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The Effect of Forecast Bias on Market Behavior: Evidence from Experimental Asset Markets

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Abstract: This paper reports the results of 15 experimental asset markets designed to investigate the effect of optimistic forecast bias on market behavior. Each market is organized as a double oral auction in which participants trade a single-period asset with uncertain value. Traders are informed of the asset value distribution and, prior to trading, given the opportunity to acquire a forecast of the asset's period-end value. The degree of forecast bias is manipulated across experimental sessions so that in some sessions the forecast contains a systematic, upward (low or high) bias. We conduct sessions with inexperienced and experienced traders. The results suggest that market prices are supportive of a full revelation unbiased price in the unbiased markets and the experienced, low-bias markets. The results from the low-bias markets indicate that as long as traders have sufficient experience with such forecasts, asset prices reflect the debiased forecasts. In contrast, we find no evidence that high-bias forecasts are reflected in market prices, regardless of experience. We also find that the demand for forecasted information persists over time, but it is greater in the unbiased and low-bias conditions than in the high-bias condition. Finally, we provide little evidence that the net profit (that is, net of the information cost) of informed and uninformed traders differs, regardless of bias condition or experience level.

JEL classification: C92, D82

Key words: forecast bias, earnings forecasts, experimental asset markets

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The Effect of Forecast Bias on Market Behavior:

Evidence From Experimental Asset Markets

1. Introduction

This paper reports the results of a series of experimental asset markets designed to investigate the effect of optimistic forecast bias on market behavior. Although empirical evidence suggests that analysts' earnings forecasts have information content and are valued by market participants (Lys and Sohn [1990] and Stickel [1991]), many archival studies document that such forecasts are biased upward (e.g., De Bondt and Thaler [1990], Abarbanell [1991], and Ali, Klein, and Rosenfeld [1992]). For example, published reports put analysts' estimates of earnings growth for the S&P 500 in 1999 at 19 percent, as compared to market strategists' and economists' estimates of 4.1 percent (Browning, Ip, and Scism [November 24, 1998, p. A10:1] and *New York Tines* [November 25, 1998, p. C7:3]). The popular press suggests that analysts routinely play up good news and sugarcoat bad news (Laderman [1998, p. 150]).

Academic research suggests that analysts have incentives to issue optimistic forecasts (Schipper [1991], Francis and Philbrick [1993], and Lin and McNichols [1998]) or withhold pessimistic ones (McNichols and O'Brien [1997]). Dugar and Nathan (1995) and Lin and McNichols (1998) find that analysts whose firms have underwriting relationships issue more favorable recommendations than unaffiliated analysts. While the importance of such incentives is recognized, the effect of optimistic bias on market behavior is not well understood. For example, Lin and McNichols find a significant market reaction to affiliated and unaffiliated analysts' reports while Dugar and Nathan find no stock price response to affiliated analysts' reports.

Prior research has also examined the effect of optimistic bias on behavior in judgment and decision-making tasks. Hirst, Koonce, and Simko (1995) find that investors are cognizant of analysts' differential incentives; however, such knowledge does not necessarily affect their assessments of stock performance. Ackert, Church, and Shehata (1997a) report that individuals recognize the usefulness of forecasts with a small upward bias and learn to adjust for the bias. By comparison, individuals have much more difficulty with forecasts that reflect a large bias because the information is not perceived to be useful. Ackert, Church, and Shehata (1996) offer additional evidence that the perceived usefulness of information affects individuals' performance in judgment tasks. The current study extends this line of experimental research. We provide a controlled examination of the effect of optimistic bias on behavior in a market setting.

Briefly, we conduct 15 experimental markets, each organized as a double oral auction, in which participants trade a single-period asset with uncertain value. Traders are informed of the asset value distribution and given the opportunity to acquire a forecast of the asset's period-end value prior to trading. The degree of forecast bias is manipulated across experimental sessions so that in some sessions the forecast contains a systematic, upward (low or high) bias. We conduct sessions with inexperienced and experienced traders because prior findings suggest that traders' participation in an earlier market with identical features can affect observed behavior (e.g., Forsythe and Lundholm [1990] and Ackert and Church [1998a]). We recognize that biased forecasts may introduce additional complexities in a market setting and that experience may be necessary in order for behavior to settle down.

Several benefits arise from the use of an experimental approach. We are able to carefully regulate the degree of forecast bias, flow of information to the market, and fundamental

determinants of asset value. These aspects create the potential for confounds and are difficult to control in studies using archival data. Our primary objective is to examine the effect of forecast bias on price dynamics in a market setting. The crucial question is how individual behavior translates into market behavior. To shed insight into price dynamics we also investigate forecast acquisition decisions and the distribution of profit across informed and uninformed traders. We investigate whether prices reflect adjustment for bias (the debiased forecast) and the efficient dissemination of information available to market participants. Although previous experimental research has examined market behavior in the presence of private information, these studies have not explored instances in which private information contains a systematic, upward bias.[1] The current study provides an opportunity to examine the effect of such a bias on market outcomes.

Our results suggest that market prices support the full revelation unbiased price in the unbiased markets. In addition, asset prices reflect adjusted low bias forecasts as long as traders have sufficient experience with such forecasts. Private information is disseminated in these markets and prices reflect the debiased forecast. In contrast, we do not find any evidence that high bias forecasts are reflected in market prices, regardless of experience. We also find that the demand for forecasted information persists over time, but demand is greater in the unbiased and low bias conditions than the high bias condition. The forecast acquisition data suggest that traders in the high bias condition have more difficulty recognizing the usefulness of forecasts than those in the low bias condition. Finally, we provide little evidence of differences in the profit, net of information cost, of informed and uninformed traders, regardless of bias condition or experience level.

The framework for the study is provided in section 2. The experimental procedures are described in section 3 with the results presented in section 4. The final section provides a summary and concluding remarks.

2. Framework

We examine three forecast bias conditions: forecasts are unbiased, forecasts contain low systematic upward bias, and forecasts contain high systematic upward bias. In the unbiased condition, the forecast is equal to the asset value plus a small, mean zero stochastic error term. In the two bias conditions, the forecast is equal to the unbiased forecast plus a positive constant. In addition, we investigate whether experience in an earlier market affects behavior. For each market set we investigate (1) observed asset prices, (2) the frequency of forecast acquisition, and (3) the profit of informed versus uninformed traders.

If market prices reflect all available information and market participants are able to use the information contained in the forecast, prices should converge to the forecast less the constant, systematic bias. We refer to the benchmark in this case as the full revelation unbiased price (FR^U). Alternatively, private information may not be disseminated and prices may converge to the mean of the asset value distribution. This case is referred to as the no revelation price (NR).

Experimental markets studies indicate that under various conditions private information about asset value is fully revealed in transaction prices (Plott and Sunder [1982], Banks [1985], and Sunder [1992]). In our study private information provides a useful signal of asset value, but is not perfect. The extent to which market prices reflect private information is affected fundamentally by informed agents' abilities to decipher the relationship between forecasts and

asset value. Ackert, Church, and Shehata (1997a) report that individuals are able to effectively use unbiased and low bias forecasts, but encounter difficulties assessing a high bias. Hence, we expect to observe convergence to FR^U in the unbiased and low bias conditions and NR in the high bias condition.

