CORNELL AGRICULTURAL ECONOMICS STAFF PAPER

WORLD WHEAT PRICE VARIABILITY: CHANGES IN ITS MAGNITUDE AND SOURCE

by

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December 1982

82-33

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Abstract

Estimates are presented of potential variability in real world price and its source. The estimated variance of potential deviations from trend has roughly doubled since 1960/61. The bulk of this variability is attributable to the effects of fluctuations in domestic production in LDC and CPC importers. The potential variability attributable to LDC production is increasing, and is further accentuated by their precautionary purchasing behavior. The key factor in market stability is the short-run responsiveness of U.S. wheat exports to price. Recent policy changes affecting the world market may increase future potential price instability by adding to market rigiditiy.

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WORLD WHEAT PRICE VARIABILITY: CHANGES IN ITS MAGNITUDE AND SOURCE

International trade in wheat is an important element in the world food balance equation. World exports averaged 77 million metric tonnes (MMT) during 1978-80 compared to 11 MMT for rice, and represented over 18 percent of world wheat production.[1/] The availability of wheat from the world market provides a buffer against food shortages in many nations, particularly in those of the Third World. The demand for wheat internationally provides an important outlet for a number of wheat producing countries such as the United States, Canada, and Australia.

Since the early 1970's, instability in the world wheat market, particularly in terms of price, has been a major issue facing exporters and importers.[2/] The "world food crisis" of 1973/74 with its rapid increase in the world wheat prices, forcefully demonstrated to many poorer countries their potential vulnerability to production fluctuations in other areas. Even in richer countries, who were able to pay the higher prices for imported wheat, concern was generated by the inflationary effect of rapid increases in the cost of basic foodstuffs.

Although the crisis atmosphere of the early 1970's no longer exists, the possibility that a series of poor harvests could again lead to a rapid upswing in prices remains. In the light of this, this paper explores the nature of potential price instability in the

world wheat market. It provides an insight into the determinants of short term fluctuations in exports and imports of the major participants in the market. It uses this information to estimate the magnitude of potential world price variability over the past two decades and to identify its sources. Finally, it explores some of the policy determinants of price variability.

The Structure of the World Wheat Market

As indicated by table 1, world wheat exports are dominated by just five countries -- Argentina, Australia, Canada, France and the United States. Collectively, they now account for roughly 90 percent of world exports. Given the export dominance of these countries, it is evident that the role which each of these countries plays in the generation and/or absorption of variability in the world market should be examined individually.

On the import side, there is much less national concentration than in the case of exports; so the traditional FAO aggregates of Centrally Planned Countries (CPCs), Developed Market Economy Countries (DCs) and Less Developed Market Economy Countries (LDCs) are used. The import shares for these aggregates, shown on table 1, indicate that over the last two decades there has been a marked increase in the share of world imports going to the CPCs and LDCs. In the 1979/80 marketing year, these two aggregates collectively accounted for 85 percent of world imports, up from 60 percent in 1960/61. As a consequence, the DCs now have a relatively minor position in terms of world wheat imports.

These structural changes may have had an impact on the nature of the generation and/or absorption of world market variability. In order to explore this, it is necessary to examine the determinants of short-term fluctuations in exports or imports in exporting and importing countries or regions.

Nature of Short-Term Variability in Exports and Imports

For the purposes of this analysis, short-term variability is defined as that relating to a single marketing year. It is assumed that the two principal determinants of annual fluctuations in the quantity of regional exports or imports are annual fluctuations in real world wheat prices, and annual fluctuations in the quantity of wheat produced in the exporting or importing regions. Since wheat, which is not produced in large quantities by many LDCs, is frequently imported by them to make up for production shortfalls in other food grains, annual fluctuations in total grain production is the appropriate explanatory variable in the case of LDCs.

Using ordinary least squares regression, linear trend lines were fitted to traded volumes and production for each of the countries or regions listed in table 1, and to an indicator of real world wheat price over the period 1960/61 to 1979/80.[3/] This detrending removes the longer-term systematic changes in the variables and permits annual fluctuations (represented by the residuals of the fitted equations) to be isolated and analyzed.

