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Survey data (collected before the publication of official statistics) on agents' perceptions of the recent inflation rate are used to test the hypotheses that those perceptions are unbiased, and free of serially correlated errors. The second of these hypotheses if rejected, and given the nature of the data, this departure from "rationality" cannot be attributed to the effects of "Peso problems".

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I. The Problem

The rational expectations hypothesis, as usually set out, states that when they form expectations about an economic variable, agents make use of all available information, in such a way that the expectation in question is an unbiased estimate of the variable's realized value. Applied to the price level, or equivalently the inflation rate, this hypothesis is of central importance to contemporary macroeconomics.[1] It is a key component of both New–classical models in the style of Robert E. Lucas (1973), and more "Keynesian" overlapping contracts models, such as those of Stanley Fischer (1977), Edmund Phelps and John Taylor (1977), and Taylor (1979). The hypothesis is nevertheless very hard to test. It must usually be combined with other postulates, for example that of clearing competitive markets, in order to yield empirical predictions; and if these predictions turn out to be wrong, rational expectations can always be rescued by attributing such errors to the influence of those other postulates.

The availability of survey evidence on agents' expectations does, in principle, permit us to conduct direct tests of rational expectations which are free of this particular problem, but such tests create difficulties of their own. Even setting aside the matter of relying on the truthfulness of the answers which respondents give to questionnaires, it is hard to make unambiguous inferences about the rationality of *ex ante* expectations about variables by comparing them with *ex post* outcomes. Even evidence of serial correlation in expectational errors, at one time thought to be inconsistent with rational expectations, does not definitely refute the hypothesis, as consideration of the by now widely understood "Peso problem" makes clear.[2]

Suppose we had been forming expectations about the future value of the Mexican Peso against the United States Dollar over a period when there was a positive probability of the Peso being devalued. *Ex ante* rational expectations of its value would have taken account of this probability. Suppose, however, that devaluation did not occur. *Ex post*, our expectations would appear to be subject to systematic error for as long as the positive *ex ante* probability of devaluation persisted without the event actually taking place. The error in question, though, would not reflect the neglect of any available information in the generation of expectations. The "Peso problem" is not a mere curiosity. It is a particular case of a rather general phenomenon. Whenever there exists a positive probability of a unique event occurring, and whenever that positive probability persists over time without the event in question taking place, then *ex ante* rational expectations about variables, whose values the occurrence of that event would affect, will be systematically erroneous *ex post*. *Ex post* systematic errors in expectations, therefore, do not always amount to conclusive evidence of an *ex ante* lack of rationality about those expectations.

This problem is pervasive, but it is not universal. Certain variables, notably the general price level, are difficult to observe contemporaneously. Indeed, in Lucas' (1973) model of the aggregate supply curve, the possibility of output varying in the short run as a function of the price level depends crucially on the occurrence of discrepancies between the current value of the price level and agents' rationally formed "expectations" – *contemporaneous perceptions* would be a better phrase – of that value. Such contemporaneous perceptions are not susceptible to "Peso problem" effects. Even if the occurrence or not of some unique event is relevant to the current value of the price level, information about whether or not that event has actually occurred will be available to agents by the time the price level is realised; and, if they are rational, agents will have built it into their *contemporaneous perceptions* of the price level's value even though it could not have been incorporated into their *ex ante expectations*.

Thus, survey data on agents' perceptions of the current price level (or equivalently of the amount by which the price level has changed from some known value at a well defined date in the past), gathered at a time when official measures of that variable are not available to them, can be used with greater confidence to test the rational expectations hypothesis than can survey data on *ex ante* expectations. Such data are available. In this paper we shall use them to test the hypothesis that agents' perceptions of the current price level, formed at the very time at which the information used to construct official measures of that same variable are collected, but before they are made public, are rational.[3]

II. The Data

The data to which we refer above come from a quarterly survey which has been carried out regularly by the National Institute of Economic Research in Stockholm since July 1979. A unique feature of this survey is that it explores *both* the inflation perceptions *and* inflation expectations of a large representative sample of the Swedish public. About 6,500 people are usually questioned on each occasion, though the sample size has on one occasion (October 1984) fallen to 1500. Individuals remain in the sample for not more than four successive surveys.

