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Chapter 14

Global Grain Stocks and World Market Stability Revisited

Stephen Martinez and Jerry Sharples*

Introduction

We examine in this chapter how well grain stocks have performed since the late 1970's in adding stability to world grain markets.¹ First, we examine the world-aggregate grain data and find that stocks adjustments have been doing a better job of enhancing world market stability since the late 1970's than they did earlier. Then we examine country data to see who may have provided that added stability. The United States has played a dominant role in providing stability to the coarse grain market, while the European Community (EC) has adjusted stocks to help stabilize the wheat and coarse grain markets in recent years. Reductions in these stabilizing stocks resulting from global free trade talks could have important implications for market stability.

In the late 1970's and early 1980's, many studies examined world grain market stability and grain stocks issues (Houck and Ryan, 1980; Blandford, 1983). These studies were in response to grain shortages and the increase in grain market volatility in the 1970's. They generally concluded that world grain price volatility was excessive due to suboptimal management of the world's grain stocks. Further, the forces creating that volatility were not expected to diminish. Various national and multinational solutions were proposed either to improve management of stocks or to reduce other destabilizing forces affecting world grain markets. Several studies further suggested that only a few countries,

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¹ In this report, "grain" refers to wheat plus coarse grains.

mainly the United States, used their grain stocks in a way that adds stability to world grain markets (Josling, 1980; Sharples and Goodloe, 1984).

As global grain stocks grew in the 1980's, interest in the topic waned. Now, after nearly a decade, interest in market stability and grain stocks has been rekindled. There were two main reasons for the renewed interest. First was the sharp drop in world grain stocks. World wheat and coarse grain stocks dropped to 18 percent of world use in 1990, near the record low of 16 percent in 1974. Second was the discussion of actual and potential policy changes that could change stockholding behavior of governments and individuals around the world. Examples of the latter were the new U.S. farm legislation and the GATT negotiations.

The Global Picture

Evidence since the late 1970's suggests that the world's grain stocks are doing a better job of protecting consumers from the year-to-year volatility of the world's grain production (table 1). One measure of stock performance is to compare the volatility of global grain consumption with the volatility of global grain production. If the former is less than the latter, then that is evidence that adjustments of end-of-year grain stocks reduced the effect of production variability on consumers.²

The variation of world wheat production around trend, as measured by standard error, was 16.7 million tons (5 percent of total wheat production) during 1960-77 (table 1). The standard error of consumption in those years was 10.4 million tons (3 percent of total wheat consumption). Thus, the world's wheat stocks helped stabilize grain consumption. From 1978 to 1989, the standard error of wheat production remained at 16.7 million tons (3 percent of average wheat production) but the standard error of global wheat consumption declined to only 6.7 million tons (1 percent of wheat consumption) evidence that the world's wheat stocks provided even more protection to consumers than in the earlier years.

² We use "volatility" and "variability" interchangeably, although "volatility" is associated with more negative connotations.

Table 1--Measures of annual dispersion from trend in world wheat and coarse grain price, production, and consumption over specified years

Item	Unit	1960 to 1977	1978 to 1989
Wheat production:			
Standard error	<i>Metric tons</i>	16.7	16.7 ¹
Coefficient of dispersion	<i>Percent</i>	5.3	3.4 ²
Wheat consumption:			
Standard error	<i>Metric tons</i>	10.4	6.7
Coefficient of dispersion	<i>Percent</i>	3.3	1.4
Wheat price:³			
Standard error	<i>Dollars/ton</i>	29.4	21.3
Coefficient of dispersion	<i>Percent</i>	34.0	14.1
Coarse grain production:			
Standard error	<i>Metric tons</i>	17.9	44.3
Coefficient of dispersion	<i>Percent</i>	3.2	5.7
Coarse grain consumption:			
Standard error	<i>Metric tons</i>	14.8	10.5
Coefficient of dispersion	<i>Percent</i>	2.6	1.4
Coarse grain price:⁴			
Standard error	<i>Dollars/ton</i>	17.5	18.7
Coefficient of dispersion	<i>Percent</i>	24.5	16.6

¹Standard error of deviations from trend.

²Coefficient of dispersion (CD) is expressed in percentage terms and is calculated by dividing the standard error by the mean and multiplying the result by 100. It is a unitless measure of variation, which removes the effect of production levels on variability.

³U.S. Gulf f.o.b. hard red winter (ordinary) wheat price.

⁴U.S. Gulf f.o.b. corn price (no. 2).

Sources: U.S. Department of Agriculture, For. Agr. Serv., PS&D Database, November 1990. U.S. Department of Agriculture, Econ. Res. Serv., *Wheat Situation and Outlook Yearbook* and *Feed Situation and Outlook Yearbook*. Various years.

