DISCUSSION PAPERS

EXPECTATIONS OF INFLATION AND SHORT-TERM INTEREST RATES IN AUSTRALIA 1968(1)–1979(2)

P.A. Volker
Discussion Paper No. 41
January 1982

P.O. Box 4, Canberra 2600, Australia
EXPECTATIONS OF INFLATION AND SHORT-TERM
INTEREST RATES IN AUSTRALIA 1968(1)-1979(2)

Paul A. Volker*

Discussion Paper No. 41

January 1982

A Paper presented to the Symposium on Interest Rates
Macquarie University, 28 November 1980

ISBN: 0 949838 41 1
ISSN: 0725-430X

* Department of Economics, Research School of Social Sciences,
Australian National University. I wish to thank Alan Hall, Trevor
Swan and Adrian Pagan for very useful discussions and Eva Klug for
carrying out the empirical analysis. The responsibility for all
errors remains my own.
The paper examines the relationship between short term nominal interest rates and inflationary expectations in Australia over the period 1968(1) to 1979(2). A number of models were estimated using alternative measures of inflationary expectations. The conclusion reached was that such expectations exerted a significant but relatively small influence on the interest rate. The degree of influence was puzzling but did not appear to arise from errors in measurement in the expectations variable.
# TABLE OF CONTENTS

**DISCUSSION PAPER NO. 61**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>DEVELOPMENTS IN THE THEORY AND RELATED EMPirical FINDINGS</td>
<td>2</td>
</tr>
<tr>
<td>EMPIRICAL INVESTIGATION OF VARIOUS MODELS</td>
<td></td>
</tr>
<tr>
<td>Alternative Specifications</td>
<td>6</td>
</tr>
<tr>
<td>Model Selection</td>
<td>11</td>
</tr>
<tr>
<td>Errors-in-Measurement Model</td>
<td>14</td>
</tr>
<tr>
<td>'Rationally' Determined Expectations</td>
<td>15</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>17</td>
</tr>
<tr>
<td>DATA APPENDIX</td>
<td>18</td>
</tr>
<tr>
<td>FOOTNOTES</td>
<td>20</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>21</td>
</tr>
<tr>
<td><strong>FIGURE 1</strong></td>
<td>22</td>
</tr>
<tr>
<td>Within Sample Predictive Performance of</td>
<td>25</td>
</tr>
<tr>
<td>Equation 9</td>
<td></td>
</tr>
<tr>
<td><strong>FIGURE 2</strong></td>
<td>25</td>
</tr>
<tr>
<td>Within Sample Predictive Performance of</td>
<td></td>
</tr>
<tr>
<td>Equation 11</td>
<td></td>
</tr>
</tbody>
</table>
1. INTRODUCTION

The relationship between the nominal rate of interest and the anticipated rate of inflation is one which has fascinated economists ever since it was pointed out by Fisher (1930) that such expectations ought to be fully reflected in the nominal rate. Borrowers, it was argued, would continue to demand funds until the nominal interest rate rose by the amount of the expected inflation since the nominal yield on investment was also expected to rise by this amount. Similarly, lenders would be willing to lend only at a rate which maintained their original real rate of return.

A large number of papers (e.g. Sargent (1969), Feldstein-Eckstein (1970), Carr, Pesando and Smith (1976)) sought to determine in various contexts the extent to which Fisher's hypothesis held. Traditionally these studies have been hampered by a need to proxy their most important explanatory variable and this fact in combination with the often ad hoc nature of the employed proxies appears to be responsible for a certain scepticism about, and lack of consistency in, the results. The emergence in recent years of inflation as an intermediate term phenomenon at the same time as the availability of more directly observable price expectations (survey) data has generated a renewed interest in the issue.

In this paper we estimate a number of models in an attempt to determine the importance of such expectations in the formulation of the level of the 90 day Bank Accepted Commercial Bill Rate in Australia. This rate is chosen since it is one of the few market determined rates available and it possesses a term structure equal to the time horizon of price expectations data derived from the ACMA-Bank of New South Wales survey. As a precursor to looking at the Australian data we refer briefly to a number of factors which are likely
to affect the extent to which the two variables move together.

2. DEVELOPMENTS IN THE THEORY AND RELATED EMPIRICAL FINDINGS

In the original (Fisher) formulation the nominal rate of interest (rn) was expressed as the sum of a real rate of interest (rr) and an expected inflation rate (\( \hat{\pi}^e \))

\[ r_n = r_r + \hat{\pi}^e \]

(1)

where typically \( \hat{\pi}^e \) has been proxied as a distributed lag of current and past rates of price change

\[ \hat{\pi}^e_t = \sum_{i=0}^{n} w_t \hat{\pi}_{t-i} \]

(2)

The paper best known for using this approach is Yoo and Karnosky (1969) who found that a sustained increase in the rate of inflation of 1% led to an eventual increase (after 16 quarters) of .84% in the level of the 4-6 month commercial paper rate.

