comparability between the SNC and FMP models could be assured if the FMP equations were run for the same period. This was done in (13, pp. 256 - 7), but it is not repeated here, since none of the results reported here were altered. Empirical estimates for different sample periods and certain subperiods, as well as alternative interest rate formulations, may be obtained from the author upon request.

[5] The effective rate of the investment tax credit was taken to be 5.87 percent, which is a weighted average of the rates used by Hall and Jorgenson (see their study in (5]). The depreciation pattern is assumed to be given by the sum - of - the - years - digits method for the SNC equations and by a weighted average of this and the straight- line method for the FMP model, with the weights being 0.6 and 0.4, respectively (for a rationalization of these weights, see (13)).

[6] For a discussion of the role of (i), (ii), and (iii) in the selection process, see (11).

[7] An extensive experimentation with different lag periods, different degrees, and alternative restrictions produced only two cases in which this modified criterion was applied. Consequently, none of the conclusions reached in this paper would be altered if the standard minimum error criterion were applicable, irrespective of the shape and the statistical significance of the distributed lag.

for changes in the corporate income tax. This rate was chosen because of its better fit relative to those given by (2.1) and (2.2) in preliminary tests of the SNC model. Accordingly, the nonstatic expectations model is given by (2.6). The nominal interest rate model of investment behavior is shown to outperform all the real rate models. All the equations presented in Table 1, however, display one or more undesirable features which render their reliability questionable : several of the lagged coefficients are statistically insignificant and/or negative; the coefficient of the capital stock is either unrealistic (negative) or unreasonably high; the standard error for the sum of b_i's is frequently high in relation to the

TABLE 1

Estimates of (2.7) with Static and Nonstatic Price Expectations [a]

Model	Static	FEL	MI	YOH	L12	L6	HEN
b_0	—8.47*[b]	9.02	0.83	4.41	—0.33	—6.33	—5.55
Σb_i	0.0367*	0.0474*	0.0234*	0.0222	0.0092	—0.0009	0.0061
Significant b's[c]	10/15	12/15	8/15	6/15	5/15	10/15	9/15
Negative b_i's	none	none	3	4	7	9	8
b_{n+1}	—0.04	—0.30	—0.01	—0.01	0.14	0.28*	0.21*
R^2[d]	.9952	.9943	.9943	.9940	.9938	.9937	.9936
SEE[d]	0.9554	1.0432	1.0476	1.0752	1.0905	1.1050	1.1076
ρ[e]	.742	.939	.857	.906	.923	.933	.920
D.W.	1.676	1.631	1.607	1.565	1.655	1.641	1.609

[a] The interest rate for the static and nonstatic models is given by (2.3) and (2.6), respectively.

[b] Asterisk denotes significance at the 5 % level.

[c] Indicates number of statistically significant coefficients out of total; e.g., 10/15 means ten out of fifteen.

[d] Unadjusted, since the same length was used in all lags.

[e] Coefficient of autoregression.

Note: For all equations an Almon lag of third - degree and of no far - zero restriction is employed.

sum of the coefficient[8]. These results may explain why Bischoff in [2] found that the static expectations SNC model explains aggregate investment spending better than its nonstatic expectations counterpart[9]. Accordingly, specification (2.7) might not be the appropriate vehicle for evaluating their relative performance, as Hall correctly suspected.

Similar results are obtained when specification (2.8) of the FMP model is estimated with any of the three interest rate formulations. When (2.8) is combined with (2.1) and (2.4), the best performance of this specification is obtained. Table 2 presents the resulting estimates. The undesirable characteristics encountered in the estimation of (2.7) are present here as well, though to a lesser extent, and they are found in both the static and nonstatic expectation equations.