During 1960-77, coarse grain stocks were not nearly as effective as wheat stocks in reducing the year-to-year variability of consumption. The standard error of production was 17.9 million tons (3 percent of coarse grain production), and the standard error of consumption was 14.8 million tons (3 percent of coarse grain consumption). The reason

probably relates to the fact that the major consumers of coarse grains are livestock rather than people. Livestock numbers and feeding rates can be more easily adjusted to the grain supply. Since 1978, the world's coarse grain stocks were extremely effective in offsetting the huge increase in production variability. The standard error of production more than doubled to 44.3 million tons (6 percent of coarse grain production), but the standard error of consumption dropped to 10.5 million tons (1 percent of coarse grain consumption).

Another measure of market volatility is the deviation around trend in annual grain prices. The data show a significant reduction in the volatility of wheat and coarse grain prices since 1978, as measured by the coefficient of dispersion (table 1). Theory suggests that reduced price volatility might be caused by improved management of the world's stocks or by other forces such as a reduction of trade barriers (Grennes and others, 1978).³

Stocks Behavior: Selected Countries

The rules for managing the world's grain stocks are set by countries. There is no explicit global strategy. To understand how the world's stocks are managed, one needs to examine stocks management in the major grain stockholding countries. Guiding our examination of country data are two questions. To what extent do major grain producing countries manage year-end stocks to offset their own production variability, and as an associated issue, to what extent do these countries pass domestic production variability onto the world market and make it more volatile? To what extent do these countries adjust their grain stocks to absorb some of the grain market volatility generated by other countries?

Results show which countries tend to be the major sources of world grain market volatility, and which countries adjust their stocks in ways adding stability to the world market.

Previous studies have suggested that the Soviet Union is the most important potential "transmitter" of production variability to the grain market while the United States (and to a lesser extent Canada and several

³ The term "management" in this chapter does not imply that stocks are adjusted with any particular objectives in mind. Adjustments in stocks may simply be an outgrowth of domestic policies.

other countries) has contributed to market stability through stock adjustments. Grain stocks in the EC made no noticeable contribution to world grain market stability (Sharples and Goodloe, 1984; Blandford, 1983; Josling, 1980).

A recent report by Sharples and Krutzfeldt (1990) gives an overview of who are the world's current major holders of grain stocks and how those stocks are used. They conclude that, as in the past, the United States still holds most of the world's buffer stocks that are available to the world market to help stabilize it.

The country analysis reported here is a more quantitative followup to the Sharples-Krutzfeldt report. Using revised methods and more recent data, we examine the major conclusions of reports of the late 1970's and early 1980's.

We proceed by separately examining the wheat and coarse grains stocks behavior in selected countries because stocks behavior differs between the two. We also compare more recent behavior, based on 1978-89 data, with that observed in earlier years (1960-77) to see if there is evidence of change in a country's grain stocks management strategies. The two time periods were divided at 1978 because that year marked the beginning of several significant events in the world grain markets:

- (1) Import variability in China increased,
- (2) Soviet grain production leveled off, and
- (3) An upward trend began in EC grain net exports.

By examining differences between the two time periods, one can gain insight into how changes in country policies have affected stock adjustments. Relating observed stockholding behavior to country policies or examining optimal stockholding, however, is a topic for further exploration.⁴

Stocks Adjustments and Domestic Production Variability

A major source of supply instability in a country is domestic grain production. When any major grain producing country has an unusual

⁴ See Gardner (1979) for a detailed discussion of the theory behind optimal stock levels and a thorough reference listing for literature in this area.

harvest, it can adjust to that shock in any of three ways: by adjusting domestic grain consumption, by adjusting the amount of grain stocks carried over to the next year, or by adjusting the quantity traded. The choice of action could have a significant effect on the stability of both the domestic and world grain markets.

For example, suppose that an importing country had an unusually poor wheat harvest 1 year. It might fully domestically absorb the effect of the poor harvest by cutting back on consumption and/or reducing carryover stocks. On the other hand, it could completely "export" its production shock into the world market by maintaining trend consumption and trend stock levels and by increasing wheat imports to offset the poor harvest. Conversely, when the harvest was above normal, the country could consume more and also build up ending stocks, or it could simply reduce imports. A strategy of relying on the world market to offset most of its own production variability could add instability to the world market.

India, Argentina, and the United States illustrate extreme cases of each of the three possible responses to domestic coarse grain production shocks. In India, practically all coarse grain production is consumed domestically (fig. 1). Coarse grains consumption varies from year to year in response to changes in production. India apparently did not use trade or adjustments in coarse grain stocks to offset production variability.