The full revelation price prediction assumes that forecasted information is demanded. In our markets, participants are given the opportunity to purchase a forecast of the asset's value each period at a fixed price. Theoretically if asset prices fully reveal information, the number of traders who acquire the forecast should converge to zero. But zero forecast acquisitions is not an equilibrium because when no one acquires the information, every trader has the incentive to purchase the forecast.

Sunder (1992) finds that perfect information is demanded across a variety of conditions in a market setting. Ackert, Church, and Shehata (1997b) find similar results with imperfect information. Both studies document that demand for information fluctuates, sometimes widely, and shows no evidence of convergence to zero. Other research on individual behavior indicates that participants perceive that forecasted information is useful, even when the information contains optimistic bias (Ackert, Church, and Shehata [1996]). However the magnitude of the bias may affect information acquisition decisions. Ackert, Church, and Shehata (1997a) report that a majority of participants acquire unbiased and low bias forecasts on a continuing basis, whereas the demand for high bias forecasts is significantly less. Given the prior results, we expect that forecasted information will be acquired and that the number of traders acquiring the forecast will not converge to zero over time, regardless of the degree of forecast bias. Based on the findings of Ackert, Church, and Shehata (1997a), we also investigate whether forecast bias affects

the frequency of forecast acquisition: that is, whether traders in the high bias condition acquire forecasts less frequently than those in the unbiased and low bias conditions.

Traders may acquire forecasted information over time as along as they believe that, at a minimum, the cost of the forecast can be recovered. Price variation, particularly early in a trading period, may allow informed traders to recover the cost of the forecast. Sunder (1992) finds that prices fail to instantaneously reflect private information so that the net profit of informed traders (i.e., earnings less information cost) is not significantly different from that of the uninformed. Under FR^U, informed traders are expected to effectively use forecasted information and recover the cost of such information.[2] Hence, we do not expect the net profit of informed and uninformed traders to differ in the unbiased and low bias conditions. The expectation differs in the high bias condition, in which case informed agents are expected to have difficulty assessing the bias. They may be unable to effectively use forecasted information and, as a consequence, may not recover the cost of the information. We examine whether the net profit of informed traders is less than that of the uninformed in the high bias condition.

3. Experimental Method

3.1 DESIGN

Fifteen experimental asset markets are conducted. We vary the degree of forecast bias across sessions. In markets 1-3 and 1x-2x, the forecast is an unbiased estimate of asset value (i.e., the period-end dividend). In markets 4-9 and 3x-6x, the forecast contains a systematic, upward bias. The relative magnitude of the bias is low in markets 4-6 and 3x-4x and high in markets 7-9 and 5x-6x. Participants are inexperienced in markets 1-9 and experienced in markets 1x-6x,

where experienced traders have taken part in an earlier market under the same forecast bias condition. The experimental design is summarized in table 1.

3.2 PROCEDURES

At the beginning of each session, participants receive a set of instructions that is read aloud by an experimenter. Each market has eight traders, who are recruited from third- and fourth-year undergraduate and fifth-year post baccalaureate students at a medium-sized university. Substantially all of the participants are students in business or economics.[3] Students earn from $16.44 to $33.49, with an average of $26.05, for participating approximately 120 minutes.

Each market consists of 12 periods during which participants trade certificates with one-period lives. A dividend is received for each certificate held at period end. Participants are instructed that the period-end dividend is determined by drawing from a normal distribution with a mean of $1,200 and a standard deviation of $400.[4] The instructions include a diagram of the density function and state that the dividend is between $800 and $1,600 with a probability of 0.6826, between $600 and $1,800 with a probability of 0.8664, and between $400 and $2,000 with a probability of 0.9544. Further, we note that practically speaking, the dividend is always nonnegative.

Each period participants are endowed with two certificates and $50,000. Participants are informed that they may pay a tax on their dividend earnings, where their tax rate can be either zero or 40 percent. The instructions indicate that the tax rates differ across traders and between periods. Each period half of the participants are randomly assigned each tax rate, with the

constraint that each participant is assigned each rate the same number of times. The different tax rates introduce different preferences for dividend earnings and create incentives to trade.

Prior to the commencement of trading, participants are allowed to purchase a forecast of the period-end asset value at a fixed price of $100. Participants are not, however, provided with any information about the accuracy of the forecast. In the unbiased condition, the forecast is computed as the asset value plus a mean zero, random error term, which is determined by drawing from a normal distribution with a standard deviation of $30. In the low (high) bias condition, the forecast is computed as the unbiased forecast plus a constant of $200 ($400). The unbiased forecast and asset values per period are randomly determined prior to the markets and the same values are used across markets.[5] The preselected values are shown in table 2.

Each period traders are free to make verbal offers to buy or sell one certificate at a designated price and all offers are publicly announced and recorded. Outstanding offers stand until accepted or replaced by a better bid or ask price. All periods last four minutes and participants are not informed beforehand of the number of periods.

At the end of each period, the value of the dividend is publicly announced and the same dividend is received for all certificates held by a participant. Period-end cash balances are computed as follows. The number of certificates on hand is multiplied by the dividend per certificate to determine dividend earnings. This amount is converted to an after-tax figure by multiplying by one minus the tax rate. Participants add the after-tax dividend earnings to their cash balance and then subtract the initial endowment of $50,000. The net amount represents participants' profits for the period. Endowments are reinitialized at the beginning of the subsequent period.

At the conclusion of each session, participants are paid 0.001 of their experimental profits in cash and a post-experiment questionnaire is administered. The questionnaire is designed to collect general information about the participants and how they view the experiment.[6]

4. Results

4.1 OBSERVED PRICES

For each market we investigate whether asset prices converge to the FR^U or NR benchmark. We plot the last transaction price per period along with the relevant benchmark prices. The focus is on the last price per period because earlier transactions are informative.[7] The price plots of six markets are presented in figures 1-6. The markets selected are representative of the different experimental conditions: two markets from each forecast bias condition, with one consisting of inexperienced traders and the other experienced traders. The figures also include the number of forecast acquisitions per period, which is discussed later.

We investigate whether asset prices converge to FR^U in the unbiased and low bias conditions and NR in the high bias condition. An inspection of the price plots suggests that in the unbiased group, asset prices closely track FR^U, particularly when traders are experienced (refer to figures 1-2). In the low bias group, a similar pattern emerges, although the difference between the inexperienced and experienced markets is more pronounced: the markets with experienced traders more closely follow FR^U (refer to figures 3-4). In the high bias group, asset prices do not seem to deviate too much from NR (refer to figures 5-6).

For each market, we count the number of times that the last price per period is closer to FR^U or NR.[8] A summary of the counts by experimental condition is shown table 3. For the

unbiased and low bias markets, we conduct binomial tests to assess whether the proportion of times that the last price is closer to FR^U is greater than a chance occurrence of 50 percent. We focus on the FR^U proportion because in these markets prices are expected to converge to FR^U. As shown in table 3, all four comparisons are statistically significant at $p < 0.005$ (one-tailed tests). Further, the z-statistics are larger for markets with experienced traders, which suggests that experience reinforces a convergence to FR^U. For the high bias markets, we test whether the proportion of times that the last price is closer to NR is greater than 50 percent. The focus is on the NR proportion because in these markets prices are expected to converge to NR. When traders are inexperienced (experienced), the difference is statistically significant at $p = 0.004$ ($p = 0.052$). Overall, the findings are consistent with our a priori expectations.