The data on perceptions of inflation used in the following tests are generated in the following way. Respondents are first asked about the behaviour of "prices in general" during the past twelve months: "Have they risen, fallen, or stayed the same?" Those who answer that prices have fallen or stayed the same, negligible proportions never exceeding, respectively, 0.1 and 2.0 percent of respondents over the period of our sample, when prices did rise continuously, are not questioned further. The vast majority, who have answered "risen" are then asked: "By how much?" They are, that is, asked to give a numerical point estimate of the inflation rate. Respondents are permitted to offer an interval estimate or to answer "don't know" to this question, if they are unwilling to give a point estimate; on average, about 53 percent avail themselves of these options. However, with an initial sample size usually in excess of 6,000, each survey nevertheless yields a large sample of quantitative point estimates of the inflation rate. (October 1984 is again an exception here.) Our measure of perceived inflation is the mean value of these point estimates for each of the 23 surveys taken over the period July 1979 – January 1985. Those agents answering that prices have fallen, or stayed the same, and those not offering a quantitative point estimate of inflation are ignored, rather than having a zero value assigned to them.[4] Even so, 54,917 individual answers form the basis of the data we use.

It should be noted explicitly that information about the officially registered consumer price index, and thus about the actual rate of inflation during the twelve months preceding each survey, is not available to respondents at the time of the survey. The data on which official price level statistics for the survey month are based are in fact gathered at roughly the same time as the survey is conducted, namely the first two weeks of January, April, July and October, but the official statistics themselves are not published until a few weeks after the questionnaire has been completed. Our tests are based on comparisons of the actual rate of consumer price inflation as measured by the official consumer price index and the perceived rate of inflation as measured by the surveys over the period 1978–1984. The relevant data are presented in Chart I, where inflation rates, both actual and perceived, are measured as annual percentage changes over the preceding twelve months. The perception error, also plotted in Chart I, is measured as the percentage point difference between the actual and perceived rates of inflation.

It is immediately apparent from inspection of Chart I that the perceived inflation rate follows a smoother time path than does the actual rate. The latter is characterised by pronounced cyclical movement, and also reflects the influence of various easily identified policy measures, such as the two devaluations of the Swedish currency which took place in the August 1981 and October 1982 respectively, as well as a number of changes in subsidies and indirect taxes. In comparison with the actual rate, the perceived inflation rate fluctuates with a smaller amplitude, so that perceptions of inflation are systematically higher than actual inflation when the latter is falling, and systematically lower during periods of rising inflation. The mean perception error for all twenty–five surveys covered by Chart I is 1.08 percentage points. Evidently, over the sample period, the Swedish public on average overestimated the actual inflation rate, but as we shall see, this small mean prediction error is not statistically different from zero and it would be wrong to attach any economic significance to it. Only a larger set of data, which will become available with the passage of time, can throw further light on whether or not there does exist a systematic long–run bias in the Swedish public's perceptions of inflation.

III. The Tests

The rational expectations hypothesis, as it is usually formulated, implies that the difference between the actual inflation rate and its perceived value is a serially uncorrelated variable with a zero mean. Where p_t is the actual rate of inflation over the twelve–month period ending at time t, per_t is the perceived rate of inflation for the same period formed at time t, and u_t is a random error, this version of the hypothesis may be tested partially by estimating the following equation:

$$(1) \qquad p_t = a + b\, per_t + u_t$$

The economic hypothesis that the perceived rate of inflation over the previous year is an unbiased predictor of the actual – but unknown at time t – rate implies the joint statistical hypothesis that (a,b) = (0,1). This test of unbiasedness is generally considered to be a "weak" test of rationality, because it says nothing about the properties of the error term u_t, which ought, according to the rational expectations hypothesis, to be uncorrelated with any information, including any of its own lagged values, available at the time t to which agents' perceptions refer.