The reported estimates indicate that specifications (2.7) and (2.8) are not appropriate for estimating aggregate investment functions, and suggest that the constant term be dropped and the capital stock variable be omitted or replaced by replacement investment. To a large extent, (2.11) meets these requirements and Hall's criticisms. Estimates and summary statistics of (2.11), when interest rates are given by (2.3) and (2.6), are presented in Table 3. The equations reported represent the «best» trials in the sense that an exhaustive search has been made for the length of the lag (from six to twenty quarters), the degree of the polynomial (from the second to the sixth degree), and the zero restriction that minimized the standard error of the equations. It can be seen that the disturbing estimates and features of (2.7) are not present here; (2.11) is shown to provide a better fit. Furthermore, real interest rate equations, based on observed price expectations (provided by Livingston and The University of Michigan) and those generated by the Feldstein-Chamberlain models, appear superior to the nominal interest rate equation[10]. This is in line with the results obtained by Jorgenson and Siebert on disaggregated data (see [8,9]) and moves toward filling the gap existing with respect to the role of price expectations in the SNC model estimated with aggregate data.

Most of the expected price models show rather short lags when compared to those reported in other studies[11]. To substantiate the feature, a wide range

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[8] Employing different sample periods (even the subperiod 1961 (I)-1973 (IV)) and the alternative specifications of the cost of capital changed the relative ranking of the expected price models, but not the above pattern of the estimated parameters.

[9] I have not reproduced Bischoff's regressions, but the evidence presented here and in (12), according to which a nominal interest rate model outperforms any model based on alternative real rate formulations (i.e., RR^1, RR^2, and RR^3) and expected price variables (YOH, L12, etc.) suggests that it is the specification of the investment function and not the effect of expected prices that is responsible for the inferior fit of the real rate model of investment behavior.

[10] The ranking of the various models is sensitive to the sample period used. What seems to hold invariably is that there are always some nonstatic expectations models which outperform the static expectations model.

[11] For example, by Bischoff in (2).

of n values were tried, but the results remained unchanged. Furthermore, when the regressions were run for two subperiods, 1950(I) - 1961(IV) and 1962(I) – 1973(IV), there was a tendency for the lag period to become longer in the 1960's and early 1970's, as is shown in Table 4 [12]. The mean lags of most models suggest that new equipment spending spreads over a considerably longer period in the 1960's - 1970's [13].

TABLE 2

Estimates of (2.8) with Static and Nonstatic Price Expectations[a]

Model	Static	YOH[b]	L6	L12	HEN	MI	FEL
β_o^c	—23.36*	27.26*	26.27*	24.02*	6.44*	5.91*	5.97*
$\Sigma\beta_{i,\,i-1}$	0.0438	0.5940*	0.6927*	0.6440*	0.4695*	0.3271*	0.3624*
$\Sigma\beta_{i,\,i}$	—0.0199	—0.5519*	—0.6781*	—0.6207*	—0.4620*	—0.3293*	—0.3635*
Significant β's[d]	14/23	21/21	22/22	22/22	22/22	22/22	23/23
β_{n+1}	0.02	—0.61*	—0.25*	—0.36*	0.00	0.24*	0.21*
R^{2e}	.9965	.9966	.9966	.9965	.9963	.9955	.9955
SEE[e]	0.8841	0.8727	0.8739	0.8805	0.9133	0.9843	0.9845
ρ	.345	.623	.680	.675	.483	.626	.559
D.W.	1.97	1.91	1.93	1.94	2.01	2.19	2.12

[a] The interest rate in the static model is given by (2.1) and in the nonstatic models by (2.4).

[b] The order of the expected price models in this table is different from the one followed in Table 1 to reflect the ranking of these models.

[c] Asterisk denotes significance at the 5% level.

[d] The number of statistically significant coefficients is the same for both groups of coefficients, $\beta_{i,\,i-1}$ and $\beta_{i,\,i}$.

[e] Unadjusted; the adjustment for the degrees of freedom was generally omitted when the ranking of the models was not altered by it.

Note : A far - zero restriction and a third-degree Almon lag was imposed on all equations except the MI and FEL models, for which a second - degree lag was used. All nonstatic equations had positive $\beta_{i,\,i-1}$ coefficients; the static model, however, was found to have twelve negative $\beta_{i,\,i-1}$ coefficients.

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[12] The HEN model is not shown here because it produces values only for the 1960's.

[13] It should be noted that it is the nonstatic expectations models which are characterized by short lags. I suspect that this is due to the fact that price change accelerations or decelerations did not persist for a relatively long period of time during the sample period. On the contrary, they usually lasted less than an investment boom or downswing; therefore, a relatively short lag is prone to capture better the effect of price changes on investment.