An alternative and richer model of the determination of nominal rates was proposed by Sargent (1969). This more interesting specification was developed along the following lines. First the nominal interest rate was written as the identity

\[ r_n = r_e + (r_m - r_e) + (r_m - r_m) \]

(3)

where \( r_e \) is the real rate equating intended savings and investment and \( r_m \) is the prevailing real market rate. If, as argued by Sargent, \( I_t \) (intended real investment) = \( f(r_m, \Delta Y) \) (change in real income) \( S_t \) (intended real savings) = \( g(Y, r_m) \) then in equilibrium \( r_e = h(Y, \Delta Y) \). Deviations of \( r_n \) from \( r_e \) on the other hand may be induced through lending supplementary to intended savings. In true Wicksellian tradition Sargent attributes the source of this extra lending to banks. Since such new lending is likely to affect money holdings and to be affected by it, it is proxied by the rate of growth of the real money stock, \( \hat{m} \) (however defined). The
deviation of nominal from real rates \((\sim r_t - r_m)\) is expressed as a function of the anticipated rate of inflation \(\hat{p}_t^e\). The reduced form of the model is therefore \(r_t = f(Y_t, \Delta Y_t, \hat{e}_t, p_t^e)\). Following Yohn and Karmosky the model can be illustrated as follows.

![Diagram showing the relationship between interest rate, real saving, and investment](image)

where \(AB\) represents the (Pliskewichian) level of supplementary funding, \(r_e\) is the equilibrium real rate and \(r_m - r_e\) is the vertical shift in both supply and demand curves for funds due to inflationary expectations. If expectations are homogenous between lenders and borrowers the nominal interest rate will increase by the level of expected inflation.

An alternative, liquidity preference, model was proposed by Feldstein-Eckstein (1970). If the demand for real money holdings is expressed as a function of real income and the interest rate, and nominal money supply is a function of the nominal monetary base, then in market equilibrium the reduced form determinants of the interest rate are real income, nominal money base and the price level. The form of this model is very similar to the loanable funds model of Sargent when inflationary expectations are added. Some differences between the two models can be engendered through different dynamic specifications. In particular, the response of the money supply to changes in the money base may be lagged, as may be the effect of income or the interest rate on money demand. A number of supplementary factors were also proposed by Feldstein-Eckstein. The government borrowing
requirement, for example, was seen as exercising a potentially positive influence on the interest rate.

A number of additional models have been proposed from time to time. In general these specifications constitute variations on a theme. Carr and Smith (1972), for example, develop a model which places particular emphasis on the difference between the actual and expected rates of monetary growth. Jenkins and Lim (1973) argue that the real rate evolves slowly over time and that it can be influenced in the short run by variations in the rate of growth of the money supply and the level of real privately held government debt. Similarly, Domar and Duck (1978) develop a loanable funds model which recognizes the open nature of the British economy. Their final estimating form, however, differs little from the Sargent specification though it recognizes through the inclusion of a lagged dependent variable that adjustment of even short term interest rates may not be instantaneous.

The majority of these models have argued that sooner or later nominal interest rates incorporate most of the effect of anticipated inflation. From an estimation point of view one can have little confidence in some of the results, however. In a number of cases implausibly long mean lags (sometimes over 20 years) have been derived. A large number of models using distributed lags of past rates of inflation as a means of proxying inflation expectations have imposed very low order polynomials on very long lags, sometimes inducing between 20 and 30 (untested) implicit constraints. In other cases the actual lag length has been set with an acknowledged objective of obtaining a sum of weights equal to unity, the central hypothesis being examined.

Those papers such as Gibson (1972), Lahiri (1976), and Domar and Duck (1978) which use directly observable price expectations series have in some ways been on safer ground. The difficulty of obtaining appropriate distributed lag specifications has been avoided and, naturally, apparent
speeds of adjustment have been more rapid. On the other hand, the use of such series has not been accepted without reservation. Various models which have sought to explain the US (Livingstone) data have appeared from time to time to be unstable. There is, furthermore, always the question of the extent to which the views of the respondents to the survey reflect those of participants in the particular market being studied. Recent studies by Carlson (1977) and Lahiri (1976) suggest the issue of instability may be exaggerated, however. One way of responding to some of the scepticism associated with such series may be to postulate an errors in measurement model as in Lahiri, and to test whether such errors are an important component of the series.

The extent to which inflationary expectations ought to be reflected in nominal rates of interest is another issue which is unclear. Mundell (1963) argued that the nominal rate would rise by less than the rate of anticipated inflation because of the real balance effect. Darby (1975), on the other hand, pointed out that income tax considerations ought to cause the nominal rate of interest to increase by more than the increase in the anticipated rate of inflation. He argued that the correct relationship between the nominal and real rate of interest in a simple Fisher type model ought to be

$$r_{n} = (r_{r} + r_{e})/(1 - \tau)$$

where $\tau$ is the effective marginal tax rate in period $t$.