Next, we perform an analysis-of-variance (ANOVA) to formally assess the effects of forecast bias and experience on asset price behavior. In order to perform a parsimonious analysis, we examine deviations in price from FR^U. The dependent variable is the absolute value of the difference between the last price per period and FR^U normalized by FR^U. Although not reported, inferences are unaffected if we examine deviations in price from NR.

The ANOVA results, shown in panel A of table 4, indicate that both main effects are significant at $p < 0.015$ and that the interaction effect is significant at $p = 0.062$.[9] The cell means, presented in panel B of table 4, indicate that price deviations increase as forecast bias increases and decrease with experience. Additional analysis, however, is necessary because of the marginally significant interaction term. To gain insight into the ANOVA results, we examine the simple effects of forecast bias and experience on price behavior. We find that the price deviations of the unbiased and high bias groups are significantly different at $p < 0.001$ (Tukey HSD pairwise

tests), regardless of experience level. The placement of the low bias group, on the other hand, hinges on experience. This group is significantly different from the unbiased group ($p = 0.027$), but not the high bias group ($p = 0.118$), when traders are inexperienced. Conversely, the low bias group is significantly different from the high bias group ($p < 0.001$), but not the unbiased group ($p = 0.984$) when traders are experienced. Subsequent analysis reveals that experience reduces price deviations in the unbiased and low bias groups ($p < 0.05$), but not the high bias group ($p = 0.906$). Overall, the deviations in price from FR^U are relatively small in the unbiased markets and in the experienced, low bias markets. By comparison, the deviations are much larger (three times larger at a minimum) in the high bias markets.

4.2 FORECAST ACQUISITIONS

We examine the frequency of forecast acquisitions per period and assess whether there are differences across groups. For each experimental condition, the mean and standard deviation of the number of acquisitions per period, computed over periods 1-6, 7-12, and 1-12, are shown in table 5. Approximately six of eight traders (or 75 percent) acquire forecasts in the unbiased and low bias conditions. In contrast, only about four of eight (or 50 percent) acquire forecasts in the high bias condition. The frequency of forecast acquisitions does not appear to be affected by experience nor does it appear to differ across periods 1-6 and 7-12. Inspection of the data indicates that across the 15 markets forecast acquisitions range from two to eight per period and never converge to zero. This finding is consistent with Sunder (1992) and Ackert, Church, and Shehata (1997b) and provides evidence that forecasted information is demanded in a market setting even if it contains an optimistic bias. Further inspection of the data (refer to figures 1-6)

indicates that the number of acquisitions per period typically ranges from five to seven in the unbiased and low bias groups and three to five in the high bias group. Moreover, no discernible pattern in the frequency of forecast acquisitions is apparent over time.

We perform an analysis of variance (ANOVA) to formally assess the effects of forecast bias and experience on the frequency of forecast acquisition. The dependent variable is the proportion of times that each trader acquires the forecast over periods 1-12.[10] The ANOVA results, shown in panel A of table 6, indicate that forecast bias is statistically significant at $p = 0.003$. The mean proportion of acquisitions, shown in panel B of table 6, is 0.773, 0.767, and 0.542 in the unbiased, low bias, and high bias groups, respectively. Tukey HSD pairwise tests indicate that the unbiased and low bias groups are significantly different from the high bias group at $p < 0.01$. This finding is consistent with Ackert, Church, and Shehata (1997a) and suggests that, in a market setting, participants are less willing to acquire high bias forecasts than unbiased or low bias forecasts. Overall, the forecast acquisition results are consistent with a priori expectations.

To gain additional insight into participants' forecast acquisition decisions, we investigate their responses to the post-experiment questionnaire, which includes the following: if you acquired the forecast at all during the experiment, what affected your decision to continue or stop acquiring the information? Participants' responses and corresponding frequencies are summarized in table 7. The most commonly listed factor is that the forecast provides a range or guide to determine trading behavior. Tax rates are the next most frequently listed factor. Subsequent investigation indicates that forecasts are acquired more often when a trader's tax rate (on dividend earnings) is zero as opposed to 40 percent ($\chi^2 = 44.74$, $p < 0.001$).[11] Participants may perceive

that forecasted information is less useful when their tax rate is 40 percent because, for the most part, they are only interested in selling certificates: transaction prices must be at least 40 percent below the asset's period-end value for them to benefit from buying certificates. When participants have a tax rate of zero, on the other hand, they may benefit from buying or selling certificates. By acquiring the forecast, participants can refine their expectation of the asset's period-end value, which helps them determine whether to buy or sell certificates.

One other factor is listed frequently as underlying participants' forecast acquisition decisions: the perceived accuracy of the forecast. A closer examination of participants' responses reveals a fundamental difference across the forecast bias groups. Those in the unbiased and low bias groups indicate that the forecast is accurate, whereas those in the high bias group indicate that it is not accurate and, thus, of little use. This finding is consistent with Ackert, Church, and Shehata (1997a) and reinforces our earlier results (refer to table 6).

4.3 TRADING PROFIT

Trading profit may be affected by participants' forecast acquisition decisions, pricing efficiencies, and allocational efficiencies. Initially we examine allocational efficiencies to assess the proportion of assets held at period end by traders with a zero tax rate. In the absence of mispricing, all certificates should be held by those who are not taxed on dividend earnings. For each experimental condition, the mean proportion of assets held by these traders, computed over periods 1-6, 7-12, and 1-12, is shown in table 8. Across the different experimental groups, the mean proportion ranges from 73.21 percent to 97.59 percent. The allocational efficiencies are high and similar to those reported elsewhere (e.g., Sunder [1992]). Further examination of the

data suggests that allocational efficiencies improve as time progresses and with experience. We perform an ANOVA to formally test this assertion. The dependent measure is the proportion of assets per period held by traders with a zero tax rate.[12] The independent variables include forecast bias, experience, an interaction term, and a covariate for period. The ANOVA results indicate that experience ($F = 10.12$, $p = 0.002$) and period ($F = 16.73$, $p < 0.001$) are statistically significant and that the sign of the covariate is positive. No other variables are significant at any conventional level. These findings are consistent with our observations.[13]

Next we compare the profit of informed versus uninformed traders. For each market, we compute an average net profit per period for informed and uninformed traders. The computed net profit is then normalized by the period-end dividend. The normalization is necessary because trading profit is directly affected by the magnitude of the dividend which varies across periods. The difference between the normalized net profit of informed and uninformed traders is computed using data from periods 1-6, 7-12, and 1-12. The resulting means by experimental condition are shown in table 9.

We test whether the normalized net profit of informed traders is equal to (less than) that of the uninformed in the unbiased and low bias (high bias) groups. We perform parametric, paired t-tests and nonparametric, Wilcoxon signed ranks tests using data from periods 1-12. For the unbiased and low bias groups, seven of eight test statistics are not significant at conventional levels (refer to table 9). The net profit of informed traders, in general, is not significantly different from that of uninformed traders. This result is consistent with a priori expectations. For the high bias group, two of four test statistics are significant at $p < 0.07$ (refer to table 9). With experienced (inexperienced) traders, the net profit of the informed is significantly less than (not

significantly different from) that of the uninformed. These findings are partially consistent with a priori expectations.