These deviations from trend were then regressed upon deviations from trend in regional wheat or grain production and upon deviations from trend in real world price. If either the coefficient on price

or production displayed low precision (high standard error relative to the coefficient) the variable was eliminated and the equation re-estimated. The final equations and the elasticities they imply, together with additional notes on data and methodology, are given in the Appendix. Despite its relative simplicity, this two equation approach (trend equation plus annual fluctuation equation) explains a sizable proportion of the total variability in exports or imports in most cases (table A1).

The export fluctuation equations suggest that for four of the five major exporters, the principal determinant of annual deviations from trend exports is fluctuations in their production. A positive relationship between production and export fluctuations is indicated. That is, when production deviates above trend, exports are increased above trend. When production deviates below trend, exports are decreased below trend. The degree of response varies, with Australian and Canadian exports being relatively unresponsive to short-run fluctuations in domestic production (elasticities at the mean less than unity) while Argentina and France are relatively responsive to such fluctuations (elasticities at the mean greater than unity). In none of these exporters is there evidence of responsiveness to short-term fluctuations in world price. However, in the case of the United States, a measurable response to short-run fluctuations in price is found. When prices deviate above trend, exports increase above trend and vice versa.

These results are consistent with the fact that during the period of analysis, the U.S. was the only exporter with sufficient

storage capacity and a storage program which allows significant export response to short-term price fluctuations. The only other exporter with significant stocks, Canada, has been less able to respond to short-term price changes because of its tendency to contract sales forward through its marketing board and because of the constraints imposed by its transportation system.

The results obtained for the three importing regions suggest that their imports are all responsive to short-term fluctuations in domestic production. When domestic production is above trend in a given year then (other things being equal) imports are reduced below trend and vice versa. This tendency is particularly marked in the case of the CPCs (elasticity at the mean in excess of unity). Both the DCs and the LDCs also demonstrate short-run responsiveness to price fluctuations. In the case of the DCs, the nature of response is consistent with demand theory. When prices are above trend, imports are reduced below trend and vice versa. In the case of the LDCs, however, exactly the opposite relationship applies. Above trend prices seem to stimulate above trend imports and vice versa. Although the price elasticity estimated is not large (0.2 at the mean) it does seem to suggest that LDCs have tended to behave in a precautionary way with respect to import purchases[4/]. In particular, when world prices increase above trend, LDCs enter the market in the expectation that prices may rise even further and to ensure that, in this eventuality, they will maintain sufficient supplies of grain.

Estimates of the Source and Magnitude of Potential Price Variability

The regression equations estimated for each region provide insight into the nature of their short-term fluctuations in exports or imports. However, as observed above, since the early 1960s significant changes have occurred in the relative importance of these regions in the world market. In order to explore the implications of this change, a simple equilibrium model is defined in which the annual deviation from trend in the real world price of wheat is determined as the outcome of an equilibrium between annual deviations from trend in the exports of exporting countries and in the imports of importing regions. The model (which is given in the Appendix) is structured so as to reflect the impact of changes in market shares on world price fluctuations.

On the basis of this simple model, an expression for the variance of potential price deviations from trend in each year can be derived. An estimate of the variance of price deviations in a given year can then be computed by using information on market shares derived from the export/import trend lines, the production and price response coefficients derived from the export/import fluctuation equations, and the variances and covariances of production fluctuations derived from the residuals of the production trendlines. This formula (whose derivation is given in the Appendix) also permits an estimate to be made of the percentage of the potential variation in world price due to potential production variations in each exporter and importer[5/].

In table 2, the estimated price variance and the proportion of this due to production fluctuations in each country is given for the marketing years 1960/61, 1969/70 and 1979/80. It indicates that estimated variance has roughly doubled over this twenty-year period and that the bulk of the potential variability in prices derives from production fluctuations in importing countries. In 1960/61, roughly 12 percent of the variance can be directly attributed to exporters and 86 percent to the importers. By 1979/80, the exporter share is estimated at 7 percent and the importer share at 90 percent.