TABLE 3

Estimates of (2.11) with Static and Nonstatic Price Expectations[a]

Model	Static	L12	L6	MI	FEL	YOH	HEN
Σbi	.1785*[b]	.0475*	.0342*	.0601*	.2192*	.0532*	.0399*
Defree of lag	4	4	4	3	3	3	3
Length of lag	17	8	8	8	17	7	7
Mean lag	6.5	3.8	3.7	3.8	7.0	2.8	2.8
γ	1.22*	1.27*	1.29*	1.27*	1.32*	1.30*	1.30*
R^2[c]	.9942	.9945	.9945	.9944	.9941	.9937	.9933
SEE[c]	1.0510	1.019	1.0301	1.0341	1.0499	1.0850	1.1164
ρ	.932	.946	.947	.948	.874	.940	.945
D.W.	1.74	1.78	1.69	1.61	1.63	1.66	1.61

[a] The interest rate in the static model is given by (2.3) and in the nonstatic models by (2.6).

[b] Asterisk denotes significance at the 5 % level.

[c] Unadjusted; no adjustment was undertaken because it was found that increasing the length of the distributed lag, and thus reducing the available degrees of freedom, did not raise the explanatory power of the regressions as measured by both the R^2 and SEE.

Note : The b_i coefficients were found to be positive in all equations and a far - zero restriction was imposed on all equations, except the MI one.

TABLE 4

Estimated Length of the Lag Period

Model	Static	L12	L6	MI	FEL	YOH
Mean Lag in 1950 - 61[a]	2.3	2.7	2.8	2.9	3.9	1.3
Mean Lag in 1962 - 73[a]	7.3	4.0	4.1	4.0	7.0	3.0

[a] The mean lag is measured in quarters.

If price expectations do not influence investment decisions appreciably, then lowering the cost of capital by the expected rate of price change should tend to statistically overestimate investment. This ought to be true, particularly for the most recent period; for example, the 1970 - 74 period which was characterized by persistent inflationary pressures. In fact, Bishoff (see [2]) found that SNC equipment equations with nonstatic expectations overpredicted investment in simulations of the 1969 - 70 period. A comparison of investment expenditures estimated by a static expectations model with those estimated by the six expected price models revealed no tendency on the part of the latter models to produce buoyant predictions in the period 1971(I) - 1973(IV)[14].

Most of the above remarks - mutatis mutandis - are confirmed when the alternative specification of the FMP model is used. Estimates of (2.12), combined with a variable pre-tax interest rate without leverage adjustment, given by (2.1) and (2.4), are presented in Table 5[15]. With the exception of the nominal interest rate model, the statistical fit of all the equations is satisfactory[16]. There are no unrealistic estimates and interaction among the constant term, the capital stock, and the lagged variables. Most expected price models are shown to outperform the static expectations model, though by a relatively low margin[17].

A comparison between specifications (2.7) and (2.11) of the SNC model, as well as between (2.8) and (2.12) of the FMP model, reveals that the «more general» form of these two functions produces unsatisfactory estimates of the distributed lag on relative prices and output. In fact, it was shown that one can «buy» some degree of explanatory power (notice the higher R^2 of all equations estimated by (2.7) and (2.8) relative to those estimated by dropping the constant term and the capital stock variable) by employing a more general specification, but only at the expense of obtaining seriously disturbed and almost meaningless coefficients. Consequently, these specifications should be avoided in estimating either the SNC or the FMP model.

Specifications (2.11) and (2.12) yield distributed lags which are satisfactory on all conventional statistical criteria for most equations tested. However, complacency is not warranted here, either. Besides the bizarre fact that, in the context of the FMP function, most coefficients of the static expectations model are insignificant, some behavioral characteristics of these specifications require our attention. Allowing the interest rate to influence investment spending not directly

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[14] Tables with the relevant residual patterns may be obtained from the author.

[15] Estimates of (2.12) when the remaining two formulations of the cost of capital were used produced similar results and can be made available on request.

[16] This statement may appear incorrect as far as the MI equation is concerned. A careful inspection, however, reveals that $(\Sigma\beta_{i,\,i-1} + \Sigma\beta_{i,\,i})$ is found negative when (2.8) is used, and positive when (2.12) is used — the theoretically expected sign being positive (see (2)).

