

Inflation Expectations

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3 Inflation expectations and empirical tests

Theoretical models and empirical tests

Richard Curtin

Realism and relevance

John Muth began his classic article on rational expectations by noting that survey data on expectations were as accurate as the elaborate models of economists, and he noted that there were considerable differences of opinion in the cross-sectional survey data (Muth, 1961). His basic insight was that economic agents form their expectations so that they are essentially the same as the predictions of the relevant economic theory. The assumption that expectations were formed rationally was, for Muth, the natural extension of economic theory, which already held that firms rationally maximize profits and consumers rationally maximize utility. Nonetheless, Muth noted that rationality was an assumption that could be tested by systematic comparison with alternative theories in explaining observed expectations.

Muth's hypothesis has indeed sparked an enormous amount of research, as well as wide divisions between disciplines, in how rationality should be conceptualized and how the hypothesis should be tested. Economics views rationality in terms of the choices it produces (substantive or full rationality), whereas other social sciences view rationality in terms of the process that is used to make choices (procedural or bounded rationality). It was Friedman's (1953) celebrated essay on methodology that declared the validity of economic theories as independent of their psychological assumptions. Economists have accordingly focused on whether they postulate of unbounded or bounded rationality was the more productive theoretical construct in terms of its predictive accuracy.

Compared with tests of utility maximization, expectations have the unique advantage that they can be measured and subjected to empirical tests.¹ The rigor of the tests of the rational expectations hypothesis ranges from tests of bias and predictive accuracy to how efficiently every possible piece of relevant information is used in forming the expectations. There is a virtual absence of empirical tests of the assumptions surrounding utility maximization, including tests on whether agents gather and process the relevant economic information and use it efficiently to maximize utility, and whether consumers know all the relevant facts at any given time or if there is informational heterogeneity.

There are some economists that take seriously the implicit assumptions that there are negligible costs associated with collecting and processing all the relevant information, and that all agents know the correct dynamic model. When asked about the stringent assumptions surrounding utility maximization, economists quickly allow that what those simplifying assumptions lack in realism they make up for in predictive performance. The lack of recognition of Friedman's basic methodological points in the discussion of rational expectations is quite amazing.

It should not be surprising that the debate about the rational expectations hypothesis has continued unabated in the nearly 50 years since Muth first published his theory. Perhaps it is as Lovell (1986) lamented two decades ago in his review of empirical tests of the rational expectations hypothesis: "Why should data spoil such a good story?" Indeed, the clear advantage of the rational expectations hypothesis is its theoretical strength. The hypothesis has proved to be enormously productive in transforming macroeconomic theory, given that the rationality assumption enables the powerful tools of optimization to systematically expand the depth and breadth of economic theories.

While the empirical tests have generally not fully supported the hypothesis, the criteria for acceptance are rigorous, and the lack of evidence is comparable to that found in tests of the full rationality postulate in many other aspects of economic theory. In contrast, while bounded rationality has frequently been confirmed in empirical studies, research on bounded rationality has not led to an integrated theoretical structure that could spark further theoretical advances. Indeed, the findings attributable to bounded rationality have been generally classified as "anomalies" rather than being incorporated into mainstream theory. The list of such anomalies includes the impact of framing, asymmetry of gains and losses, relative reference points, anchoring, and confirmatory bias, among other findings (Tversky and Kahneman, 1982; Earl, 1990; Thaler, 1991, 1992; Rabin, 1998; Rabin and Schrag, 1999). Only recently has there been a concerted effort to incorporate a more realistic account of expectations into mainstream economic theory, rather than relegating them to anomaly status.

Costs and benefits of rational expectations

Like most economic phenomena, inflation expectations can be integrated into mainstream theory by the systematic recognition of the costs and benefits associated with rational expectations. Rational expectations are costly to form and their benefits are derived from their use in economic decisions. As long as there is any positive cost involved in collecting and processing information using the relevant dynamic model, some agents will sometimes choose to hold less accurate expectations. The terms "sticky information" or "rational inattention" have been used to describe the impact of costs on the formation process (Mankiw and Reis, 2002; Sims, 2003; Bacchetta and Wincoop, 2005). These theories postulate that rational consumers may find the costs associated with updating their expectations to exceed the benefits. At any given time some people will find it worth-

while to incur the costs, especially if that information is critical to a pending decision. Most of the time, however, rational inattention is the optimal course. Alternatively, agents may base their expectations on imperfect information, which can be conceptualized as less costly than perfect information. Whatever the cause, the process creates staggered changes in expectations, whereby at any given time expectations reflect a combination of current and past information across different people.

Disagreement across people in their expectations at any given time is taken as an indication of such a process (Mankiw *et al.*, 2004). Some have modeled the disagreements as the result of factors other than costs, such as an epidemiological process in which “expert opinion” spreads slowly through a population, like the spread of a disease (Carroll, 2003). Costs can also be assumed to vary across demographic subgroups, as some encounter lower costs for acquiring and using information, and other, more economically active, subgroups derive greater benefits from updating their expectations more frequently. This interpretation of disagreements or inaccuracies in expectations stands in contrast to the older and still more common interpretation that the very existence of differences across demographic subgroups indicates non-rational expectations (Bryan and Venkatu, 2001; Souleles, 2004).

Staggered changes could be created by a wide range of processes that either encourage or discourage agents from updating their expectations. A common hypothesis for staggered updating holds that it is due to asymmetric responses to economic information, with agents updating their expectations much more quickly in response to bad news about inflation. Akerlof *et al.* (2001) suggest that bad economic news is perceived by consumers to contain more potentially relevant information about their financial situation. The volume of news also matters, especially the volume of bad news, as well as news that represents a sharp and negative break from the past (Carroll, 2003). Sims (2003) shows that, based on information theory, the tone and volume of economic reporting affects expectations beyond the information contained in the reports. This added impact of news, however, may be short-lived, usually lasting less than a few months (Doms and Morin, 2004).

It is not clear when the news media creates expectations and when their reporting simply responds to ongoing changes in expectations. Like any other business, the news media cater to consumers’ preferences (Hamilton, 2004). For example, large shifts in expectations for future changes in the unemployment rate were found to change in advance of shifts in media reports about unemployment (Curtin, 2003).

The same staggered information flows have been hypothesized to result from uncertainty about the correct structural model of the economy. Since model uncertainty is costly to resolve, it results in less frequent updating of expectations (Branch, 2005). Although the data that indicates disagreement in expectations is similar to what could be expected to result from model uncertainty, these two concepts are distinct. More importantly, the prevalence of disagreement may be much more variable over time than uncertainty.

The models developed to capture the impact of staggered information are similar to consumption models that incorporate the division between “rule of thumb” and rational consumers. In this context, the switching models capture the difference between those that update their expectations regularly and those that base their expectations on pre-existing information. Mankiw and Reis (2003), Carroll (2003), and Khan and Zhu (2002) estimated that rather than continuously updating their expectations, most people update their expectations only a few times a year.

Sticky information theories result in differences in inflation expectations across agents. There are, however, other reasons to expect heterogeneity which represent more fundamental issues. Conventional economic theory assumes that the same information is available to all agents and the same models are used to generate expectations about the future. The result is that there is only one rational expectation at any given time for a given information set. Thus, while staggered information and model uncertainty may result in heterogeneity of expectations, there is no theoretical basis for expecting heterogeneity among those that have recently updated their expectations. The allowance of private information, in addition to public and official information, to influence the formation of expectations would provide a theoretical reason for heterogeneity in expectations. For example, the impact of private information has been found to be pivotal in the formation of unemployment expectations (Curtin, 2003).