Feldstein et al (1978) show that the effect of actual inflation on interest rates depends upon the allowable rate of depreciation as well as the marginal rate of taxation while Levi and Makin (1978) find little reason to hold strong expectations about the extent to which anticipated inflation will be incorporated into nominal rates. In their general equilibrium model they find that

$$\frac{\partial r}{\partial \delta}$$

is a function of a number of variables including the elasticity of savings with respect to changes in the level of
real money balances, the elasticity of real investment with respect to
the real after-tax rate of return, the interest elasticity of the demand
for money, and the elasticity of the money wage demanded with respect to
the level of prices. Davidson (1980) also argues in the context of a
macroeconomic model that the effect of anticipated inflation is ambiguous.
In summary, therefore, there appears to be little a priori justification on
theoretical grounds for expecting the Fisher hypothesis to hold exactly.
Empirically, estimates have ranged from the implausible negative relation-
ship of Neumann (1977) through the relatively low value of .32 found by
Pyle (1972), to unity which most analysts have (in some cases more
actively than others) approached. There appears to be little support
for the Darby hypothesis that estimates should be greater than one.

It is with this brief outline of some of the issues and empirical
results in mind that we turn to the question of the relationship between
the 90 day Commercial Bill Rate and inflationary expectations in Australia.
As far as I am aware the only paper which has attempted to examine this
question empirically is Porter (1980). In this paper the bill rate was
estimated as a distributed lag of current and past rates of growth of
the narrowly defined money stock, M1. Since the lag structure is
rather ad hoc the findings are somewhat suspect. No attempt was made to
incorporate anticipated inflation explicitly in the model but one (qualified)
interpretation of the results is that only about half of the level of
inflationary expectations is reflected in the nominal rate.

3. EMPIRICAL INVESTIGATION OF VARIOUS MODELS

It could well be argued that the open nature of the Australian
economy might militate against the appropriateness of the Fisher hypothesis
advanced above. However, following Derry and Duck let us assume:
\( R_A - R_w = \varepsilon^* \), i.e., the difference between the Australian
nominal interest rate and the exogenous world rate of the same maturity, is equal
to the anticipated rate of change in the exchange rate; and (b) \( R_w = u_0 + \hat{P}_w^0 \),
i.e. the world nominal rate is primarily a function of the world expected
inflation rate. Then under either (c) \( E^0 = P_H^0 - P_W^0 \), i.e. the expected change \( E^0 \)
the (flexible) exchange rate is a function of the difference between the antici-
pat rates of inflation in Australia and the rest of the world, or (d) as a limiting
case \( E^0 = 0 \) (i.e. exchange rates are fixed and \( P_H^0 = P_W^0 \), we can write
\( R_A = w_0 + \hat{P}_A^0 \). While these assumptions are restrictive they do suggest that even
for an open economy the domestic interest rate can still be expressed as a functi-
of domestic inflationary expectations. We return to this issue later.

First, however, we discuss the results from estimation of a number of
traditional models starting with the simple Fisher hypothesis. All models are
estimated over the period 1968(1) - 1979(2) using end of quarter data which has
not been seasonally adjusted. The inflationary expectations variable has been
supplied by the Reserve Bank of Australia and is based on the Carlson-Parkin
(1975) method of conversion of qualitative (ACMA-Bank of NSW) survey responses
into a quantitative series. The scaling factor of 2.756 adopted in this
series may be less appropriate over the latter part of the sample since it is
based on the lower rates of inflation prevailing in the late 1960's and early
70's. This fact should be borne in mind when examining the size of the
coefficients obtained for the inflationary expectations variable. The mean value
of the commercial bill rate and the inflationary expectations rate series over the
sample period are 8.12 and 13.46 respectively.

The simple Fisher model which has been augmented to allow for seasonal
variation and lagged adjustment, generates the following estimates for the survey
based expectations variable.\(^a\)

\[
\begin{align*}
\text{BILL}_t &= 1.108 + 0.0081 + 1.53782 + 0.07783 + \cdot 61\hat{P}_L^0 + \cdot 533\text{BILL}_{t-1} \\
&\text{ (1.46) (1.03) (2.61) (.13) (3.94) (5.14) } \\
R^2 &= .760 \quad \text{D.W.} = 1.85 \quad \text{S.E.E.} = 1.39 \\
\end{align*}
\]

Corr. a.c.f. lag 1 2 3 4 5 6 7 8
't' .62 .68 2.35 -2.14 -.92 -.54 -2.42 -1.50

\(^a\) 't' statistics in parentheses.
The estimated long run elasticity of the price expectations variable in
this equation (r = .57 at the mean) is similar to the implicit estimate obtained
by Porter. Nevertheless the structure of the Autocorrelation Function and the
poor prediction of the model in 1974(2) when the rate reached 10.6% suggest that
this specification is likely to be unstable implying the need for more elaborate
or alternative model forms.

One such model we might consider is the loanable funds model of Sargent
outlined in Section 2. This specification can be generalised somewhat by
acknowledging that seasonal elements may be important, that adjustment may
not be instantaneous and that additional funds may be required to finance an
external trade imbalance. In so far as the latter may be expressed as a function
of the level of income, there is no need to alter the basic reduced form.
Additional government borrowing, if sufficiently large, is likely to exert a
positive impact on the interest rate. The significance of this effect may be
evaluated through including in the reduced form of a variable equal to the change
in the real value of the government securities outstanding.