[17] The likely reasons are explained in (13). However, I have no explanation for the failure of the static expectations version to yield statistically significant coefficients, despite an intensive and exhaustive search.

but as a component part of the rental price of capital appears theoretically sound, but is too restrictive as far as the econometric aspects are concerned. Lumping the cost of capital together with the investment tax credit, the corporate tax structure, and the opportunities of accelerated depreciation creates a composite variable, the rental price of capital. Furthermore, combining this variable with the price of output and, in the SNC model, with the level of output gives rise to a conglomerate term which is rather *heterogeneous*. It is particularly so in the statistical sense : all individual variables composing it are constrained to affect investment with the same lag structure; that is, the length of the lag, its shape (degree), and the various restrictions on the (i + 1) and (n + 1) terms are supposed (or sought) to be identical for all individual variables. This assumption is unduly restrictive and should be relaxed. Introducing separate lags for some of the variables included in the conglomerate terms and the rental price of capital is possible and potentially rewarding, without giving up undue degrees of freedom.

TABLE 5

Estimates of (2.12) with Static and Nonstatic Price Expectations[a]

Model	Static	L6	L12	YOH	HEN	FEL	MI
$\Sigma\beta_{i,\,i-1}$	0.1638	0.4651*[b]	0.4615*	0.3638*	0.4404*	0.2762*	0.2247*
$\Sigma\beta_{i,\,i}$	—0.1453	—0.4567*	—0.4516*	—0.3523*	—0.4307*	— 0.2642*	—0.2123*
Significant β's[c]	4/23	22/22	22/22	21/21	22/22	23/23	17/22
Degree of Lag	3	3	3	3	3	2	2
Length of Lag	23	22	22	21	22	23	22
Mean Lag	7.0	10.8	10.3	8.8	10.0	9.2	8.0
R^2[d]	.9950	.9959	.9958	.9955	.9954	.9949	.9946
SEE[d]	1.0392	0.9461	0.9494	0.9905	0.9921	1.0296	1.0616
ρ	.985	.977	.927	.814	.924	.946	.995
D.W.	2.191	2.169	2.151	2.159	2.205	2.272	2.061

[a] The interest rate of the static model is given by (2.1) and of the nonstatic model by (2.4)

[b] Asterisk denotes significance at the 5 % level.

[c] The number of statistically significant coefficients is the same for both sets of coefficients.

[d] Unadjusted for the same reasons as those cited in Table 3.

Note : Except for two coefficients of the static model, all the $\beta_{i,\,i-1}$ coefficients were positive (as expected) and they were all estimated using a far - zero restriction on the Almou polynomial.

TABLE 6

Estimates of (2.8) when the After - Tax Real Cost of Capital is Assumed to Equal Zero

β_0	$\Sigma\beta_{i,i-1}$	$\Sigma\beta_{i,i}$	Significant β's	β_{n+1}	R^2 [b]	SEE [b]	ρ	D.W.
—10.69*[a]	0.1385*	—0.1280*	10/12	0.0689*	.9964	0.8893	0.40	1.94

[a] Asterisk denotes significance at the 5 % level.

[b] Unadjusted.

Note : A third-degree polynomial, a twelve-quarter lag, and a far - zero restriction were used with data covering the period 1956 (I) - 1974 (III).

(For example, a logarithmic transformation may be employed for this purpose.) Unless the interest rate is allowed to have an independent and direct effect on investment expenditures, one may expect that its impact on investment is likely to be overshadowed by the effects of the other variables. Some support for this view is provided by the relatively low sensitivity of the statistical results to changes in the specification of the interest rate and the price variable used. Further support for the view that the specifications explored in this study are not suitable for examining the effect of the interest rate on investment is provided by tests in which the cost of capital was assumed to be constant and equal to zero over the entire period. To keep the estimation within a realistic framework, the nominal interest rate (high-grade bond rate) was used for discounting depreciation changes. It turned out that such a model performed quite well and produced results which were close to those obtained with a nominal or real cost of capital. The summary statistics obtained when the after-tax real cost of capital is set equal to zero and (2.8) is used are presented in Table 6. I think that the closeness of the results should not be taken as evidence that the interest rate is a negligible factor but that it should be attributed to the particular specification utilized by the SNC and FMP model, unless one is inclined to believe that the deductible of interest payments from taxable income and price inflation can completely offset the nominal cost of capital [18]. Nevertheless, one cannot have much faith in a model that can hardly discriminate between a positive and a zero real rate of interest [19].