5. Concluding Remarks

This study reports the results of 15 experimental asset markets. We find that market prices reflect unbiased forecasts and, once traders have sufficient experience, low bias forecasts. In the unbiased and experienced, low bias markets, observed prices are supportive of a full revelation unbiased price. In contrast, we do not find any evidence that asset prices reflect high bias forecasts, regardless of experience. The forecast acquisition data indicate that traders acquire unbiased and low bias forecasts more frequently than high bias forecasts and that traders have greater difficulty using high bias forecasts. Our results, taken together with those of Ackert, Church, and Shehata (1997a), suggest that individual behavior *can* translate into market behavior (see also Ganguly, Kagel, and Moser [1994]). Notably, the difficulties that individuals have with high bias forecasts do not appear to be mitigated in a market setting.

Our results have implications for research that has examined the use of analysts' forecasts as a proxy for market expectations. Previous studies have documented an optimistic bias (e.g., Francis and Philbrick [1993] and Dugar and Nathan [1995]). Our findings suggest that market prices adjust for low bias forecasts and fail to reflect high bias forecasts. Hence, the use of unadjusted forecasts as a proxy for market expectations may not be appropriate.

Our results also indicate that the demand for high bias forecasts persists over time, although such forecasts are acquired less frequently than unbiased and low bias forecasts. The finding is curious because informed traders are not always able to recover the cost of high bias

forecasts. We speculate that once traders have extensive experience, the demand for such forecasts may diminish. This issue is left for future research. Another issue that our study does not address is the market value of biased forecasts. Sunder (1992) and Ackert, Church, and Shehata (1997b) find that the price of perfect and imperfect information, respectively, falls over time and approaches zero. Future studies may examine whether similar results are obtained with low and high bias forecasts.

ENDNOTES

1. Prior studies have examined private information that is perfect, imperfect, and incomplete. Perfect information reveals an asset's period-end value with certainty (e.g., Plott and Sunder [1982], Banks [1985], and Sunder [1992]), whereas imperfect information reveals value with a known probability (Ackert, Church, and Shehata [1997b]). Incomplete information allows traders to reduce the number of possible outcome values (e.g., Plott and Sunder [1988], Forsythe and Lundholm [1990], Ackert and Church [1998b]).
2. Informed traders are not expected to generate greater net profit than the uninformed because, under such conditions, everyone would have an incentive to acquire the forecast.
3. Markets 1, 7, 8, and 5x each included one participant who was not majoring in business or economics.
4. The dividend draw is rounded to the nearest dollar and all trading is in dollars.
5. Cason and Friedman (1996) discuss the benefits of using a preselected sequence.
6. Participants' responses to the questionnaire suggest that they found the experiment interesting and the monetary incentives motivating. Participants were asked to respond on a seven-point scale as to how interesting they found the experiment, where 1=not very interesting and 7=very interesting. The mean response was 5.99. Participants also responded on a seven-point scale as to how they would characterize the money earned for taking part in the experiment, where 1=nominal amount and 7=considerable amount. The mean response was 5.41.
7. Although not reported, we also examine the average of the last three prices and find that inferences are not affected.
8. The FR^U price predictions assume that two or more traders with a zero tax rate acquire the forecast in a particular period. Across the 15 markets, this requirement is satisfied in 174 of 180 periods (96.67 percent). The requirement is violated twice in market 7, once in market 8, and three times in market 9. All analyses are repeated excluding these periods and inferences are unaffected. We are indebted to Larry Wall for bringing this point to our attention.
9. We also included the number of forecast acquisitions as a covariate and repeated the analysis. Inferences are unaffected. The sign of the covariate is negative and statistically significant with $t = -2.234$, $p = 0.027$.
10. Press (1972) warns that heteroskedasticity may be a problem when the dependent variable is a proportion. He recommends an arcsine, square-root transformation to circumvent the problem. We repeat the analysis applying this transformation to the dependent variable and find that inferences are unaffected. In addition, we repeat the analysis restricting the data to periods 1-6 and 7-12 and find that inferences are unaffected.
11. We find that traders acquire forecasts 558 of 720 times (77.50 percent) when their tax rate is zero and 441 of 720 time (61.25 percent) when their tax rate is 40 percent. Further differences in the relative proportions are not apparent across the experimental groups.
12. We repeat the analysis after applying an arcsine, square-root transformation to the dependent variable and find that inferences are unaffected (refer to note 10).

13. We also examined whether trading activity differs across experimental conditions. We perform an ANOVA in which the dependent measure is the number of transactions per period. The independent variables include forecast bias, experience, and an interaction term. Although not reported, none of the independent variables are statistically significant at any conventional level.

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Table 1

Experimental Design

Market	Forecast Bias	Experience[a]
1-3	Unbiased	Inexperienced
4-6	Low Bias	Inexperienced
7-9	High Bias	Inexperienced
1x-2x	Unbiased	Experienced
3x-4x	Low Bias	Experienced
5x-6x	High Bias	Experienced

[a]Experienced traders participated in an earlier market under the same forecast bias condition.

Table 2

Unbiased Forecast and Period-End Asset Values

Period	Markets 1-9		Markets 1x-6x	
	Unbiased Forecast[a]	Period-End Asset Value	Unbiased Forecast[a]	Period-End Asset Value
1	$1,533	$1,543	$1,650	$1,670
2	1,002	1,030	980	974
3	656	665	1,280	1,290
4	772	777	632	624
5	1,591	1,564	793	768
6	1,965	2,012	1,420	1,390
7	1,544	1,584	814	860
8	1,228	1,264	1,010	1,030
9	1,207	1,145	750	796
10	662	655	1,170	1,190
11	970	963	1,780	1,810
12	1,480	1,478	971	957

[a]In markets 4-6 and 3x-4x, the low bias forecast is the unbiased forecast plus $200. In markets 7-9 and 5x-6x, the high bias forecast is the unbiased forecast plus $400. Traders are inexperienced in markets 1-9 and experienced in markets 1x-6x.

Table 3

The Frequency With Which the Last Price Per Period is Consistent With FR^U and NR

Experimental Condition		Last Price Per Period is Closer To[a]		Binomial Test[b]
Forecast Bias	Experience	FR^U	NR	z-statistic (p-value)
Unbiased	Inexperienced	26	10	2.67 (0.004)
	Experienced	21	3	3.67 (0.000)
Low Bias	Inexperienced	27	9	3.00 (0.001)
	Experienced	23	1	4.49 (0.000)
High Bias	Inexperienced	10	26	2.67 (0.004)
	Experienced	8	16	1.63 (0.052)

[a]FR^U is the full revelation unbiased price (i.e., the unbiased forecast) and NR is the no revelation price (i.e., the mean of the asset value distribution).

[b]For each experimental condition, we test whether the relevant proportion is greater than a chance occurrence of 50 percent. For the unbiased and low bias markets, we compare the proportion of times that the last price is closer to FR^U. For the high bias markets, we compare the proportion of times that the last price is closer to NR. The reported p-values are for one-tailed tests.