Monetary policy implications of staggered information flows

Whatever the cause, the presence of sticky information is hypothesized to be the key to understanding dynamics of the macro economy. Sticky information has a long history in research on forward-looking Phillips curves (Woodford, 2003). The sticky information has ranged from staggered wage contracts, to staggered pricing models, to staggered information flows. Whatever the source, the existence of sticky information indicates the non-neutrality of monetary policy.

While there is now a widespread belief that monetary policy can influence output and employment, there is no consensus on the mechanisms that produce the impact. To be sure, if inflation expectations were fully rational, prices were perfectly flexible and the central bank was fully committed to price stability, there would be no impact on output and employment. Non-neutrality may derive from non-rationality in expectations, or from a lack of commitment to price stability on the part of the central bank.

The optimal situation is when the central bank enjoys widespread credibility and expectations are fully rational, allowing the central bank to reduce inflation without any loss in output or employment. Although central banks differ widely in the credibility they enjoy, economic losses cannot be completely avoided even among those that have the highest credibility.

When these optimal conditions are not present, expected inflation can become self-fulfilling due to what has been termed the “expectations trap” (Chari *et al.*, 1998; Albanesi *et al.*, 2002; Leduc *et al.*, 2003). The enticement into the trap is

the higher cost in terms of output and employment that would result following the choices already made by households and firms in anticipation of higher inflation: consumers typically favor debt (whose repayment will be eroded by higher inflation), and firms typically raise prices in advance to protect the real value of their profits. These actions would imply relatively larger future losses in output and employment if the central bank adopted a policy aimed at price stability. Since the actions already taken by both consumers and firms act to lower the costs of inflation, the central bank is “trapped” into an accommodative policy that confirms the higher inflation expectations.

While full rationality and a fully committed central bank may seem too much to expect, Woodford (2005) advanced the notion that the main conclusions for optimal monetary policy also pertain to the assumption of near-rational expectations. While there is no accepted standard to judge whether expectations are “near-rational,” the analysis of inflation expectations can help to sort out the various properties of expectations.

This chapter investigates a broad range of these issues, including whether inflation expectations are backward or forward looking, whether there is any support for the staggered information hypothesis, the interpretation of disagreement data, and some other methodological issues. Prior to the analytic sections, the rational expectations model and the adaptation models are defined. The analysis then turns to household inflation expectations collected by the University of Michigan, variously based on cross-section data, panel data, and times-series data. Finally, the analytic results are discussed along with their implication for monetary policies.

Theoretical models of expectations

Expectations are beliefs about the future. This definition was cited by Plato more than 2,000 years ago, and it remains to this day the generally accepted meaning of the term.² The formation of expectations depends on two factors: informational inputs (I) and the model or process of transforming information into expectations (f). Let the expectation of the inflation rate (P^e) formed by the i_{it} individual be defined as:

$$P_t^{e-1} = f(I_{t-1})$$

where the subscript t on P indicates the period for which the expectation applies, and the expectation formed based on the information that was available in a prior period denoted by e_{t-1} . The two dominant specifications of this equation are the rational expectations hypothesis and the extrapolative, adaptive, and error-learning models, which I will refer to collectively as “adaptive” expectations.

The format of the appropriate empirical tests of these two models is just as distinctive as their assumptions about rationality. The adaptive expectations models define what information is used and how it is used in the formation of expectations, including the availability and cost of information as well as the

capacity of individuals to effectively utilize the information. The empirical tests were designed to determine whether variations in expectations are related to these hypothesized factors. In contrast, tests of the rational expectations hypothesis focus on whether the observed expectations are unbiased future forecasts and whether all of the information was used efficiently and optimally. In the former case, expectations are analyzed as the dependent variable, while in the latter case expectations are viewed as an independent variable in the analysis.

This difference makes the comparison of the relative merits of the two models difficult. For the adaptive expectations models, confirmation essentially entails finding a significant empirical relationship between expectations and some informational inputs. Confirmation of the rational expectations hypothesis, in contrast, requires finding unbiased and efficient future predictions. In tests of adaptive expectations, any statistically significant finding is taken as confirmation even if it accounts for a trivial proportion of the variance, whereas anything short of full rationality requires the rejection of the rational expectations hypothesis. This asymmetry in the evaluation of empirical evidence has stunted theoretical developments.

This situation is nowhere more important than in the assessment of the forward-looking content of expectations. Adaptive expectations models are inherently bound to the past. Aside from the special case where future outcomes are extrapolations of the past, no method is usually hypothesized to test the forward-looking content of expectations. Indeed, by their very construction, adaptive expectations models portray the formation process as a relatively transparent function of past outcomes where individuals never fully learn from their past errors. Rational expectations models, in contrast, place their entire emphasis on assessing the forward-looking information, but do not posit any specific process for the formation of expectations. When empirically rejected, the rational expectations framework provides no insight into which limitations on rationality prove most important.

Adaptive expectations

The various adaptive, extrapolative, and error-learning models can be summarized by the following autoregressive distributive lag representation:

$$P_t^e = \alpha + \sum_j \beta_j P_{t-j}^e + \sum_j \gamma_j P_{t-j} + \varepsilon_t$$

where P^e is inflation expectations, P is the actual inflation rate, j is the lag length, and ε_t is the error term, with the i subscript dropped for convenience. Variables other than the inflation rate that are part of the relevant information could also be included in the equation. Defining the unique characteristics of the various models involves the specification of coefficients α , β , γ , and ε .

Perhaps the most basic hypothesis is that expectations essentially represent random responses to the survey questions, unrelated to either the past realizations of the variable or even past expectations. In this case, the β , and γ coefficients

would be hypothesized to be equal to 0, so that variations in expectations about its mean (α) are simply equal to the error term.

The pure extrapolative model is obtained by setting the coefficient β equal to zero, so that expectations solely depend on the lagged inflation rate. The most restricted version of this model can be characterized as “static expectations,” where expectations simply depend on the most recent realization. The more general version holds that expectations represent a weighted average of past realizations. Under the extrapolative hypothesis, the γ coefficients are hypothesized to be any positive fraction between 0 and 1.

The adaptive or error-learning hypothesis posits that consumers revise their expectations for the following period based on the error in their expectations in the current period (Fisher, 1930; Cagan, 1956; Friedman, 1957; Nerlove 1958). In terms of the above equation, this implies that only one lag of the actual and expectation variables are used, with the coefficient on the difference between the expected and actual outcomes (the speed of the learning adjustment) hypothesized as being positive with an upper bound of 1.0. By use of the Koyck (1954) transformation, however, the adaptive expectations model can be shown to be equivalent to a weighted average of past realizations.

Another approach has been to utilize error correction models (ECM), which postulate equality in long-run equilibrium between inflation expectations and the inflation rate. The basic ECM can be expressed by using one lag of the expectations variable and two lags of the actual inflation rate, and fixing these coefficients at 1.0 to express the notion that the equilibrium rate of inflation is equal to its expectation. The ECM equation thus relates the change in expectations to past changes in the actual inflation rate, as well as the error in the prior period's expectation.

The reliance on information about past changes in inflation is the source of the most important disadvantage of all adaptive expectations models because systematic prediction errors result since expectations tend to underestimate (overestimate) the true change whenever the underlying variable is following an upward (downward) trend. In response to this deficiency, augmented models have been proposed which incorporate information on other variables that are assumed to influence the formation of expectations. The use of this additional information can help to offset the tendency toward systematic prediction errors.

