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APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

Error Decomposition in Commodity Price Forecast Evaluation

by

Dean T. Chen

ERROR DECOMPOSITION IN COMMODITY PRICE FORECAST EVALUATION

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I. Introduction

Predictive testing of econometric models and commodity futures markets has long been an important area of applied econometric research. An analysis of the model's predictive performance is useful for model evaluation and selection, and for detecting the areas of deficiencies in model enhancement. Similarly, careful examination of the futures price quotations against the cash market movement should help explain the commodity market behavior, especially the dynamic process of price determination.

The theory of econometric error analysis can best be considered a mirror reflection of the theory of econometric prediction. In a

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broad sense, there are two major areas of empirical investigations: one relates to the questions on the statistical inferences of predictive errors, and the other concerns the analytic (economic) content of prediction errors. A casual look at the existing literature suggests that much of the recent empirical research has focused on the statistical inference area. This includes a price-forecasting performance analysis of large-scale econometric models in comparison forecasting techniques for commodity price forecast (Brandt and Bessler), and a testing of the efficient market hypothesis, and the hypothesis on rational price formation (Martin and Garcia).

However, aside from the purely mechanical testing results in the accuracy of prediction, none of the aforementioned studies seem to provide adequate information about the predictive performance of econometric model forecasts *per se*. Obviously, the mechanical calculation of the error statistics does not reveal much information about the predictive performance of the model because of the complexity of the error structures and the divergent sources of uncertainties associated with them.

To shed some light, this paper proposes to examine the predictive performance of the Wharton Agricultural Model by decomposing the predictive errors into parts for a quantitative assessment of the various sources of uncertainty and the contributing factors. To be most useful in this respect, I will present a formal theoretical framework for error decomposition analysis in Section II. With a proper error decomposition, I can then explore the role of conditional forecasting of commodity prices with respect to responsiveness of the model to unusual policy shifts and exogenous disturbances of supply, demand, and inventory stocks over time.

A major objective of this paper is to describe the dynamic process of formulating expectations of the key exogenous variables, and to determine their impacts on commodity prices. In this respect, I found the 1980 corn price forecasting experiences to be a perfect example for empirical testing. The statistical results of the simulation analysis of the 1980 summer drought and Soviet grain embargo are presented in Sections III and IV. The final section of this paper summarizes the analysis and assesses implications for future research.

II. The Theoretical Framework

For a formal treatment of the statistical inference of econometric predictions, Mariano and Brown (1981) summarized into two major categories dealing with either a stochastic or a non-stochastic simulation analysis, and provided a detailed analytical review of the asymptotic properties of predictors in a non-linear simultaneous equation system. In practical application, it is a common practice for econometric model forecasts to be generated by a deterministic or non-stochastic solution approach, and that the structural disturbances be replaced by the expected values of zero. Given such a forecasting exercise, I will briefly describe the structure of an econometric model system and the various error components in prediction.

In abstract terms, the structural equations of a basic econometric model system can be written as:

(1) $F(y_t, x_t; \theta) = U_t$

where F is an nxl vector of functions of the nxl vector of endogenous variables y_t, the mxl vector of exogenous variables x_t, and the Pxl vector of parameters θ. We also make the standard assumptions about the statistical properties of the random disturbances of terms of U_t.

Given this generalized formulation of an econometric model system and the assumption that the inverse relationships can be derived either explicitly as reduced form equations or implicitly through numerical analysis, I can then demonstrate the predictive property of the model according to a single inverse relationship

(2) $Y_t = g(u_t, x_t; \theta)$.

In an actual forecasting exercise, the model is used to generate the predicted values of the endogenous variables based on the estimated values of parameters θ from historical sample period data, the expected values of the structural disturbances of u_t at zero, and the assumed input values of exogenous variables $\hat{x}_t$ over the prediction period. Under such circumstances (with the proper substitutions), the actual forecasting problem can be easily expressed by the following relationship:

(3) $Y_t = g(0, \hat{x}_t; \hat{\theta})$.

Perhaps I should also mention the model adjustment procedure which has long been a necessary part of any on-going forecasting operation of econometric models. Largely as a result of data revision, external disturbances, structural changes, and the availability of non-sample and non-model information, the econometric forecasters must adjust the model so as to align its performance and therefore enhance the quality of a forecast. In this respect, adjustment can be made to the intercepts or coefficients of any behavioral equation. Taking this type of adjustment into account, Equation (3) must be rewritten as

$$(4) \quad Y_t = g(0,\hat{x}_t,\tilde{\theta})$$

where $\tilde{\theta}$ is the vector of adjusted values of the parameters actually used in the preparation of a forecast solution.

A careful examination of Equations (2), (3), and (4) clearly indicates the possible areas of uncertainty and the major sources of forecasting errors. Summarizing these into four main areas, uncertainty is due to (1) stochastic disturbance terms associated with the model, U_t; (2) the parameters of the model, either the estimated terms from sample data, $\hat{\theta}$; or the adjusted terms used for the forecast, $\tilde{\theta}$; (3) the assumed input values of exogenous variables, $\hat{x}_t$; and (4) the possible misspecification of the model, g(.).

The basic advantages of this type of error decomposition analysis over the procedure of computing root mean squared errors or root mean squared percentage error (as argued by Fair) are its ability to determine the sources of the forecast errors as they change over time, especially the errors from the exogenous variable forecasts (Fair, 1980, p. 355).