Table 4

The Effect of Forecast Bias and Experience on the

Deviations in Price From FR^U[a]

Panel A: ANOVA Results

Variable	Sum of Squares	df	F-statistic	p-value
Forecast Bias	1.32	2	26.89	0.000
Experience	0.15	1	6.19	0.014
Interaction	0.14	2	2.87	0.062
Error	4.28	174		

Panel B: Cell Means

	Inexperienced	Experienced	Total
Unbiased	0.078	0.049	0.065
Low Bias	0.189	0.051	0.133
High Bias	0.273	0.266	0.270
Total	0.180	0.121	0.156

[a]FR^U is the full revelation unbiased price (i.e., the unbiased forecast). The dependent measure in the ANOVA is the absolute difference between the final transaction price per period and FR^U normalized by FR^U.

Table 5

Mean (Standard Deviation) Forecast Acquisitions[a]

Experimental Condition		Periods		
Forecast Bias	Experience	1-6	7-12	1-12
Unbiased	Inexperienced	6.11 (0.90)	6.06 (0.73)	6.08 (0.81)
	Experienced	6.08 (0.51)	6.58 (0.67)	6.33 (0.64)
Low Bias	Inexperienced	6.00 (0.84)	6.00 (0.49)	6.00 (0.68)
	Experienced	6.42 (1.00)	6.25 (0.62)	6.33 (0.82)
High Bias	Inexperienced	4.11 (1.13)	4.39 (0.85)	4.25 (1.00)
	Experienced	4.33 (1.23)	4.58 (1.08)	4.46 (1.14)

[a]The cell entries indicate the mean (standard deviation) of the number of forecast acquisitions per period.

Table 6

The Effect of Forecast Bias and Experience on the Frequency of Forecast Acquisition[a]

Panel A: ANOVA Results

Variable	Sum of Squares	df	F-statistic	p-value
Forecast Bias	96.84	2	6.27	0.003
Experience	4.51	1	0.29	0.590
Interaction	0.09	2	0.01	0.994
Error	15.45	114		

Panel B: Cell Means

	Inexperienced	Experienced	Total
Unbiased	0.760	0.792	0.773
Low Bias	0.750	0.792	0.767
High Bias	0.531	0.557	0.542
Total	0.681	0.714	0.694

[a]The dependent measure in the ANOVA is the proportion of times that each trader acquires the forecast over periods 1-12.

Table 7

Factors that Affect Participants: Forecast Acquisition Decisions and Frequency of Responses[a]

Factor	Market[b]						
	1-3	4-6	7-9	1x-2x	3x-4x	5x-6x	Total
the forecast provides a range for trading	11	8	9	6	6	3	43
the tax rate	9	7	8	7	4	4	39
the perceived forecast accuracy	8	7	9	3	4	6	37
the ability to infer the forecast from the behavior of others	4	6	0	2	2	0	14
other[c]	1	1	0	2	2	1	7

[a]Several participants listed more than one factor in their response. All factors listed are included in the table.
[b]Forecasts are unbiased in markets 1-3 and 1x-2x, contain a low bias in markets 4-6 and 3x-4x, and contain a high bias in markets 7-9 and 5x-6x. Traders are inexperienced in markets 1-9 and experienced in markets 1x-6x.
[c]Other factors were incomprehensible or listed by only one participant.

Table 8

The Proportion of Assets Held at Period-End by

Traders With a Zero Tax Rate

Experimental Condition		Periods		
Forecast Bias	Experience	1-6	7-12	1-12
Unbiased	Inexperienced	73.70	97.59	85.65
	Experienced	94.44	96.89	95.67
Low Bias	Inexperienced	73.21	84.75	78.89
	Experienced	88.18	94.39	91.29
High Bias	Inexperienced	79.58	87.02	83.30
	Experienced	87.23	89.69	88.46

[a]The cell entries indicate the mean proportion of assets held by traders with a tax rate of zero, which provides a measure of allocational efficiencies.

Table 9

Normalized Net Profit of Informed Over Uninformed Traders

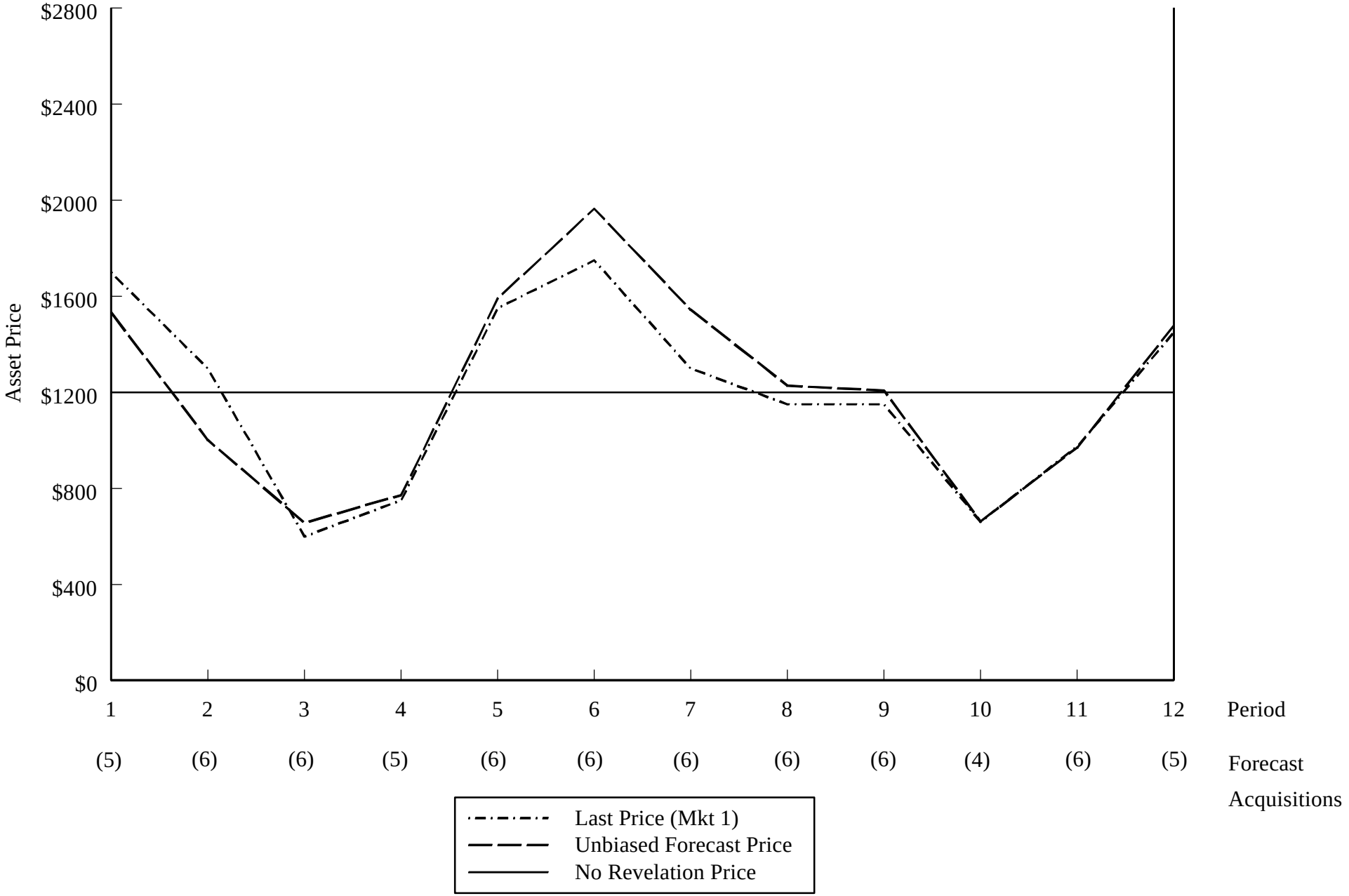
Experimental Condition		Periods[a]			t-statistic[b] (p-value)	z-statistic[c] (p-value)
Forecast Bias	Experience	1-6	7-12	1-12		
Unbiased	Inexperienced	-0.008	0.022	0.008	0.07 (0.946)	-0.16 (0.871)
	Experienced	-0.043	-0.010	-0.027	-0.83 (0.416)	-0.74 (0.458)
Low Bias	Inexperienced	-0.001	-0.117	-0.061	-0.54 (0.592)	-1.43 (0.153)
	Experienced	-0.126	-0.049	-0.084	-1.92 (0.068)	-1.51 (0.131)
High Bias	Inexperienced	0.281	0.050	0.17	1.45 (0.422)	-1.147 (0.375)
	Experienced	-0.445	-0.227	-0.34	-1.82 (0.041)	-1.54 (0.062)