In Argentina, most production shocks are passed onto the international market (fig. 2). Consumption and stock levels are relatively stable. In the United States, coarse grain production has been highly variable since the late 1970's, but consumption has been considerably less variable due to offsetting stock adjustments (fig. 3). The magnitude of year-to-year changes in both U.S. production and stocks are huge by world standards in the 1980's. However, the production shocks did not result in large changes in coarse grain exports. U.S. stocks, rather than the world market, absorbed most of the production variability.⁵

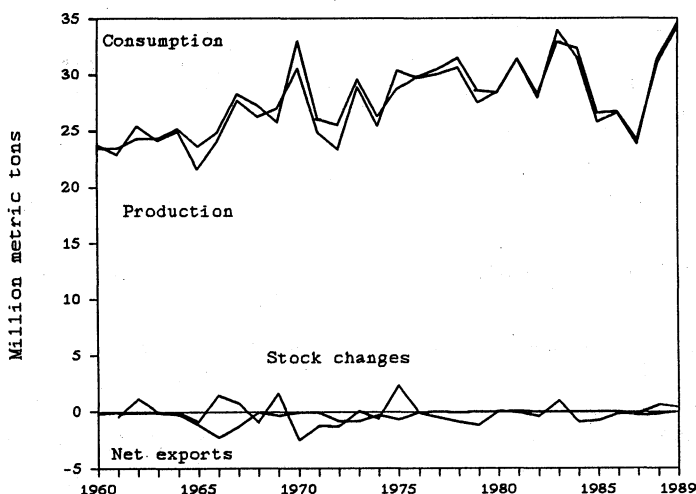
These three examples indicate that these countries each pursued different coarse grain policy strategies. Argentina's year-to-year changes in production have been a source of world grain market volatility, while

⁵ The fact that net exports showed little variability, however, does not mean that U.S. production variability failed to generate instability on the world market. World prices reacted to the large fluctuations in the quantity of coarse grains supplies available for export from the United States.

India and the United States passed on relatively little of their production shocks to the world market. Stocks absorbed production shocks in the United States. India represents a rare case where consumption rather than stocks absorbed most of its production shocks.

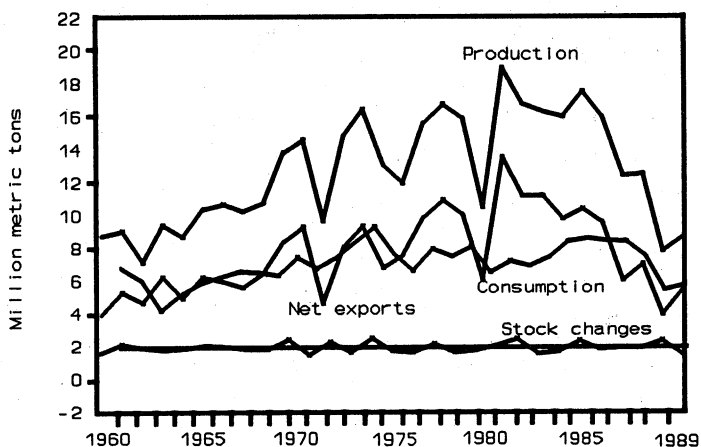
Most major grain producing countries attempt to stabilize grain consumption. If domestic stocks do not adjust to offset production shocks, then the affected country usually adjusts trade. Therefore, a country that does not adjust stocks is likely to be transmitting domestic production variability to the world market. In this way, the tradeoff between stock and trade adjustments becomes linked to world grain market stability.

Figure 1
India coarse grains, 1960-89



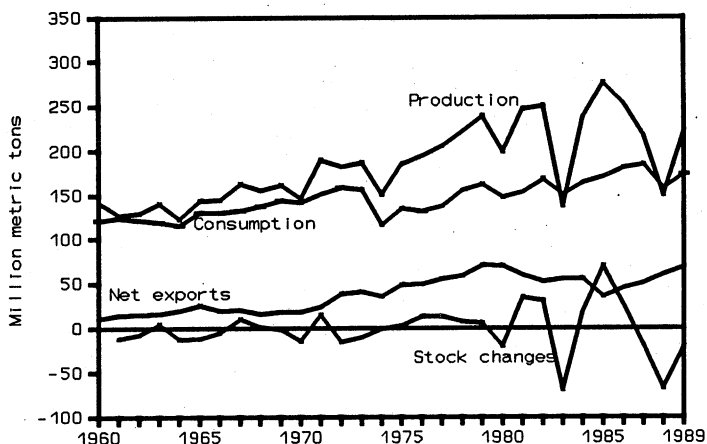
Source: U.S. Department of Agriculture,
PS&D Database, For. Agr. Serv., Nov. 1991.

Figure 2
Argentina coarse grains, 1960-89



Source: U.S. Department of Agriculture, PS&D Database, For. Agr. Serv., Nov. 1991.

Figure 3
U.S. coarse grains, 1960-89



Source: U.S. Department of Agriculture, PS&D Database, For. Agr. Serv., Nov. 1991.

Destination of Domestic Production Shocks

For most major grain producing countries, adjustments to production shocks are not as obvious as in the above examples. However, simple regressions can be used to suggest how they have responded to domestic production shocks. The following equations were estimated for each country for each of two time periods, 1960 to 1977 and 1978 to 1989:

$$(1) \quad C = (a_1 * Q) + e_1$$

$$(2) \quad T = (a_2 * Q) + e_2$$

$$(3) \quad S = (a_3 * Q) + e_3$$

where Q is the change in production⁶ from the previous year, C is the change in domestic use, T is the change in net exports (exports minus imports), and S is the adjustment in stocks.⁷ Specifying the equation in this manner forces the equality, $a_1 + a_2 + a_3 = 1.0$, which is convenient for comparison purposes. A larger coefficient suggests greater adjustments in response to production shocks. Estimates of the coefficients in the production shock absorption equations, (1) to (3), are presented in table 2 (wheat) and table 3 (coarse grains).

