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International Commodity Markets

-WPS-0435

International Economics Department
The World Bank
June 1990
WPS 435

Rational Expectations and Commodity Price Forecasts

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Forecasts for the primary commodity market by the Bank's International Commodity Markets Division — with significant but not excessive adaptation to spot-price movements — probably are reasonable, optimal short-term forecasts, superior to "naive" forecasts or futures prices.

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This paper — a product of the International Commodity Markets Division, International Economics Department — is part of a larger effort in PRE to understand the short- and long-run behavior of primary commodity prices and the implications of movements in these prices for the developing countries. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Sarah Lipscomb, room S7-062, extension 33718 (22 pages with tables).

Forecasts of primary commodity prices, which the Bank's International Commodity Markets Division has been preparing for more than two decades, are used mainly for project evaluation and balance-of-payments projections for developing countries. There has been some concern about their accuracy. Until very recently, the majority of studies of both survey expectations and futures prices, including previous retrospective studies of the division's price forecasts, found that expectations are formed irrationally and inefficiently. Lately, however, attempts have been made to explain the sources of forecast biases to put the irrationality of expectations in question.

Choe takes a new look at these forecasts in light of recent theoretical and empirical work on the formation of expectations. The forecast data analyzed are one year-ahead forecasts made for 10 commodity prices over the 1979-88 period. His main findings are:

- The division's forecasts tend to show positive forecast errors — overestimating future spot prices.

- Among the expectations models estimated, the adaptive expectations model appears to describe the division's forecast behavior most closely.

- The division's forecasts are stabilizing, whatever the expectations model used. There are no indications of "bandwagon" behavior.

- The division's forecasts are far from static since they put much less weight on current spot prices than other expectations data — they are not as adaptive as others to the latest price changes.

- The rationality of the division's forecasts cannot be rejected.

Rational Expectations and Commodity Price Forecasts

by
Boum-Jong Choe

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I. INTRODUCTION

For more than two decades, the International Commodity Markets Division (CM) of the World Bank has been forecasting primary commodity prices. The forecasts have been used mainly for project evaluation and balance-of-payments projections for developing countries. As a part of the institution's planning framework, the accuracy of the forecasts has been a matter of great concern. Thus, several retrospective studies of the past forecast performance have been attempted, such as Castelli et al. (1985) and Warr (1988). Their main conclusions were that the CM forecasts are biased and are informationally inefficient -- forecast errors show serial correlation because the forecasters tend to adhere to their previous forecasts.

Recently, there has been a rapidly growing body of theoretical and empirical literature on expectations formation. On the empirical side, investigations have focused on direct observations on expectations obtained from surveys as well as market expectations contained in futures prices. Until very recently, the majority of studies of both survey expectations and futures prices found results similar to those of Castelli et al. and Warr -- i.e., expectations are probably formed irrationally. See, for example, Brown and Maital (1981), Hansen and Hodrick (1980), Friedman (1986), and Frankel and Froot (1987), to name only a few. However, evidence to the contrary has begun to emerge. Lewis (1989) finds that systematic forecast errors in forward exchange rates are mostly attributable to slow adaptation to regime change. Dokko and Edelstein (1989) find it difficult to reject the hypothesis that expectations are formed rationally in the Livingston survey of stock price expectations when the change from the base level is redefined and recalculated.

The main purpose of this paper is to take a new look at the CM price forecasts in light of these recent investigations. The CM forecasts are similar in nature to the survey expectations in that both solicit market experts' opinions about future price developments. However, there are important differences: CM forecasts are more of the consensus-type forecasts than survey data and deal with physical goods that are subject to different risks and constraints. It is, therefore, of considerable interest to see whether the expectational behavior implied by the CM forecasts differs significantly from that of survey expectations analyzed by Frankel and Froot, for example. Furthermore, it is important to find the sources of forecast biases, if any, perhaps along the lines suggested by Lewis and by Dokko and Edelstein.

In the next section, the characteristics of the CM forecasts are reviewed in relation to the futures prices of the same commodities. An analysis of the relationship between the CM forecasts and futures prices will be the subject of another paper. Section III estimates the alternative expectational models. Section

IV tests the rationality of the expectational behavior. Section V concludes the paper.

II. DATA AND AN OVERVIEW

A. Data

The International Commodity Markets Division of the World Bank has been forecasting the prices of many primary commodities over the last two decades. From the late 1970s, the forecast interval has been regular; every two years, forecasts are made for the short term (one to two years ahead) and for the long term (10-15 years), with an extensive reassessment of the global market balance. These forecasts are revised every six months, primarily focusing on the short-term outlook. For the purpose of this study, only the short-term forecasts made during the 1979-88 period are analyzed. At around the middle of each year, forecasts were made of the average price expected to prevail in the following year. Thus, the forecast horizon is about a year. The choice of the data period and forecast horizon was constrained by the availability of the corresponding futures prices used in a related study.[1] Because of the limited availability of futures prices, only the following 10 commodities could be included in this study -- aluminum, copper, sugar, coffee, cocoa, maize, cotton, wheat, soybeans, and crude oil.

B. Forecasts vs. Actual Changes

Table 1 lists the data in the form of percentage changes. Let p_t denote the logarithm of the spot price at time t, and $E_t p_{t+1}$ be the logarithm of the spot price expected to prevail in t+1 on the basis of information available in t. Then, the percentage change in the spot price expected to take place between t and t+1 is measured by $E_t p_{t+1} - p_t$; the actual percentage change is defined by $p_{t+1} - p_t$. Summary statistics of the data are shown in Table 2.