The results also indicate a marked shift in the distribution of the potential variability attributable to importers' production fluctuations. In 1960/61, the principal source of potential price variability was the variability of CPC imports in response to their domestic production fluctuations. In 1979/80, the LDCs dominated the picture with over 50 percent of the potential price variability attributable to their production fluctuations. Reflecting their declining import share, production fluctuations in DC importers had become insignificant by 1979/80.

The estimates of variances can be combined with the trend value of real price to estimate the probability distribution for price fluctuations in any given year (see Appendix). Table 3 presents a summary of estimates for potential price increases for the same years as in table 2. It indicates, for example, that in 1960/61 there was a 7 percent chance that world price would be above trend by 25 percent or more and a 2 percent chance that it would be 50

percent or more above trend. By 1979/80, these probabilities are estimated to have increased to 26 percent and 10 percent, respectively. Also by 1979/80, there was an estimated 3 percent chance that price in this year could increase by 75 percent or more above trend, while this probability had been negligible in the earlier years. These estimates provide an indication of the magnitude of the increase in potential short-run price instability in the world wheat market over the last two decades.

Policy and Potential Price Variability

In the analysis of export and import fluctuations discussed earlier, two policy-related factors were identified as being of particular significance. First, the evidence of precautionary import purchasing on the part of LDCs and second, the fact that only one of the major exporters, the United States, displayed significant short-term price responsiveness. In this section, the implication of changes in these two factors for potential world price variability is briefly explored.

In order to assess the effect of precautionary purchasing by LDCs, their price responsiveness was eliminated from the model and the probability distribution for price re-estimated for the 1979/80 marketing year. With this change, it is assumed that LDCs continue to transmit their fluctuations in domestic grain production to the world market in the same way, but that their wheat imports display no responsiveness to fluctuations in world wheat prices.

The corresponding estimated probability distribution is given in the second line of table 4 and may be compared to the base case

taken from table 3. It may be seen that the elimination of precautionary buying has a sizable impact on the estimated probabilities. The estimated probability of an increase from trend price of 25 percent or more falls by half, from roughly 1 in 4 to roughly 1 in 8, and the likelihood of a 50 percent or more increase in price falls from 1 in 10 to 1 in 100. These results suggest that precautionary buying by LDCs adds significantly to the potential variability of world wheat prices.

A second important policy factor reflected in the model is the willingness and ability of the U.S. to respond to short-term variations in world prices because of its storage program. If this ability or willingness were to be reduced then its effects would be felt through a reduction in short-run export responsiveness. Although the model used in this paper is too simplistic to permit the incorporation of specific changes in U.S. commodity programs and their effects upon stocks and exports, it is possible to explore the implications of reduced U.S. export response for world price variability. To this end, several lower price elasticities than the one estimated for the U.S. were incorporated into the model and the probability distribution of price fluctuations re-computed.

As the results in table 4 demonstrate, when the elasticity of U.S. export response is reduced, a sizable change in the estimated probability distribution of world price results. As the elasticity is reduced from its actual value of 0.5 (by successive decrements of 0.1) to a value of 0.2, the potential variability of world price increases significantly. For example, with an elasticity of 0.4

there is only a 3 in 100 chance of an increase in price from trend of 100 percent or more. This probability increases to 3 in 20 with an elasticity of 0.3 and to 2 in 5 with an elasticity of 0.2. These results indicate the extremely significant role played by wheat stocks in the U.S. in moderating short-run price variability in the world market. This role became painfully apparent during the 1973-74 "world food crisis" when U.S. stocks fell to low levels and world prices rose sharply.

Conclusions

The analysis presented in this paper suggests that the potential variability of world wheat prices is increasing. It also indicates that the bulk of this variability is attributable to the transmission of fluctuations in domestic grain production in LDCs and CPCs to the world market. The share of potential variability due to production fluctuations in LDCs is growing and their effect is further accentuated by the tendency of LDCs to display precautionary purchasing behavior, i.e., to increase their purchases when prices fluctuate above trend. The analysis also indicates that the key stabilizing factor in the market is the ability and the willingness of the United States to respond to short-term production fluctuations in other countries by varying its exports.