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[18] 18. Comparing the estimates and statistics of Table 6 to those presented in Table 2, one sees that a zero - cost model explains the data as well as a nominal rate model and better than several of the real rate models.

[19] 19. A comparison of the performance of the two investment models examined was not an aim of the present study and, therefore, no effort was made to facilitate such a comparison. However, if one wishes to do so, he can pair equation (2.7) with (2.8) and (2.11) with (2.12). It can be seen that the FMP equations provide a marginally better fit than their SNC counterparts.

Furthermore, one could rank the various expected price models vis-a-vis each other. Such ranking could be important for theoretical and policy purposes. If investment ought to be determined by the real rate of interes, the price variable that helped to produce the best fit should be used for obtaining reliable estimates of the real interest rate. Accordingly, a comment on the performance of the various price expectations seems worthwhile, provided one wants to confine oneself to the more successful specifications. Livingston's series of price expectations appears to produce a better fit in both the SNC and FMP models. A second best is (when the SNC model is used) the household expectations surveyed by the Institute of Social Research of The University of Michigan and (when the FMP model is used) price expectations generated by regressing nominal interest rates on current and past price changes alone.

4. Are intdrest rates fully adjusted for the expected rate of inflation? Some evidence from the investment function.

If price expectations are strongly influenced by concurrent or recent rates of price changes, nominal rates of interest do not seem to be fully adjusted for the expected rate of price changes. Yet, the Fisherian hypothesis points to such an adjustment. The conflict between theory and historical data was noticed by Fisher, and his effort to explain it focused on the expected rate of price changes which was postulated to be formed slowly and on the basis of multi-year experience [20]. However, the thrust of the Fisherian thesis, which is the notion that the nominal rate can be decomposed into two components, the real rate and the expected rate of price changes, coud be preserved if it were combined with any of the following two hypotheses :

Hypothesis I : nominal interest rates are only partially adjusted for the expected rate of price changes.

Hypothesis II : some proportion of the investors fully adjust the cost of capital for the expected rate of price changes, while the remainder do not adjust them at all [21].

In a study by AMRT (see [1]), an indirect effort was made to incorporate hypothesis I into an investment function. A direct test of this hypothesis could be introduced by formulating the after-tax real cost of capital, for example (2.4), as follows :

$$RR^{*1}_{t} = (1 - U_t)\ RN_t - g(\mathring{P}^{e}_{t}) \qquad (4.1)$$

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[20] 20. Empirical research suggests that either full adjustment does not take place or expectations are formed considerably faster than hypothesized by Fisher — or both — (see (6)).

[21] 21. A third hypothesis could be formulated according to which different groups of decision makers adjust the interest rates to a different extent.

TABLE 7

Estimates of (2.12) when the Adjustment of Nominal Interest Rates to Expected Price Changes is Allowed to Vary [a]

Model	L6	L12	YOH	HEN	FEL [b]	MI [b]
g	0.6	0.7	0.8	0.8	0.8(1.1)	1.0(1.2)
$\Sigma\beta_{i,\, i-1}$	0.3950*[c]	0.4050*	0.4457*	0.4245*	0.2207*(0.2607*)	0.2247*(0.2741*)
$\Sigma\beta_{i,\, i}$	−0.3834*	−0.3936*	−0.4341*	−0.4138*	−0.2080*(−0.2495*)	−0.2123*(−0.2630*)
Significant β's [d]	21/22	21/22	21/21	22/22	14/23(23/23)	17/22(22/22)
Mean Lag	8.7	8.5	8.1	8.8	8.6(9.2)	8.0(8.6)
R^2 [e]	.9962	.9962	.9963	.9961	.9951(.9950)	.9946(.9941)
SEE [e]	0.9017	0.9063	0.8927	0.9204	1.0124(1.0189)	1.0616(1.1150)
ρ	.686	.650	.492	.647	.945(.938)	.995(.909)
D.W.	2.05	2.02	2.04	2.11	2.28(2.24)	2.06(1.98)

[a] The distributed lags in the equations of this table are similar in specifications (degree, length, etc.) to those used for the regressions presented in Table 5. The period covered is again 1956(I) - 1974(III).

