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A null Hypothesis of the Unrmployment Rate vis-?-vis the Inflation Rate in Israel; An Empirical Examination, 1990-98

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1. Introduction

Ever since the seminal paper by Friedman (1968) and Phelps (1967), the natural rate hypothesis has occupied a pivotal position in macroeconomics. This hypothesis states that only unexpected changes in the rate of inflation affect real variables such as unemployment and real output. In its rational expectations version, developed by Lucas (1972,1973), the hypothesis implies that policy makers should ignore any temporary tradeoffs and strive only for low inflation. Other economists, such as Ball (1997) and Romer and Romer (1994) argue that for a variety of reasons (the nature of labor markets, menu costs, hysteresis, etc.) tight monetary policies, aimed at reducing inflation, can also have a lasting effect on employment and output.

There have been numerous empirical tests of the natural rate hypothesis[1], although a problem common to virtually all of them is the lack of a reliable measure of inflationary expectations. As a result of this problem, one is always faced with the difficulty of disentangling the results of a joint hypothesis – that expected inflation does not have any real effects and that inflationary expectations are formed in one way or another.

The purpose of this paper is to test the naturality hypothesis by using market extracted inflationary expectations from Israeli data. As is argued below, these expectations enable one to conduct a better test of the natural rate hypothesis than the usual alternatives. These expectations are derived from the yields of nominal and CPI linked bonds of identical maturities. Such bonds are traded regularly on the Tel-Aviv stock exchange. The paper is organized as follows: in section 2 we discuss the advantages of using the market extracted inflationary expectations. Section 3 describes the data. Section 4 describes the econometric approach and presents the empirical results. Section 5 provides a brief conclusion.

2. *The advantages of using market extracted inflationary expectations*

A major difficulty in many of the tests of the natural rate hypothesis is the lack of reliable measures of inflationary expectations. Two ways of dealing with this problem have been offered and neither of them is satisfactory[2]. The usual approach is simply to assume that expectations are formed in a particular way. One way is to assume that expectations are adaptive but this is rather arbitrary and has several theoretical shortcomings[3]. Another way is to assume that expectations are rational or model consistent. The problem in this case is that the researcher and the public have to know the

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[1]See King and Watson (1997) for a recent and comprehensive survey.

[2]See Mishkin (1983) and Pesaran (1987).

"true" model including the parameters of the reaction functions of the central bank and the government. These are obviously very strong assumptions. In both cases it is impossible to separate the validity of the natural rate hypothesis from the validity of the assumed formation of inflationary expectations.

An alternative approach is to use survey measures, but here too there are problems. First, it is necessary to assume that those surveyed are indeed true representatives of the relevant economic agents. Second, it has to be assumed that their responses are the basis for their economic decisions. These again are strong assumptions[4].

In the present paper we use market extracted inflationary expectations derived from the difference between nominal and CPI linked bonds with identical maturities. The obvious advantage of the data is that they reflect directly the behavior of market participants and can be thought of as a daily survey backed by "dollar votes". Thus, they enable one to set up a clear test of the natural rate hypothesis. All we need to assume is that the two bonds are perfect substitutes up to a factor that is connected with the distribution of future inflation. This seems to us a weak assumption in comparison to the existing alternatives.

3. ***The Data***

The novelty of this paper is the use of market derived inflationary expectations. We employ quarterly data so that the bond market data reflect the inflation rate which was expected, at the end of the last quarter, to prevail during the present quarter[5]. Because our measure of inflation expectations is derived from nominal and CPI linked bonds, it also includes an unobservable inflation risk premium and thus unexpected inflation also includes this risk premium. If that risk premium is not constant, this might make it more difficult to identify the relationship between unemployment and unexpected inflation. For the moment assume that this risk premium is constant. In appendix C we will show that, in the context of our data, relaxing this assumption has no empirical bearing on testing the natural rate hypothesis.