Rational expectations

The strong appeal of the rational expectations hypothesis is that it avoids the bias toward systematic prediction errors by shifting its focus from the variable's history to its future realizations. The rational expectations hypothesis equates the expectation with the expected value of the actual subsequent realization, conditional on all available information (Muth, 1961). Unbiased expectations under the rational expectations hypothesis require that the coefficients α and β are 0 and 1, respectively, in the equation:

$$P_t = \alpha + \beta P_t^{e-j} + \varepsilon_t$$

The strong test of rationality also requires that all of the available information has been efficiently and optimally used in forming the expectation. This involves tests on the statistical properties of the prediction errors to determine if they are consistent with those stipulated by the hypothesis (orthogonality, efficiency, consistency, and unbiasedness). Tests of this assumption take the form:

$$\zeta_t = \alpha + \sum \beta_j P_{t-j} + \sum \gamma_j Z_{t-j} + \varepsilon_t$$

where ζ is the prediction error, the coefficients β and γ are expected to be zero, and the prediction errors are serially uncorrelated. This expresses the notion that if any of the available information was systematically related to the prediction errors, the information was not efficiently and optimally incorporated into the formation of the original expectation.

Reification of economic data in tests of expectations

Some economists seem to believe the only source of information about the actual inflation rate is the official announcements by the government's statistical agency. The assumption that consumers only utilize official sources of economic information reflects the widespread tendency to reify economic data—that is, treating conceptual measures as if they had a concrete existence. All economic data represent estimates of the underlying concepts, and some price indexes are measured with more error than others. There is no evidence that consumers revise their inflation expectations each time the government issues new monthly estimates, revises old figures or revises its measurement methodology. More importantly, aside for those who have their incomes or pensions indexed to official indices, theory suggests that consumers will use whatever measure best reflects their own expenditures. It would make no sense for consumers to take into account future prices that they will not face when making decisions.

The recent debate about whether tests on inflation expectations should be based on real-time data or revised data reflects this tendency toward data reification (Mehra, 2002; Croushore and Stark, 1999; Kean and Runcle, 1989; Zarnowitz, 1985). The information set at any given time is usually assumed to only include past data on the official inflation rate, usually outdated by at least one month (the official release of US data on the Consumer Price Index (CPI) for any given month is by the middle of the following month). While economists may condition their forecasts only on official data, consumers can be expected to actively use all the information available to them to gauge ongoing changes in price trends. Rather than relying on official information, consumers more often report and depend on private information.

If anything, consumers suffer from an overload of private information about prices. In comparison to the official information that has been released once a month in nearly the same format for decades, private information has increased substantially. The media have been repeatedly reinvented to provide expanded information, from newspapers, to television, to 24/7 operations of cable news,

the internet, and the self-proclaimed experts that now inhabit all media. More importantly, people gain information on prices in every daily transaction in the marketplace. This personal collection of information is typically reported by consumers to be the most critical to the formation of their expectations.

One way of exploring the impact of private versus official information is to compare changes in expectations with the official release dates. The key analytic issue is how to devise a proxy measure of the unobserved inflation rate prior to the official announcement. This issue is easy to solve: the best estimate of the current month's inflation is the official inflation rate. And the hypothesis could be easily tested: the current month's price index should be dominated by last month's inflation index for the official information hypothesis to hold, and the current month's price index should dominate last month's official release if private information dominates. Such a test provides little support for the notion that consumers base their expectations on the official announcement.

The last issue is which inflation rate is the most appropriate to use to model consumer expectations. The inflation index most often favored by economists is a core rate that excludes energy and food prices, and is either based on the CPI or the personal consumption deflator. Consumers generally identify inflation with the overall CPI or personal consumption deflator as they best capture the prices of the goods and services that they actually purchase. The analyses included in this chapter focus on changes in the overall Consumer Price Index (CPI-u).

Data on inflation expectations

The University of Michigan has collected data on the inflation expectations of consumers for more than 50 years. Two questions are now asked of all consumers about expected price changes: the expected *direction* of change in prices and the expected *extent* of change. The question on the expected direction of change has been asked in a comparable format since 1946, while the question on the extent of change has been modified several times. In the 1940s and 1950s, the question simply asked whether prices would go up a little or go up a lot; from the 1960s to the mid-1970s, the question included a series of fixed percentage intervals from which the respondent was asked to choose; and from the mid-1970s to the present, the question simply asked the percentage rate of inflation that the consumer expected. This chapter focuses only on the monthly data collected since 1978 for the open-ended question on inflation expectations.

There is much cross-section and time-series variation in consumers' responses. The variation in responses is due to a number of factors, including differences in information and computational capacities, uncertainty about the correct dynamic model, and measurement errors.

These differences are discussed from several perspectives based on cross-section, time-series, and panel data.

Cross-section variation in responses

The unweighted distribution of responses across the surveys conducted between 1978 and 2005, covering about 200,000 cases, is shown in Figure 3.1. The response codes from 1 percent to 5 percent contain 54 percent of all the responses; including up to response code 10 percent adds another 16 percent; and including up to response code 15 percent adds another 4 percent for a total of 74 percent of all responses. As a result, three-quarters of all responses fell within the same range recorded by the CPI over the same time period—the year-over-year change in the CPI ranged from a low of 1.0 percent in 2002 to a high of 14.6 percent in 1980.

The upper tail of the distribution is quite long, although just 5 percent of all response codes were above 15 percent, and only 0.5 percent of all responses indicated an expected inflation rate of 50 percent or more. The lower tail of the distribution, in contrast, was sharply truncated, with just 3 percent of all responses expecting an overall decline in prices. The most distinctive, and perhaps the most difficult to explain, phenomena was the comparatively large number who expected a 0 percent inflation rate. Across the past 25 years, overall prices were anticipated to remain unchanged by 18 percent of all respondents. Yet, just 3 percent expected declines in prices.

One might have reasonably anticipated that the distribution of responses would not change so abruptly at zero. The lumping of inflation expectations at zero seems to suggest that a negative inflation rate incorporates some psychological aspects that consumers actively avoid, or perhaps that consumers consider the underlying probability distribution discontinuous at zero. The psychological hypothesis was more common in the decades following the depression of the 1930s, when consumers associated price declines with income declines, but in more recent years most consumers have eagerly embraced whatever product price declines they encountered in the marketplace. The single, and important, exception is house prices. Rather than a kink in the underlying probability distribution, the lumping at zero may simply reflect rounding, with consumers actually expecting a very low rate of inflation and not price declines.

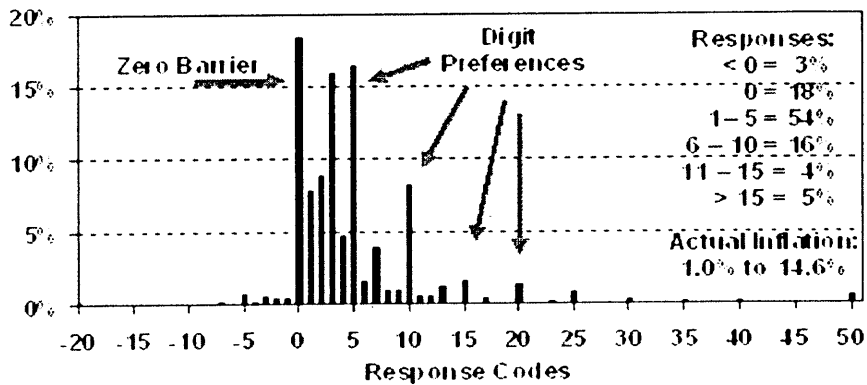


Figure 3.1 Year-ahead inflation expectations: distributions of responses, 1978–2005.