The following observations from Tables 1 and 2 are worth noting. First, the extreme volatility of commodity prices is shown by high percentage changes in the actual as well as forecast prices. Table 2 shows that standard deviations of both the forecast and actual price changes are high compared with the mean. Furthermore, actual price changes often turned out to be much greater than the forecasts -- standard deviations of actual price changes are often more than twice those of the forecasts. Secondly,

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[1] The futures price data were retrieved from the commodity database (DRICOM) of Data Resources Inc. For each CM forecast, the matching futures price is the average price of all futures contracts maturing in the target year of the price forecast, observed during the week when the forecast was made.

the actual price changes over the 1980-88 period appear to have been more or less random; the cases of actual price increases and declines are divided about equally (42 against 48). However, there is a clear pattern over time -- the actual prices generally increased in 1980, declined in 1981-82, increased in 1983, declined in 1984-86, and increased in 1987-88. On the other hand, the CM forecasts have been expecting more price increases than declines (71 against 19). Table 2 shows that the means of the forecasted percentage changes are all positive and larger in absolute terms

Table 1: CM Forecasts vs. Actuals
(percent per annum)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
				CM Forecasts					
Aluminum	-7.1	2.3	42.9	58.9	5.4	21.6	20.8	10.1	-10.9
Copper	-11.4	7.5	40.0	52.8	30.6	14.7	4.5	10.9	-15.8
Sugar	35.4	-68.6	22.0	68.3	11.4	45.3	40.5	42.7	62.6
Coffee	-11.5	15.6	16.2	0.3	5.8	2.8	6.5	-8.2	23.6
Cocoa	11.3	30.7	18.6	15.0	-4.4	-10.8	-9.9	3.9	-0.9
Maize	35.0	15.2	22.3	11.5	5.5	-2.9	-2.6	34.3	17.8
Cotton	18.8	-0.9	19.1	20.5	7.4	13.5	14.6	28.2	-10.5
Wheat	29.5	7.1	7.6	13.9	11.3	10.2	-8.6	-14.8	21.0
Soybeans	-12.4	4.3	24.0	16.6	13.8	8.8	9.8	0.5	10.1
Crude Oil	-15.7	7.3	13.8	5.8	5.8	6.4	2.3	60.9	5.6
				Actual Price Movements					
Aluminum	4.3	-24.9	-20.5	39.2	-14.6	-11.8	16.2	25.7	35.5
Copper	3.8	-16.1	-13.9	20.3	-21.1	5.7	-7.1	28.3	39.3
Sugar	130.1	-87.1	-66.3	21.3	-70.2	1.1	64.2	20.0	59.6
Coffee	12.0	-0.7	20.8	-6.7	11.7	0.0	36.4	-41.5	29.8
Cocoa	-22.3	-10.5	4.7	31.3	4.3	-12.1	-6.5	-1.5	-23.9
Maize	10.9	-6.6	-22.1	16.8	-3.6	-21.6	-26.8	-8.8	39.6
Cotton	22.3	-15.9	-17.2	10.2	-8.6	-22.9	-23.4	68.7	-31.1
Wheat	26.9	-10.6	-12.9	5.4	-1.2	9.1	-4.8	-17.7	37.3
Soybeans	-1.3	-16.6	-17.2	10.5	7.0	-15.3	-7.0	3.3	34.6
Crude Oil	49.5	7.3	-10.4	-13.3	-2.9	-1.9	-64.4	68.2	-27.5

Note: The years shown are the target years of forecasts.
Source: International Economics Department, World Bank.

Table 2: Mean and Standard Deviation of Forecast and Actual Percentage Changes

	CM Forecasts		Actual Prices	
	Mean	Standard Deviation	Mean	Standard Deviation
Aluminun	16.0	22.9	5.4	24.7
Copper	14.9	22.7	4.4	21.1
Sugar	28.9	40.6	8.1	72.3
Coffee	5.7	11.5	6.9	23.1
Cocoa	5.9	14.0	-4.1	16.7
Maize	15.1	14.0	-2.5	21.6
Cotton	12.3	11.9	-2.0	31.5
Wheat	8.6	13.6	3.5	18.5
Soybeans	8.4	10.4	-0.2	16.7
Crude Oil	9.7	20.8	0.5	39.3

Source: International Economics Department, World Bank.

than the actual changes. The overprediction occurred mostly during 1981-82 and 1984-86 when commodity prices were depressed. Thirdly, the CM forecasts had about a 50/50 chance of correctly predicting the direction of actual price changes; the sign was correctly predicted in 43 out of 90 cases. Again, most of the errors were made during the years of low commodity prices. As expected, commodities with lower standard deviation generally had a better forecast record. A notable exception to this has been sugar which has the highest price volatility, but the direction of its price change was correctly forecasted in seven out of nine times.

C. Forecast Bias: A Comparison

A simple test of the rational expectations hypothesis is the test of unconditional bias. As a first step, we look at the unconditional biases of the CM forecasts and compare them with those of futures prices. The rational expectations hypothesis states that the agents use efficiently all available information to make forecasts of the future variable. Under the additional assumption that the agents know the structure that determines the variable and the probability distribution of the relevant economic disturbances, the hypothesis implies that forecast errors are uncorrelated to the information set and have mean zero.