A number of experiments were conducted with different definitions of
variables. In particular, the Capacity Utilisation Variable of the Treasury
model was proposed as an alternative index of economic activity. Similarly,
changes in the real value of privately held Treasury Notes was substituted for
changes in a broader definition of government debt on the grounds that the value
of short term debt outstanding may be more relevant to a short term interest rate.
Additionally the rate of growth of real M₁ (growth of M₁) was considered as an
alternative to the rate of growth of real M₃. After deletion of variables
insignificant at the 10% level the most reasonable specification was

\[
\begin{align*}
\text{CBILL}_t &= \beta_0 + \beta_1 \text{CBILL}_{t-1} + \beta_2 \text{MGDP} + \beta_3 \text{GDP} + \beta_4 \text{GDP}_t + \epsilon_t \\
R^2 &= 0.808 \quad \text{D.F.} = 2.08 \quad \text{S.E.E.} = 1.278
\end{align*}
\]
Despite the significance of a number of additional regressors the equation continues to manifest the same problems as (5). Two points about (6) are important, however. Firstly, the impact of inflationary expectations has fallen to about half that implied in (5). Secondly, narrower rather than broader definitions of liquidity appear to be more relevant. On this latter point a note of caution is in order. It is not clear that causality runs in a unidirectional manner from liquidity to the interest rate in this equation. If increases in the bill rate occur at the same time as increases in the perceived opportunity cost of holding M2 (either in terms of the return on various components of M2 or M3 or on treasury notes or bills themselves), then the direction of influence may well be opposite to that implied in the model.

It might be better, therefore, to proxy the supply of loanable funds from (trading) banks more directly. In order to do this we note that Valentine (1973) argues that the supply of new trading bank lending rights is a function of, amongst other things, the level of excess LGS reserves in the previous period. We therefore estimated a model in which the real value of last periods excess LGS reserves were substituted for the rate of growth of the real money stock as follows:

\[
\begin{align*}
\text{GBILL}_t & = 12.804 + .92951 + 1.21052 + .71283 + .000526P_t - .000256P_t \\
& \quad (2.74) (9.9) (6.9) (7.6) (2.58) (4.2) \\
& + .200P_{it} - 2.4791mLGS_{t-1} - .00356B_t - .056CBILL_{t-1} \\
& \quad (4.09) (2.90) (2.74) (2.4) \\
R^2 & = .828 \quad D.W. = 2.13 \quad S.E.R. = 1.241
\end{align*}
\]

Corr. a.c.f. lag 1 2 3 4 5 6 7 8

\[
\begin{align*}
't' & = -.69 -1.07 1.93 -2.79 -1.21 1.12 -1.22 -1.44 \\
\end{align*}
\]

* *'t' statistics in parentheses.
Interestingly enough, in this specification the significance of a number of regressors has improved and there appears little evidence of lagged adjustment. While this aspect of the results is more plausible the net sales of government bonds variable enters with the wrong sign and this is not reversed by re-estimation with a fourth order moving-average error correction mechanism.

The liquidity preference model of Pedersen-Backstein generates an alternative but basically similar specification. As noted earlier the nominal interest rate should be a function of, amongst other things, the level of real income, nominal money base adjusted for changes in reserve requirements, inflationary expectations and the price level. Although most studies have considered only current values of the monetary base there is no reason to believe the money stock adjusts instantaneously. Accordingly, equations were estimated which included current and lagged values of the money base both broadly and narrowly defined respectively as the augmented and cash base. The latter specification corrected for serially correlated errors, was superior as*

\[ \text{CBILL}_t = -56.37 + .9496 \text{ ln } P_t + .00982 + 1.41783 + .00016 \text{ t} + .2095 \text{ t}^2 \]

\[ (1.24) \quad (1.69) \quad (1.01) \quad (1.09) \quad (1.12) \quad (4.36) \]

\[ = 6.499 \text{ ln } P_t + 8.14 \text{ ln Base}_t - 14.994 \Delta \text{ ln Base}_t \]

\[ (1.14) \quad (1.25) \quad (2.05) \]

\[ - 30.62 \Delta \text{ ln Base}_{t-1} - 13.754 \Delta \text{ ln Base}_{t-2} + \varepsilon_t - 0.503 \varepsilon_{t-1} - 0.498 \varepsilon_{t-3} \]

\[ (3.61) \quad (2.00) \quad (2.65) \quad (2.46) \]

\[ R^2 = .873 \quad D.W. = 1.73 \quad S.E.E. = 1.11 \]

s.e.f. lag 1 2 3 4 5 6 7 8

\[ 't' \quad .60 \quad .82 \quad .14 \quad -1.45 \quad -.65 \quad -.38 \quad -1.28 \quad -1.51 \]

* 't' statistics in parentheses

The coefficients continue to indicate that the contribution of anticipated inflation to the bill rate is fairly small. A number of obvious inadequacies to the model led us to reject it in favour of subsequent specifications.
Alternative Specifications