Note that equation (1) is not subject to those common econometric problems which arise when expressions of a similar form are used to test for the unbiasedness and efficiency of *expectations*, and the forecast horizon embedded in those expectations is longer than the interval of observation: for example, when data from quarterly surveys of expectations about inflation over the succeeding twelve months are used.[6] In such a case, an *ex ante* random error in forecasting the inflation rate in a particular quarter can enter into no fewer than four successive forecasts of the annual inflation rate, and hence can induce serial correlation into the errors of the latter. Equation 1, however, deals with *backcasts* rather than *forecasts*. At any time, the actual inflation rate over the first three of the preceding four quarters is public knowledge, available for agents to use in constructing their estimate of inflation over the previous year. Their only scope for error, therefore, arises in misestimating inflation over the immediately preceding quarter.

It is of course possible that agents do not use readily available data regularly to update their backcasts of inflation, and if they fail to do so, this will indeed induce serial correlation into the errors of backcasts of the annual inflation rate made at quarterly intervals. However, given that the data needed for the relevant adjustments are public knowledge, serial correlation induced by such means would be more than a statistical artifact, as it is in the analogous forecast case. Rather, it would be evidence that readily available and relevant information was being neglected, and hence that the rational expectations hypothesis, as usually formulated, is erroneous.

Now Chart I clearly indicates that changes in the actual rate of inflation are associated with changes in the perceived rate. It might be thought worthwhile to ask whether the public is able to estimate the rate of change of the inflation rate in a rational way. This question may be answered by fitting an equation of the following form to our data:

(2) $$p_t - p_{t-1} = c + d(per_t - p_{t-1}) + w_t$$

Here unbiasedness of expectations implies the joint hypothesis (c,d) = (0,1), while their efficiency again requires that the error term be white noise.

As we shall see in a moment, the outcome of fitting equation (1) is to show that the inflation perceptions of the public are unbiased. However, as inspection of Chart 1 strongly suggests, the error term of that equation is in fact positively serially correlated. The actual rate of inflation up to the end of the quarter preceding the survey, and the value the inflation rate perceived by respondents up to the end of that previous quarter, represent information freely available to respondents. Hence it is worth asking about whether, and the extent to which, perception errors could be reduced by using information about previous errors. The following relationship between the current perception error and its own lagged value was therefore estimated.

$$(3) \qquad p_t - per_t = e + g(p_{t-1} - per_{t-1}) + v_t$$

Here efficiency in the use of information implies the joint hypothesis that (e,g) = (0,0). This test is identical to that used by, among others, Stephen Figlewski and Paul Wachtel (1981) in examining the relationship between recent and past forecast errors of expectations data for the United States.

Of course the lagged value of the perception error is not the only candidate for use as "relevant information" in testing for efficiency of expectations. We also experimented with the following equation

$$(4) \qquad p_t - per_t = e + g(p_{t-1} - per_{t-1}) + h(x) + v_t$$

where x represented successively import price inflation (imp) in the previous quarter, and the rate of unemployment (u) in the previous quarter. Efficiency here implies (e,g,h) = (0,0,0). $h \neq 0$ suggests that other information in addition to previous errors could be used to improve the accuracy of inflation perceptions in the current period.

IV. The Results

Table 1 reports the results of fitting equations (1)–(4) to our data. A common property of all these results is that the intercept of the relevant equation is never statistically significantly different from zero. Furthermore, in regression (1), the slope coefficient is not statistically significantly different from one. These parameter values are consistent with inflation perceptions being unbiased. The critical value for F to accept the unbiasedness hypothesis at the 99% level of confidence, is 5.78, and its actual value is 0.44. However, the low Durbin–Watson statistic for regression (1) indicates the presence of first–order serial correlation in perception errors of the inflation rate. In the presence of such serial correlation, the F test to which we have just alluded is not valid. If we apply the Cochrane–Orcutt adjustment procedure to equation (1) we obtain equation (1'). Here the F test, now valid, yields a value of 0.85 and continues to confirm the unbiasedness of inflation perceptions, but the high value of ρ, 0.763 also confirms the initial impression that perception errors persist over time.