Diagram A1 in appendix A displays a plot of inflation, expected inflation and unexpected inflation for the period reviewed: 1988:II 1998:III. Table A1 in Appendix A presents the correlogram of unexpected inflation (up to 12 lags) and the Q statistic, which tests the internal outocorrelation of this variable. As can be observed, the unexpected inflation in each quarter is not correlated with previous values of itself.

[3]See Pesaran (1987).

[4]See Pesaran (1987) for a discussion of these difficulties.

According to the hypotheses advanced by Friedman and Phelps, and later by Lucas, there should be a negative relationship between unexpected inflation and the deviation of unemployment from its natural rate (or deviation of output from its potential). The difference between the natural and actual rates of unemployment is measured here by using the Hodrik-Presscott technique. In applying this technique there is a pre-chosen parameter (λ) which determines how close the actual rate of unemployment is relative to its derived trend. We chose this parameter in the following way: we lowered it gradually and stopped as soon as the derived unemployment gap became stationary.

To calculate potential output we used two alternatives: the Hodrik-Prescott method and the regression of actual output over time. In both cases we obtained similar results and so we will show only the results obtained by using a time trend for potential output. (All the data used are provided in appendix D).

4. The Econometric Approach

The model used by Lucas (1973) and Sargent (1979) is:

$$(1)\ U_t = \beta * (dp - edp)_t + \gamma * U_{t-1} + e_t$$

Where: U_t is the gap between the actual and natural rates of unemployment (the unemployment gap), dp_t and edp_t stand respectively for the rate of inflation during period t and the expected rate of inflation for period t formed at the end of period t-1. The term e_t is the residual.

This equation can be written also as:

$$(2) U_t = \beta * \sum_{i=0}^{\infty} \gamma^i * (dp - edp)_{t-i} + n_t$$

Where n_t is a random error.

According to equation (2) U_t is the weighted sum of all the lags of unexpected inflation, where the weights take a very special form (Koych distributive lags). This lag structure is convenient for estimation purposes because it requires that only two parameters be estimated (equation (1)). It suffers from two main problems however: a). There is no a priori reason for assuming the Koych lag; it is possible to have different distributive lag structures. b) Even if we agree that the Koych lag

[5]A detailed explanation of how these expectations are derived appears in Yariv (1990).

is the appropriate structure in equation (2), there remain two econometric problems in estimating equation (1). First, U_t and unexpected inflation are determined simultaneously, which means that OLS estimators are inconsistent. A way out of it could be to use the instrumental variable method. However, finding instrumental variable for unexpected inflation might be next to impossible as it should be correlated with unexpected inflation but not with the error term. Clearly, if inflation expectations are rational, the past values of any variable are of no help since any information about the future embodied in it is already reflected in expectations and thus is not correlated with unexpected inflation. Second, even if the error term of (2) is serially uncorrelated, those of (1) will normally be serially correlated and thus also correlated also with U_{t-1}. This means that in order to obtain consistent estimators of (1) we also need to find an instrument also for U_{t-1}.[6]

For these reasons we use the following approach: First, we regress U_t on lags of unexpected inflation without restricting the lag structure. Second, based on the regression results, we place some restriction on the lag structure and test several hypotheses.

Our starting point is the following equation[7]

$$(3)\ U_t = \alpha + \beta_0 * z_t + \beta_1 * z_{t-1} + \beta_2 * z_{t-2} + \ldots\ldots\ldots\ldots + \beta_k * z_{t-k} + e_t$$

where z_t stands for unexpected inflation. In order to avoid simultaneity problems z_t is omitted from the regression[8]. The results in Table 1 show that 12 lags of z were found to be relevant and with the expected signs. All the coefficients of the various lags of z are negative and eight of them have a t value greater than 2.