The truncation does not reflect the averaging of a few surveys where expectations of declines were common, with many more surveys where they were uncommon. Figure 3.2 shows the response distribution for 1980, when inflation expectations were at their highest levels; Figure 3.3 shows the response distribution for 2001, when inflation expectations were at their lowest levels. The same truncation in responses is evident in both cases. The major difference is that the 1980 distribution is shifted to the right and has a greater dispersion of responses.³

Whatever the cause, the data clearly indicate a truncated lower tail rather than a normal distribution. Importantly, the extent of the truncation provides information for those utilizing distribution assumptions to calculate a numerical estimate from qualitative response scales on inflation expectations, as is commonly done among EU countries.⁴

Digit preference

A close examination of the response distribution indicates the prevalence of certain digits, namely 0, 5, 10, 15, 20, and so on up to 50. This tendency to favor certain digits has been termed “digit preference.” Digit preference is a wide-

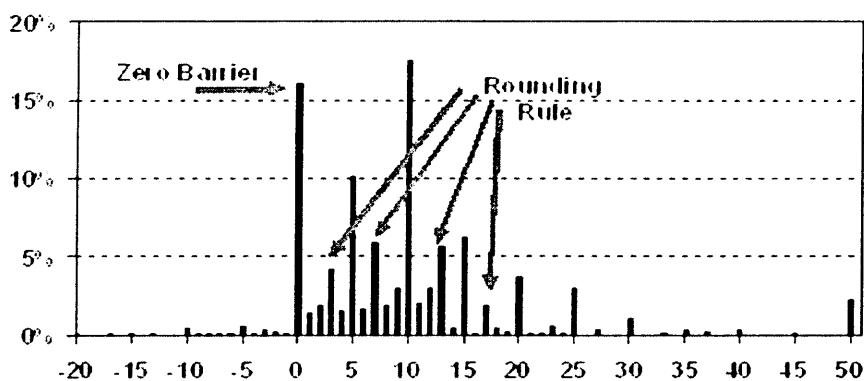


Figure 3.2 Year-ahead inflation expectations: distributions of responses, 1980.

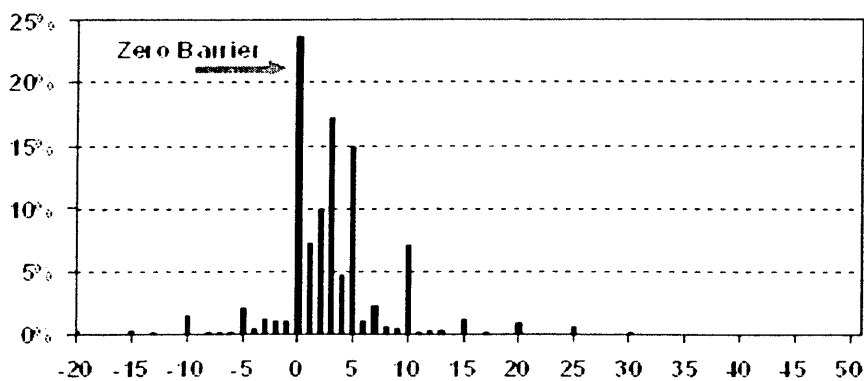


Figure 3.3 Year-ahead inflation expectations: distributions of responses, 2001.

spread phenomena, exhibited in nearly all responses to open-ended numeric questions (Baker, 1992; Edouard and Senthilselvan, 1997). The questions could ask about dollar amounts of income, assets, debts, product prices, or probabilities of the occurrence of certain events, from the weather to a variety of economic or political outcomes, and even in response to attributes of the person, such as weight. The typical explanation of digit preference is that it represents “rounded” answers based on considerations of the cost of providing more exact responses. Economists may favor a “near rationality” interpretation whereby the rounding represents the level of precision that is associated with differences that matter to the respondent.

An even closer inspection will reveal the prevalence of 3, 7, 13, 17, and so on. This reflects coding rules implemented by the survey organization to provide a consistent means to code range responses. All responses are recorded as integers, and the very few decimal responses are rounded and coded as integers without any fractional values. The key part of the rule states that coders should round 0.5 to the nearest odd number, e.g. 3.5 would be rounded to 3 and 4.5 would be rounded to 5. This rule, in combination with the prevalence of range responses, produces the high prevalence of the coded values 3, 7, 13 and so forth. For example, a response of 5–10 percent would be coded as 7 percent; a response of 10–15 percent would be coded as 13 percent. Overall, range responses are quite rare. Whenever a respondent would give a range response, it was always probed for a more exact point estimate in the Michigan surveys, but some respondents insisted that they could not narrow the range to a single best integer estimate.

Digit preference and the frequency of range responses are usually considered survey measurement errors, given that they result in less precise measures. Experiments have been conducted with the data before rounding (from one decimal) and the characteristics of the response distribution have been nearly identical to the rounded figures, as one would expect. Range responses are likely to reflect uncertainty about the future course of inflation, or the lack of information that a more precise answer would require (presumably due to its high cost).

Some have misinterpreted digit preferences as “focal points” in the distribution, and suggest that this indicates that inflation expectations are more qualitative than quantitative in nature (Bryan and Palmqvist, 2005). The near-universal presence of digit preferences would mean that the same conclusion would also be valid for measurements of income, assets, prices, and so forth, meaning that surveys could measure only qualitative variables. The stability of the same integers as “focal points” in the distribution over time has been misinterpreted as indicating that the distribution of responses was not responsive to changes in the inflation or policies pursued by the central bank

Time-series variation

Rather than focusing on cross-section data, most economists are more interested in how the distribution changes from month-to-month. Given the pronounced

skew in the distribution of inflation expectations, it is no surprise that the mean of the distribution always exceeds the median. Moreover, given that the long upper tail of the distribution is likely to represent measurement errors, the median rather than the mean of the distribution may provide the better measure of central tendency.⁵ Indeed, the difference between the mean and median was substantial, with the mean being about 25 percent higher than the median, or 1.0 percentage points higher (see Figure 3.4). Over the period from January 1978–August 2005, the mean of the monthly distributions was 4.8 percent, while the median was 3.8 percent. Despite the difference in the levels, the time-series correlation between the mean and median was 0.98, indicating that either measure provided nearly identical time-series information. The median inflation expectation is typically the measure of choice, and I will restrict my focus to the median in this chapter.

The interquartile difference, defined as the difference between the twenty-fifth and seventy-fifth percentiles, can be used as an estimate of the variance in the monthly data.⁶ Over the 1978–2005 period, the interquartile range averaged 4.7 percentage points, with the twenty-fifth percentile averaging 1.5 percentage points and the seventy-fifth percentile averaging 6.2 percentage points, meaning that half of all respondents held expectations within that range. The time-series correlations were quite high, as the correlation between the twenty-fifth percentile and the median was 0.91 and the correlation between the seventy-fifth percentile and the median was 0.97 (see Figure 3.5).

The interquartile range provides some interesting information about trends in inflation expectations. Increases in the variance occur abruptly, but decreases take place over an extended time period. Perhaps the clearest example is the sudden increase in variance at the time of the first war with Iraq in 1991. Following that increase, the variance of inflation expectation decreased gradually over the next decade (see Figure 3.6). Central banks have interpreted this to indicate that their credibility can be lost suddenly, and can then take a considerable period of time to re-establish.