In this paper, I will focus my attention on forecasting errors of exogenous variables, especially for a quantitative assessment of the impacts of unpredictable changes in weather conditions (e.g., the 1980 summer drought), and the important policy shifts (e.g., the Soviet grain embargo). If I take strictly the prediction errors of exogenous variables as an argument, these error terms can be expressed as:

$$(5)\quad \hat{x}_t = x_*^T + V_*$$

where x_*^T is the true exogenous variables' value and V_* the prediction errors of the exogenous variables that the forecasters used as the inputs into the model. As a result, it is possible to derive an analytical solution of the forecasting errors of y_t with respect strictly to the prediction errors of exogenous variables:[1]

$$(6)\quad g(0,\hat{x}_t;\tilde{\theta}) = g(0,x_*^T;\tilde{\theta}) + \frac{\partial g(0,x_*^T;\tilde{\theta})}{\partial x_*^T} \cdot V_* + \text{remainder.}$$

While we can give some insights into the asymptotic behavior of this error component, my purpose here is to examine the ex-ante forecasting performance of the Wharton Monthly Crop Price Forecasting Model. Given the theoretical description of error decomposition analysis outlined above, empirical testing of the predictive performance of the model can be done with the use of the predicted values of the exogenous variables of $\hat{x}_t$ for the baseline solution in comparison to the shocked solutions with the actual values of exogenous variables X_*^T as input to the model. The results of these simulation analyses will be reported in the next two sections.

III. External Disturbances to Agricultural Markets

An unusual combination of external events--the partial suspension of grain sales to the USSR in January and the severe crop failures induced by drought conditions in the summer--have made 1980 an excellent year for predictive performance analysis using an econometric model. A test of the accuracy of econometric forecasts, together with a comparative analysis of futures markets movements, should provide important insights into econometric forecasting techniques and the behavior of futures markets.

To begin with, it is useful to provide a brief background discussion of the events that unfolded in 1980. My basic purpose is to identify the key exogenous variables that are important inputs in the Wharton Monthly Crop Price Model for forecasting market prices under the conditions of the 1980 summer drought and the grain embargo. To this end, the role of market expectations of these key exogenous variables will be examined in terms of the dynamic process of revision and realization. It is argued in this paper that there are differential price impacts on the econometric model and the futures market in response to the external shocks generated by the summer drought and the Soviet grain embargo.

1980 Summer drought

The deterioration of the corn crop started in mid-July 1980 after the release of the USDA Monthly Crop Production report. There were wide speculations regarding the magnitude of possible corn production cutbacks during the early stage of the drought. The August report put the crop estimates at 6,645 million bushels, a sharp 427 million decline in a single month. Based on our best assessment of the crop condition across the country and a review of the historical record of forecast revisions, Wharton forecasters expected the final crop size to be 6,900 million bushels for the year. While taking the official figure of 6,646 million bushels as input values of exogenous variables into the model for August and September, we also anticipated some upward production revisions during the latter part of the year. Consequently, we used our own crop forecasts of 6,750 million bushels for October and 6,850 million bushels for November.

With a further deterioration in drought conditions in the Midwest and Southeast during September and October, the USDA corn crop forecasts showed a steady decline in these two months until the crop condition stabilized in November. With the final estimates of 1980-81 corn production at 6,511 million bushels in December, the net impact of drought-induced production cutbacks amounted to 562 million bushels in six months between July and December 1980. This figure, however, represents a huge 1,427 million bushel decline in corn production from the record 1979 harvest total of 7,939 million bushels.

Obviously, weather uncertainty and crop failure generally had the most significant impact on commodity markets. The market appeared to be overly sensitive to the crop production expectation, especially during the July and September period when some private crop forecasters put the 1980 corn production forecast at a level as low as 5,700 million, nearly 2,238 million bushels below last year's total. It is reasonable to expect that cash and futures prices for corn will rise very strongly under such unusual market conditions.

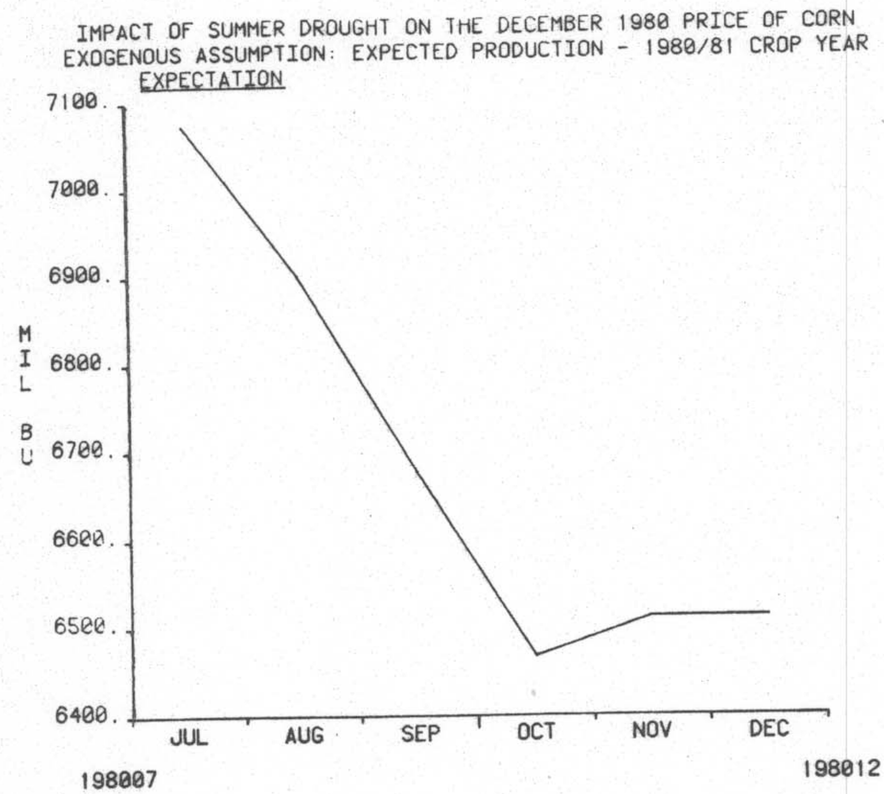
Soviet grain embargo

Economic impact analyses of the partial suspension of grain sales to the USSR has been a controversial issue ever since its announcement on January 4, 1980. A precise quantitative assessment of this policy decision is hard to obtain because of difficulties in three areas: (1) obtaining an accurate estimate of the net impact of export reductions on the U.S. corn export for the overall year; (2) identifying the offsetting effects of government programs designed to protect farmers and traders from the adverse consequences of the embargo, especially the increases in farmer-held reserve stocks; and (3) evaluating the other emerging market factors which had important effects on commodity prices during and after the embargo, such as the upward revision of crop production.