Earlier studies of CM forecasts confirmed the presence of biases in the forecast errors. In this section we only investigate whether forecast biases are present in the data set; for the purpose of comparison, forecast biases implied by the commodity futures prices are also shown. Let f_t be the logarithm of the price in period t of a futures contract maturing in t+1. Then, the errors of the CM forecasts and futures prices are measured, respectively, by $E_t p_{t+1} - p_{t+1}$ and $f_t - p_{t+1}$. Table 3 shows the mean percentage errors and their statistical significance.

Although the mean percentage forecast errors are large for both the CM forecasts and the futures prices, they are all not statistically different from zero because of the large standard deviation associated with them. The standard deviations of the forecast errors are large mostly because the actual and forecasted price changes (Table 2) are large. In 6 out of 10 commodities, standard errors of futures price forecast errors are larger than those of CM forecasts, but the differences are relatively minor.

It can be seen that the CM forecasts have larger absolute mean forecast errors than the futures prices for all commodities except coffee. The CM forecasts on average also show an overestimation bias compared with the futures prices. The mean forecast error of CM forecasts is positive in 8 out of 10 commodities, compared with 6 out of 10 for futures prices; they are also larger for all commodities except for aluminum. For all commodities except cotton and wheat, the direction of CM forecast bias matches that of the futures prices, indicating that both share common information.

Both CM forecasts and futures prices failed to anticipate the severity of the commodity price depressions in the 1981-86 period. This failure was mainly responsible for the large upward biases in

Table 3: Errors of CM Forecasts and Futures Prices
(Percent per annum)

	CM Forecasts			Futures Prices		
Commodities	Mean	S.D.	t-Ratio	Mean	S.D.	t-Ratio
Copper	10.5	35.3	0.30	2.9	27.0	0.11
Sugar	20.8	56.1	0.37	10.7	68.2	0.16
Coffee	-1.2	19.2	-0.06	-10.6	24.7	-0.53
Cocoa	10.0	19.5	0.53	7.9	15.7	0.49
Maize	17.6	21.3	0.84	10.5	20.1	0.53
Cotton	14.3	24.8	0.57	-1.6	29.4	-0.06
Wheat	5.1	11.3	0.46	-1.6	20.5	-0.08
Soybean	8.6	19.8	0.43	3.9	19.9	0.20
Aluminum[a]	-6.6	33.6	-0.18	-1.2	27.0	-0.04
Crude Oil[a]	23.9	31.9	0.75	5.8	41.3	0.14

[a] Calculated from 1985-88 data.
Source: International Economics Department, World Bank

forecast errors. Nor did they anticipate the extent of the post-1987 price recovery, resulting in underestimation of expected prices for that period. However, it would appear from the mean forecast errors that the futures prices are informationally more efficient than CM forecasts.[2]

III. FORMATION OF COMMODITY PRICE FORECASTS

The CM forecasts are made by individual commodity specialists under given macroeconomic assumptions adopted by the institution for planning purposes, including assumptions about economic growth and inflation; they are thus conditional forecasts. Since the forecasts are finalized only after peer reviews, they are also consensus forecasts. In short, the CM forecasts are more institutional in character than most other expectational data, which are basically forecasts made by individuals. In the subsequent analysis, we discuss the implications of this characteristic for the estimation results.

Various models of expectations formation have been estimated with expectational data. In this section, following Frankel and Froot, we estimate three standard models of expectations formation with the CM data -- the extrapolative, adaptive and regressive models. The null hypothesis against which these models are tested is the static expectations model, i.e., that the forecasts are completely random around the current spot price.

Extrapolative Expectations

The extrapolative model states that the agent's expectations are arrived at by extrapolating the recent market trend. Thus, if the price has been rising, it is expected to rise further, and vice versa. This "bandwagon" behavior may be represented by

$$E_t p_{t+1} - p_t = \alpha_1 + \beta_1 \; (p_t - p_{t-1}), \tag{1}$$

where the maintained hypothesis is $\beta_1 > 0$ against the null hypothesis (static expectations) that $\beta_1 = 0$. Agents could expect

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[2] A statistical test of this proposition is made difficult because of the "peso problem," which arises when there is a small probability of large changes. Such possibilities abound in the case of primary commodity prices. Adverse weather, labor strikes, changes in market structure due to collapse of producer cartels, and demand fluctuations are known to have caused wide swings in commodity prices, sometimes violating the normality assumption in their probability distribution.

prices to decline when it has risen recently, which will be the case if $\beta_1 < 0$. The equation (1) then becomes equivalent to a simple form of distributed lag expectations:

$$E_t p_{t+1} = (1+\beta_1)\ p_t - \beta_1\ p_{t-1}.$$

The slope parameter β_1 represents the elasticity of expectations with respect to the current spot price. If its absolute value is less than one, then expectations are inelastic or stabilizing.

The extrapolative model in (1) is estimated using ordinary least squares (OLS) under the assumption that the error term added to it represents the random measurement error and therefore is white noise. The OLS requirements will be violated if the CM forecasts affect the current spot price or the error term is autocorrelated. Since the CM forecasts are intended for the World Bank's internal use for purposes other than commodity trading, we assume that there is little danger of simultaneity between the forecasts and spot prices. Table 4 reports the estimation results.

It is interesting to note that the estimates of β_1 are all negative, strongly rejecting the bandwagon behavior in favor of the distributed lag expectations. In half of the 10 commodities, the estimates of β_1 are significantly different from zero at the 5% level or better, implying that the CM forecasts are not static. Their absolute values are all less than one, meaning that the CM forecasts are of the stabilizing kind. For example, a 10% price increase in the current period leads the CM to forecast a 2-6% decline for the next period.