What do the cross-section and time-series variations in inflation expectations indicate? There have been some that have used these variations as a strong

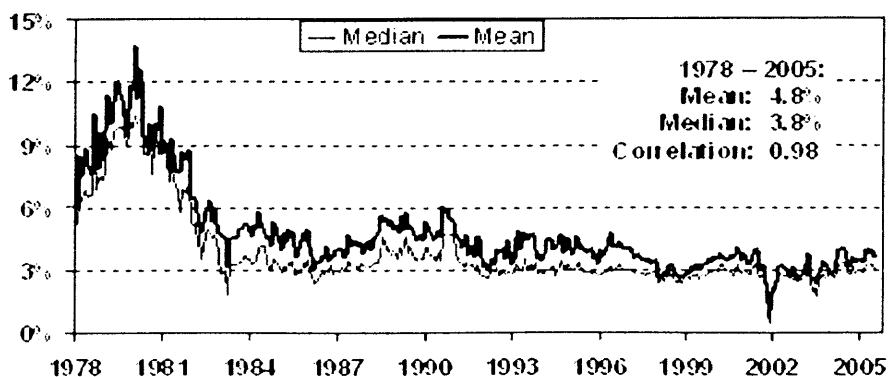


Figure 3.4 Median and mean inflation expectations (monthly data, 1978–2005).

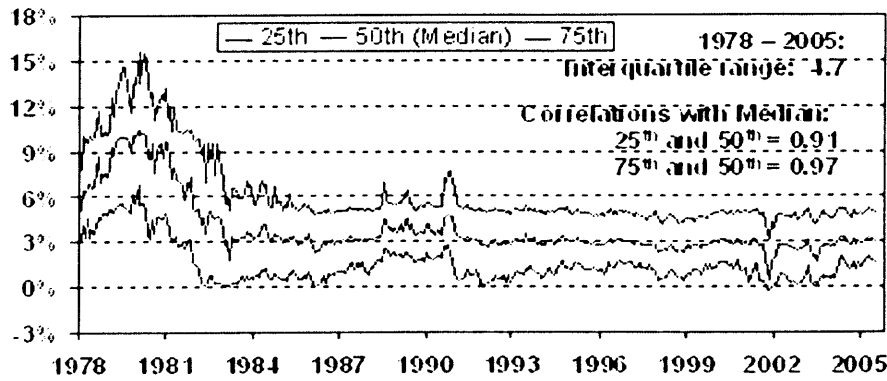


Figure 3.5 Inflation expectations: twenty-fifth, fiftieth, and seventy-fifth percentiles.

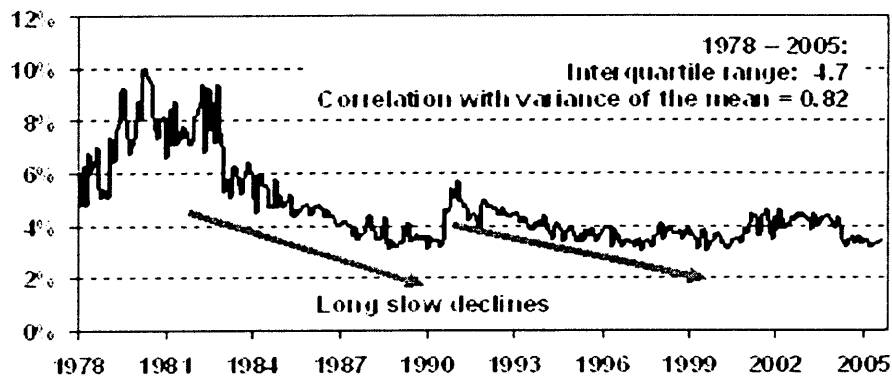


Figure 3.6 Inflation expectations: interquartile range.

indicator of vast measurement error, making the data worthless. Others, as I have already noted, interpret the variations as a reflection of the costs of collecting and processing information, which results in a staggered updating across respondents. While the more extreme responses may well reflect measurement errors, most of the disagreement or heterogeneity reflects the balancing of costs and benefits of updating expectations. To explore these issues in more detail, repeated measures on the same individuals are needed.

Panel data on expectations

The sample design of the monthly surveys of consumers includes a rotating panel. In the rotating panel design, each monthly sample is composed of a new representative subsample, as well as a re-interview subsample of all respondents who were first interviewed six months earlier. The design was chosen to enhance the study of change in expectations and behavior. In the present context, the sample design means that, for each respondent, two measures of inflation expectations were collected six months apart. In each interview, respondents were asked about the expected inflation rate during the following 12 months. As a

result, the two instances of the question do not ask about identical time periods but do contain overlapping periods of six months.

This design enables a partial test of the hypothesis of staggered information flows. The staggered information hypothesis suggests that in any given monthly survey only some of the respondents would have updated their expectations. For this analysis, the sample was restricted to the range January 1993–August 2005, when the inflation rate was more stable, averaging 2.5 percent. More importantly, the average change in the actual inflation rate over all six-month intervals within this time period was nearly zero, or more exactly 0.0005 percentage points. In comparison, the average change in inflation expectations among identical individuals was -0.247 , or a decrease of one-quarter of a percentage point. The negative change in inflation expectations probably reflects the persistent declines in the inflation rate over the 1993–2005 period. Overall, given that the consumer data on inflation expectations are collected as rounded integers, the two sources were remarkably close.

The average absolute differences, however, clearly indicate much greater change in the inflation expectations data among panel members. The average absolute differences were 0.48 percentage points for the change in the actual inflation rate and 2.8 percentage points for the change in inflation expectations. This amounted to absolute changes in expectations that were more than five times the change in the actual inflation rate.

A simple regression indicated that for each percentage point change in the actual annualized rate of inflation during the prior six months, consumers changed their inflation expectations by about 0.5 percentage points. This response indicates that consumers did not fully update their inflation expectations, as would be suggested by the staggered information hypothesis. Indeed, across all respondents from 1993 to 2005, 27 percent reported the same inflation expectation in the two surveys. Among the 73 percent that updated their expectations, 35 percent reported a higher inflation expectation in the second interview and 38 percent reported a lower inflation expectation.

Costs of updating expectations

Any observed change in inflation expectations over the six-month period cannot be taken as proof that inflation expectations were updated. The observed change may simply indicate measurement error rather than true change. A noted advantage of panel surveys is that stable sources of measurement error can be eliminated by taking the difference between the two interview measures. Since it is usually assumed that measurement error reflects specific questions and specific subgroups, by asking the same person the same question on two occasions, the measurement error would be eliminated by taking the difference of the two responses.

This by no means eliminates all measurement error, but it does eliminate errors that are likely to be associated with systematic bias. Random error in measurement remains, which increases the variance of the measurements. For

example, if expectations were not updated, measurement errors could create a difference where none had existed. Such random variation increases the proportion of unexplained variance, but does not create biased estimates.

Based on the six-month differences, comparisons were made across selected demographic subgroups that could be reasonably expected to differ in the costs of updating inflation expectations. Education was selected given that the formation of inflation expectations is assumed to critically depend on the ability of the respondents to gather and interpret information; gender was selected since information gathered from personal shopping experience may provide advantage to women;⁷ age and income were selected since the economic situation and experiences are likely to differ over the life cycle.