In the design of simulation studies, I chose the three-month periods before and after the embargo, October 1979 through March 1980, as our sample period of observation. The basic research strategy focused on a

Table 1. Impact of 1980 Summer Drought (Corn Production Forecast for 1980-81/million bushels)

Forecast month	Wharton Monthly Model					USDA Ag supply and demand estimates
	Date of forecast					
	7/21/80	8/19/80	9/18/80	10/22/80	11/25/80	
7/80	7,073					7,073
8/80	7,073	6,646				6,646
9/80	7,073	6,646	6,534			6,534
10/80	7,073	6,750	6,678	6,467		6,467
11/80	7,073	6,580	6,678	6,467	6,461	6,461
12/80	7,073	6,900	6,678	6,647	6,511	6,511


IMPACT OF SUMMER DROUGHT ON THE DECEMBER 1980 PRICE OF CORN
EXOGENOUS ASSUMPTION: EXPECTED PRODUCTION - 1980/81 CROP YEAR
EXPECTATION
7100.
7000.
6900.
6800.
6700.
6600.
6500.
6400.
MIL BU
JUL
AUG
SEP
OCT
NOV
DEC
198007
198012

quantitative assessment of the impacts on the two strategy exogenous variables--the U.S. corn exports and the farmer-held reserve stocks--during the six-month period. At a latter stage of research, I also discovered the importance of upward production revisions for the 1979-80 corn crop. Let me comment briefly on the changes of these three exogenous variables in the simulation period.

Based on a special grain embargo release of the Wharton Agricultural Model on January 7, 1980, our estimates of the embargo impact on corn exports for the 1979-80 crop season ranged from a minimum of 382 million bsuhels to the medium level of 512 million bushels and the maximum of 591 million bushels. In preparing the January 1980 Wharton Monthly Model control solution, the export assumption used as input into the model was 2,150 million bushels for the 1979-80 crop year, a 350 million cutback from the pre-embargo projection of 2,500 million bushels during the October-December 1979 period (see Table 2). However, a timely reassessment of our improved export prospects with the other regions, especially Mexico and China, led to significant upward revisions of corn export forecasts in February (2,275 million bushels) and March (2,400 million bushels). These figures compare well with the actual export shipments for the year--2,433 million bushels at the end of the October 1980 crop season.

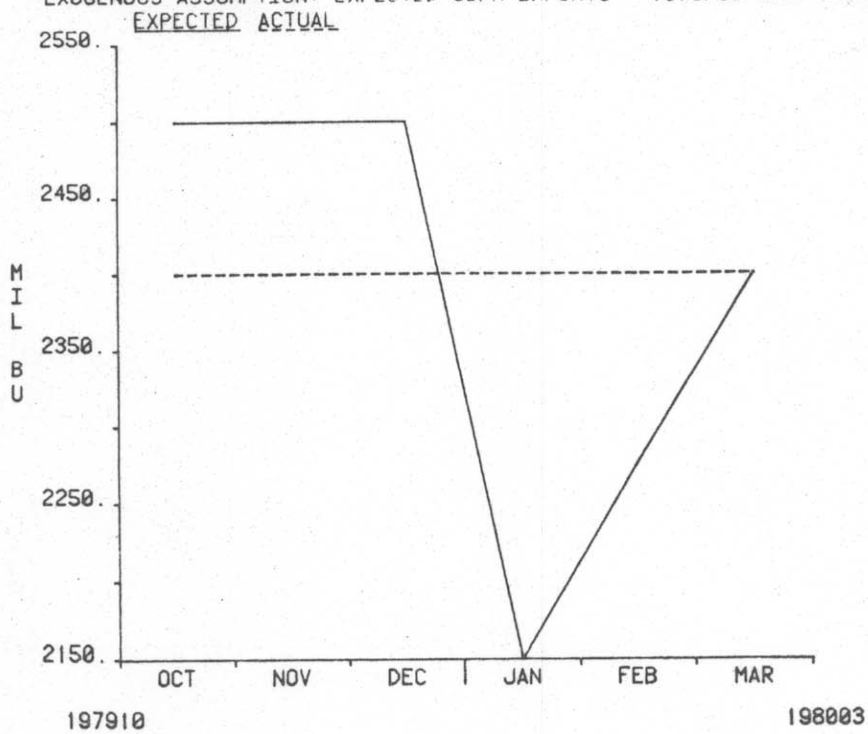
Judging from our post-embargo export forecast record, the net impact of the embargo appeared to be substantially low for corn--a net reduction of less than 100 million bushels below the pre-embargo projections. The lower-than-expected decline in export shipments can best be explained by the fact that we increased our sales to new foreign buyers and some new suppliers increased their sales to the Soviet Union. It is also argued by traders and farmers that if the suspended corn sales to the Soviet Union were added to the already strong volume, total exports for the 1979-80 crop season would be substantially larger than the actual realized volume (Cochrane, 1980, p. 3).

I believe that two other factors are important to our analysis of the 1980 grain embargo scenario: first, the counter-embargo policy move for outright purchase of embargoed grain and increased farmer-held reserves by the government, and second, the negative price effects due to an unexpected large upward revision of the 1979-80 corn crop. As shown in Table 2, comparing our December forecast of farmer-held reserve stocks of 530 million bushels for March 1980 with the post-embargo projection of 820 million bushels for the same period points to a sharp increase of 290 million bushels of corn to be put into the government reserve program. On the other hand, it is interesting to note that the 1979 corn crop estimate was raised by nearly 353 million bushels from 7,586 million bushels to 7,939 million bushels for the year.