Wheat Results

The Soviet Union has by far the largest production variability, as measured by standard error (table 2, column 2). The United States is second, and China is third. In relative terms, however, Argentina, Australia, and Canada have the most production variability (column 3). Note the low relative production variability since 1977 in Eastern Europe, the EC, China, and India.

⁶ Similar equations were estimated for 1960 to 1982 in Sharples and Goodloe (1984). However, they used supply (production plus beginning stocks) rather than production as the independent variable. Use of supply provided ambiguous results for major stockholding countries because volatility of beginning stocks would affect the results.

⁷ S measures the difference between the change in stocks in the current period and the change in stocks in the previous period:

$$S_t = (E_t - B_t) - (E_{t-1} - B_{t-1})$$

where E is ending stocks and B is beginning stocks.

Table 2--Allocation of domestic wheat production shocks for the major stockholding countries/regions, 1960/61-77/78 versus 1978/79-89/90

Country	Average	<u>Production</u>	CD ¹	<u>Proportion of production</u>		
		<u>Standard</u>		<u>Domestic</u>	<u>Trade²</u>	<u>Stocks²</u>
		<u>error¹</u>		<u>use</u>		
	<i>Million metric tons</i>			<i>-----Percent-----</i>		
China:*						
1960-77	29.7	3.3	11	0.20	0.23	0.57
1978-89	75.6	6.4	8	.26	.19	.55
Soviet Union:*						
1960-77	81.7	13.9	17	.09	.25	.66
1978-89	87.6	12.5	14	.04	.22	.74
United States:**						
1960-77	41.6	4.0	10	.04	-.21	1.17
1978-89	62.0	9.4	15	-.06	.35	.71
EC-12:**						
1960-77	42.8	3.4	8	.22	.35	.43
1978-89	67.3	5.3	8	.09	.23	.68
India						
1960-77	17.9	2.6	14	.40	.38	.22
1978-89	41.4	2.5	6	.37	.03	.60
Canada:**						
1960-77	16.3	4.0	24	.02	.16	.82
1978-89	23.2	4.5	19	.05	.54	.41
Australia:**						
1960-77	9.6	2.2	23	.34	.66	
1978-89	15.3	3.7	24	-.08	.45	.63
Eastern Europe:*						
1960-77	25.3	1.9	7	.51	.27	.22
1978-89	37.2	3.0	8	.66	.28	.06
Turkey:**						
1960-77	8.8	1.2	14	.19	.22	.59
1978-89	13.3	.9	7	-.13	.86	.27
Argentina:**						
1960-77	6.8	2.0	29	.22	.73	.05
1978-89	9.8	2.5	25	.05	.98	-.03
Mexico:*						
1960-77	2.0	.3	15	.15	.60	.25
1978-89	3.5	.6	17	.24	.51	.25

See footnotes at end of table.

Continued--

Table 2--Allocation of domestic wheat production shocks for the major stockholding countries/regions, 1960/61-77/78 versus 1978/79-89/90
--Continued

Country	Average	<u>Production</u> Standard error ¹	CD ¹	Proportion of production deviations absorbed by --		
		Domestic use		Trade ²	Stocks ²	
<i>Million metric tons</i>			<i>-----Percent-----</i>			
South Africa:						
1960-77	1.3	.2	15	.09	.67	.24
1978-89	2.2	.5	23	.01	.61	.38
World:						
1960-77	312.8	16.7	5	.19	---	.81
1978-89	484.3	16.7	3	.28	---	.72

--- = Not applicable.

¹See definitions in table 1.

²"Trade" is defined as exports minus imports, and "Stocks" is defined as ending stocks minus beginning stocks.

*Major importer in 1985-89.

*Major exporter in 1985-89.

Source: U.S. Department of Agriculture, PS&D Database, For. Agr. Serv., November 1990.

Results show that major grain producers tend to protect their consumers from domestic production variability, as indicated in table 2 by the low coefficients shown under "Domestic use" (column 4). Eastern Europe is a major exception. The lower income countries of India, Mexico, and China also exhibit a tendency of having their consumers absorb a higher proportion of domestic production variability.

The countries that in recent years have used trade to absorb much of their production variability are Argentina, Turkey, South Africa, Mexico, Canada, and Australia (see the coefficients under "Trade" (column 5). At the other extreme, trade has not been used by India in recent years to offset the variability of domestic wheat production.