If variables other than the latest price change also affect CM forecasts and they are autocorrelated in totality, the model in (1) may have the serial correlation problem in the error term. The Durbin-Watson statistics in Table 4 suggest the presence of first-order serial correlation for at least seven of the commodities. Mankiw and Shapiro (1986) have shown that the asymptotic test statistics can lead to rejection of the true model (in our case, the static expectations model) too frequently when the time series is highly autocorrelated and the sample size is small. Since, in the case of the model in equation (1), the independent variable (percent change in spot price) is not "highly" autocorrelated,[3] the

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[3] For most of the commodities, the autocorrelation coefficient of the percentage change in spot price is estimated in the 0.1-0.6 range, way below the minimum of 0.9 used in the Mankiw and Shapiro Monte Carlo simulations. For the adaptive and regressive expectational models, the autocorrelation coefficients of the independent variables are estimated, respectively, in the range of 0.3-0.7 and 0.2-0.6, which also do not qualify as "highly" autocorrelated.

t-test results in Table 4 probably are still mostly valid.

As an additional safeguard, the Cochrane-Orcutt procedure is used for the commodities with low Durbin-Watson statistics to see if the rejection of the null hypothesis could have been due to a serial correlation bias. The correction for AR(1) significantly improves the Durbin-Watson statistic for sugar and coffee but does not significantly change the t-test results for the null hypothesis

Table 4: Extrapolative Expectations

Commodities	α_1	β_1	$t:\beta_1=0$	D-W	$\bar{R}$**2
Aluminum	0.195	-0.630	-3.25**	1.31	0.58
	(0.052)	(0.194)			
Copper	0.169	-0.573	-1.67	1.26	0.20
	(0.069)	(0.343)			
Sugar	0.266	-0.360	-2.80*	0.70	0.49
	(0.011)	(0.129)			
with AR(1)	0.460	-0.211	-2.44*	2.25	0.14
correction	(0.128)	(0.086)			
Coffee	0.064	-0.377	-5.17**	0.78	0.79
	(0.017)	(0.073)			
with AR(1)	0.043	-0.377	-8.90**	2.56	0.90
correction	(0.024)	(0.042)			
Cocoa	0.027	-0.429	-2.31*	1.10	0.38
	(0.043)	(0.186)			
with AR(1)	-0.031	-0.130	-0.86	2.02	0.55
correction	(0.063)	(0.150)			
Cotton	0.121	-0.297	-8.29**	1.47	0.91
	(0.014)	(0.036)			
Maize	0.114	-0.219	-0.86	1.70	-0.04
	(0.048)	(0.219)			
Wheat	0.056	-0.172	-0.74	1.70	-0.07
	(0.044)	(0.231)			
Soybean	0.095	-0.353	-1.43	1.50	0.13
	(0.026)	(0.247)			
Crude Oil	0.127	-0.306	-3.66**	1.17	0.64
	(0.042)	(0.083)			

Notes: OLS and Cochrane-Orcutt standard errors are shown in parentheses.
* Singificant at 5% level.
** Significant at 1% level.
Source: International Economics Department, World Bank.

-- the static expectations hypothesis is rejected with or without AR(1) correction. For aluminum, copper, cotton, soybeans, and crude oil, the serial correlation correction neither improved the Durbin-Watson statistic nor changed the t-test results. For these commodities, the low Durbin-Watson statistics resulted from reasons other than first-order autocorrelation. Cocoa is the only commodity for which the t-test results changed from significant rejection to non-rejection after AR(1) correction. Overall, serial correlation does not appear to have seriously biased the estimates towards rejection of the static expectations hypothesis.

Adaptive Expectations

The adaptive expectations model has been widely used in various dynamic economic models. It states that agents update their expectations in view of the latest information; more specifically, the expected price in the next period is a weighted average of the current spot price and the price that was expected to prevail in the current period:

$$E_t p_{t+1} = (1-\beta_2)\ p_t + \beta_2\ E_{t-1} p_t, \qquad (2)$$

where stability of expectations requires that $0 < \beta_2 < 1$. By rearranging the terms and adding a constant term:

$$E_t p_{t+1} - p_t = \alpha_2 + \beta_2\ (E_{t-1} p_t - p_t). \qquad (3)$$

OLS estimates of (3) are reported in Table 5, together with those of AR(1) correction for some of the commodities. Overall, it is clear that the adaptive expectations model explains the CM forecasts much better than the extrapolative (distributed lag) model. In fact, as will be seen subsequently, the adaptive model yields the best fit among the three models. This result is significant in view of Muth's (1960) proof that when commodity price innovations are white noise processes, expectations formed adaptively are minimum error variance (rational) forecasts. The estimates of β_2 are all positive and significantly greater than zero except for wheat, soybeans and maize. They are all less than unity to meet the stability requirement.

More importantly, the estimates of β_2 are quite large, exceeding 0.5 for many commodities and thus strongly rejecting the static expectations hypothesis for CM forecasts. Again, this result does not appear to be significantly influenced by serial correlation of the residuals. Here, the Durbin-Watson statistics are generally higher than in the extrapolative model. Even when they are low, AR(1) correction either does not affect the result too much and therefore not reported in Table 5 (aluminum and sugar) -- the null hypothesis is still rejected -- or the estimate of first-order serial correlation coefficient is not significant (copper and coffee).

The estimates of β_2 above are in sharp contrast to those of other studies, usually less than 0.1 - 0.2 for the survey of exchange rate expectations reported in Frankel and Froot and stock price expectations studied by Dokko and Edelstein. This confirms the earlier findings by Castelli et al. that the CM forecasts attach heavy weight to previous forecasts, probably excessively. The rationality of this behavior will be discussed in the next section.