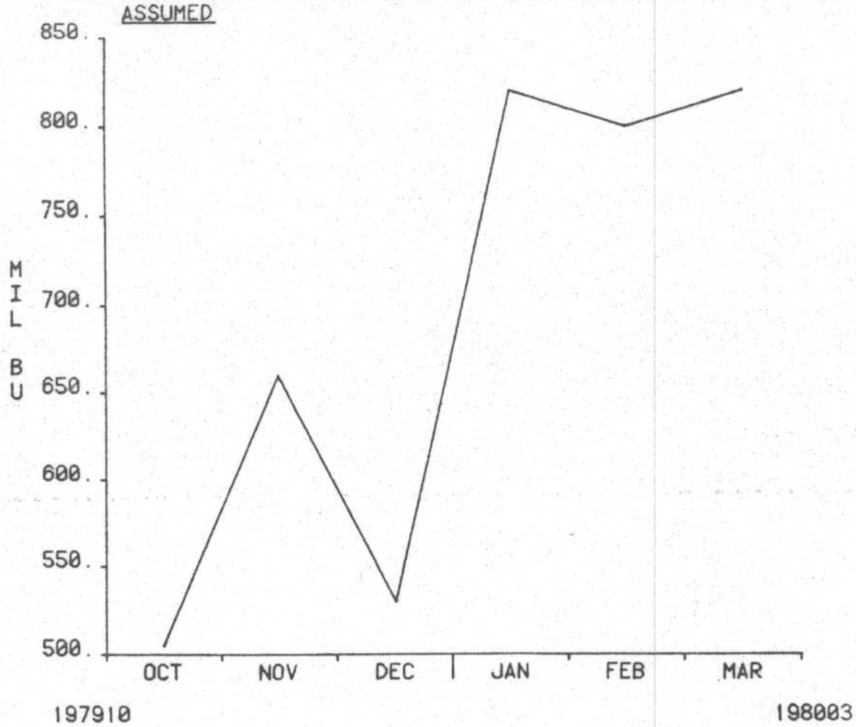
Table 2. Impact of Grain Embargo (Exogenous assumptions of exports, reserve and 1979 crop/million bushels)

Forecast month	1979-80 Corn exports	Wharton Monthly Model: Farmer-held reserve stocks end of March 1980	USDA Ag supply and demand estimates 1979-80 corn production estimated
10/79	2,500	505	7,390
11/79	2,500	660	7,586
12/79	2,500	530	7,586
1/80	2,150	820	7,764
2/80	2,275	800	7,764
3/80	2,400	820	7,764
Actual	2,433	820	7,939

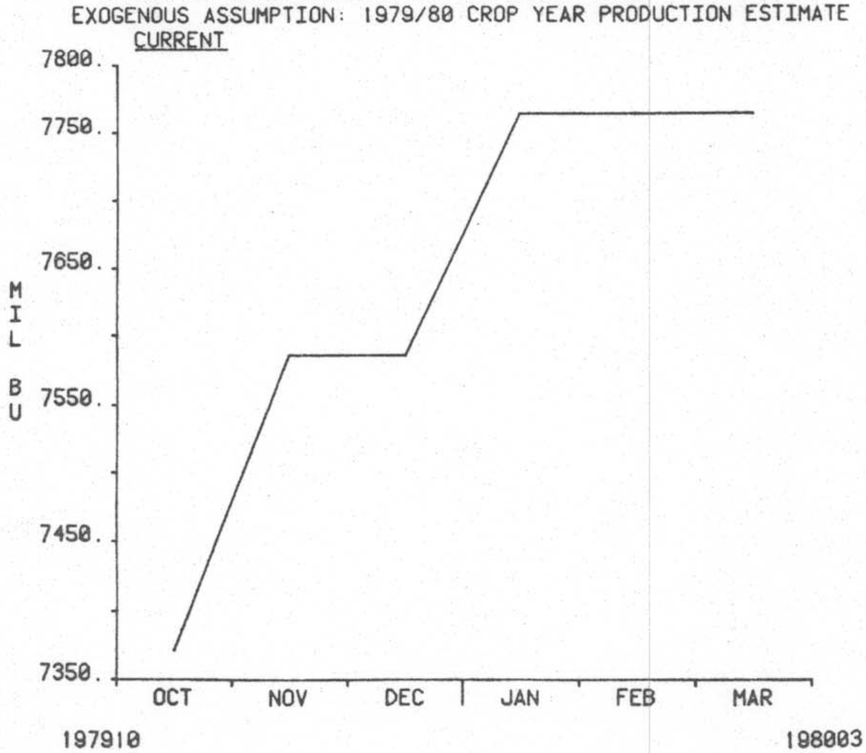
IMPACT OF GRAIN EMBARGO ON THE MARCH 1980 PRICE OF CORN
EXOGENOUS ASSUMPTION: EXPECTED CORN EXPORTS - 1979/80 CROP YEAR



IMPACT OF GRAIN EMBARGO ON THE MARCH 1980 PRICE OF CORN
EXOGENOUS ASSUMPTION: FARMER HELD CORN RESERVES, MARCH 1980



IMPACT OF GRAIN EMBARGO ON THE MARCH 1980 PRICE OF CORN
EXOGENOUS ASSUMPTION: 1979/80 CROP YEAR PRODUCTION ESTIMATE



IV. Price Impact of 1980 Summer Drought and Grains Embargo

Empirical results from simulation studies of the 1980 corn price forecasting experiences which are discussed in this section address three major questions: (1) What is the dynamic response pattern of commodity prices to external disturbances based on the actual results of an on-going econometric forecasting model? (2) How effective an econometric model can be used for quantitative assessment of uncertainty as shown by the actual deviations of exogenous assumptions from the baseline solutions? and (3) Are there significant differences in price-forecasting performance of econometric models and futures markets under stable and unstable conditions? The answers to the first two questions are self-explanatory, while the third question needs to be answered with additional statistical evidence.