Most of the major wheat producing countries use end-of-year stock adjustments to offset at least part of their domestic production variability (see the coefficients in the "Stocks" column). For example, the Soviet

Union, which has to contend with highly variable production, apparently uses wheat stocks to offset a large portion of that variability.⁸ Wheat stocks in Eastern Europe and Argentina, however, absorbed very little of their production variability in recent years.

Some significant changes have occurred since 1977 in how countries respond to their own wheat production variability. Stocks have become more important in offsetting production variability in the EC and in India, and less important in the United States and Canada.

Coarse Grain Results

The United States dominates the coarse grain story (table 3). More than twice as much coarse grains are produced in the United States as in any other country, and over recent years the biggest shocks to global production have come from the United States. Note that the standard error of coarse grain production for the United States was 42.7 million tons since 1978/79, whereas it was only 12.8 million tons for the rest of the world.

During 1960-77, the United States let domestic use absorb about half of the production variability with much of the remainder absorbed by stock adjustments. Since then, however, stocks have played a very important role in absorbing the extreme production variability. Over the last 30 years, the United States has not tended to "export" its production shocks by adjusting the quantity exported.

After the United States, the Soviet Union has the second largest standard error of production (table 3). Results show that, in the most recent period, domestic use absorbed much less of its production variability. The Soviets turned to the export market, not to stocks, to provide more stability to consumption.

The EC and Eastern Europe exhibited low absolute and relative levels of coarse grain production variability since 1960. Their stocks coefficients in table 3 indicate that they both increased their use of stocks to absorb domestic production shocks since 1978/79.

⁸ One must discount conclusions that are drawn from grain stock numbers for the Soviet Union and China. Their stock numbers are subject to substantial error.

A Note on Global Aggregate Stock Adjustments

At the global level, there are only two ways for the world as a whole to respond to year-to-year changes in grain production: by adjusting consumption or carryover stocks. Results since the late 1970's show that the world's wheat consumers absorbed about 28 percent of year-to-year production variability, and ending stocks absorbed the rest (table 2). Thus, stocks provided substantial, but far from complete, protection to the world's wheat consumers from production shocks.

An analysis of world totals for coarse grains after 1977 show that (1) there was a substantial increase in the variability of production, and (2) stock adjustments became much more important in absorbing production shocks (table 3). These global results for coarse grains were mainly caused by what was happening in the United States.

Although different analytical methods were used, world-total conclusions, drawn from table 3, are consistent with results in table 1 for the latter time period. The world results for wheat in table 2, however, suggest that consumers absorbed more of the world's wheat production variability after 1977, which appears to contradict findings in table 1.

Quantifying Transmission of Production Shocks

An estimate of the magnitude of a country's production variability that is transmitted to the world market is obtained by multiplying the domestic production standard error by the fraction absorbed by domestic trade (table 4). The result suggests the potential that a country has for transmitting domestic instability to the world. This potential can be high if domestic production variability is high and/or relatively large adjustments in trade occur in response to changes in domestic production.

Major sources of shocks to the world grain market were the Soviet Union, Argentina (exporter), the United States (exporter), Canada (exporter), and Australia (exporter). Consistent with earlier studies, results show that the Soviet Union (a major grain importer) transferred the most domestic production variability onto the world wheat market (table 4). The standard error of wheat production in the Soviet Union is relatively large compared with some of the other major producing countries. For this reason, the potential for transmitting instability is high even though stocks absorb most of the production shocks.

Table 3--Allocation of domestic coarse grain production shocks for the major stockholding countries/regions

Country	Production			Proportion of production deviations absorbed by --		
	Average	Standard error ¹	CD ¹	Domestic use	Trade ²	Stocks ²
	<i>Million metric tons</i>			<i>-----Percent-----</i>		
United States:™						
1960-77	159.5	13.3	8	0.47	0.16	0.37
1978-89	220.5	42.7	19	.18	-.04	.86
Rest of world:³						
1960-77	400.4	13.6	3	.74	.05	.21
1978-89	553.5	12.8	2	.66	-.05	.39
China:™						
1960-77	54.2	4.0	7	.63	.02	.35
1978-89	87.2	4.5	5	.34	.01	.65
Soviet Union:°						
1960-77	72.3	11.4	16	.61	.22	.17
1978-89	95.2	11.3	12	.33	.56	.11
EC-12:™						
1960-77	61.0	4.3	7	.33	.56	.11
1978-89	82.3	4.7	6	.17	.27	.56
Eastern Europe:°						
1960-77	48.9	2.6	5	.79	.08	.13
1978-89	65.9	4.2	6	.37	.29	.34
India:						
1960-77	26.1	2.1	8	.87	.00	.13
1978-89	29.4	3.1	10	.87	.01	.12
Canada:™						
1960-77	17.0	2.2	13	.35	.19	.46
1978-89	22.9	2.7	12	.04	.29	.67

See footnotes at end of table.