One measure which has traditionally been regarded as an important indicator of liquidity in the Australian context is the ratio of excess LGS assets to deposits (see Davis and Lewis (1980), p. 93). A variable along these lines has been used in recent versions of the RBA model as a key determinant of the commercial bill rate. In that model excess LGS assets were standardized by the volume of loans and advances outstanding rather than by the volume of deposits. The basic equation using this measure of liquidity took the form

\[
CBL_{t} = -6.544 + 1.92051 - .05082 + .24853 + .0003GDP_{t} \\
(4.77) (4.56) (.61) (.62) (3.23)
\]

\[
- 3.1441\ln(XLS/L)_{t} + .151P_{t}^{S} \\
(11.57) (5.90)
\]

\[R^{2} = .919 \quad D.W. = 2.19 \quad S.E.E. = .817\]

s.c.f.  lag  1  2  3  4  5  6  7  8

\[
t' = -1.12 -1.29 1.01 -.65 -.82 .70 .08 .13
\]

Compared with previous specifications this equation 'performs' rather well. The degree of explanation is relatively high, and there is no evidence of serially correlated errors. The equation also appears to predict rather well and as is evident from Figure 1, this is true even in 1974(2). The model also easily passed the cusum and cusum of squares criteria of Brown, Durbin and Evans at the 5% level. The coefficient of the inflationary expectations variable is not markedly different from the estimates of earlier experiments, however. Additional regressors such as the lagged dependent variable and the net change in the volume of government debt outstanding were rejected since they failed to make a significant contribution to the model.

One difficulty with this specification arises from potential simultaneity associated with the liquidity measure. As noted earlier, variation in the interest rate can reasonably be expected to induce changes in bank deposits either through a reallocation of domestic portfolios
of their augmentation through non-sterilised capital flows. In order to 
determine the extent to which the coefficients of the model are subject to 
simultaneity problems we applied Sargon's (1958) Generalised Instrumental 
Variable Estimator using the lagged value of the liquidity ratio as an 
instrument for the current value as follows * 

\[
\text{CBILL}_t = 6.642 + 1.954 \text{SLL}_t + .133 \text{SLL}_t + .192 \text{SLL}_t + .0003 \text{GDP}_t \\
(4.72) (4.57) (.30) (.46) (3.15)
\]

\[- 3.282 \ln(\text{MGS}/\text{L})_t + .148 \text{SLL}_t \]

(8.65) (5.62)

\[
R^2 = .919 \quad D.W. = 2.18 \quad S.E.E. = .819
\]

a.c.f. lag 1 2 3 4 5 6 7 8

\[t' -1.10 -1.37 .86 -.52 -.67 .89 .33 .16\]

* 't' statistics in parentheses

These estimates suggest that simultaneity problems are quite minor. A similar 
experiment aimed at detecting the effect of potential simultaneity between 
income and the interest rate was conducted using a Trend variable as the major 
instrument for real GDP. Once again the difference between the coefficients 
resulting from this experiment and those of (9) was very small.

As indicated in Section 2, a traditional alternative to the use of a 
directly observable inflation expectations series has been to model 
expectations as a distributed lag of past inflation rates. The problem with 
such attempts has been the ad hoc nature of the authors' selection of the lag 
length and order of polynomial, most authors using an Almon lag procedure. 
Recently there has been considerable advance in the methodology of selecting 
appropriate characteristics of such structures. The approach used here is 
outlined in detail in Hendry and Pagan (1979) and constitutes a procedure for 
determining simultaneously both length of lag and order of polynomial. The 
major difficulty with the approach involves selection of a starting value 
for the length of lag. The procedure may be outlined in brief as follows. 
Once the initial lag length (\(j\)') is selected (hopefully being longer than 
the true lag length), the optimal polynomial order is determined for this 
lag by a series of F tests as in Godfrey and Peskitt (1975). The question
of whether the lag is too long can then be considered through a 't' test on \( w_j \). We already know \( w_j \) lies on the derived (and any higher order) polynomial. The only question is whether \( w_j \) is zero or not. If it is significantly different from zero, the procedure stops. If, on the other hand it is not, the lag structure is shortened one period and the correct order polynomial is again derived and the process repeated. Since the procedure constitutes a sequence of tests of hypothesis its power is a function of the number of steps in the process. It is important, therefore, not to overstate the initial choice of lag length by too much.

This methodology was followed in an attempt to derive the appropriate characteristics of a polynomial distributed lag on quarterly inflation. The starting lag length was eight quarters. The final Almon variable selected was a third order polynomial with a seven period lag. No attempt was made to impose any end point constraints. The estimated model was

\[
\begin{align*}
C(t) &= 4.561 + 1.55551 - 0.59132 - 0.72683 + 0.0006505 - 3.5071 \ln(\text{XGDP/L}) \\
&= (4.16) (3.50) (1.98) (1.55) (1.32) (15.85) \\
&= \sum_{j=0}^{7} w_j t^{k-j} + c_t - 0.577 c_{t-2} \\
&= (3.64)
\end{align*}
\]

\( w_0 = 0.092 \quad w_1 = 0.078 \quad w_2 = 0.036 \quad w_3 = -0.011 \quad w_4 = -0.035 \quad w_5 = -0.021 \quad w_6 = 0.081 \quad w_7 = 0.093 \)

\( \Sigma w = 0.283 \quad \text{Mean Lag} = 3.08 \) quarters

\( R^2 = 0.935 \quad D.W. = 2.16 \quad S.E.E. = 0.775 \)

a.c.f. lag 1 2 3 4 5 6 7 8

\( 't' = 0.84 \quad -0.22 \quad -1.37 \quad 0.15 \quad -0.81 \quad 1.22 \quad -0.31 \quad -1.13 \)

't' statistics in parentheses.