Table 5: Adaptive Expectations

	α_2	β_2	$t:\beta_2=0$	D-W	$\bar{R}$**2
Aluminum	0.058	0.710	5.82**	1.24	0.82
	(0.041)	(0.122)			
with AR(1)	0.041	0.755	5.93**	1.61	0.84
correction	(0.064)	(0.127)			
Copper	0.057	0.596	3.12*	1.44	0.55
	(0.065)	(0.191)			
Sugar	0.140	0.490	4.30**	0.84	0.71
	(0.088)	(0.114)			
with AR(1)	0.313	0.298	2.07*	1.54	0.21
correction	(0.131)	(0.144)			
Coffee	0.048	0.420	3.81**	1.14	0.66
	(0.023)	(0.110)			
Cocoa	-0.001	0.421	3.95**	2.32	0.68
	(0.033)	(0.106)			
Cotton	0.070	0.335	7.06**	2.02	0.87
	(0.033)	(0.048)			
Maize	0.060	0.328	1.32	2.52	0.10
	(0.066)	(0.248)			
Wheat	0.013	0.516	1.49	1.78	0.15
	(0.050)	(0.346)			
Soybeans	0.088	0.180	1.28	1.75	0.08
	(0.030)	(0.140)			
Crude Oil	0.093	0.313	3.11*	1.62	0.55
	(0.048)	(0.101)			

Notes: See Table 4.
Source: International Economics Department, World Bank.

Regressive Expectations

The regressive expectations model is based on the hypothesis that prices tend to converge to their long-run equilibrium values. Agents, therefore, expect prices to return to their long-term levels whenever the current spot prices deviate from them. A simple version of this hypothesis may be written as:

$$E_t p_{t+1} = (1-\gamma) p_t + \gamma p^*_t, \tag{4}$$

where p^*_t is the long-run equilibrium price. The higher the value of γ, the faster the adjustment of expectations to the long-run equilibrium.

One can think of different ways of defining the long-run equilibrium price. The simplest way is to assume that it is a constant, i.e., $\gamma p^*_t = \alpha_3$, where α_3 is a constant. Then, rearranging the terms in (4) gives:

$$E_t p_{t+1} - p_t = \alpha_3 + \beta_3 p_t, \tag{5}$$

where $\beta_3 = -\gamma$. Results of estimating (5) are reported in Table 6.

A more realistic assumption about the long-term equilibrium price is to posit that it changes over time in proportion to the overall rate of inflation, i.e.,

$$p^*_t = pc_0 + \log(I_t/I_0), \tag{6}$$

where pc_0 is the long-run equilibrium price in constant dollars of the base period 0 and I_t is the index of inflation. For the purpose of estimation, we measure pc_0 by the average constant-dollar prices during the 1970-79 period. Inflation is measured by the unit value of manufactured exports from industrial to developing countries; this is the inflation assumption used in arriving at the CM forecasts. By substituting (6) into (4) and rearranging terms, we get:

$$E_t p_{t+1} - p_t = \alpha_4 + \beta_4 \, (p_t - p^*_t), \tag{7}$$

where $\beta_4 = -\gamma$. Table 7 presents the results of estimating (7).

Results in Tables 6 and 7 are not much different from each other. Both indicate that the CM forecasts tend to converge to long-term equilibrium prices. In 8 out of the 10 commodities, including those with serial correlation correction, the estimates of the slope coefficient are significantly different from zero. For copper, cocoa and wheat, AR(1) correction enhances the power of the t-test. The estimates of γ are all positive and fall between zero and one, implying that the CM forecasts are stabilizing. The weight for the long-term price ranges between 0.4 and 0.7 in many cases, which is considerably larger than the estimate by Frankel and Froot of about 0.25 from annual survey data. Again, the CM forecasts are less adaptive to the current spot price and tend to converge faster to the long-term level than other survey forecasts.

Table 6: Regressive Expectations I

	α_3	β_3	t:β_3=0	D-W	$\bar{R}$**2
Aluminum	6.665	-0.900	-3.84**	0.74	0.63
	(1.692)	(0.234)			
Copper	4.557	-0.597	-1.43	0.58	0.12
	(3.084)	(0.417)			
with AR(1)	4.779	-0.633	-1.87	1.02	0.41
correction	(2.484)	(0.339)			
Sugar	2.579	-0.442	-4.18**	1.72	0.67
	(0.554)	(0.106)			
Coffee	3.761	-0.652	-4.16**	1.97	0.67
	(0.889)	(0.156)			
Cocoa	0.829	-0.143	-0.61	0.61	-0.08
	(1.259)	(0.234)			
with AR(1)	2.158	-0.409	-2.08*	2.30	0.59
correction	(1.029)	(0.196)			
Cotton	1.526	-0.276	-2.35*	1.21	0.36
	(0.598)	(0.117)			
with AR(1)	2.212	-0.442	-5.56**	2.12	0.60
correction	(0.449)	(0.080)			
Maize	1.379	-0.259	-1.33	1.43	0.90
	(0.926)	(0.195)			
Wheat	1.767	-0.330	-1.09	0.95	0.02
	(1.539)	(0.302)			
with AR(1)	3.280	-0.639	-3.01*	1.55	0.28
correction	(1.084)	(0.213)			
Soybeans	0.414	-0.059	-0.25	1.11	-0.13
	(1.328)	(0.239)			
Crude Oil	1.027	-0.295	-2.08*	1.84	0.29
	(0.452)	(0.142)			

Notes: See Table 4.
Source: International Economics Department, World Bank.