Continued--

Table 3--Allocation of domestic coarse grain production shocks for the major stockholding countries/regions -- Continued

Country	Production			Proportion of production deviations absorbed by --		
	Average	Standard error ¹	CD ¹	Domestic use	Trade ²	Stocks ²
	<i>Million metric tons</i>			<i>-----Percent-----</i>		
Argentina:™						
1960-77	12.2	2.0	16	0.22	0.73	0.05
1978-89	15.1	3.8	25	.16	.83	.01
Mexico:™						
1960-77	9.9	.9	9	.43	.46	.11
1978-89	14.0	1.7	12	.22	.79	-.01
South Africa:™						
1960-77	7.6	1.9	25	.05	.45	.50
1978-89	9.2	3.2	35	.03	.58	.39
Australia:™						
1960-77	3.8	.8	21	.22	.52	.26
1978-89	6.9	1.4	20	.03	.81	.16
Turkey:						
1960-77	6.2	.6	10	.68	.02	.30
1978-89	8.4	.7	8	.15	.42	.43
World:						
1960-77	559.9	17.9	3	.70	---	.30
1978-89	774.0	44.3	6	.18	---	.82

--- = Not applicable.

¹See definitions in table 1.

²"Trade" is defined as exports minus imports and "Stocks" is defined as ending stocks minus beginning stocks.

³World total less United States.

™Major importer in 1985-89.

™Major exporter in 1985-89.

Source: U.S. Department of Agriculture, PS&D Database, For. Agr. Serv., November 1990.

Table 4--"Standardized" annual domestic production shocks transferred to the world grain market¹

Country	Wheat		Coarse grain		Total	
	1960-77	1978-89	1960-77	1978-89	1960-77	1978-89
<i>Million tons</i>						
Soviet Union	3.5	2.7	2.5	6.3	6.0	9.0
Argentina	1.5	2.4	1.5	3.1	3.0	5.5
United States	.8	3.3	2.1	1.7	2.9	5.0
Canada	.6	2.4	.4	.8	1.0	3.2
Australia	.7	1.7	.4	1.1	1.1	2.8
European Community-12 ²	1.2	1.2	2.4	1.3	3.6	2.5
South Africa	.1	.3	.8	1.9	1.0	2.2
Eastern Europe ²	.5	.8	.2	1.2	.7	2.0
Mexico	.2	.3	.4	1.3	.6	1.6
China	.8	1.2	.1	0	.9	1.2
Turkey	.3	.8	0	.3	.3	1.1
India	1.0	.1	0	0	1.0	.1
Total	11.2	17.2	10.8	19.0	22.0	36.2

¹Values in this table are obtained from the equation:

$S = F * E$ where: S (million tons) is the portion of the average annual change in domestic production that is transferred to the world market, F is the fraction of the annual change in domestic production that is absorbed by changes in net trade volume (a_2 in tables 2 and 3), and E is the standard error of production from trend (from tables 2 and 3).

²The region is treated as one country.

Although wheat production variability in Argentina is not as high as some of the other top-producing countries, the potential for transmitting instability is still quite high. This situation is largely due to the substantial portion of production variation that is absorbed by trade adjustments.

In the United States, coarse grain production variability has increased dramatically in the latter period. Although a small percentage of this variability is exported to the world coarse grain market, extremely variable production makes the United States an important source of potential market instability.

Earlier, we observed that the global evidence showed that stocks were better at providing stable levels of grain to the world's consumers after 1978. One possible explanation was that the major grain producing countries might have used their carryover stocks to absorb more of their own production variability than in previous years. If true, less of that variability would be absorbed by fluctuations in their grain trade. The data in table 4, however, contradict this explanation. Among major grain producing countries, more production variability was transferred to the world market after 1978 than before.

A second possible explanation was that since 1978 more of the world's grain stocks responded to external shocks to the world market; that is, shocks that originated outside effected the country. This possibility is examined in the next section.

Relationship Between Domestic Stocks and World Price

Countries may be unwilling to make domestic grain stock adjustments (or other domestic market adjustments) in response to the external volatility of the international grain market. They can accomplish this by putting policies in place that isolate their domestic grain market from the effects of world grain shortages or surpluses. Domestic stocks in countries following this strategy are perceived as being unresponsive to world prices. Their stocks tend to provide no stability to the world market.

On the other hand, countries can manage stocks so that they are responsive to world grain prices, by accumulating stocks when the world price falls, and by drawing them down when the world price rises. Their stocks response would tend to dampen world price fluctuations. Thus, a negative relationship between a country's grain stock levels and international price suggests that their stocks have a stabilizing impact on the world market.

Stocks Regression Equation

We used the following equation to measure this relation between stocks and world price after eliminating the effect of trend:

$$(4)S^* = a + bP^* + e, \quad S^* = S - \bar{S}, \quad P^* = P - \bar{P}$$

where S is ending stocks, S' is trend ending stocks, P is the annual average wheat or corn (used for coarse grain) price at U.S. Gulf ports, such as P' is trend price. Deviations from trend (S' , P') in the regression equation removes the effect of trend in the analysis. A statistically significant negative coefficient on price suggests that a country's stocks tend to have a stabilizing effect on the world market price.