[b] Estimates resulting from $g > 1$ are reported in parentheses.

[c] Asterisk denotes significance at the 5 % level.

[d] The number of statistically significant coefficients is the same for both sets of coefficients.

[d] Unadjusted.

TABLE 8

Standard Errors of Estimate for Selected Models [a]

Model	L6	L12	YOH	HEN
Complete Adjustment ($g = 1$)	0.9461	0.9494	0.9905	0.9921
Incomplete Adjustment ($g < 1$)	0.9017	0.9063	0.8927	0.9204

[a] The figures are taken from Tables 5 and 7.

where g stands for the adjustment coefficient. The value of the coefficient should not be set *a priori*, but it should be estimated. Such an estimation was carried out in the context of the FMP model by replacing (2.4) by (4.1) in the equations of Table 5. The expected price models of investment behavior were re-run for various values of g, ranging from 0.2 to 1.3, to account for underadjustment as well as overadjustment (the latter because the level of expected prices was considerably lower in some series compared to that of others). Adjustment coefficients which produced the best fit and the corresponding estimates are presented in Table 7. The equations shown in Table 5 are a special case of the more general (variable adjustment) specification given by (4.1), resulting from $g = 1$, and, therefore, are not repeated in Table 7. On the basis of the summary statistics of Table 7, the following points may be made :

1. With the exception of the MI model, allowing for incomplete adjustment of the nominal interest rate to the expected rate of price change leads to an improvement in the statistical fit (which is more obvious in terms of SEE than in R^2), as it is shown in Table 8, where the SEE figures from Tables 5 and 7 are compared. The performance of the simple Fisherian model of price expectations (i.e., the YOH equation) is impressively affected, to the extent that it now outranks all expected price models. Furthermore, there is a discernible tendency, at least for the first four models, to come closer in terms of explanatory power [22].
2. The reported adjustment coefficients provide evidence of incomplete adjustment, ranging from 60 to 80 percent [23]. The partial adjustment hypothesis is supported not only by the better fit of the relevant equations but also by improvements in other aspects of the estimated regressions as, for example, in the coefficient of autocorrelation, ρ, which in the first four models is reduced by 30 to 45 percent. If, however, our focus shifts to price expectations derived from a Feldstein-Chamberlain (FEL) model or from household surveys (MI), there is some evidence of a rather full adjustment-even of a moderate overadjustment-provided not so much by the minimum error criterion as by the number of statistically significant coefficients. An inspection of the FEL and particularly of the MI series of price expectations reveals, indeed, that a slight overadjustment might be reasonable in view of the relatively low level of expected prices characterizing these two series. Therefore, such adjustment is not really conflicting with the evidence provided by the other models.

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[22] For the same equations, such a tendency is observed with respect to the sum of the lagged coefficients as well, an outcome which suggests that, to some extent, the previous differences in the expected price equations were due to the mis - specification of the interest rate variable rather than to differences in the price expectation series used.

[23] The adjustment is smaller for (Livingston's) short-term expectations than for longer term expectations (i.e., the L12 series), as theoretically expected.

TABLE 9

Mean Lags for Selected Models [a]

Model	L6	L12	YOH	HEN
Full Adjustment ($g = 1$)	10.8	10.3	8.8	10.0
Partial Adjustment ($g < 1$)	8.7	8.5	8.1	8.8

[a] Lags are given in quarters and the figures are taken from Tables 5 and 7.

3. Expected prices tend to influence investment spending with a lag which is considerably shorter than that appropriate for the other independent variables. This is supported by the fact that the minimum standard error, produced by an incomplete adjustment, is not obtained as a result of the best distribution lag; on the contrary, minimum SEE coincides with a smaller number of statistically significant lagged coefficients. Reflecting this feature, the mean lag obtained with incomplete adjustment is appreciably shorter, as shown in Table 9. The fact that a shorter lag appears appropriate for price expectations than for the output and/or the relative price terms comprises direct evidence on the limitations of the usually employed specifications of the SNC and FMP investment models, as was pointed out in the preceding section [24].