To summarize, among the three expectational models estimated above, the adaptive expectations model appears to most closely approximate the expectational behavior of CM forecasters. This contrasts with the Frankel and Froot result where the distributed lag model produced the best estimates. Of course, more complicated models could have produced a better fit, but the small sample size rules out such an opportunity.

Table 7: Regressive Expections II

	α_4	β_4	t:β_4=0	D-W	$\bar{R}$**2
Aluminum	0.103	-0.783	-2.67*	0.46	0.43
	(0.061)	(0.293)			
with AR(1)	-0.332	-0.992	-6.42**	1.33	0.78
correction	(0.507)	(0.154)			
Copper	-0.028	-0.300	-0.77	0.58	-0.05
	(0.233)	(0.387)			
with AR(1)	-1.311	-0.671	-2.23*	1.29	0.42
correction	(1.577)	(0.301)			
Sugar	-0.030	-0.441	-4.43**	1.78	0.70
	(0.103)	(0.100)			
Coffee	-0.056	-0.490	-4.21**	1.87	0.68
	(0.346)	(0.116)			
Cocoa	0.034	-0.132	-0.72	0.58	-0.06
	(0.056)	(0.183)			
with AR(1)	-0.145	-0.383	-2.65*	2.47	0.67
correction	(0.124)	(0.144)			
Cotton	0.071	-0.178	-1.44	1.55	0.12
	(0.052)	(0.123)			
Maize	0.082	-0.182	-1.23	1.42	0.06
	(0.072)	(0.148)			
Wheat	0.043	-0.134	-0.57	1.23	-0.09
	(0.088)	(0.234)			
with AR(1)	-0.270	-0.598	-3.06*	1.77	0.23
correction	(0.179)	(0.195)			
Soybeans	0.063	-0.055	-0.33	1.10	-0.13
	(0.075)	(0.168)			
Crude Oil	0.284	-0.269	-2.17*	1.90	0.32
	(0.104)	(0.124)			

Notes: See Table 4.
Source: International Economics Department, World Bank.

IV. RATIONALITY OF CM FORECASTS

Have the CM commodity price forecasts been rational? This question can be answered by comparing the expectational models estimated above with the spot price behavior. One of the main findings above was that the CM forecasts do not adapt to spot price changes as fast as others (as reflected in futures prices). One way of judging whether this particular characteristic of the CM forecasts was justified is to compare the parameters of the expectational model and the spot price process. This information could be useful in improving the accuracy of the CM forecasts. The comparison amounts to tests of the rationality of CM expectations. It was noted previously that the null hypothesis of rational expectations imply mean zero and serially uncorrelated expectational errors.

We postulate that the spot price process can be described by the same functional form as the expectational model under consideration. In the case of extrapolative expectations, for example, it is assumed that the spot price process can be represented by:

$$p_{t+1} - p_t = a_1 + b_1 (p_t - p_{t-1}), \tag{8}$$

where the parameters are subject to the same constraints for stability as in (1). Subtracting (8) from (1):

$$E_t p_{t+1} - p_{t+1} = (\alpha_1 - a_1) + (\beta_1 - b_1) (p_t - p_{t-1}). \tag{9}$$

The null hypothesis of rational expectations implies $\alpha_1 - a_1 = \beta_1 - b_1 = 0$. Results of estimating (9) with OLS appear in Table 8.

The F-test statistics in Table 8 show that the null hypothesis of rationality cannot be rejected for all the commodities at the usual significance level. The null hypothesis is rejected at the 15% level for two commodities (aluminum and cocoa). Again, none of the slope coefficients are significant at the usual significance level, indicating that the CM forecasts cannot be considered to have been irrational. The Mankiw and Shapiro considerations in the context of small samples strengthen the non-rejection of rationality, although the difference in the power of the test statistics would have been small because of the lack of high autocorrelation.

In four of the commodities, the slope is significantly different from zero at the 15% level. In six of the commodities, the estimates of the slope coefficient are positive, meaning the CM forecasts overestimated the tendency for the spot price to move in the same direction as in the recent past. In the remaining four commodities, the CM forecasts underestimated the tendency. In any case, the degree of overestimation or underestimation is quite large for all commodities except maize, although they are not statistically significant because of large standard errors. The intercept coefficients are all positive and most of them are significant only at the 15% level, indicating that the CM forecasts have apparently been biased upward.

Estimates of the adaptive expectation model showed that the CM forecasters placed a heavy weight on the previous forecasts. Is this rational? We proceed as before and assume that the true model for the spot price process is described by:

$$p_{t+1} - p_t = a_2 + b_2 (E_{t-1} p_t - p_t). \tag{10}$$

Table 8: Rationality of Extrapolative Expectations

	α_1-a_1	β_1-b_1	t: $\beta_1-b_1=0$	D-W	$\bar{R}$**2	F-test $\alpha_1-a_1=0$ $\beta_1-b_1=0$
Aluminum	0.139 (0.099)	0.713 (0.369)	1.93*	1.39	0.28	3.74*
Copper	0.126 (0.133)	0.524 (0.655)	0.80	1.26	-0.05	0.64
Sugar	0.347 (0.140)	0.118 (0.164)	0.72	1.71	-0.07	0.52
Coffee	0.030 (0.062)	-0.378 (0.268)	-1.41*	2.07	0.12	1.99
Cocoa	0.044 (0.060)	0.443 (0.262)	1.69*	1.65	0.21	2.85*
Cotton	0.162 (0.094)	-0.182 (0.249)	-0.73	2.15	-0.07	0.54
Maize	0.163 (0.090)	0.079 (0.479)	0.16	2.17	-0.16	0.03
Wheat	0.060 (0.041)	-0.281 (0.217)	-1.29*	1.11	0.09	1.67
Soybeans	0.089 (0.078)	0.535 (0.741)	0.72	0.90	-0.07	0.52
Crude Oil	0.185 (0.084)	-0.121 (0.166)	-0.73	2.49	-0.07	0.53

* Significant at 15%.
Source: International Economics Department, World Bank.