Stocks and World Price Stability Results

Three major points are drawn from the results shown in tables 5 and 6. First, stocks of wheat and coarse grains appear to be much more of a stabilizing force on world markets after 1977 than before. The simple regression for the world total wheat stocks shows that stocks decreased 0.93 million tons for each U.S. dollar increase in the per ton wheat price. For 1960-77, the relationship was not as strong between world wheat stock levels and world price. Price responsiveness of world coarse grain stocks was also much higher after 1977.

Second, the United States was the major source of the world's price-responsive stocks since 1977. The U.S. stocks coefficient for wheat was nearly half the size of the world total (-0.392 compared with a world total of -0.934). The U.S. coarse grains stocks coefficient accounted for most of the world total.

The U.S. results for 1978-89 are consistent with results from other studies cited above; that is, the United States tends to hold a very large share of the world's buffer stocks of grain. As explained in Sharples and Goodloe (1984) and Sharples and Krutzfeldt (1990), U.S. stock levels tend to be driven by domestic grain policy objectives, not by world price stabilization objectives. Grain stockpiles tend to be viewed by the domestic agricultural community as undesirable.

Third, after being a destabilizing force in the world grain markets prior to 1977, EC grain stocks thereafter became a significant stabilizing force. During 1960-77, EC wheat and coarse grain stocks showed a significant positive relationship with world price as a destabilizing force on the world wheat market. Since 1977, grain stocks in the EC exhibit a significant negative relationship with price. Although the estimated coefficients are small, this change in behavior appears to be significant.

Table 5--Relationship between wheat stocks and world wheat price by leading stockholding countries

Country	Average stocks		Price coefficient ¹	
	1960-77	1978-89	1960-77	1978-89
<i>Million tons</i>				
United States	24.1	33.0	-0.078	-0.392*
Rest of world ²	63.7	104.5	-.138	-.542*
China	9.9	30.0	.034	-.057
Soviet Union	11.9	16.7	-.024	-.132**
EC-12	8.6	12.8	.025*	-.083*
India	4.5	9.6	-.032***	-.134*
Canada	14.5	9.2	-.120*	-.079*
Australia	2.2	4.3	-.025***	-.027
Turkey	1.8	4.2	-.012***	-.015**
Eastern Europe	1.4	1.8	-.003	.001
Argentina	.9	.6	.002	-.002
South Africa	.4	.6	-.001***	.000
Mexico	.2	.4	.001***	-.000
World	87.8	139.7	-.216***	-.934*

*Significant at the 5-percent level.

**Significant at the 10-percent level.

***Significant at the 20-percent level.

(¹ $S = a + bP$ where S is annual detrended stocks and P is annual detrended U.S. Gulf f.o.b.) hard red winter (ordinary) wheat price in U.S. dollars per ton.

² World excluding United States.

The EC stocks response of recent years is a new stabilizing force on the world grain market. The significant negative (stabilizing) relationship between EC stock levels and world price for 1978-89 is especially interesting since the EC grain markets are completely insulated from world prices. The change in EC stock management patterns appears to be related to the EC becoming a large grain exporter. In the 1960's and 1970's, the EC was a net importer. It turned to the world market in response to supply needs, especially for coarse grains, as indicated by the trade coefficients (tables 2 and 3). As EC exports rapidly expanded in the

late 1970's and 1980's, government export subsidies were provided to make up the difference between high internal support prices and the world price. When world prices fell, some grain apparently tended to be stored rather than exported for the government to hold down the high export subsidy payments. At higher world prices, stocks could be drawn down and exported with lower export subsidies. Hence, the stabilizing effect on world prices of EC stock adjustments likely has been caused by domestic budget considerations.

Conclusions and Policy Implications

Since 1977, world grain markets appear to be doing a better job than earlier in allocating the world's grain from year to year. Evidence of this is (1) less year-to-year variability around trend in global grain consumption, even though world production variability has increased, and (2) less world grain price volatility than prior to 1978, despite transmission of more production variability onto the world market by major producing countries. The world's grain stocks apparently are providing more market stability than they did prior to 1978.

This study examines the role of each of the major grain producing countries--who are also the major holders of grain stocks--in generating instability or providing stability to world grain markets by how they manage their own stocks. The rules determining how grain stocks are managed vary among countries. In this study, we do not examine those rules. Rather, we examine actual stock adjustments. The forces determining a country's stock management behavior should be the subject of further research.

A country's grain stocks can contribute to world market stability two ways:

- (1) Stocks may be used to offset a country's own production variability so that it would not need to vary its grain trade (imports or exports) to stabilize consumption.
- (2) Stocks may be used to offset surpluses or shortages on the world market.