Drought induced price run-up

The cash prices of corn at Chicago moved rather slowly within a narrow range of \$2.54 to \$2.70 per bushel during the first six months of 1980. By mid-July, the Chicago corn market set in motion for a sharp upturn in response to drought conditions, pushing up corn prices from a monthly average of \$2.70 in June to \$3.54 by December 1980. This sizeable 84 cent per bushel gain in corn prices in the second half of the year was due primarily to the weather-induced crop failures in the summer months.

Let me take December prices of corn for both the cash and the futures markets as a reference point for an econometric analysis of short-term price movement. Looking at our forecasting record and the futures market quotations of December corn prices, we can trace the price movement closely in line with the 1980 corn crop development. It is clear that before the drought conditions developed in mid-July, the Wharton model forecast and futures market quotations on June 23, 1980, underestimated the December prices by substantial margins. Largely reflecting our expectations of a large 1980 corn crop (7.2 billion bushels) on the heels of a record 1979 harvest (7.9 billion bushels) and downward export pressures from the grain embargo, the Wharton Model put the December corn price at $2.61 per bushel, while the futures market quotation was $2.96 on the same date of the forecast. As a result, the futures market underestimated December prices by 58 cents in contrast to 93 cents for the Wharton model for the forecast six months ahead.

Responding to the drought conditions and the expectations of crop failures for the year, Wharton's upward revisions of December prices ranged from 16 cents in July, 41 cents in August, 3 cents in September, and another 44 cents in October. These figures compared well with the corresponding increases in futures market quotations of 27 cents, 17 cents, 12 cents, and 17 cents for each month. The upward revisions of Wharton price forecasts matched closely with our corn production forecasts over these four months. The most interesting aspects of the Wharton forecasting record were a substantial underestimation of of the drought-induced crop damage in August and an overestimation of the production cutback in October.

A careful examination of the price-forecasting errors for the Wharton model clearly demonstrates a close relationship between the errors in forecasting prices and the error in forecasting 1980 corn production. My research strategy was to isolate the price impact of the drought from the model by using the actual figure of 1980 corn production as input values into the model instead of the baseline solution assumptions of the various crop sizes for each month. Comparing simulation results of these "shock solutions" with the actual "baseline solutions," we can then easily calculate the price impacts of drought conditions over the six-month period of 1980. The results are indeed encouraging because a main part of the price-forecasting error can be explained by the price impact of the drought. For example, a total of 93 percent of the forecasting error in June (87 cents versus 93 cents) and July (71 cents versus 77 cents) was caused by the drought-induced cutback of the 1980 corn crop. An interesting contrast was our October forecast when we overestimated the price increase by 11 cents for December, and 10 cents of this was due to our overestimation of the crop damage for the year.

There are no easy ways to describe the simulation results of the model without a proper discussion of the model's specification. In a sense, the Wharton Monthly Crop Price Model is a dynamic expectation model reflecting the process in formulating, revising, and realizing the market expectations with which the supply-demand

Table 3. Impact of 1980 Summer Drought on December Prices of Corn (June 1980 through December 1980, actual corn price for December 1980, $3.54/bu)

	Wharton Monthly Model			Future Market Price	
Forecast month	Forecast	Deviation from actual	Price impact of drought	Quotation	Deviation from actual
6/23/80	$2.61	-0.93	0.87	$2.96	-0.58
7/21/80	2.77	-0.77	0.71	3.23	-0.31
8/19/80	3.18	-0.36	0.51	3.40	-0.14
9/18/80	3.21	-0.33	0.20	3.52	-0.02
10/22/80	3.65	0.11	-0.10	3.69	0.15
11/25/80	3.44	-0.14	-0.07	3.87	0.33
12/16/80	3.46	-0.12	-0.07	3.60	0.06

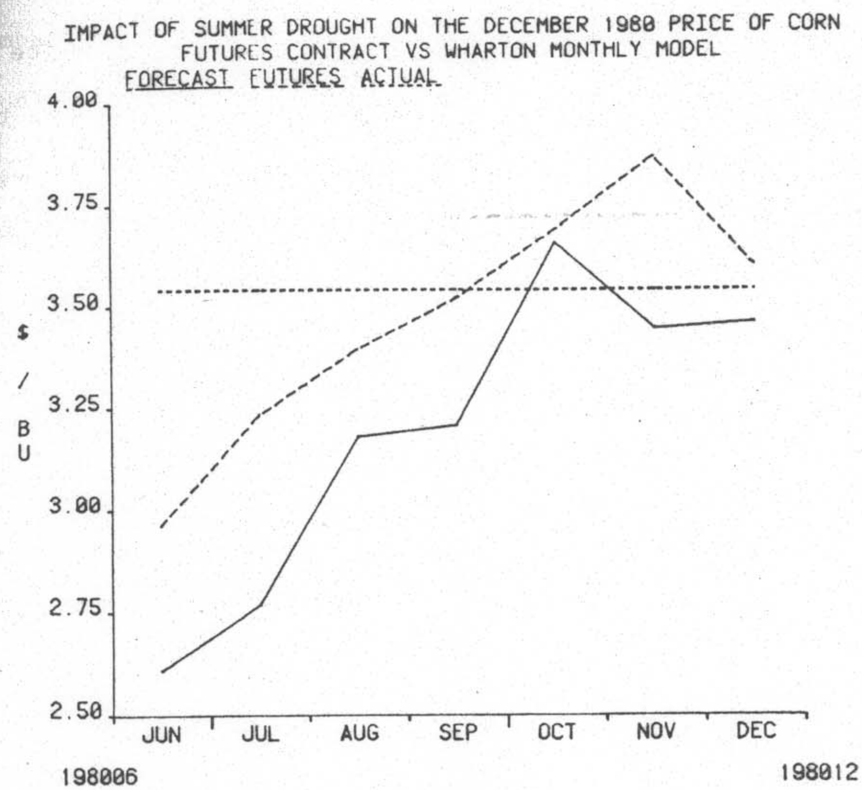
adjustments are made to reach market equilibrium conditions. Perhaps a short-cut method for describing the simulation results is through a brief discussion of the impact used for analysis. In this case, we have the impact multipliers for corn production with regard to a 100 million bushel cutback of 1980 crops.