The results presented indicate in several respects the importance of policies for potential variability in world prices. Considerable rigidity exists in the market and is reflected by a marked unresponsiveness to short-term fluctuations in world prices. To some extent, this may be due to natural constraints (e.g., upon

handling or transportation systems), but it also reflects the insulating effects of policies in the trading countries. Such insulation contributes to the variability of world prices.[6/]

Recent policy changes relating to trade in wheat seem likely to accentuate the existing market rigidity. The proliferation of bilateral agreements may reduce the ability of the market to reallocate supplies between importing regions in the face of production fluctuations. The recently introduced IMF food financing facility may allow the largest importing group, the LDCs, to further insulate their domestic markets to changes in world prices.[7/] Moves by the current administration to limit the amount of subsidized grain storage may reduce U.S. export flexibility in the face of short-term price fluctuations. Although all of these measures may individually have justifiable aims, collectively they seem likely to further accentuate potential price instability in the world wheat market.

FOOTNOTES

1/ Data used in this paper are from the U.S. Department of Agriculture's Oasis Databank. They are discussed by Leonardo A. Paulino and Shen Sheng Tseng in "A comparative study of FAO and USDA data on production, area, and trade of major food staples" Research Report 19, International Food Policy Research Institute, October 1980.

2/ See, for example, Robert Bain, "Changes in the international grain trade in the 1980's" Foreign Agricultural Economic Report 167, USDA Economic Research Service, July 1981, and Terry N. Barr, "The world food situation and global grain prospects", Science, Vol. 214, No. 4, 1981, pp. 1087-1095.

3/ The linear trend does have some undesirable characteristics. In particular, it implies that with upward trending production, relative variability will decline through time. For this reason, it would appear that other functions, e.g., the semi-logarithmic might be preferable. Inspection of the data suggested that the linear trend was appropriate and it yielded a better statistical fit than the semi-logarithmic.

4/ The existence of this type of behavior during the early 1970's was discussed by Alexander H. Sarris in The Economics of International Grain Reserve Systems, unpublished Ph.D. dissertation, Massachusetts Institute of Technology, 1976.

5/ This is not equivalent to the total price variability attributable to exporter/importer behavior, which would also include the impact of their responses to price.

6/ This factor is discussed in detail for all the major traded temperate zone commodities in The Instability of Agricultural Commodity Markets, Organisation for Economic Co-operation and Development, Paris, 1980.

7/ An important question here is whether the existence of the facility will reduce precautionary purchasing behavior on the parts of LDCs. If it does, then the facility need not increase potential price variability.

Table 1. Structure of World Wheat Trade in Selected Years.

	Proportion of World Trade[a/]		
	1960/61	1969/70	1979/80
	percent		
Exports			
Argentina	2	4	4
Australia	15	14	15
Canada	22	17	16
France	3	10	11
United States	41	29	42
Total - Major Exporters	83	74	88
Imports[b/]			
Centrally Planned Countries	19	21	33
Developed Countries	40	33	15
Less-Developed Countries	41	46	52
World Trade in Million Metric Tons[c/]	44	56	86

a/ Gross exports or imports, years quoted are July/June marketing years.

b/ World gross imports, shares adjusted to sum to 100% in 1960/61 and 1969/70 by distributing exports to "undesignated areas". Regional definitions correspond to those of the FAO.

c/ Gross exports.

Source: USDA, OASIS Databank.

Table 2. Estimated Variance of World Wheat Price Fluctuations and Source of Variance.