Because the DW statistic falls within the inconclusive range we used other tests. The Langrange multiplier test of Brush-Godfrey, for a first order serial correlation, gets a value of 1.94 (a Pvalue of 0.164). Also, when testing the corellogram, with up to 8 lags, the results show that the Q statistic of the first lag gets the lowest Pvalue (0.167). We can therefore conclude that we cannot reject the hypothesis of no serial correlation in the errors, at any reasonable level of significance. Observing the coefficients of the regression, it is clear that the lag structure of the z is not of the Koych type but resembles a bell shape. However, we cannot reject the hypothesis that the coefficients of the various lags are equal[9].

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[6] Since unexpected inflation is not correlated with U_{t-1}, its omission from equation (1) should not bias the estimate of the coefficient of U_{t-1}, but doing so will prevent us from testing the hypothesis to begin with.

[7] This equation is identical to that used by Mishkin (1983).

[8] Since the z's are serially uncorrelated this omission does not have any effect on the estimates of the other lags of z.

[9] The F statistics for testing the hypothesis, which is distributed as F(11,17), gets the value of 0.6.

Table 1 – Estimates of Equation (3) Using 12 lags of Unexpected Iinflation

Dependent Variable: U				
Method: Least Squares				
Sample (adjusted): 1991:2 1998:3				
Included observations: 30 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.155	0.069	2.3	0.037
Z(-1)	-0.023	0.012	-1.9	0.073
Z(-2)	-0.012	0.011	-1.0	0.309
Z(-3)	-0.011	0.011	-0.9	0.359
Z(-4)	-0.040	0.010	-3.8	0.001
Z(-5)	-0.024	0.010	-2.4	0.030
Z(-6)	-0.026	0.012	-2.3	0.037
Z(-7)	-0.036	0.012	-3.1	0.006
Z(-8)	-0.013	0.010	-1.4	0.181
Z(-9)	-0.034	0.010	-3.5	0.003
Z(-10)	-0.027	0.010	-2.6	0.017
Z(-11)	-0.023	0.011	-2.2	0.044
Z(-12)	-0.024	0.011	-2.2	0.040
R-squared	0.723	Mean dependent var		0.056
Adjusted R-squared	0.528	S.D. dependent var		0.530
S.E. of regression	0.364			
Sum squared resid	2.253			
Log likelihood	-3.736	F-statistic		3.705
Durbin-Watson stat	1.388	Prob(F-statistic)		0.007

When we impose such restriction we obtain the following results: .

$$(3.1)\ U = 0.146\ \ - 0.268 * z(1,12)$$
$$(2.2)\ \ (-6.2)$$
$$R^2=0.580\quad DW=1.605\quad s=0.350\quad T=30\ (1991.2\text{-}1998.3)$$

Where z(1,12) is the moving average of z from the first lag to the twelfth.

As can be clearly seen, the moving average of unexpected inflation has a negative significant effect on the deviation of unemployment from its natural rate. Thus, if in a given quarter, actual inflation is higher than expected inflation, unemployment will be below its natural rate for several quarters. Imposing the restriction of equal coefficients on the lags raises also the DW statistic to 1.65, above its critical upper value (du = 1.49).

In estimating equation (3) it was assumed that there is no long-run trade-off between expected inflation and the unemployment gap. We shall now test whether in fact this is so by estimating the following regression:[10]

$$(4)U_t = \alpha + \sum_{i=0}^{k} \beta_i * (dp - edp)_{t-i} + \sum_{i=0}^{k} \delta_i * edp_{t-i} + e_t$$

A long-run trade-off between expected inflation and unemployment means that at least one of the coefficients of expected inflation is different from zero. In order to test this we estimated equation (4) with 12 lags of z and 12 lags of edp. The results are presented in Table B1 in Appendix B. An F test clearly shows that the contribution of the lags of expected inflation to the deviations of unemployment from its natural rate is insignificant. Similar results are obtained when we use the same moving average for expected and unexpected inflation respectively. These results are presented in the following equation:

$$(4.1)\ U = -0.189 \ - 0.225 * z(1,12) + 0.025 * edp(1,12)$$

$$(-0.7) \quad (-4.0) \qquad\qquad (1.2)$$

R^2=0.602 DW=1.6205 s=0.347 T=30 (1991.2-1998.3)

If one believed in a long-run trade-off, one would expect to find that expected inflation has a significant negative effect on the unemployment gap, similar in magnitude to that of unexpected inflation. The results indicate that the effect of expected inflation is not significantly different from zero, however.