As shown in Table 4, the impact multipliers for corn production range from $0.019 cor expectation components, $0.102 for revision components and $0.05 per bushel for realization components. In other words, the total net impact of a 100 million bushel reduction in the corn crop is expected to cause a $0.171 per bushel increase in cash corn price according to our simulation experimentation results. Given these impact multipliers, together with the calculations of the exogenous variable deviations from the actual levels, the net contribution of the impacts of drought conditions can be determined through a simple multiplication of two items. Adding up all three types of impacts (expectation, revision, and realization),[2] we can easily obtain the total contribution of price impacts from drought conditions for each month from June through December of 1980. The results are summarized on the bottom of Table 4.

Judging from the simulation results presented in Table 4, I found that the econometric model forecasting performance is surprisingly good for tracking short-term price movements. A casual look at the time path of econometric model forecasts in comparison to the futures market price movement suggests that econometric price forecasts outperform futures markets significantly at the time crop conditions were stabilized. In this case, the Wharton forecasts were consistently better than the futures markets for October and November forecasts of December corn prices or forecasts that are one or two months ahead. For long forecasting horizons, the Wharton Monthly model would also perform extremely well with good crop forecasts as input into the model.

Table 4. Impact of 1980 Summer Drought on December Prices of Corn (June 1980 through December 1980

Impact variable	Date of Forecast and Future Contract Quotation						
	6/23/80	7/21/80	8/19/80	9/18/80	10/22/80	11/25/80	12/16/80
1980-81 Corn production decrease of 100 million bushels							
1. Impact multiplier							
1.1. Expectation	0.019	0.019	0.019	0.019	0.019	0.019	0.019
1.2. Revision	0.102	0.102	0.102	0.102	0.102	0.102	0.102
1.3. Realization	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2. Exogenous assumptions							
2.1. Expectation	6.886	5.619	3.886	1.666	-0.444	0.0	0.0
2.2. Revision	4.502	3.831	3.053	1.666	-0.444	0.0	0.0
2.3. Realization	5.525	4.258	2.525	0.305	-0.943	-1.361	-1.361
3. Contribution							
3.1. Expectation (3.1)=(1.1)x(2.1)	0.131	0.147	0.074	0.032	-0.009	0.0	0.0
3.2. Revision (3.2)=(1.2)x(2.2)	0.459	0.391	0.311	0.169	-0.045	0.0	0.0
3.3. Realization (3.3)=(1.3)x(2.3)	0.276	0.213	0.126	0.002	-0.047	-0.068	-0.068
4. Total contribution (4)=(3.1)+(3.2)+(3.3)	0.87	0.71	0.51	0.20	-0.10	-0.07	-0.07


IMPACT OF SUMMER DROUGHT ON THE DECEMBER 1980 PRICE OF CORN
FUTURES CONTRACT VS WHARTON MONTHLY MODEL
FORECAST FUTURES ACTUAL
4.00
3.75
3.50
3.25
3.00
2.75
2.50
$ / BU
JUN
JUL
AUG
SEP
OCT
NOV
DEC
198006
198012

Embargo and upward crop revision depressed prices

As an interesting contrast to the drought-induced price upturn, the Soviet grain embargo and upward revision of the 1979 crop estimates combined to put significant downward pressures on corn prices. For the simulation analysis, I used the March 1980 corn price made on October 20, 1979 which pointed to a monthly average cash price of $2.99, virtually the same as the futures market quotations on the same date at $2.98 per bushel. However, Wharton forecasts were revised substantially downward in November and December in response to record large harvests of the 1979 crop and the seasonal downturn of cash prices. By the same token, the March contract prices also lost some ground in November and December even though the price quotations remained slightly higher than Wharton model forecasts.

The impact of the grain embargo was most significantly reflected in the Wharton forecast on January 23, 1980 where our forecast of March corn prices registered a sharp 35 cents per bushel decline from a $2.84 to $2.49 average for the month. On the other hand, the futures market quotation on the same date was $2.71, a decline of 16 cents from the pre-embargo forecast of $2.87 made in December. I must stress that January's Wharton forecast of March corn prices was based on an important export assumption for corn--2,150 million bushels for the 1980-81 crop year. This reflected our best assessments of expected reduction of export sales to the Soviet Union, without the necessary adjustment of increased export sales to other regions. For this reason, our January export projections turned out to be substantially lower than the actual shipment realized for the year (2,433 million bushels). As a result, the bearish export assumption caused a sharp drop in the March corn price forecast.

It is true that the counter-embargo policy move in the purchase of embargoed grain and in the increase of farmer-held reserves also played a significant positive role in supporting corn prices during the first three months of 1980. This positive price impact, however, was reversed strongly by the unexpected large upward revisions of the 1979 corn harvest from 7,586 million bushels to 7,939 million bushels.

Based on the same impact simulation techniques as adopted in the drought analysis, I obtained all the necessary statistics on the impact multiplier for a 100 million bushel cutback in corn exports, a 100 million bushel increase in the 1979 corn crop, and a 100 million bushel increase in farmer-held reserve stocks as shown in Table 5. These impact multipliers, together with the calculated results of the deviations of actual exogenous variable assumptions from the assumed input values used in the baseline solution, made it possible for us to calculate the net price contributions from the changes in assumptions of corn exports, farmer-held reserve stocks, and 1979 corn production revisions.