Subtraction of (10) from (3) yields:

$$E_t p_{t+1} - p_{t+1} = (\alpha_2 - a_2) + (\beta_2 - b_2)\ (E_{t-1} p_t - p_t). \qquad (11)$$

Equation (11) expresses forecast errors as a linear function of their lagged value. A test of the rationality of adaptive expectations, therefore, amounts to a test of serial correlation in the forecast error. The null hypothesis of rational expectations implies $\alpha_2-a_2 = \beta_2-b_2 = 0$. Estimation results of equation (11) are shown in Table 9.

F-test results show that the null hypothesis cannot be rejected at the usual significance level; it can be rejected at the 15% level only for coffee. The non-rejection result here is somewhat stronger than in the case of extrapolative expectations, probably because adaptive behavior approximates the reality more closely than the distributed lag representation. None of the slope

Table 9: Rationality of Adaptive Expectations

	α_2-a_2	β_2-b_2	t: $\beta_2-b_2=0$	D-W	$\bar{R}$**2	F test $\alpha_2-a_2=0$ $\beta_2-b_2=0$
Aluminum	0.026 (0.130)	0.581 (0.392)	1.48*	1.21	0.15	2.20
Copper	0.009 (0.153)	0.613 (0.448)	1.37*	1.50	0.11	1.87
Sugar	0.341 (0.160)	0.037 (0.201)	0.18	1.64	-0.16	0.03
Coffee	0.055 (0.061)	-0.538 (0.298)	-1.81*	1.92	0.24	3.27*
Cocoa	0.032 (0.068)	0.300 (0.220)	1.36*	1.33	0.11	1.85
Cotton	0.204 (0.096)	-0.292 (0.272)	-1.07	1.97	0.02	1.15
Maize	0.270 (0.122)	-0.502 (0.460)	-1.09	2.16	0.03	1.19
Wheat	0.054 (0.059)	0.002 (0.412)	0.006	0.73	-0.17	0.00
Soybeans	0.096 (0.091)	0.121 (0.424)	0.29	1.01	-0.15	0.08
Crude Oil	0.194 (0.089)	-0.081 (0.184)	-0.44	2.66	-0.13	0.19

Notes: See Table 8.
Source: International Economics Department, World Bank.

terms are significant at 5%; only at the 15% level, do four commodities show significant slopes.

Although statistically not significant, the slope term is estimated to be quite large in at least seven commodities, which may be grounds for suspecting the presence of serial correlation in forecast errors. In six of the ten commodities, the coefficient is positive; for these commodities, the forecaster attaches too much weight to the previous forecast and, therefore, can improve the forecast by shifting the weight more to the current spot price. This is in sharp contrast to the findings by Frankel and Froot that most exchange rate forecasters surveyed adapt too fast to spot rate changes. In four of the commodities with a negative slope coefficient, the opposite holds.

The intercept terms are not significantly different from zero for six of the commodities; for these commodities, forecast errors arise not because of unconditional bias but because either too little or too much attention is given to the previous forecasts. Even when the intercept is significant, its size is smaller than in the case of extrapolative expectations.

Following the same method, we now test the rationality of the regressive expectation estimates. The forecast errors are regressed on p_t and $p_t - p^*_t$, respectively, and the results are shown in Tables 10 and 11. For both versions of regressive expectations, the null hypothesis of rational expectations is rejected only for cotton and wheat. For both of these commodities, significantly positive slope coefficients indicate that actual spot prices tended to converge to the long-term equilibrium levels much faster than the CM forecasts. In version I, the slope coefficients are all positive except for the metals, implying that the CM forecasts can be improved by converging to the long-term prices more rapidly. In version II, the same recommendation applies to all commodities except aluminum. For copper and aluminum, it was shown in Tables 6 and 7 that the CM forecasts put high weight (60% to 90%) on the long-run price. These are found to be excessive.

Table 10: Rationality of Regressive Expectations I

	α_3-a_3	β_3-b_3	t: β_3-b_3=0	D-W	$\bar{R}$**2	F-test α_3-a_3=0 β_3-b_3=0
Aluminum	3.716	-0.500	-0.92	1.02	-0.02	0.84
	(3.939)	(0.545)				
Copper	1.294	-0.161	-0.22	0.77	-0.13	0.05
	(5.433)	(0.735)				
Sugar	-0.767	0.188	0.71	0.94	-0.07	0.51
	(1.378)	(0.263)				
Coffee	-3.174	0.557	1.26	2.31	0.07	1.59
	(2.505)	(0.441)				
Cocoa	-2.105	0.410	1.39	0.83	0.10	1.93
	(1.587)	(0.295)				
Cotton	-2.756	0.570	2.32*	1.82	0.35	5.36*
	(1.587)	(0.295)				
Maize	-1.214	0.293	0.94	2.31	-0.02	0.88
	(1.485)	(0.313)				
Wheat	-3.074	0.613	4.30**	1.71	0.69	18.48**
	(0.727)	(0.143)				
Soybeans	-2.988	0.553	1.35	1.34	0.09	1.83
	(2.272)	(0.409)				
Crude Oil	-0.737	0.263	0.91	1.02	-0.02	0.84
	(0.915)	(0.288)				

Notes: See Table 4.
Source: International Economics Department, World Bank.