The major differences between this specification and the earlier one based on directly observable price expectations are the moving average error term and the reduced significance of the income variable. The shape of the distributed lag appears reasonable with last period's inflation exercising the major impact on inflationary expectations relevant to the next period. The reduced contribution of the current quarter's inflation is easily
explained by the fact that CPI figures are not available for some time after the end of the quarter. When account is taken of the difference in the mean values between the series \( \bar{p} \) and quarterly inflation (calculated at an annual rate) the estimated impact of 1% increase in anticipated inflation does not vary greatly between models. The elasticity of the former is .250, that of the latter .268.

**Model Selection**

A number of criteria might be selected to choose between models (9) and (11)

The predictions of equation (11) are presented in Figure 2. The pattern does not differ much from that in Figure 1. But merely comparing the predictive behaviour of the specifications does not take account of the increased number of parameters in the distributed lag model. Some prediction criteria do penalize models with larger numbers of regressors. A number of these, viz. the Theil, Amemiya, Akaike and Deaton criteria presented in Table 1 below allow a more appropriate comparison of the two specifications.

**TABLE 1**

**MODEL SELECTION CRITERIA**

Applied to Equations (9) and (11) respectively

<table>
<thead>
<tr>
<th>Model</th>
<th>Theil</th>
<th>Amemiya</th>
<th>Akaike</th>
<th>Deaton</th>
<th>Cox</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( R^2 = \frac{T}{1-R^2(1-R^2)} )</td>
<td>( R^2 = \frac{T}{1-R^2(1-R^2)} )</td>
<td>( R^2 )</td>
<td>( R^2 )</td>
<td>( R^2 )</td>
</tr>
<tr>
<td>Eqn.9</td>
<td>.9049</td>
<td>.8904</td>
<td>.8907</td>
<td>.8878</td>
<td>-4.903</td>
</tr>
<tr>
<td>Eqn.11</td>
<td>.9143</td>
<td>.8938</td>
<td>.8948</td>
<td>.8874</td>
<td>-2.839</td>
</tr>
</tbody>
</table>

Three of these criteria favour the Almon lag model rather than the model using directly observable data but it appears there is relatively little difference between them.

An alternative method of selecting between models is provided by the Cox Test (1962). This test evaluates a model in the presence of a competing specification under alternative assumptions as to which of the two
In the true model, and is based on the philosophy that a good model ought not only to fit the data well but be able to predict the consequences of a poor one. It is possible that a model while not explaining the data well enough to be accepted itself still contains enough information to allow for the rejection of the alternative. Empirical application of the Cox Test as developed by Pesaran (1974) considers the quantities

\[ \phi_0 = \frac{N}{2} \log \frac{\hat{\sigma}_1^2}{\sigma_1^2} \]

where \( \hat{\sigma}_1^2 \) is the value of the residual variance of model \( H_1 \) predicted by model \( H_0 \). The argument is that if \( H_0 \) is the true model, \( \phi_0 \approx 0 \). The corollary to this holds as well so that we also calculate under the hypothesis that \( H_1 \) is the true model

\[ \phi_1 = \frac{N}{2} \log \frac{\hat{\sigma}_0^2}{\sigma_0^2} \]

The two quantities \( \phi_0 \) and \( \phi_1 \) are compared with their standard errors. We might reject \( H_0 \) or \( H_1 \) according to whether \( \phi_0 \) and \( \phi_1 \) are, or are not, significantly different from zero. Unlike the previous criteria, the Cox Test allows for rejection or acceptance of both models. The final column in Table 1 indicates that both of our models in fact should be rejected. If we can make such a qualitative statement it would appear that the distributed lag specification is relatively favoured. Nevertheless this result constitutes something of a blow to our hopes at this point, and may suggest that our models should be treated with some reservation.

Errors-in-Measurement Model

With this result in mind we consider another specification problem which may generate some insight into at least one of the two models. It is quite conceivable that the observed price expectations series contains an error in measurement. Indeed, some scepticism does prevail about the accuracy and reliability of forecasts derived from the survey we use. A model which
allows us to test a simple version of this hypothesis has been developed by Lahiri (1976) who postulates the structural model

$$\hat{p}_t^o = \hat{p}_t + u_{1t}$$ (12)

$$r_{t} = a + \hat{R}_t^e + u_{2t}$$ (11)

$$\hat{y}_t = \frac{y_t}{1 + \hat{\lambda}_t} + u_{3t}$$ (14)

where

- $\hat{p}_t^o$ is observed (survey) inflationary expectations,
- $\hat{y}_t$ is actual inflationary expectations, and $u_1$, $u_2$ and $u_3$ are random error terms.