The simulation results of these impact analyses suggest that Wharton corn price forecasting errors during the pre-embargo period of October (39 cents), November (22 cents), and December (24 cents) of 1980 can largely be explained by the price impacts of the embargo (40 cents in October, 29 cents in November, and 23 cents in December) (see

Table 5. Impact of Grain Embargo on March Prices of Corn (October 1979 through March 1980, actual corn price for March 1980, $2.60/ bushel)

	Wharton Monthly Model			Futures Market Price	
Forecast month	Forecast	Deviation from actual	Price impact of embargo and production revisions	Quotation	Deviation from actual
10/20/79	$2.99	0.39	-0.40	$2.98	0.38
11/19/79	2.82	0.22	-0.29	2.89	0.29
12/23/79	2.84	0.24	-0.23	2.87	0.27
1/23/80	2.49	-0.11	0.05	2.71	0.11
2/21/80	2.61	0.01	-0.06	2.70	0.10
3/20/80	2.60	0.0	-0.14	2.65	0.05

Table 5). The most impressive aspect of this simulation study is the positive price impact for January, which helped to offset the underestimation error of our export projections for the 1980-81 crop season.

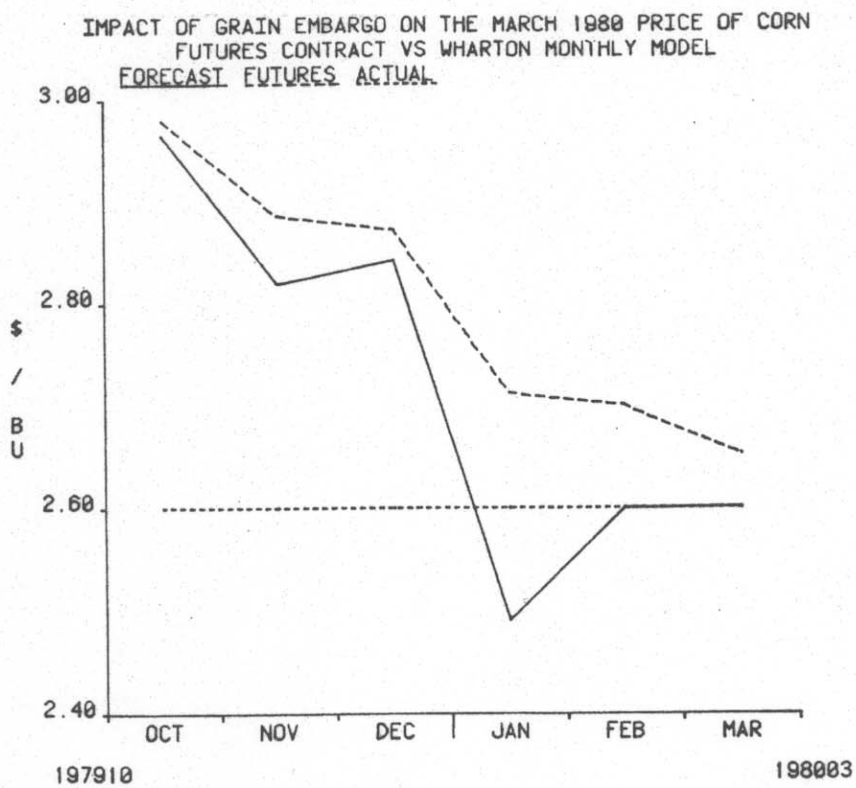
I must also stress the surprisingly good forecasting performance of the econometric model in tracking short-term price movement. In this case, the February and March forecasts of the monthly average price for March 1980 were indeed encouraging. My experiences with testing the Wharton Monthly Crop Price Model helped dispel any lingering doubt about a consensus opinion that econometric models are not useful for short-term price forecasting, especially for predicting commodity prices.

Table 6. Impact of Soviet Grain Embargo on March 1980 corn prices (October 1979 through March 1980)

Impact variable	Date of Forecast and Future Contract Quotations					
	10/20/79	11/19/79	12/23/79	1/23/80	2/21/80	3/20/80
Corn Exports						
1. Impact multiplier						
1.1. Expectation decrease 100 million bu/year	-0.064	-0.064	-0.064	-0.064	-0.064	-0.064
1.2. Actual decrease 10 million bu/month	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
2. Exogenous assumptions Deviation from actual						
2.2. Expectation	1.000	1.000	1.000	-2.500	-1.250	0.0
2.3. Actual	-0.366	-0.800	-1.621	-9.633	-1.000	-0.900
3. Contribution						
3.1. Expectation (3.1)=(1.1)x(2.1)	-0.064	-0.064	-0.064	0.160	0.080	0.0
3.2. Actual (3.2)=(1.2)x(2.2)	0.002	0.004	0.008	0.048	0.006	0.005
3.3. Total (3.3)=(3.1)+(3.2)	-0.062	-0.060	-0.056	0.208	0.086	0.005
Farmer-owned reserve						
4. Impact multiplier Increase of 100 million bushels Jan. through March 1980	0.034	0.034	0.034	0.034	0.034	0.034
5. Exogenous assumptions Deviation from actual	4.47	2.20	4.01	-0.10	0.27	0.0
6. Contribution (6)=(4)x(5)	0.152	0.075	0.136	-0.003	0.009	0.0

Table 6 (Continued)

Impact variable	Date of Forecast and Future Contract Quotations					
	10/20/79	11/19/79	12/23/79	1/23/80	2/21/80	3/20/80
Upward production revision: 1979 crop						
7. Impact multiplier Increase of 100 mil bu	-0.087	-0.087	-0.087	-0.087	-0.087	-0.087
8. Exogenous assumptions Deviation from actual	5.677	3.528	3.528	1.742	1.742	1.742
9. Contribution (9)=(7)x(8)	-0.494	-0.307	-0.307	-0.152	-0.152	-0.152
10. Total net contribution (10)=(9)+(6)+(3)	-0.40	-0.29	-0.23	0.05	-0.06	-0.14


IMPACT OF GRAIN EMBARGO ON THE MARCH 1980 PRICE OF CORN
FUTURES CONTRACT VS WHARTON MONTHLY MODEL
FORECAST FUTURES ACTUAL
3.00
2.80
2.60
2.40
$ / BU
OCT
NOV
DEC
JAN
FEB
MAR
197910
198003

Forecasting accuracy in stable and unstable time periods

It is argued in this paper that the relatively "superior" performance of the futures markets over that of econometric models was due mainly to price impacts of external disturbances. The built-in bias component of futures market prices would make the price-forecasting performance analysis difficult when the market experiences a major price upturn generated by weather-induced crop failures.