[a]Normalized net profit of informed over uninformed traders is the difference in the net profit of the two types of traders per period divided by the period-end dividend. The cell entries indicate the mean normalized net profit of informed over uninformed traders using data from periods 1-6, 7-12, and 1-12.

[b]The t-statistic (p-value) is for a paired test to compare the net profit of informed and uninformed traders per period using data from periods 1-12. We test whether the net profit of the informed is equal to (less than) that of the uninformed for the unbiased and low bias (high bias) groups. Accordingly, the p-values are for two-tailed (one-tailed) tests.

[c]The z-statistic (p-value) is for a Wilcoxon signed ranks test to compare the net profit of informed and uninformed traders using data from periods 1-12. We test whether the net profit of the informed is equal to (less than) that of the uninformed for the unbiased and low bias (high bias) groups. Accordingly, the p-values are for two-tailed (one-tailed) tests.

Figure 1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Unbiased Forecast Price
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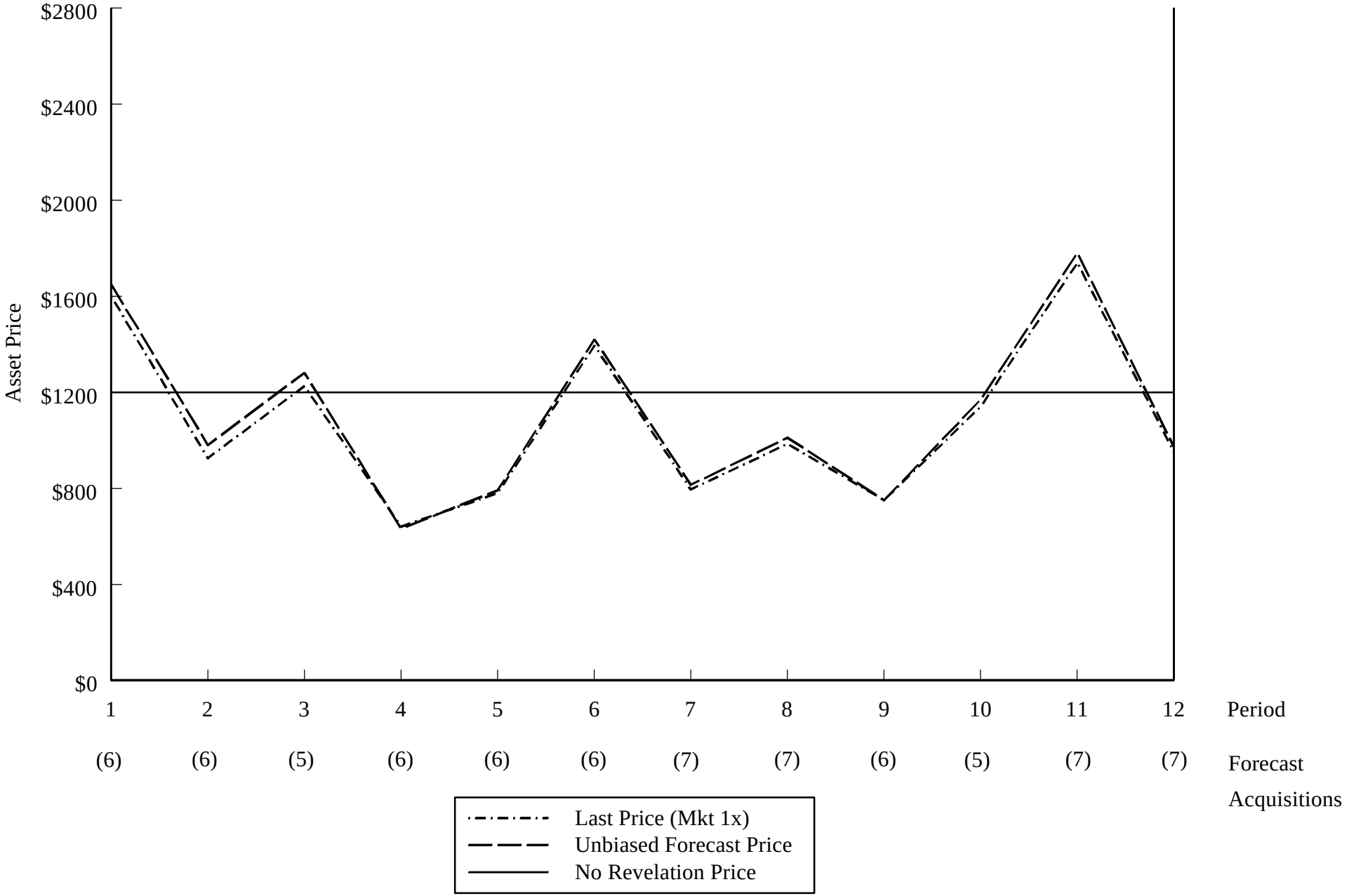
Figure 2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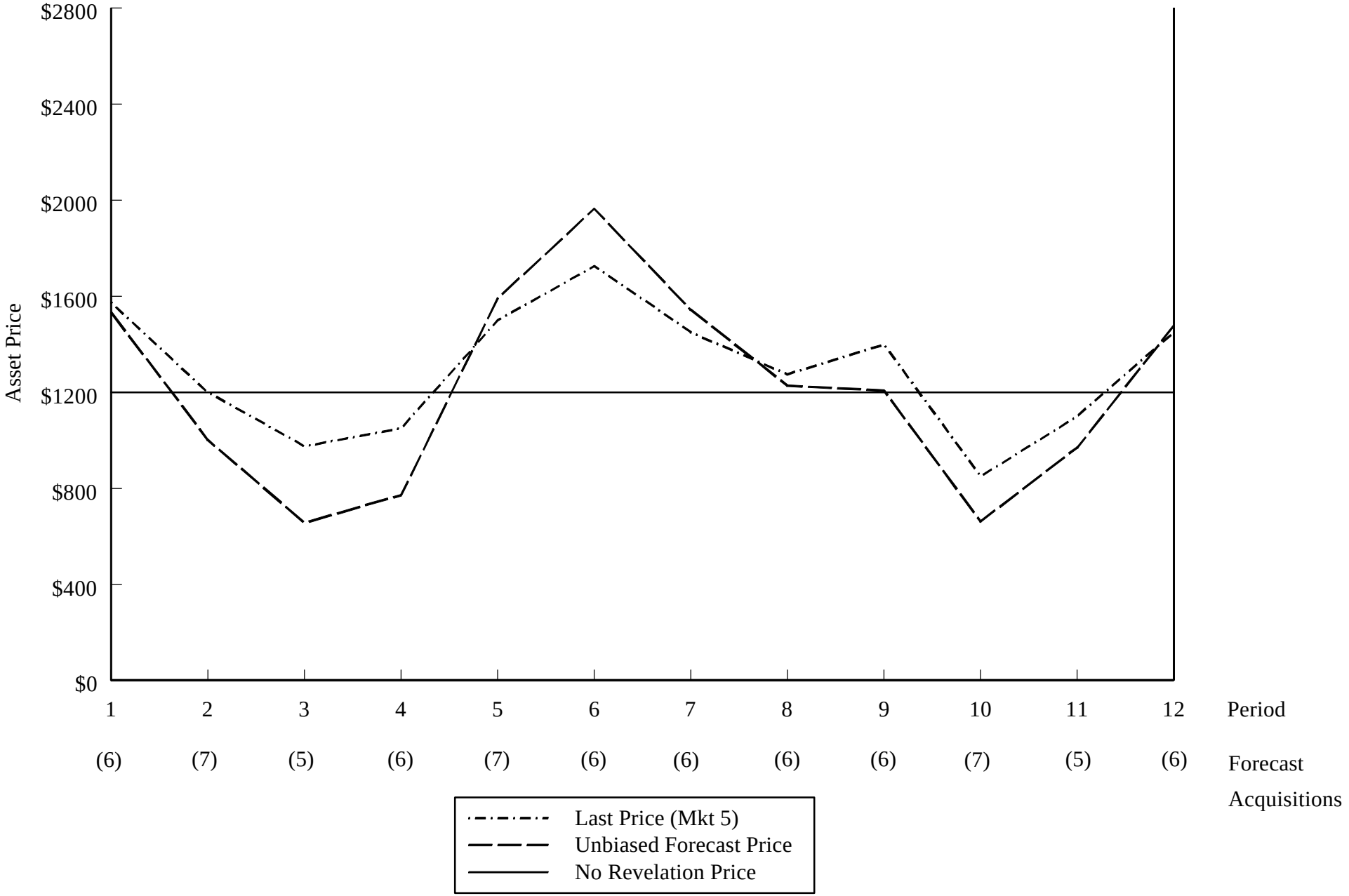
Last Price (Mkt 1x)
Unbiased Forecast Price
No Revelation Price