Given that the purpose of the analysis is to identify groups with relatively high or low heterogeneity, the overall sample mean was subtracted, with the analysis focused on the deviations from the mean. Recall that the observed change in inflation expectations was one-quarter of a percentage point, compared with the change in the actual CPI across all six-month intervals of zero in the 1993–2005 period.

A second measure of relative heterogeneity is the ratio of individual differences to the sample difference. Thus, when the ratio was above 1.0 for a particular subgroup, it would exhibit more heterogeneity than the rest of the panel during that six-month interval. The sample consisted of 26,611 cases that had complete data on both measures, with the interviews conducted from 1993 to 2005.

Consider the results for gender as shown in Table 3.1. Men raised their inflation expectations by +0.080 percentage points over the six-month interval on average, nearly the exact opposite of the –0.075 decline recorded by women. Recall that the overall sample mean was –0.247, so the positive deviation of +0.080 for men was closer to the average actual change in the CPI of 0.0. The absolute differences were also offsetting, although the average absolute differences were much larger: men recorded a smaller than average absolute error of –0.452 and women a larger error of +0.424. The ratio data indicated that the error among men was 67.6 percent of the average and for women it was 130.4 percent of the sample average. The difference was somewhat narrower with the ratio of the absolute errors.

The differences by education level conform to the hypothesis that the costs of collecting and processing relevant data decline as education increases. In the lowest education subgroup, the average change in inflation expectations was 2.9 times as large as the average, while among the highest education subgroup the change was just about half the average. The effect across education subgroups was nearly linear and significant, with higher education groups exhibiting less heterogeneity.

The results indicated that both the youngest and oldest age groups exhibited greater heterogeneity in expectations. The results, however, were not as large nor as consistent as those recorded by education. Indeed, none of the average deviations were significant, and only some of the absolute deviations proved to

Table 3.1 Change in inflation expectations over the six-month interval within selected demographic subgroups, panel data 1993–2005

Population subgroup	Deviations from sample means		Ratio to sample means	
	ΔP^e (standard error)	$ \Delta P^e $ (standard error)	ΔP^* (standard error)	$ \Delta P^e $ (standard error)
All households	0.000 (0.032)	0.000 (0.026)	1.000 (0.128)	1.000 (0.009)
Gender				
Male	0.080 (0.038) ^a	-0.452 (0.031) ^a	0.676 (0.152) ^b	0.843 (0.011) ^b
Female	-0.075 (0.050)	0.424 (0.042) ^a	1.304 (0.204)	1.147 (0.015) ^b
Education				
Less than high school	-0.476 (0.209) ^a	1.504 (0.179) ^a	2.925 (0.847) ^b	1.522 (0.062) ^b
High school	-0.176 (0.067) ^a	0.368 (0.055) ^a	1.713 (0.269) ^b	1.128 (0.019) ^b
Some college	0.078 (0.065)	0.086 (0.053)	0.683 (0.263)	1.030 (0.018)
College degree	0.157 (0.050) ^a	-0.425 (0.041) ^a	0.365 (0.203) ^b	0.852 (0.014) ^b
Graduate studies	0.122 (0.059) ^a	-0.631 (0.048) ^a	0.508 (0.240) ^b	0.781 (0.017) ^b
Age				
18–34	-0.097 (0.069)	0.326 (0.058) ^a	1.392 (0.280)	1.113 (0.020) ^b
35–44	-0.037 (0.061)	-0.084 (0.051)	1.151 (0.247)	0.971 (0.018)
45–54	0.075 (0.063)	-0.255 (0.052) ^a	0.696 (0.256)	0.911 (0.018) ^b
55–64	0.119 (0.081)	-0.203 (0.067) ^a	0.519 (0.325)	0.929 (0.023) ^b
65 or older	0.009 (0.086)	0.106 (0.072)	0.964 (0.346)	1.037 (0.025)
Household income				
Bottom fifth	-0.177 (0.130)	1.005 (0.109) ^a	1.714 (0.528)	1.349 (0.038) ^b
Second fifth	-0.122 (0.093)	0.453 (0.078) ^a	1.494 (0.378)	1.157 (0.027) ^b
Middle fifth	-0.172 (0.071) ^a	0.098 (0.059)	1.696 (0.289) ^b	1.034 (0.020)
Fourth fifth	0.111 (0.059)	-0.248 (0.048) ^a	0.552 (0.237)	0.914 (0.017) ^b
Top fifth	0.194 (0.048) ^a	-0.579 (0.039) ^a	0.216 (0.194) ^b	0.799 (0.014) ^b

Note

The average actual change in the CPI-u inflation rate was 0.0 across all six-month intervals.

a Significantly different from 0.0 at 95 percent confidence level.

b Significantly different from 1.0 at 95 percent confidence level.

be significant. The results by income groups indicate that the least heterogeneity was among the top 40 percent of the income distribution, and the largest heterogeneity was among those in the lowest fifth of the income distribution.

Overall, the data provide some support for the hypothesis that the costs involved in collecting and processing information play a role in the decision to update inflation expectations. Among groups that faced higher costs, the level of heterogeneity was greater, indicating less frequent updating, most notably among the least educated. Correspondingly, groups that faced lower costs and higher benefits exhibited more frequent updating and less heterogeneity, most strongly shown by upper income subgroups.

Staggered information flows

Although the two-wave panel data cannot rigorously test theories of staggered information flows, it can provide some guidance. The theory is typically expressed in terms of the delayed response in updating expectations. Since the panel includes a measure of only one change in expectations, an analysis of the timing of the updating of expectations over time is not possible. Instead, the process can be conceptualized in reverse: rather than postulating that a given change in the actual inflation rate has a staggered impact on a series of future changes in expectations, it is postulated that a given change in inflation expectations resulted from the staggered impact of a series of past changes in the actual inflation rate.

Past changes in the actual inflation rate were used as predictors in a regression analysis of the change in inflation expectations. For this analysis, the past change in the inflation rate was defined as the difference between the monthly change in the CPI (at annual rates) at time t and t_{-j} . Since the measured change in inflation expectations occurred over a six-month interval, changes in the actual inflation rate within that six-month interval would not unambiguously support the hypothesis of staggered information flows. Changes in the actual inflation rate that occurred more than six months ago could more reasonably be anticipated to support the hypothesis. Twelve lagged changes in the monthly inflation rate were entered into the regression. Dummy variables for the demographic characteristics discussed above were also included.

The results of the regression are shown in Table 3.2. While the first six lags of the actual change in the inflation rate were significant contributors to the change in inflation expectations, this could simply reflect normal updating, not the staggered information hypothesis. The coefficients increase from the first lag to the fourth lag and reach a peak at the sixth lag. The significance of the seventh to the tenth lags offers greater support for the hypothesis that staggered information flows have a significant impact on expectations. It is of some importance to note that all of these variables combined explained just 1 percent of the total variation in inflation expectations. So, even if the data support the staggered information hypothesis, the support is quite meager.