Another way of showing the kind of relationship between expected (and unexpected) inflation and the unemployment gap is in the following scatter diagrams. Diagram 1 shows no relation between edp(1,12) and U, while in diagram 2 a clear negative relationship between z(1,12) and U is evident.

Diagram 1

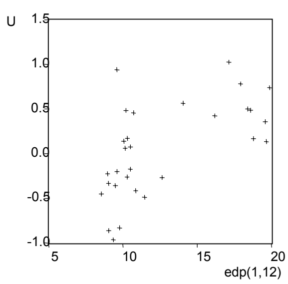
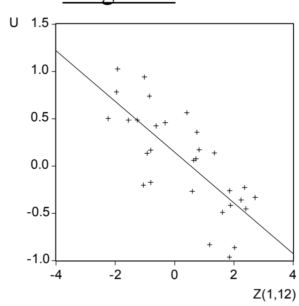


Diagram 2



[10]This formulation follows Sargent (1973) and Mishkin (1983) .

In the above regressions and diagrams we used a moving average based on 12 quarters of the z's. One obvious question is why do we observe such long lags? Obviously, factors such as the cost adjustment of hiring and firing labor and staggered wage contracts (such as in Fisher (1977)) are important; but whether they can explain such long lags, which also appear in other empirical studies on this topic, remains an open question.

In order to increase our confidence in our results we also ran an equation similar to (4.1), with the output gap as the dependent variable[11]. The results, which are reported in (4.2) below, suggest that only unexpected inflation affects the output gap and in the expected direction, while expected inflation has no significant effect. In this case, however, the lags of unexpected inflation are shorter than in the unemployment test.

$$(4.2)\ \ ygap = \underset{(-0.9)}{-1.542} + \underset{(-4.2)}{0.799} * z(1,5) + \underset{(1.1)}{0.159} * edp(1,5)$$

R^2=0.394   DW=1.549   s=2.693   T=30 (1991.2-1998.3)

5. Conclusion

In this study inflationary expectations extracted from nominal and CPI. linked bonds in Israel were used to test the neutrality hypothesis. The existence of such data enabled us to avoid many problems associated with joint hypothesis testing, and hence come up with sharper conclusions. The evidence strongly supports the neutrality hypothesis. The result clearly shows that only unexpected inflation affects employment and output and in the expected direction. Unexpected inflation has a longer effect on unemployment than on real output.

[11]The output gap was calculated as the gap (in percentage points) between actual and potential GDP. Potential GDP was derived from a regression of the log of actual GDP on time.

Appendix A

Diagram A1 – Inflation (dp), Expected inflation (edp) and Unexpected Inflation (z), 1988.2-1998.3.

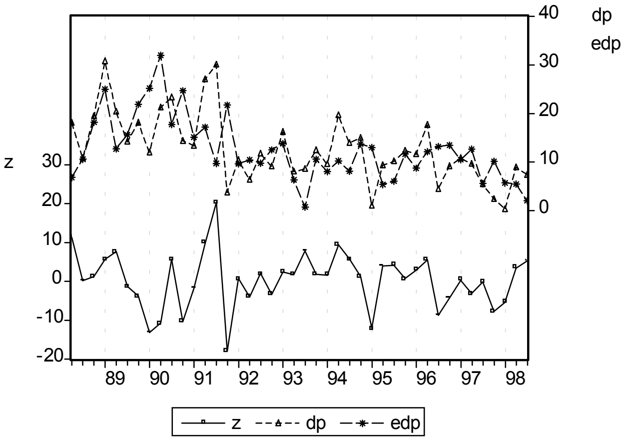


Table A1 – The Correlogram of Unexpected Inflation (z), 1988.2-1998.3.