For forecasting comparison purposes, the problem is more acute for testing the prediction errors for longer forecasting horizons. Results of our simulation study clearly demonstrate that econometric model forecasts generally outperform the futures markets for forecasting short-term price movements one to two months ahead. This is true for both stable and unstable time periods.

However, our prediction testing of econometric models in comparison to futures market performance also shows subtantially lower root mean squared errors for the model under stable market conditions over longer forecast horizons. The results are summarized in Table 7.

V. Conclusions

The empirical testing results of the Wharton Monthly Crop Price Model that are presented in this paper help demonstrate the best contributions that an on-going econometric forecasting model can possibly make, namely, (1) the accuracy in forecasting short-term

Table 7. Accuracy of Wharton Model and Futures Market (Forecast error (root mean square error))

Forecast Horizon	Stable Period 7/79-4/80		Shock Period 5/80-12/80	
	Wharton	Futures*	Wharton	Futures
One month	3.0	7.9	4.8	10.6
Two months	7.9	17.1	23.3	18.5
Three months	11.4	20.7	43.8	27.0
Four months	20.2	27.5	62.4	36.3

*Comparison of Wharton forecasts with futures quotations at coincidental points in time.

commodity price movement (one to two months ahead) under stable and unstable market conditions; (2) the accuracy in forecasting longer-term (beyond one or two months) commodity price movement under the market conditions without major external disturbances. Even under the unstable market conditions for longer-term price forecast, the econometric model can be used for quantitative assessment of unpredictable events by generating alternative forecasting solutions. The impact simulation analysis helps demonstrate highly accurate results from the model by the actual values of exogenous variables as input into the forecast solution. These forecast comparison results of econometric model and future market quotations can be summarized as follows:

Accuracy in commodity price forecast (root mean squared error)

(Winner)

	Short-term	Longer-term
Stable market condition	Model	Model
Unstable market condition	Model	(Future ?)

In presenting these forecast comparison results, I remember vividly an article "the 1973 Food Price Inflation," in which Eckstein and Heien presented their simulation results of the econometric model. They stressed the importance of a precise line of reasoning instead of specific figures. With the advantages of an on-going forecasting model, I can present my results with a high degree of confidence on both counts.

In fact, the basic objective for me in presenting the predictive performance test, the impact simulation analysis, from an econometric modeling viewpoint is that these are not just isolated cases of success. My experiences in the development and maintenance of large-scale econometric models clearly indicate the basic advantages of on-going econometric forecasting models in monitoring the day-to-day market developments, in assessing the cross-economy impacts with the U.S. and world economies, in generating the best possible forecasts for the short and long term, in identifying the areas of uncertainty for simulation analysis, and in timely generation of alternative forecasting solutions in response to major external disturbances. Our progress in these areas has been most impressive since the inception of agricultural econometric models for on-going and on-line uses in the past five to six years.

In light of the continuing improvements in data bases, statistical estimation techniques, and software and hardware of computer technology, I believe that econometric forecasting models are now available for ready use, and that the model results in commodity price forecasts reach a high degree of accuracy.

My optimistic view is not restricted to the area of forecasting accuracy alone, with which some of our accomplishments, in my judgment, can never be matched by the time series analyses or even the composite forecasting techniques. An important new area of improved applications is policy analysis. Klein argued forcefully about the value of econometric models for policy analysis in agriculture. Gardner stressed that, "In short, policy research that is worth doing professionally today almost inevitably involves quantitative modeling of agriculture" (p. 3).

Perhaps it is true, as Gardner succinctly put it that "the profession has come a long way from early studies such as Henry Schultz (1938) to recent work such as Chen (1977), Grennes, Johnson, and Thursby (1977), Burt, Koo and Duley (1980), Goodwin and Sherffin (1980) or Gallagher, et al. (1981)" (p. 4), in search of appropriate econometric methods for practical applications. The "route to Rome" has been long and bumpy, but my best evaluation today is that "we are not too far away from the St. Peters Square, and the econometric models are patiently awaiting the honor to be received by the Pope." This view is in sharp contrast to my impression of the early 1970s at the time when we were all deeply involved with the sartorial aspects of tailoring, while the King indeed had no clothes.

Footnotes

[1]The author is indebted to Robert Mariano for useful discussions and suggestions on the analytical solution on exogenous variable error components.

[2]The Wharton Monthly Model is based upon a theory of dynamic expectations in a multi-period and multi-frequency framework. The market equilibrium is hypothesized to be achieved through a dynamic process of supply-demand adjustments, taking into account explicitly the short-term (monthly) supply-demand adjustments, the short-term (monthly) expectation of the longer-term (annual) supply-demand adjustments, and the short-term revisions of the longer-term expectations over time, depending upon data availability, the biological process of farm production, and the market information mechanism. On the empirical ground, the model contains three sets of exogenous variable arguments. For example, the stock-demand ratio takes the form of

$$\left(\frac{H_t}{D_t}\right); \quad \left(\frac{H_t}{D_t}\right)^e_{t,t+k}; \quad \text{and} \quad \Delta\left(\frac{H_t}{D_t}\right)^e_{t,t+k} \quad \text{where}$$

$\frac{H_t}{D_t}$ = monthly stock-demand ratio at time t

$\left(\frac{H_t}{D_t}\right)^e_{t,t+k}$ = expected stock-demand ratio at time t for t+k period ahead,

and

$\Delta\left(\frac{H_t}{D_t}\right)^e_{t,t+k}$ = revision of the expected stock-demand ratio at time t for k period ahead.

Based upon such a specification, the impact multipliers are calculated by taking into account three different components, separately, namely the expectation, the revision and the realization components of the impact simulation study presented in this paper. A technical paper that describes the theoretical structure of this model is now under preparation.

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