Rearrangement of this set of equations generates the model

$$\hat{p}_t^o = \frac{y_t}{1 + \hat{\lambda}_t} + u_{1t} + u_{3t}$$ (15)

$$r_{t} = a + \hat{R}_t^e + u_{2t} - \hat{\nu}_{2t}$$ (16)

It is clear that under these assumptions estimation of (16) may require an instrumental variable estimator to generate consistent estimates.

A number of hypotheses have been advanced as to the manner in which inflationary expectations are formed (Turnovsky (1970)). Some of the best known are (a) the weighted expectations hypothesis in which $\hat{p}_t^e = \sum_{i=0}^{N} \omega_i \hat{p}_{t-i}$

(b) the adaptive expectations hypothesis in which $\hat{p}_t^e = \lambda \hat{p}_{t} + (1-\lambda) \hat{p}_{t-1}$

and

(c) the extrapolative expectations hypothesis where $\hat{p}_t^e = \hat{\theta}_t \hat{p}_{t-1} - \hat{\eta}_{t-1}$.

In more relaxed forms (b) and (c) can be written as $\hat{p}_t^e = \beta_0 + \beta_1 \hat{p}_t + \beta_2 \hat{p}_{t-1}$ and $\hat{p}_t^e = \beta_0 + \beta_1 \hat{p}_t + \beta_2 \hat{p}_{t-1}$ respectively. These models were estimated for our observed inflationary expectations series explaining approximately 80% of it, and generating long run elasticities with respect to $\hat{p}_t$ of .849, .881, and .759 respectively. The instrumental variable models for (16) augmented as in (9), were estimated for the weighted expectations, adaptive expectations and extrapolative expectations hypotheses respectively. The estimates are presented below for the first of these.
\[ \text{CHILL}_t = -5.885 + 1.76281 - .16452 + .19783 + .0003\text{GDP}_t \\
\quad - (4.07) \quad (4.04) \quad (.34) \quad (.48) \quad (.23) \]
\[ - 3.096\ln(\text{XLGS/L})_t + .171^2 \\
\quad (11.17) \\
R^2 = .918 \quad \text{D.W.} = 2.28 \quad \text{S.E.E.} = .823 \]

a.c.f. lag 1.2.3.4.5.6.7.8

'\(t\)' -1.40 -1.47 1.05 -.79 -.88 .65 -.05 .15

* '\(t\)' statistics in parentheses.

The equations for adaptive and extrapolative expectations are omitted for space reasons. The estimated coefficients on the anticipated inflation variable in these two models are .210 and .172 respectively. The fact that these estimates differ only marginally from that given in (9) implies that errors in measurement do not constitute a major problem. A rigorous test of this hypothesis has been proposed by Haussmann (1976) and this test involves estimating the following model:

\[ \text{CHILL}_t = \alpha + \alpha_1\text{SL}_t + \alpha_2\text{S2}_t + \alpha_3\text{S3}_t + \alpha_4\text{CDP}_t + \alpha_5\ln(\text{XLGS/L})_t \\
\quad + \alpha_6\text{P}_{\text{L}} + \alpha_7\text{P}_{\text{E}} + \varepsilon_t \\
\text{\(\hat{\varepsilon}_t\)} = w(w'w)^{-1}w'\varepsilon_t \]

where \(w\) is a matrix of instruments as outlined above. A test of whether \(\alpha_6\) is significantly different from zero constitutes a test of errors in variable \(\varepsilon_t\). Using the instruments appropriate to the various hypotheses about expectations formation in addition to other exogenous variables in (17) the estimated '\(t\)' statistics for \(\alpha_6\) were 1.16, 2.42, and .96. These results are somewhat inconclusive. An additional experiment conducted using a model which was derived by combining the adaptive and extrapolative hypotheses as in Tuckwell (1976) provided a '\(t\)' statistic of 1.53. All in all, these results seem to suggest that errors in measurement do not impose major difficulties.

'Nationally' Determined Expectations

A number of additional models were estimated on the grounds that expectations might be formed on the basis of a wider set of information than lagged values of inflation rates. In the experiments we considered lagged
values of rates of growth of money stock and nominal wages as well as a capacity utilization variable as additional instruments for observed inflationary expectations. The most sensible result (in terms of the first stage estimation) involved a set of instruments for observed price expectations which comprised four lagged values of the rate of inflation, rate of growth of M3 and rate of growth of nominal wages. The coefficient from the IV estimation of observed price expectations was .165 which was not noticeably different from earlier estimates. We do not report this equation for space reasons but note that it was quite satisfactory in terms of the usual criteria.