Sample: 1988:2 1998:3			
Included observations: 42			
	AC	Q-Stat	Prob
1	0.015	0.0107	0.918
2	-0.104	0.5084	0.776
3	-0.075	0.7723	0.856
4	0.138	1.7048	0.790
5	-0.268	5.2827	0.382
6	-0.081	5.6154	0.468
7	-0.092	6.0640	0.532
8	0.047	6.1821	0.627
9	0.159	7.6003	0.575
10	-0.153	8.9535	0.537
11	0.040	9.0497	0.617
12	0.093	9.5814	0.653

Appendix B

Table B1 – The Effect of Expected and Unexpected Inflation on the Unemployment Gap

(estimates of equation (4))

Dependent Variable: U				
Method: Least Squares				
Sample(adjusted): 1991:2 1998:3				
Included observations: 30 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.211	0.568	-0.4	0.725
z(-1)	-0.032	0.029	-1.1	0.323
z(-2)	-0.008	0.040	-0.2	0.853
z(-3)	-0.038	0.028	-1.4	0.228

z(-4)	-0.061	0.031	-2.0	0.102
z(-5)	-0.020	0.027	-0.8	0.482
z(-6)	-0.034	0.031	-1.1	0.320
z(-7)	-0.011	0.037	-0.3	0.783
z(-8)	-0.007	0.020	-0.4	0.728
z(-9)	-0.034	0.023	-1.5	0.195
z(-10)	-0.004	0.025	-0.1	0.888
z(-11)	-0.008	0.022	-0.4	0.732
z(-12)	-0.016	0.021	-0.8	0.483
edp(-1)	0.007	0.064	0.1	0.912
edp(-2)	0.053	0.055	1.0	0.376
edp(-3)	-0.014	0.053	-0.3	0.806
edp(-4)	-0.038	0.045	-0.8	0.445
edp(-5)	-0.017	0.043	-0.4	0.711
edp(-6)	-0.036	0.045	-0.8	0.463
edp(-7)	0.034	0.039	0.9	0.418
edp(-8)	0.036	0.033	1.1	0.332
edp(-9)	-0.005	0.028	-0.2	0.869
edp(-10)	0.010	0.033	0.3	0.781
edp(-11)	0.016	0.031	0.5	0.626
edp(-12)	-0.016	0.036	-0.4	0.674
R-squared	0.875	Mean dependent var		0.056
Adjusted R-squared	0.276	S.D. dependent var		0.530
S.E. of regression	0.451			
Sum squared resid	1.017			
Log likelihood	8.200	F-statistic		1.461
Durbin-Watson stat	2.111	Prob(F-statistic)		0.360

Appendix C – The Effect of the Possible Existence of a Risk Premium

As stated in the text, both expected and unexpected inflation include, with opposite signs, an inflation risk premium. In this appendix we explain why the existence of this risk premium does not affect the main results presented in the text in any substantial way.

First, the fact that the estimates of unexpected inflation (z) are not autocorrelated indicates that there is no significant serial correlation in the risk premium either. Second, the risk premium may have a large variance. This does not have any effect on estimating equation (4), where the null hypothesis is that both expected and unexpected inflation have identical coefficients. This is so because we simply add and subtract the same variable from the expected and unexpected inflation.

If, on the other hand, we are interested in the size of the coefficient of unexpected inflation in an equation such as (3), then we are confronts an error of measurement problem in the explanatory variable in the regression. This would mean that the effect of the unexpected inflation on the gap is underestimated however. (Since no serial correlation were found in the lags of z, the above also holds for the various coefficients of the lags of z). All this does not have any substantial influence on our conclusion that only unexpected inflation has an effect on employment and output.