Table 3.2 Impact of lagged changes in actual inflation rate on change in inflation expectations, 1993 to 2005

	<i>Coefficient</i>	<i>Standard error</i>
Intercept	-0.188	0.113
Monthly change in CPI		
Lag 1	0.107*	0.016
Lag 2	0.167*	0.019
Lag 3	0.238*	0.024
Lag 4	0.301*	0.027
Lag 5	0.331*	0.029
Lag 6	0.339*	0.030
Lag 7	0.252*	0.029
Lag 8	0.177*	0.029
Lag 9	0.128*	0.027
Lag 10	0.087*	0.025
Lag 11	0.024	0.020
Lag 12	0.007	0.017
Sex		
Male (excluded)		
Female	-0.130*	0.064
Education		
Less than high school	-0.560*	0.151
High school	-0.241*	0.089
Some college (excluded)		
College degree	0.032	0.091
Graduate studies	-0.038	0.105
Age		
18-34	-0.138	0.094
35-44	-0.103	0.094
45-54 (excluded)		
55-64	0.078	0.112
65 or older	0.090	0.110
Income		
Bottom fifth	0.072	0.119
Second fifth	0.062	0.103
Middle (excluded)		
Fourth fifth	0.248*	0.092
Top fifth	0.276*	0.093
R ² adjusted	0.010	
Cases	26,611	

Note

*Significantly different from 0.0 at 95 percent confidence level .

Asymmetric impact of information

The hypothesis that unfavorable information about inflation prompts widespread and prompt responses in inflation expectations can be tested by a comparison of positive and negative changes in the actual inflation rate with subsequent changes in expectations. For each six-month interval in the panel, the change in

inflation expectations was compared with the change in the actual inflation rate during the prior six months, with negative and positive changes entered separately. The regressions included 26,611 cases from 1993 to 2005.

The estimated results were consistent with the hypothesis that increases in the inflation rate had a much larger impact than declines on inflation expectations. The coefficient for an increase in inflation was 0.117 (standard error of 0.020), nearly twice the size of the coefficient for declines in inflation of 0.068 (standard error of 0.020). The estimate that negative news about inflation was twice as powerful as positive news is consistent with prospect theory (Kahneman and Tversky, 1979).

The asymmetrical response of inflation expectations may mean that there is also an asymmetrical response to changes in the perceived credibility of central banks. Increases in inflation will more promptly diminish the credibility of central banks, but declines in inflation will only slowly rebuild lost credibility.

Backward- or forward-looking expectations?

Tests of whether the formation of inflation expectations represents a backward- or forward-looking process have typically been examined in separate equations, with the analyst having the responsibility of judging the comparative evidence. There is a way to nest both hypotheses in the same reduced-form equation by regressing current inflation expectations on both past and *future* changes in the actual inflation rate. Strong support for the adaptive hypothesis would be demonstrated if past, but not future, changes in the actual inflation rate were significant predictors, while support for forward-looking expectations would be shown if future, but not past, changes in the actual inflation rate were significant predictors. The resulting equation is simply another method to test for “Granger causality” (Geweke *et al.*, 1983). The estimated equation used from 1978 to 2005 was:

$$P_t^e = 0.895 + 0.291 \sum_{j=1}^4 P_{t-j} + 0.318 P_t - 0.089 \sum_{j=1}^4 P_{t-j} \quad (0.276) \quad (0.106) \quad (0.148) \quad (0.151)$$

$$P_{t-j} + 0.172 \sum_{j=1}^4 P_{t-j}^e R^2 = 0.954 \quad (0.252)$$

The data indicate that higher *future* changes in the inflation rate were positively associated with increases in *current* expectations. The coefficients for the four-quarter lead (indicated by *t* ranging from +1 to +4) in the rate of inflation were both positive and significant, at more than twice its standard error. A separate chi-square test on the exclusion of the four-quarter lead was easily rejected ($p=0.006$). In contrast, the coefficients for the four-quarter lag (indicated by *t* ranging from -1 to -4) were clearly insignificant, thereby rejecting the adaptive

hypothesis. Moreover, the coefficients were negative, exactly the opposite of what the adaptive hypothesis would predict.

Expectations also incorporate contemporaneous information on the inflation rate, even though the survey has always been completed well in advance of the announcement of the official inflation rate. Unlike past changes in inflation, contemporaneous changes in inflation had the anticipated positive impact on expectations. The significance of the contemporaneous inflation rate indicates that consumers obtain information about current inflationary trends from sources other than the official announcements.

Rational expectations hypothesis

Tests on whether the Michigan data on inflation expectations meet the rigorous criteria imposed by the rational expectations hypothesis have been repeatedly conducted during the past 25 years.⁸ The data have never given unequivocal support to the rational expectations hypothesis, with the principle failing due to the lack of efficient use of all available information.^{9,10} Thomas (1999: 141–142) summarized his findings by noting that “consensus household inflation forecasts do surprisingly well relative to those of the presumably better-informed professional economists.” Indeed, the median consumer forecasts of year-ahead inflation rates “outperformed all other forecasts in the 1981–1997 period on simple tests of accuracy as well as on tests for unbiasedness.” Mehra (2002: 35) also finds that Michigan’s median inflation expectations outperforms the expectations of professional economists and forecasters: “They are more accurate, unbiased, have predictive content for future inflation, and are efficient with respect to economic variables generally considered pertinent to the behavior of inflation.” As noted at the start of this chapter, it was findings such as these that originally motivated Muth to advance the rational expectations hypothesis.

Let us focus on the puzzle that consumers’ performance at forecasting the inflation rate is comparable to forecasts by economists. This finding is more troublesome for those who favor some form of the adaptation hypothesis, but it is also quite difficult to argue that the costs of collecting and processing information are not significantly lower for economists than for consumers. Only under the hypothesis that the costs are trivial would no significant differences between economists and consumers be anticipated.

Another hypothesis is that the errors in consumer expectations are offsetting, and as a consequence the tests were misleading. Thus, the errors could be quite large – say, a significant underestimate among men is offset by a significant overestimate among women, or similar offsetting shifts among education or age subgroups. To examine this issue, a number of regressions were performed for a selection of demographic subgroups. Given that survey data usually involve some aggregation errors, the regression was calculated using nonlinear least squares to estimate a moving-average error term, using a consistent estimate of the covariance matrix that allows for serial correlation and heteroscedasticity. The overlapping forecast intervals generated by the survey questions could

produce serially correlated errors even among perfectly rational agents (Croushore, 1998). In fact, a significant first order moving average error term was found in all equations. The residuals are also tested for the inefficient use of information on inflation, but no tests were attempted for the inefficient use of other relevant information (what is called strong efficiency).

Regressions were estimated for men and women, as well as for different education and age subgroups. The results are reported in Table 3.3. The regressions are based on quarterly observations from 1978 to 2005. Given the rather small monthly sample sizes, to ensure that estimates for each subgroup were based on a sufficient number of cases, the independent monthly samples were pooled into quarterly observations to calculate the median inflation expectations for each subgroup.¹¹

The results of the analysis indicated that rather than offsetting errors, the year-ahead inflation expectations of each of the demographic groups were an unbiased estimate of the actual inflation rate. The null hypothesis that inflation expectations were a biased estimate was rejected for every demographic subgroup at the 95 percent confidence level: every constant term was insignificantly different from 0, and every estimated coefficient on inflation expectations was insignificantly different from 1. Every equation had a significant estimate of the moving average error term, but only among the least educated and the older respondents was there any evidence of the inefficient use of information about the inflation rate that was available at the time their expectations were formed.

These results have always been met with disbelief. Could it be that the costs of forming unbiased inflation expectations are more manageable based on staggered updating? Does the presumably lower cost and greater importance of private information play a more pivotal role in the formation of expectations than suggested by current theories? Or is the accuracy of expectations a property of groups and consensus forecasts? Could it be that the rational expectations hypothesis is true at the macro but not at the micro level?