4. CONCLUSION

Most of the experiments conducted to this point suggest that the two models (9) and (11) predict the commercial bill rate reasonably well, though we have noted at various points the need for some reservations. Probably the most striking aspect of the results, however, is the small extent to which inflationary expectations appear to be incorporated in the nominal rate. As it stands, in equation (9) only 7.8% of the variation in the bill rate is due to inflationary expectations. A number of possible explanations come to hand. First, it is conceivable that the correlation between the variable depicted as reflecting inflationary expectations and one or more of the other regressors in the model is sufficiently high to confuse the issue. Examination of the correlation coefficients between these variables, however, does not support this view with the highest coefficient between the survey based inflationary expectations series and any other regressor being .54. An alternative hypothesis is that variables correlated with these have been omitted from
the models. We have, however, considered a wide range of models, and the
impact of inflationary expectations on the bill rate does appear to be
fairly consistent. The most obvious regressor not so far considered is
the overseas interest rate. But experiments with the 90 day Eurodollar deposit
rate and the short and long term exchange rate expectations series of the REA
model do not indicate that these variables contribute significantly (at the
10% level) to the model.

A third hypothesis is that inflationary expectations may be incorporated
only partially in the bill rate because of the manner in which other
domestic rates are controlled. Indeed, if those intermediaries which hold
bills are constrained only by the need to earn a satisfactory interest
differential above the regulated rate paid on their liabilities, there
may be little incentive in the market to adjust fully, provided that the
public maintains these liabilities at a high enough level. And there is
some evidence that the Australian public does not take inflationary
expectations fully into account in the allocation of its wealth.

Williams (1979, pp.149-50) points out that

The percentage regarding it as more important to save has
remained fairly constant at around 60% even though consumers' expectations of inflation have been high ... The percentage
of respondents preferring banks to other forms of investment
was highest in 1974-75 despite the historically high levels
of inflation and inflationary expectations of this period.

Finally, it is possible that despite the indications of a number of our
experiments, neither of the measures of anticipated inflation used in this paper
is really adequate. Unfortunately there is not a lot we can do about this.
To sum up, it appears that liquidity conditions have been the major determinant
of short term interest rates in Australia over the last 10 years, and that
inflationary expectations have been reflected to a significant but relatively
small degree. Whether this continues to be the case in the freer capital market
envisioned by some submissions to the Campbell Inquiry remains to be seen.
DATA APPENDIX

CBILL = End Quarter Bank endorsed 90 day commercial bill rate

\( \delta' = \delta' \) = quarterly quantitative series of inflationary expectations supplied by the Reserve Bank of Australia, expressed at an annual rate.

GDP = Gross Domestic Product at 1974-75 prices, obtained from various issues of ABS publication, Quarterly Estimates of National Income and Expenditure

ML = end of quarter sum of notes and coin in the hands of the public plus current deposits of all cheque paying banks

M3 = end of quarter M2 plus fixed deposits, certificates of deposit and savings deposits

CBASE = end of quarter sum of currency, farm loan funds, term loan funds, SMD's, other deposits of trading banks at the Reserve Bank, trading bank notes and coin, savings bank notes and coin, savings bank deposits at the Reserve Bank and Saving Bank Treasury Bills and notes, and accumulated liberated reserves.

AUGBASE = end of quarter sum of CBASE plus Trading Bank holdings of government securities

Inflation = \( \frac{\text{CPI}_t - \text{CPI}_{t-1}}{\text{CPI}_{t-1}} \times 400 \)

XGB = real end quarter net sales of government bonds

XLGS/I = end of quarter excess LGS assets of trading banks divided by the volume of loans, advances and bills discounted.
FOOTNOTES

1. Most liquidity preference models have estimated reduced forms in which the interest rate is expressed as a function of the real money base, real income and inflationary expectations. This specification imposes, rather than tests homogeneity restrictions.

2. Yohe and Karnosky and Feldstein-Eckstein also estimated partial adjustment models.

3. The survey is conducted every three months. Respondents are asked whether excluding normal seasonal changes they think average selling prices will go up, down or stay the same over the next three months. The survey is based on a sample of firms weighted to reflect the overall structure of the manufacturing industry in Australia.

4. The autocorrelation functions for models in the paper are of two types. For standard equations they present 't' statistics calculated as the ratios of the autocorrelation coefficients to the asymptotic standard error of N/2 where N is the sample size. The (corrected) a.e.f.'s in models including lagged dependent variables as regressors account for the effect of this variable by Durbin's (1970) second method.

5. It is possible that a build up of inventories relative to sales would also increase the demand for funds. This hypothesis was investigated by including the Detrended Stocks to Sales Ratio of the Treasury Model as an additional regressor. The contribution made by the variable, however, was insignificant.

6. Williams and Defris (1979) found a small positive effect of anticipated inflation on household savings over the period 1973-78. Any such behaviour would naturally mitigate the influence of factors outlined in the loanable funds model and may serve in part to explain the low coefficient.

7. This result does imply that the bill rate will continue to increase as income rises. It is probable that as pointed out to me by Neil Johnston, the income variable is picking up the trend in interest rates over the last decade.
BIBLIOGRAPHY


Fig. 1: Within Sample Predictive Performance of Eqn 9.

Fig. 2: Within Sample Predictive Performance of Eqn 11.