Regression (2) tests hypotheses about changes in the perceived inflation rate. The goodness–of–fit here is low, and more important, the coefficient d is significantly lower than the unit value that unbiasedness in perceptions of changes in the inflation rate would generate. Apparently the Swedish public systematically underestimate changes in the inflation rate. Yet another way of looking at the same problem is provided by regression (3). Here the parameter g may be regarded as an alternative estimate of the parameter ρ obtained from (1'). Its positive value confirms that current errors in perceptions of the inflation rate are significantly positively correlated with their own past values, and could be reduced by paying attention to this readily available information. The critical value for F for accepting the joint hypothesis that (e,g.) = (0,0) at the 99 percent level is 5.72, and the actual value of this statistic 18.72, lies well outside this bound. Moreover, when a measure of previous import price inflation is added in equation (4), it turns out to make a marginally statistically significant contribution to improving its goodness of fit. Here again, we have freely available information which could be used to improve inflation perceptions, but which is, apparently, ignored. The unemployment rate, on the other hand, is a less reliable source of information. However, the unemployment rate is correlated with the lagged inflation perception error and equation (4′) is a slightly better fitting expression than (4).

To sum up, our empirical results suggest that, unbiased though they are, the Swedish public's perceptions of "actual" inflation, when actual inflation is measured by the consumer price index, could be rendered more accurate. Freely available and useful information apparently remains unutilized. There are at least two explanations of our results. First, it may simply be that the Swedish price index measures the "true" price level, relevant to the respondents of our questionnaire, imperfectly. If such a hypothetical "true" price index moved more sluggishly than the official index upon which our tests are based, the results which we have generated could be a statistical artifact of no economic significance at all. (However, to minimize this bias the respondents to the survey generating our data were asked to give point estimates of how "prices in general" have moved, not of the behavior of the prices of goods they purchase.) It is impossible to test this suggestion definitively. It would always be feasible to construct *ex post* a price index of whose behaviour our "perceptions" data provide a unbiased and efficient estimate. However, we can claim that our results do not depend crucially on the specific price index which we use to measure inflation. In particular, we have re–run our tests using the percentage rate of change of the Swedish food price index to measure inflation, and have found their results to be robust in the face of this change.[7]

Second, and, we would argue, more plausibly, it might be that the costs of gathering and processing information on perception errors, and other data too, are high enough relative to the benefits to be gained from improving inflation peceptions, for it to be *economically* irrational for agents to do this. This interpretation is consistent with recent theoretical work by John Galbraith (1988). Moreover, empirical work now being carried out by Batchelor and Jonung (see 1986 for preliminary results), using data from the same survey underlying our results, shows that differences in the accuracy and purely statistical rationality of inflationary perceptions across gender, age and income groups appear to be related to the costs and benefits of collecting information on inflation for the various groups examined.[8]

IV. Concluding Comments

In this paper we have used survey data on contemporaneous inflation perceptions to test a widely utilised version of the rational expectations hypothesis. Such data enable us to avoid the "Peso problem" alibi for this hypothesis when errors display the serial correlation which is *prima facie* inconsistent with its usual formulation. Even so, the errors generated in our tests are indeed strongly serially correlated. Though one can never completely rule out the possibility that such results as these have arisen from using the "wrong" data, we are inclined to believe that our tests are more than a mere statistical artifact, and do show that the Swedish public make serially correlated errors when estimating inflation, and do not find it worth the effort to remove them. This interpretation of the evidence is *not* inconsistent with *economic* rationality, because the benefits of improving inflation estimates may not be worth the extra cost of doing so. Nevertheless, our results do suggest that it is inappropriate to rule out *a priori* the use, in economic modelling, of expectations formulae that lead to serially correlated errors. Though the existence of the Peso problem makes it impossible to test the proposition definitively in the case of ex ante forecasts, our results for backcasts at least open up the possibility that persistent expectational errors do, after all, have a role to play, alongside other rigidities, in explaining why the responses of variables such as output and employment to exogenous shocks themselves display persistence in real world economies.

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NOTES

*Professor of Economics, Stockholm School of Economics and Professor of Economics, University of Western Ontario. We would like to thank Erling Pettersson for excellent computational assistance. We have benefitted significantly from comments by Bengt Assarsson, Roy Batchelor, Axel Leijonhufvud and Allan Meltzer and seminar participants of the Institute of International Economics, Stockholm and Flinders University, as well as two anonymous referees.

[1]Rational agents must be assumed to know the value of the price level P at any time in the past, e.g. at t–1. If they form an estimate P^e of the current price level, then this immediately implies an estimate of the recent inflation rate $P^e_t - P_{t-1}$ and vice versa.