Concluding comments

There are at least as many unresolved issues now as when the rational expectations hypothesis was first advanced nearly a half century ago. Indeed, the findings from this analysis can be summarized in much the same way as Muth did in his classic article: consumers' inflation expectations are forward looking, they are generally as accurate as the forecasts of economic models, and they more closely correspond to the hypothesis of rational expectations than to the backward-looking hypothesis of adaptation.

There is no doubt that people sometimes engage in adaptive behavior, correct past errors, or simply rely on extrapolation to form expectations. These shortcuts are used to help reduce the costs involved in collecting and processing data. These costs result in staggered changes in expectations. In turn, staggered or sticky expectations are the likely cause of the findings that consumers do not take into account all available information when forming their expectations. It is

Table 3.3 Tests of rational expectations hypothesis based on University of Michigan's inflation expectations data, quarterly data 1978-2005

Population Subgroup	Unbiased $\rightarrow \alpha = 0$ and $\beta = 1$ $P_t = \alpha + \beta P_t^{E-t}$		Efficiency $\rightarrow \delta = 0$ and $\varphi = 0$ $e_t = \delta + \varphi P_{t-s}$					
	α	β	θ	R^2	χ^2 for H_0	δ	φ	R^2
All households	-0.414 (0.533)	1.184 (0.181)	0.655* (0.108)	0.884	1.538 [0.464]	0.030 (0.158)	-0.035 (0.039)	0.005
<i>Gender</i>								
Male	-0.135 (0.524)	1.158 (0.177)	0.726* (0.081)	0.893	3.861 [0.145]	-0.004 (0.153)	-0.024 (0.037)	0.000
Female	-0.605 (0.594)	1.181 (0.186)	0.588* (0.145)	0.862	1.037 [0.594]	-0.011 (0.170)	-0.031 (0.042)	0.000
<i>Education</i>								
Less than high school	-0.323 (0.692)	1.148 (0.221)	0.574* (0.091)	0.800	0.722 [0.697]	-0.551* (0.195)	0.091* (0.033)	0.051
High school	-0.482 (0.610)	1.208 (0.189)	0.611* (0.076)	0.866	1.895 [0.388]	-0.121 (0.167)	0.001 (0.037)	0.000
Some college	0.082 (0.635)	1.064 (0.208)	0.607* (0.118)	0.850	1.946 [0.378]	-0.105 (0.204)	-0.009 (0.056)	0.000
College degree	0.113 (0.514)	1.049 (0.175)	0.568* (0.172)	0.853	1.960 [0.375]	-0.048 (0.187)	-0.021 (0.049)	0.000
Graduate studies	0.061 (0.588)	0.998 (0.189)	0.712* (0.081)	0.876	0.107 [0.948]	-0.027 (0.195)	-0.022 (0.058)	0.000
<i>Age</i>								
18-34	-0.139 (0.589)	1.068 (0.190)	0.556* (0.128)	0.849	0.243 [0.886]	-0.032 (0.199)	-0.026 (0.057)	0.000
35-44	-0.150 (0.585)	1.064 (0.184)	0.624* (0.129)	0.869	0.181 [0.914]	0.004 (0.194)	-0.029 (0.054)	0.000
45-54	-0.229 (0.582)	1.143 (0.187)	0.590* (0.095)	0.866	1.739 [0.419]	-0.052 (0.176)	-0.017 (0.041)	0.000

55-64	-0.153 (0.569)	1.233 (0.188)	0.647* (0.071)	0.864	8.089* [0.018]	-0.318* (0.158)	0.048 (0.029)	0.012
65 or older	1.356 (0.774)	0.834 (0.271)	0.766* (0.074)	0.789	8.538* [0.014]	-0.929* (0.175)	0.179* (0.042)	0.218

Notes

Standard errors in parentheses; probability level of χ^2 in brackets. All standard errors and covariances calculated using the Newey-West procedure. All estimated equations included a moving average error term.

An asterisk indicates significance at the 0.05 percent level; significance tests on all coefficients except β were for differences from 0.0 and tests on β were for differences from 1.0. R^2 adjusted for degrees of freedom.

simply too costly given the expected benefit. These findings, however, do not contradict the rational expectations hypothesis, but act to incorporate the hypothesis more fully into the standard economic framework.

Moreover, the finding that consumers are not fully rational in forming their inflation expectations is as surprising as the finding that consumers do not fully maximize their utility. The profession needs to accept what amounts to a simplifying assumption that is roughly consistent with the evidence at the macro level. The acceptance should be based on its predictive performance, not on the realism of the theory's assumptions. To be sure, full rationality is not likely to be observed in everyday life among consumers, nor even among economists. Analysis at the micro level still needs to more fully incorporate aspects of bounded rationality and other innovations of behavioral theory.

Most of the theoretical implication of rationality for monetary policy, however, may be closely approximated by "nearly rational" expectations. Without a more exact and universal definition of what "near rationality" means, that glass will be seen as half empty by some and half full by others. It is that unresolved ambiguity that continues to make monetary policy an interesting and challenging task.

Notes

- 1 Many economists have reinterpreted Muth's original hypothesis to apply at the micro rather than at the aggregate level (Begg, 1982). They reason that given that utility maximization is assumed to be true for each individual, the rational expectations hypothesis should be tested at the micro level. Some analysts have even claimed that the only appropriate test of the rational expectations hypothesis would be based on panel data. Some have also argued that the aggregation involved in time-series tests result in inconsistent estimates and masks offsetting individual differences (Figlewski and Wachtel, 1983; Kean and Runkle, 1990).
- 2 Plato wrote that "each man possesses opinions about the future, which go by the general name of expectations." (Plato, *Laws 644c*, 360BC).
- 3 The larger variance that has often been associated with higher expected inflation rates in the literature may be partially due to the truncation of the distribution at zero.
- 4 Transforming qualitative expectations into quantitative estimates has been done for inflation expectations with mixed success. Different methods have been used to "quantify" qualitative measures of expectations, with the Carlson-Parkin (1975) technique the most widely known. These techniques involve an assumption about the underlying and unobserved distribution of expectations (typically assumed normal, but other distributional assumptions have been used) combined with an assumption that across the entire time-series, expectations are unbiased and equal to realizations (although other identifying assumptions are possible). See Batchelor (1986) and Pesaran (1987) for a review of these techniques.
- 5 There is a long-standing debate about whether large estimates (say, five or more times the median or mean) should be deleted and thus treated as missing data, or whether some information can be retained, namely that the respondent expected a large increase, and the data should simply be truncated.
- 6 The correlation between the interquartile range and the variance of the mean was 0.82.
- 7 Persistent differences in inflation expectations between men and women have been documented in the past (Bryan and Venkatu, 2001).
- 8 See Lott and Miller (1982), Gramlich (1983), Grant and Thomas (1999), Thomas

- (1999), Mehra (2002), Roberts (1997), Badhestani (1992), Bryan and Gavin (1986), Noble and Fields (1982), and Batchelor and Dua (1989).
- 9 Cukierman (1986) has suggested that this is not a clear violation of the rational expectations hypothesis, since households may not always correctly distinguish between temporary and permanent shocks and thus their forecasts could exhibit serially correlated errors.
 - 10 Similar comparisons were done for year-ahead forecasts of the national unemployment rate. Curtin (1999, 2003) found that consumers' forecasts of the year-ahead unemployment rate outperformed those of professional forecasters as well as forecasts from two prominent macroeconomic models.
 - 11 Insufficient data in the first half of the period made it impossible to code real household income in a consistent fashion and so this variable was excluded from this analysis.

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