Year	Variance	Percent due to Production Fluctuations in Exports and Imports[a/]						
		Exports				Imports		
		Argentina	Australia	Canada	France	CPCs	DCs	LDCs
1960/61	591.3	1.3	2.4	8.3	0.3	41.1	12.7	31.9
1969/70	949.8	0.6	2.0	4.8	1.1	36.8	6.5	45.1
1979/80	1,240.2	0.4	1.9	3.5	1.5	33.8	3.8	52.5

[a/] Does not include effect due to positive covariance between production in France and DC importers. See appendix.

Table 3. Change in the Estimated Probability Distribution of World Price Fluctuations Through Time.

Year	Likelihood of an Increase in Price From Trend of x% or Above			
x =	25	50	75	100
	percent			
1960/61	7	2	..	..
1969/70	17	3	..	..
1979/80	26	10	3	..

.. = less than 0.5

Table 4. Estimated Probability Distribution of World Price Fluctuations in 1979/80 Under Alternative Assumptions.

Case	Likelihood of an Increase in Price From Trend of x% or Above					
x =	25	50	75	100	125	150
	percent					
1. Base[a/]	26	10	3	..	..	..
2. No precautionary purchasing by LDCs	13	1	..	..	..	..
3. U.S. short-run export supply elasticity reduced to 0.4.	32	18	9	3	1	..
4. U.S. short-run export supply elasticity reduced to 0.3	40	31	22	15	10	6
5. U.S. short-run export supply elasticity reduced to 0.2	48	46	43	41	39	37

.. less than 0.5

a/ Includes precautionary purchasing by LDCs and a U.S. short-run export supply elasticity of 0.5.

APPENDIX

The export/import fluctuation equations given in table A1 are derived from the general equation

(1) ΔX or $\Delta M = f(\Delta QP_t, \Delta P_t)$,

where ΔX, ΔM = annual deviation from linear trend in exports or imports of wheat (thousand metric tons), respectively by country or region (taken from USDA),

ΔQP = annual deviation from linear trend in production (thousand metric tons) of wheat (all grains for LDCs) in country or region (taken from USDA),

ΔP = annual deviation from linear trend in real world wheat price (U.S. No. 2 Hard Red Winter, f.o.b. Gulf ports in constant U.S. dollars taken from USDA). Deflator used to obtain constant dollar value is world consumer price index (taken from IBRD).

In the case of the trend equation for real world wheat price, a dummy variable was introduced for 1973-75 to capture the temporary upward displacement in the real price trend during this period.

The equations were all estimated using ordinary least squares despite the fact that there is probably simultaneity between price fluctuations and trade.

The equilibrium model used in deriving tables 2-4 seeks to use the information contained in the equations of table A1 which describe average import or export behavior over the entire sample period, to determine the potential change in price in a given year. It reflects the fact that market shares will affect potential fluctuations in world market price in a given year since such shares determine the relative importance of domestic fluctuations in production and

Table A1. Export/Import Fluctuation Equations.

Country/Region	Independent Variables		R^2	D.W.	Elasticity at the Mean a/		Total Explained Variability b/
	ΔQP	ΔP			Production	Price	
Exports (ΔX)							
Argentina	0.671 (0.116)		.65	1.99	+1.63	--	.65
Australia	0.366 (0.127)		.32	1.59	+0.50	--	.63
Canada	0.217 (0.147)		.11	1.75	+0.29	--	.35
France	0.517 (0.113)		.54	2.35	+1.56	--	.92
United States		86.216 (42.721)	.19	2.08	--	+0.50	.66
Imports (ΔM)							
CPC	-0.180 (0.078)		.23	1.21	-1.69	--	.40
DC c/	-0.423 (0.175)	-29.523 (17.157)	.32	1.07	-0.86	-0.16	.35
LDC d/	-0.155 (0.082)	39.523 (21.119)	.32	1.32	-0.97	+0.20	.95

a/ Calculated with respect to trend values.

b/ Proportion of total variability in exports/imports explained by trend and production fluctuations combined.

c/ Excludes Australia, Canada, France and the United States.

d/ Excludes Argentina.

response to price for world price determination. The model is a synthetic one and does not purport to explain actual price fluctuations during the period to which it is applied. Its purpose is to explore the nature of potential price fluctuations. Estimates derived from it should therefore be interpreted as indicators of changes in such potential fluctuations.