[2]On this argument, see Milton Friedman and Anna Schwartz (1982 p. 556–57).

[3]As David Laidler and Michael Parkin (1975) noted, theoretical and empirical studies on inflationary expectations assume, usually tactily, that economic agents hold uniform expectations with complete certainty. However, empirical work shows that (a) inflationary perceptions and expectations display considerable distribution across respondents, see Lars Jonung (1981), and (b) they are not held with complete certainty, see, for example, Jonung (1986). We abstract from these issues here.

[4]We believe that, in confining ourselves to data generated by agents who are sufficiently confident in the quality of their own perceptions to offer a quantitative estimate of the inflation rate, we are probably biasing our tests in favour of the rational expectations hypothesis. Note that to drop those respondents not offering a point estimate for the perceived inflation rate from our sample amounts to attributing to them an estimate of inflation equal to the mean of those offering a point estimate. In the case of respondents who perceive prices to have risen, but decline to offer a precise estimate of how much, this procedure seems appropriate. However, it introduces an upward bias to our measure of the perceived rate to the extent that agents who claim prices to have remained the same or fallen are also treated in this

way, but the number of such agents is, in fact, negligible. As far as we are aware, quantitative measures of inflationary perceptions have only been used in two previous studies: Jonung (1981) and Roy Batchelor (1983). Jonung examines in detail the first survey made for Sweden in 1978. Batchelor transforms qualitative perception data taken from the EEC consumer tendency surveys into quantitative measures of perceptions. His conversion makes actual and perceived inflation rates equal on average, ruling out any possible bias. Even so, he finds that the perceived inflation rate is less volatile than the actual rate—a finding consistent with ours for Sweden. Batchelor interprets this pattern as showing that consumers perceive only a moving average of actual inflation.

[5]The dates of the surveys are marked by circles in the chart. The regular surveys started in July 1979. The results of two preceding surveys, undertaken in January 1978 and January 1979, are included in the chart but were not used in the regressions reported in Table 1.

[6]On this point see, *inter alia*, Lars Hansen and Robert Hodrick (1980).

[7]Another possible explanation for our results may be that the respondents, when asked about the history of inflation during the past twelve months, actually had in mind when answering the rate of inflation that they perceived to have prevailed over a longer time period. To investigate this view, we calculated the perception error implied by inflation rates measured over varying time periods, starting from 6 months and going back to 36 months from the date of the survey. This perception error turned out to be minimised when we used a 27 month—not a 12 month—measure of the actual inflation rate. This result is consistent with the postulate that respondents were influenced by a history of prices going further back than the immediately prior 12 months referred to in the survey questions. The fact remains, however, that agents were asked about the previous 12 months, not 27 months, and that agents making full use of all available information would have been able to distinguish between the two.

[8]This ongoing work is also addressing a question which naturally present itself as a follow–up to the results set out here, namely whether agents' forecasts of inflation display more or less unbiasedness and efficiency than their backcasts. Preliminary results suggest that forecasts, like backcasts, are unbiased, but a comparison of their efficiency is more difficult to make. The forecasts errors made by respondents to our surveys do display serial correlation, but such correlation is in any event induced in those forecasts in a way that it is not in backcasts (see p. 6 above) by the fact that they are made at quarterly intervals for a one year period. Batchelor and Jonung have applied a technique developed by Hansen and Hodrick (1980) in an attempt to deal with this problem, but in doing so have rendered their results not directly comparable to those presented here, which are generated by applying OLS to backcast data. This exercise yielded results which did not permit the hypotheses of efficiency to be rejected in the case of forecasts, but Batchelor and Jonung attribute this result to a lack of power on the part of the Hansen –Hodrick test when applied to a small sample of data, rather than to any paradoxical proclivity on the part of the subjects of their study to form expectations efficiently and perceptions inefficiently. Clearly however this issue merits further investigation.