Figure 3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Last Price (Mkt 5)
Unbiased Forecast Price
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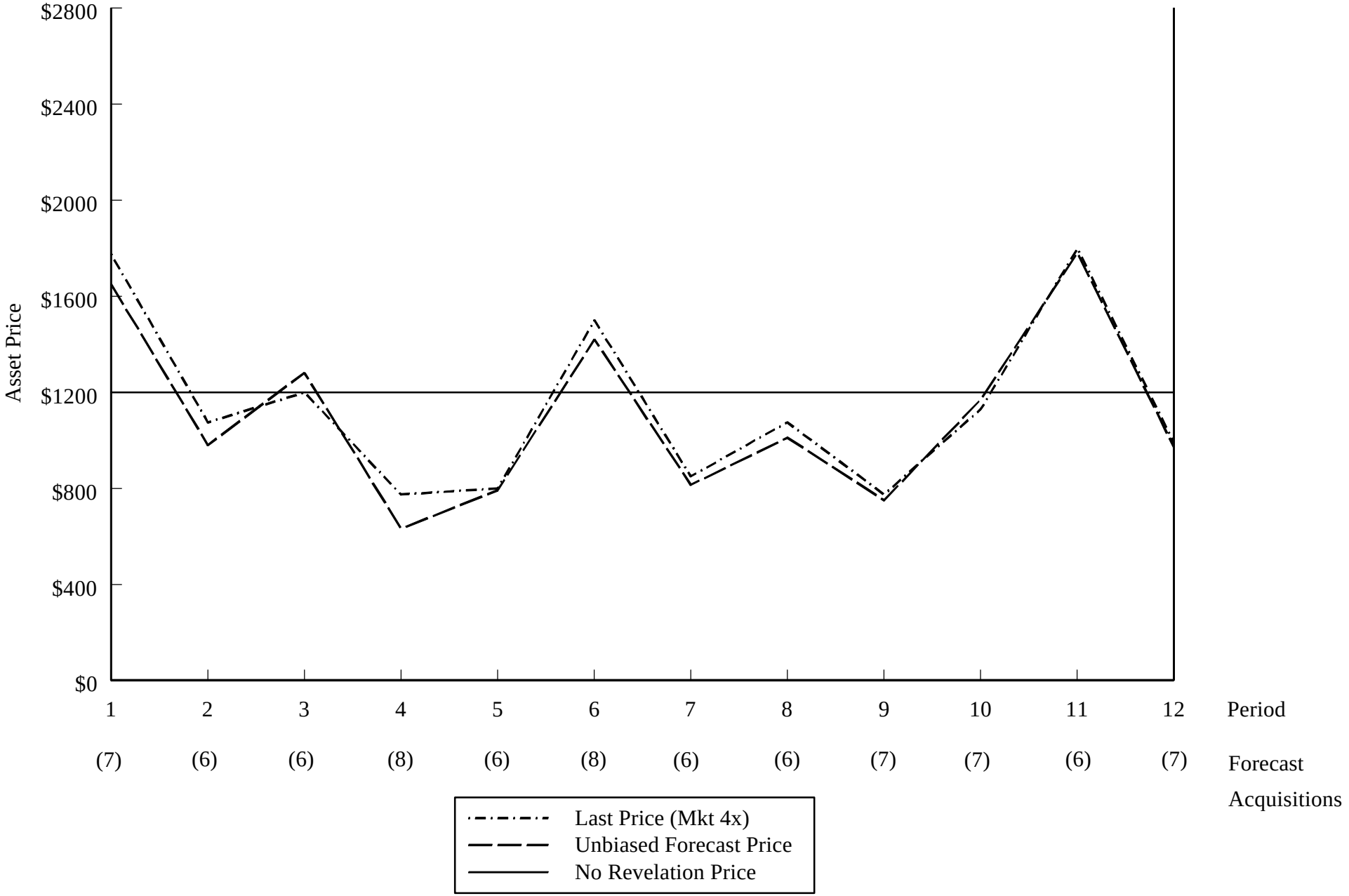
Figure 4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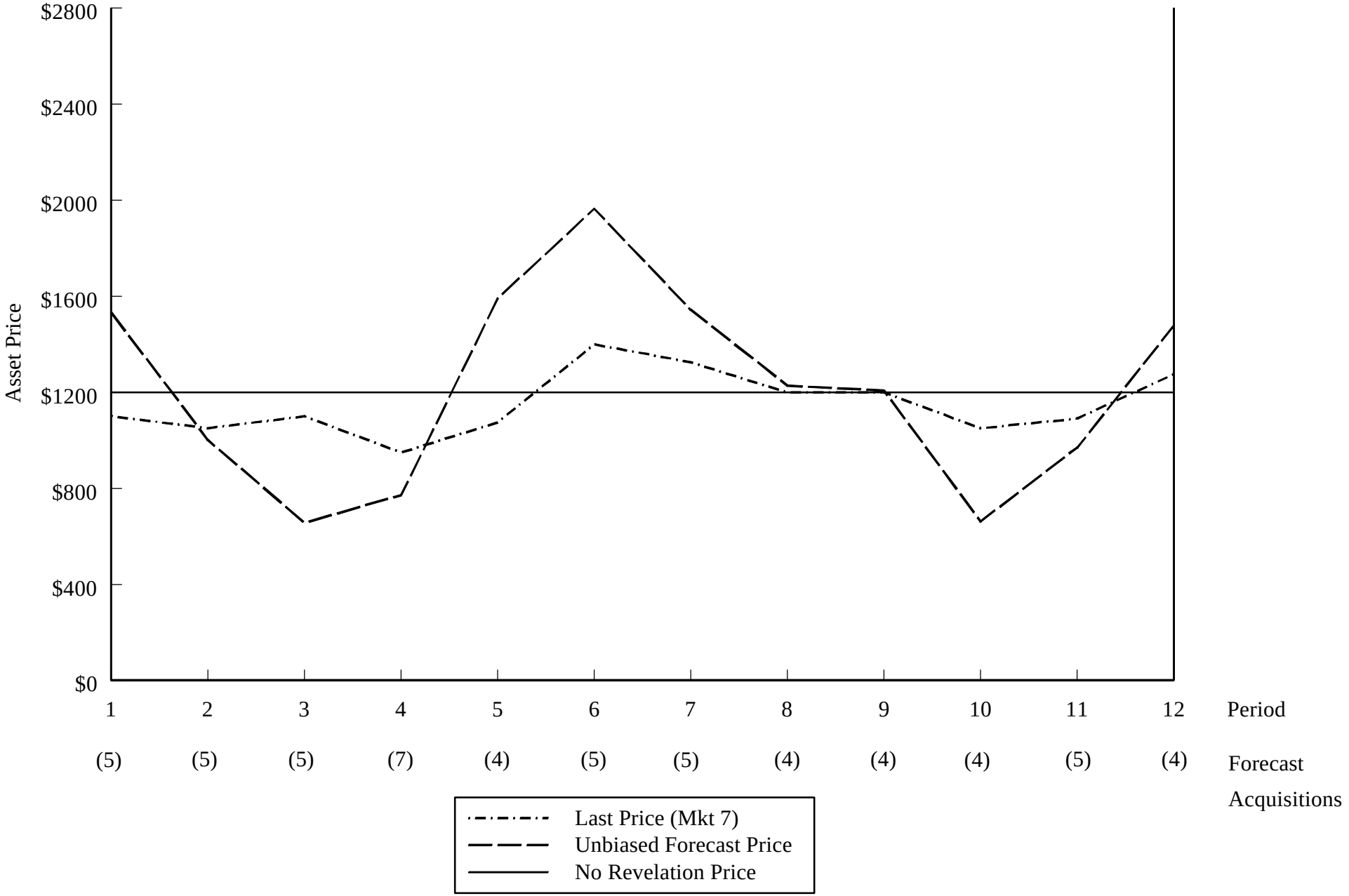
Last Price (Mkt 4x)
Unbiased Forecast Price
No Revelation Price