The structural equations are

(2) $\Delta X_{it} = \bar{x}_{it}\alpha_i\Delta Q_{it} + \bar{x}_{it}\beta_i\Delta P_t$ Exporter Equations (i = 1, 5),

(3) $\Delta M_{jt} = \bar{m}_{jt}\gamma_j\Delta Q_{jt} + \bar{m}_{jt}\delta_j\Delta P_t$ Importer Equations (j = 1, 3),

(4) $\sum_i \Delta X_{it} = \sum_i \bar{x}_{it} \sum_j \Delta M_{jt}$ Market Clearing,

where ΔX_{it} = export deviation from trend for exporter i in year t,

$\bar{x}_{it}$ = trend world export share of exporter i in year t,

ΔM_{jt} = import deviation from trend for importer j in year t,

$\bar{m}_{jt}$ = trend world import share of importer j in year t,

ΔQ = deviation from trend production in exporter i or importer j in year t,

ΔP = deviation from trend in real world wheat price,

$\alpha, \beta, \gamma, \delta$ = behavioral coefficients (obtained from table A1).

Note the use of the sum of exporter shares as a scaling factor in equation 4. This reflects the fact that not all exporters were included in the analysis of table A1. It is assumed that residual world imports (those not met by the 5 major exporters) are met exactly and have no impact upon world price.

From these equations the deviation from trend in world price in year t is

$$(5)\quad \Delta P_t = \sum_j a_{jt}\Delta Q_{jt} + \sum_i b_{it}\Delta Q_{it} ,$$

$$\text{where}\quad a_{jt} = \frac{\sum_i \bar{x}_{it}\bar{m}_{jt}\gamma_j}{\sum_i \bar{x}_{it}\beta_i - \sum_i \bar{x}_{it}\sum_j \bar{m}_{jt}\delta_j} ,\ \text{and}\ b_{it} = \frac{-\bar{x}_{it}\alpha_i}{\sum_i \bar{x}_{it}\beta_i - \sum_i \bar{x}_{it}\sum_j \bar{m}_{jt}\delta_j} .$$

The variance of price deviations from trend is

$$(6)\quad \sigma^2_{\Delta Pt} = \sum_j a^2_{jt}\sigma^2_{\Delta Qj} + 2\sum_j a_{jt}\sum_i b_{it}\ \mathrm{cov}(\Delta Q_j, \Delta Q_i) + \sum_i b^2_{it}\sigma^2_{\Delta Qi} .$$

Equation 6 thus explains the variance of price deviations from trend as the sum of the production deviations from trend in exporters and importers (where these affect exports or imports) and their covariances. In only one case, that of DC importers and France, was a significant covariance apparent (as indicated by a statistically significant value of the correlation coefficient at the 95 percent confidence level). This covariance was therefore included in the analysis. The remaining covariances were dropped to simplify the calculations.

To compute the probability of a given percentage deviation in price from trend, the standard normal distribution is employed. Since it may be assumed that the deviations in production from trend are random and normally distributed, the deviation of price from trend may also be viewed to be random and normally distributed. The standard normal distribution can be used to determine the probability of a given deviation of price from trend. The Z value,

whose probability can be taken from the standard normal table, is computed by finding that value of price (P*) in a given year which corresponds to a given percentage deviation from trend and then by using the formula

$$(7) \quad Z_t = \frac{P^*_t}{\sigma_{\Delta P_t}}$$

Note that $E(\Delta P_t) = 0$.

The probabilities given in tables 3 and 4 for potential price increases, strictly apply also to potential decreases in price. In some cases this would mean that prices could become very low or even negative. In practice, this is prevented by withdrawal of available supplies from the market through the price support programs of the major exporters. The model does not allow for such asymmetry and the probabilities derived from it can therefore be viewed to be appropriate only to potential price increases. The ability of policy intervention to effectively truncate the probability distribution of price is much more limited for upward than for downward price fluctuations.