Chart I
Perceived (—o—) and Actual (———) Inflation Rates, and Their Difference (..□..)
January 1978 – January 1985

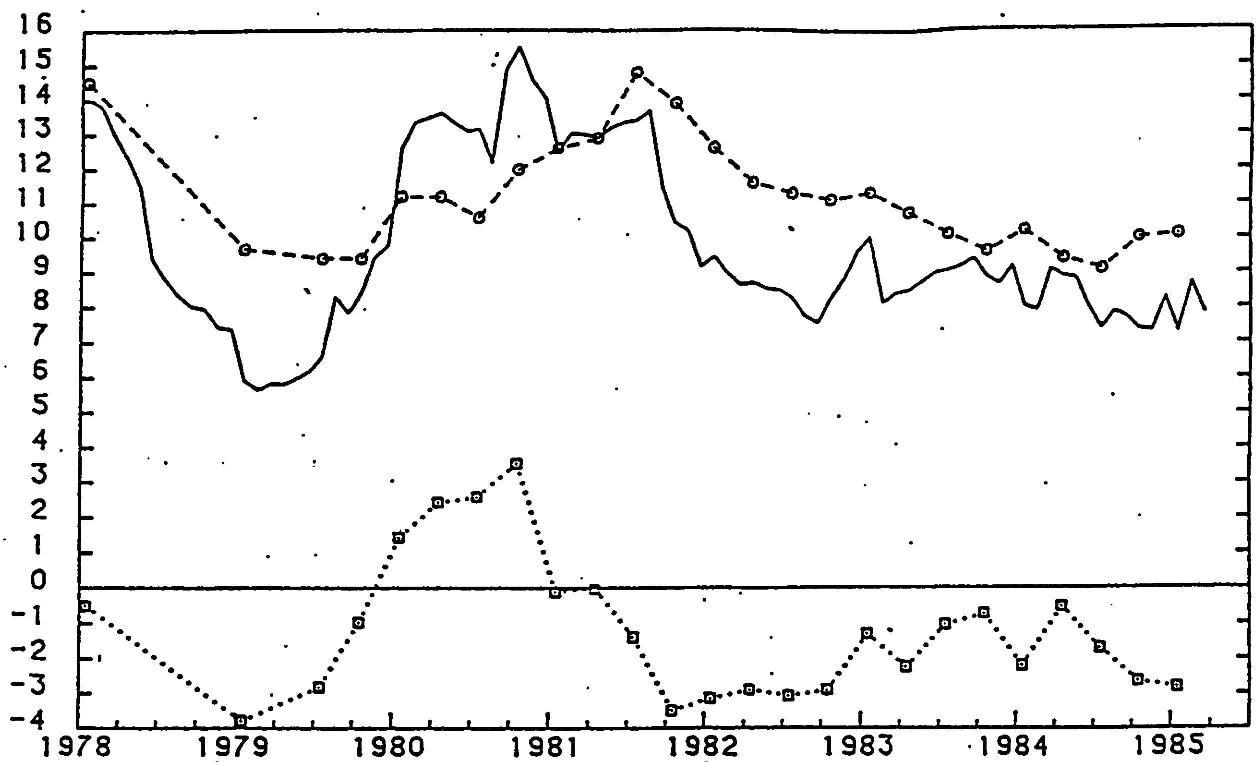

Table 1[a]

Estimates of Equations 1 - 4

Regression and Dependent Variable	Intercept	Coefficients of Independent Variables		Adjusted R^2	DW
(1) p_t =	a - 1.506 (3.235)	+ b per_t + 1.035 (0.289)		0.349	0.484
(1') p_t =	a - 1.887 (3.810)	+ b per_t + 1.032 (0.339)		0.264	1.814 (ρ=0.763)
(2) $p_t - p_{t-1}$ =	c - 0.319 (0.403)	+ d(per_t - p_{t-1} + 0.309 (0.191)		0.072	1.537
(3) $p_t - per_t$ =	e - 0.275 (0.332)	+ g(p_{t-1} - per_{t-1}) + 0.752 (0.148)		0.541	1.698
(4) $p_t - per_t$ =	e - 0.842 (0.425)	+ g(p_{t-1} - per_{t-1}) + 0.829 (0.144)	+ h imp_{t-1} + 0.246 (0.126)	0.548	1.725
(4') $p_t - per_t$ =	e 1.939 (1.428)	+ g(p_{t-1} - per_{t-1}) + 0.583 (0.178)	+ h U_{t-1} - 0.881 (0.554)	0.573	1.801

[a]Figures in parentheses are standard errors.