Appendix D

Table D1 – The data

obs	dp	edp	UN	UNP	rgdp	ygapt
	inflation	expected inflation	un-employment rate	"netural" un-employment rate	Real g.d.p	g.d.p gap (pecentage point)
1986:1	NA	NA	7.60	6.11	24503.18	NA
1986:2	29.62	NA	7.60	6.26	24723.05	NA
1986:3	12.72	NA	6.30	6.41	25662.24	NA
1986:4	30.50	NA	6.90	6.57	25941.72	NA
1987:1	19.14	NA	6.10	6.72	26025.64	0.50
1987:2	16.42	NA	5.90	6.89	27403.21	4.31
1987:3	10.08	NA	6.30	7.06	28307.93	6.21
1987:4	19.10	NA	5.90	7.24	27466.67	1.59
1988:1	17.64	NA	5.90	7.44	28598.50	4.26
1988:2	18.03	6.80	5.80	7.64	27387.08	-1.58
1988:3	10.77	10.60	6.90	7.84	28605.66	1.33
1988:4	19.46	18.20	7.10	8.05	28463.19	-0.61
1989:1	30.71	25.00	8.20	8.27	27912.90	-3.92
1989:2	20.37	12.70	8.90	8.48	28480.08	-3.37
1989:3	14.22	15.60	9.30	8.68	29265.74	-2.12
1989:4	18.08	21.90	9.10	8.88	28807.18	-5.03
1990:1	11.98	25.20	9.30	9.07	29684.57	-3.53
1990:2	21.22	32.00	9.90	9.23	30003.84	-3.89
1990:3	23.31	17.70	9.40	9.38	31190.09	-1.51
1990:4	14.32	24.70	9.60	9.51	32666.29	1.68
1991:1	13.32	15.10	9.90	9.62	30330.22	-6.94
1991:2	27.00	17.20	10.60	9.70	31885.60	-3.56
1991:3	30.02	9.70	10.70	9.76	33792.73	0.75
1991:4	3.74	21.70	11.00	9.78	35799.57	5.21
1992:1	10.38	9.60	11.40	9.78	34951.59	1.25
1992:2	6.33	10.42	11.10	9.74	36363.81	3.84
1992:3	11.75	9.76	11.00	9.68	35641.41	0.32
1992:4	9.10	12.50	11.10	9.59	35764.43	-0.77
1993:1	16.19	13.82	11.10	9.47	35309.33	-3.43
1993:2	8.02	6.33	10.20	9.33	34638.98	-6.62

1993:3	8.56	0.75	10.00	9.17	38639.26	2.68
1993:4	12.41	10.58	8.80	9.00	39118.40	2.47
1994:1	9.56	8.02	8.20	8.82	38951.17	0.58
1994:2	19.61	10.22	7.90	8.64	38357.05	-2.37
1994:3	13.90	8.12	7.70	8.46	40025.82	0.42
1994:4	14.96	13.70	7.70	8.29	42234.23	4.45
1995:1	1.01	13.00	7.00	8.13	40921.67	-0.24
1995:2	9.31	5.38	6.30	7.99	42882.44	3.05
1995:3	10.14	6.05	6.00	7.86	45620.43	8.07
1995:4	12.30	11.64	6.00	7.76	44003.26	2.75
1996:1	11.60	8.75	6.60	7.67	44521.78	2.48
1996:2	17.60	12.10	6.40	7.61	45521.96	3.28
1996:3	4.40	13.16	6.60	7.56	46432.06	3.85
1996:4	9.16	13.46	7.20	7.53	46324.08	2.13
1997:1	10.75	10.48	7.40	7.52	44983.15	-2.25
1997:2	9.59	12.67	7.50	7.51	46424.84	-0.55
1997:3	5.43	5.58	8.10	7.52	48235.41	1.85
1997:4	2.39	10.15	7.70	7.53	46700.37	-2.80
1998:1	0.26	5.70	8.60	7.55	46927.00	-3.72
1998:2	8.90	5.47	9.30	7.57	47779.00	-3.37
1998:3	7.35	2.07	8.40	7.59	47969.00	-4.37

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