Figure 5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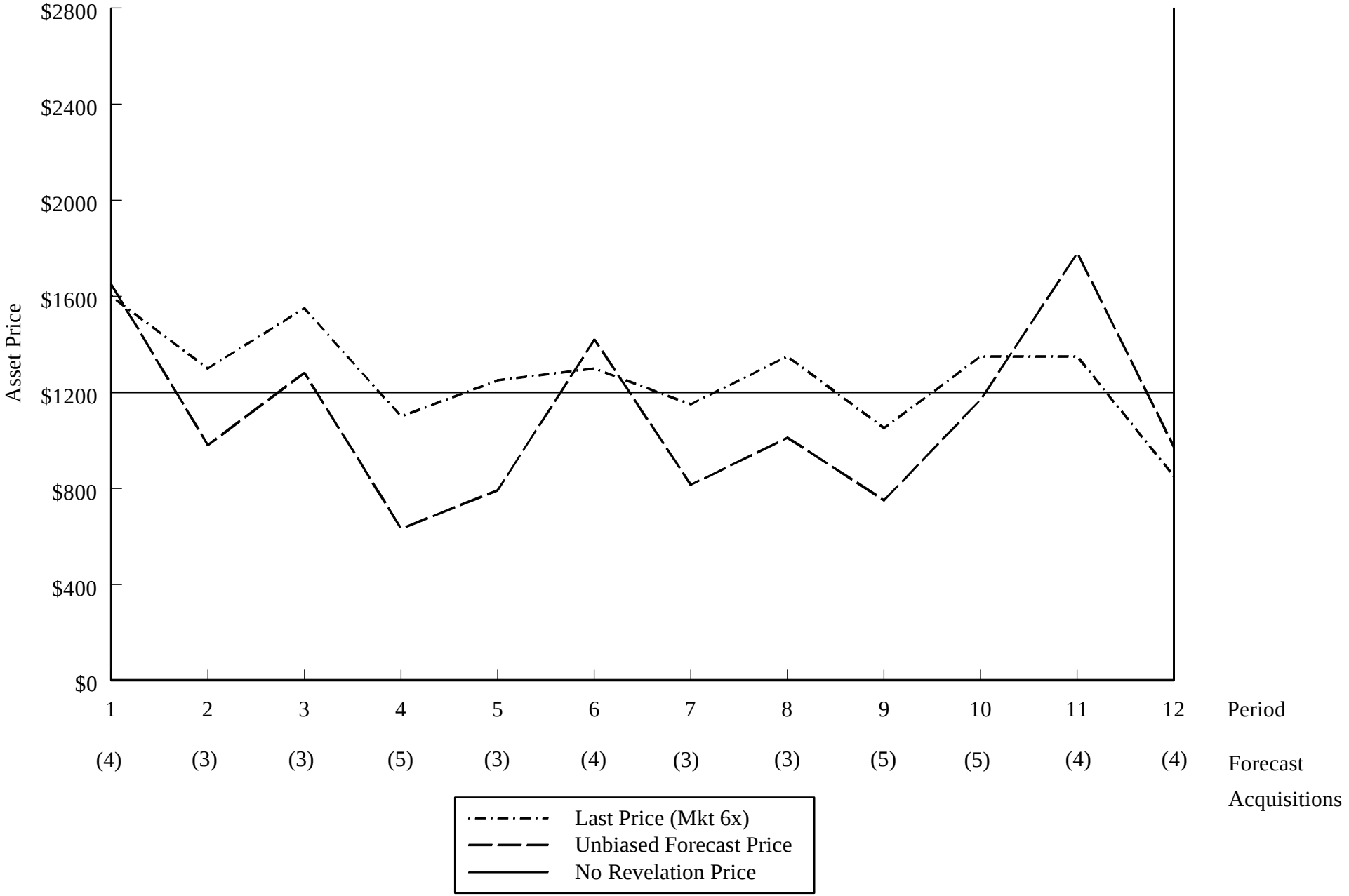
Last Price (Mkt 7)
Unbiased Forecast Price
No Revelation Price

Figure 6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