Table 6--Relationship between coarse grain stocks and world coarse grain price by leading stockholding countries

Country	Average stocks		Price coefficient ¹	
	1960-77	1978-89	1960-77	1978-89
<i>Million tons</i>				
United States	44.3	81.4	-0.190	-1.641*
Rest of world ²	52.6	78.3	.090***	-.086
China	15.2	27.7	.112*	.099**
EC-12	7.3	10.9	.036*	-.076*
Soviet Union	6.4	7.1	.016	-.047***
Canada	5.5	5.7	-.020***	-.034***
Eastern Europe	1.9	4.7	-.009***	-.031*
Mexico	.8	1.5	.008***	.036**
South Africa	1.3	1.4	.001	.015
India	4.7	1.3	-.044*	.014**
Turkey	.4	.9	-.009*	-.002
Argentina	.5	.6	.006**	-.002
Australia	.6	.5	-.015*	-.001
World	96.9	159.7	-.100	-1.727*

*Significant at the 5-percent level.

**Significant at the 10-percent level.

***Significant at the 20-percent level.

¹S = a + bP where S is annual detrended stocks and P is annual detrended U.S. Gulf f.o.b. corn price (no. 2) in U.S. dollars per ton.

²World excluding United States.

We discovered no overall improvement since 1977 in the use of grain stocks to offset domestic production variability. Thus, we conclude that the first item above was not a source of added stability to the world grain markets. We did, however, find substantial improvement in the responsiveness of grain stocks in several important countries to world market conditions (table 7). The second item listed above appears to be a significant source of reduced instability in world grain markets since 1977, especially for wheat. Not only did the unitless measure of dispersion of wheat prices fall in the latter period, but so too did the standard error (table 1).

Table 7--Summary of absorption effect in selected countries for wheat and coarse grain

Country	Coarse grains		Wheat	
	1960-77	1978-89	1960-77	1978-89
United States	---	Stabilizing	---	Stabilizing
Rest of world ¹	---	---	---	Stabilizing
China	Destabilizing	---	---	---
Soviet Union	---	---	---	---
EC-12	Destabilizing	Stabilizing	Destabilizing	Stabilizing
Canada	---	---	Stabilizing	Stabilizing
Eastern Europe	---	Stabilizing	---	---
India	Stabilizing	---	---	Stabilizing
Turkey	Stabilizing	---	---	---
Argentina	---	---	---	---
Australia	Stabilizing	---	---	---
South Africa	---	---	---	---
Mexico	---	---	---	---

--- = If the price regression coefficient in the stocks equation is not significant at the 5-percent level (tables 5 and 6), the country is presented here as having no absorption effect.

¹World excluding the United States.

The Soviet Union, Argentina, and the United States appear to be major sources of instability to world grain markets in recent years. Production variability is high in both the Soviet Union and the United States. Although Argentina's production variability is relatively small, a larger portion of this variability is passed on to the world grain markets. Argentina makes no world market-stabilizing adjustments in domestic grain stocks.

Most major grain producing countries "exported" more production variability onto the world market after 1977 than before. An exception was the EC.

Results of this study verify the conclusion of previous studies that U.S. stocks provided a major stabilizing force on world grain markets. Results since 1977 also show, however, that the United States was a major source of the world's grain production variability. Massive adjustments in U.S.

grain stock levels offset most of that production variability. Further, U.S. stocks were very responsive, in a stabilizing way, to world grain price movements.

Conclusions suggesting that the United States has borne the cost of holding stocks which help stabilize the world market appears to be supported more in the coarse grain market compared with wheat. Excluding the United States from the coarse grains market, one finds that the rest of the world has failed to adjust stocks to help stabilize the market in recent years. However, only a few countries are apparently responsible for having stabilizing effects in either of the grain markets.

Stock adjustments made in the EC in recent years appear to contribute significantly to world grain market stability. This conclusion is surprising. Our results indicate that in earlier years EC stocks were a destabilizing force on world markets.

Recent U.S. policy changes could lead to the United States playing a reduced role in stabilizing world grain markets. Because of the dominant U.S. role in stabilizing world grain markets, these policy changes could be very significant to all countries who participate in the world grain market. The 1990 farm act allows grain price supports to continue their downward adjustment. With price supports set closer to the low end of world market fluctuations, there would be little incentive for U.S. grain to go into Government stocks. The farm act also downsizes the Farmer-Owned Reserve. Finally, continued or expanded funding for the Export Enhancement Program (EEP) also would tend to destabilize world grain markets. The EEP likely would be used more aggressively to encourage U.S. grain exports (and reduce stocks) when grain prices were low and used less aggressively when grain prices were high.

Results of this study also raise questions about the effect of trade liberalization on the stability of world grain markets. Conventional economic wisdom is that reduced trade barriers would increase grain market stability. This change would occur by exposing a larger portion of the world's production, consumption, and stockholding to world prices. Results from this study also show, however, that the domestic policies of the United States and the EC induce market-stabilizing stocks behavior, although the effect of U.S. policies could be diminishing, as discussed above. Liberalizing trade could remove those policy-induced sources of market stabilization. Although some would argue that policy-induced stabilization is less desirable because it is subject to political whims, the

net effect of trade liberalization on world grain market stability appears less clear. This question warrants further research.

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