Table 11: Rationality of Regressive Expectations II

	α_4-a_4	β_4-b_4	t: $\beta_4-b_4=0$	D-W	$\bar{R}$**2	F test $\alpha_4-a_4=0$ $\beta_4-b_4=0$
Aluminum	0.098 (0.121)	-0.101 (0.579)	-0.17	0.85	-0.14	0.03
Copper	0.291 (0.369)	0.327 (0.615)	0.53	0.73	-0.10	0.28
Sugar	0.330 (0.270)	0.170 (0.260)	0.65	0.96	-0.08	0.43
Coffee	0.015 (0.108)	0.116 (0.363)	0.32	2.85	-0.13	0.10
Cocoa	0.122 (0.070)	0.234 (0.253)	0.92	0.81	-0.02	0.85
Cotton	0.296 (0.090)	0.526 (0.215)	2.44*	1.80	0.38	5.96*
Maize	0.263 (0.114)	0.230 (0.233)	0.99	2.34	-0.003	0.98
Wheat	0.191 (0.041)	0.440 (0.109)	4.03**	1.76	0.66	16.23**
Soybeans	0.259 (0.123)	0.448 (0.276)	1.62	1.44	0.17	2.63
Crude Oil	-0.029 (0.219)	0.173 (0.262)	0.66	1.16	-0.07	0.44

Notes: See Table 4.
Source: International Economics Department, World Bank.

Finally, most of the intercept terms are not significantly different from zero -- the regressive forecasts are not unconditionally biased.

V. CONCLUSIONS

This paper analyzed CM's short-term commodity price forecasts with standard expectational models. The results appear to be the following:

(1) The one year-ahead CM forecasts for the period 1979-88 on average have shown positive forecast errors (overestimated the future spot prices) which are often larger than the forecast errors of futures prices. This overforecasting may be partly due to the extended period of low commodity prices in the 1980s.

(2) Among the expectational models estimated, the adaptive expectations model appears to describe the CM forecast behavior most closely. This form of expectations probably makes the most sense as a short-term forecasting strategy.

(3) CM forecasts are stabilizing, regardless of the expectational model used. There are no indications of any "bandwagon" behavior; actually, CM forecasts tend to put less emphasis on the latest price developments than those studied by others.

(4) The CM forecasts are far from static in that they put much smaller weight on the current spot price than found in other studies. Factors other than the current spot price -- such as lagged spot price, previous forecasts, and long-term equilibrium price used in this study -- weigh more heavily in CM forecasts than in others. In other words, the CM forecasts are not as adaptive to the latest price changes as others.

(5) The characteristic of CM forecasts described in (4) above is probably less than desirable; CM short-term forecasts, can benefit by more readily adapting to the most recent price developments. However, statistical tests show that this characteristic cannot be branded as irrational. This lack of rejection of the rational expectations hypothesis contradicts the results of previous studies of these forecasts that strongly rejected the hypothesis. Considerations of the small sample size and the autocorrelation in the explanatory variables strengthen the non-rejection result.

The above findi gs seem robust despite apparent caveats. The non-rejection of ra ionality is stronger than what the test statistics suggest because much of the over-prediction during the early 1980s can be attributed to the notion of a regime change, a concept that Lewis formally introduced to explain forecast errors. Lewis found that about half of the forecast errors implied by foreign exchange futures could be attributed to the time it took agents to recognize and adapt to changes in US money demand. During the period under study here, there have been a number of important changes in the commodity markets. First, the macroeconomic assumptions on which the commodity price forecasts have been based were slow to recognize the severity and duration of the 1982-85 recession. Institutional rigidities may have played a part in this. Secondly, the market structure has changed to a more competitive environment; the most notable is the gradual weakening of the OPEC oil cartel. Thirdly, the demand growth for metals slowed down to such an extent that structural change was widely conjectured to be its cause. These are just a few of the major changes that have affected commodity prices. Because of the diversity of these changes, some specific to each commodity, it is difficult to assess their impact on the CM forecast errors, a la Lewis. Even without going through an analysis, however, it can safely be concluded that taking the regime changes into consideration will strengthen the non-rejection of rationality of CM forecasts.

There is a trade-off in giving more weight to current spot price movements, however. In its extreme form, this is equivalent to the proposition that commodity prices are martingales and thus unpredictable. However, this proposition has generally been deemed applicable to the very short term, such as day-to-day or weekly price movements, but not for a forecast horizon of a year or longer. The CM forecasts are based on the premise that prices over a year's horizon are predictable; an independent assessment of market fundamentals would be more desirable than taking the static approach if the institution has certain informational advantages. In the case of the World Bank, a clear advantage is its global network of operation. As shown at the beginning of this paper, the CM forecasts have been more successful in predicting market turnarounds and sharp price changes than static expectations or futures prices. Thus, adapting too closely to spot or futures prices is probably informationally inefficient from the institution's standpoint.

In conclusion, CM forecasts with significant but not excessive adaptation to spot price movements probably offer a reasonable and optimal short-term forecasting strategy, superior to "naive" forecasts or futures prices.

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