Finally, I would like to note that it is rather difficult to distinguish empirically between hypotheses I and II. The results presented here may be interpreted as providing support for either hypothesis, though they are designed to test hypothesis I [25].

5. Conclusions

In this study, some questions on price expectations and investment expenditures were posed and the following tentative answers were given :

1. Do price expectations affect investment spending? The answer is yes. When the specification of the investment function produces realistic and significant estimates of the distributed lag, adjusting the cost of capital for the expected

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[24] This has been well anticipated by Nerlove (see (11, pp. 221 - 7)).

[25] AMRT assumed that «...if some fraction of the decision makers adjust the money interest rate for the rate of change of prices and the rest do not, then this is similar, *in effect*, to a situation in which all decision makers adjust only partially...» (see (1, p. 400), the emphasis being mine).

price changes yields a better statistical fit. Postwar expenditures on producers' durable equipment are explained better, in the framework of two well-known models of investment behavior (SNC and FMP), by some measure of the real rate of interest than by nominal interest rates. This evidence is in contrast with the results on (2.7), presented by Bishoff in [2].

2. Are there some expected price variables which tend to constantly outperform the others in explaining investment? The answer is a qualified yes. Out of the six distinct series of price expectations tested in this study, Livingston's observed expectations and, to a lesser extent, those derived from regressing nominal interest rates on price changes alone do better than price expectations derived from regressing interest rates on price changes and other variables, those derived from the spread between dividend yields and bond rates, and those derived from observed expectations taken from households [26]. The qualification arises, however, because, when the assumption that the expected rate of price changes is fully incorporated into the cost of capital is removed, most of the expected price equations produce results which are impressively close in terms of explanatory power and estimates of the distributed lag.

3. Are the usual specifications of the SNC and FMP model appropriate for examining the role of price expectations in investment decisions? I am afraid that they are not. Forcing the various right-hand variables to affect investment with the same lag and the same constraints seems to be a serious weakness of the econometric methods employed. There is strong evidence that price expectations — and, hence, the real cost of capital — exert their influence with a considerably shorter lag than the one used in producing most of the recent sophisticated work on the investment function (see, for example, [1, 2, 8, 9]).

4. Are nominal interest rates fully adjusted for the expected rate of commodity price changes; if not, what has been the average degree of adjustment? The answer to these questions is that it depends on the expected price variable used. If real interest rates are constructed by employing expected prices derived from Livingston's data, from regressing interest rates on price changes alone, and from capital market yields, there is strong evidence of partial adjustment ranging from 60 to 80 percent. However, when price expectations generated by a Feldstein - Chamberlain model or by random surveys of households are used, almost full adjustment takes place. It should be recalled that the latter series of expected prices are characterized by relatively low levels when compared with the other price variables (a feature that facilitates the decision of whether or not to fully incorporate the expected rate of price change in the cost of capital when a price variable referred to in this paper is employed). The results presented in section 4 contrast with those in which complete adjustment is assumed (as in [8, 9]) as well as with those in which

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[26] This may be considered somehow surprising because models which tend to do better in explaining interest rates (e.g., the one associated with the Feldstein - Chamberlain model of interest rate determination) fail to do so in explaining investment expenditures.

the degree of the adjustment is not linked to the particular series of price expectations used (as in [1, 2]); the summary statistics of Table 7 show that a specification which allows for partial adjustment of interest rates can almost eliminate autoregression and produce well-fitted distributed lags and reasonable mean lags[27].

5. The empirical results presented have obvious implications for the Fisherian hypothesis of full adjustment, the policies of the fiscal and monetary authorities, and the effort to obtain real interest rates. Whether full or partial adjustment of nominal interest rates to expected price changes is to be made depends on the particular price variable used and the time horizon of its expectation, the adjustment factor ranging from 60 percent for short-term expectations to 70 or 80 percent for longer term expectations.

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[27] One should note and appreciate the fact that the mean lags of the various models presented in Table 7 are practically identical, a feature which is missing in the other tests reported here. Since the choice of a particular expected price variable by a decision maker can hardly influence his investment horizon and pace of implementation, widely different mean lags, produced simply because one price variable is substituted for another, are seriously disturbing.

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