ECONOMIC IMPLICATIONS OF INTERNATIONAL WHEAT RESERVES*

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Discussion Paper No. 1
School of Agricultural Economics and Extension Education
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* Paper presented at AIC/CAES Annual Meeting, Halifax, Nova Scotia

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1.0 Introduction

Recent developments in the international markets for wheat and other grains has focused attention on the stability and security of future supplies. This concern has led to the development, at national and international levels, of alternative proposals for setting up international reserves to be used in avoiding critical food shortages and adding stability to the markets.

The questions of paramount importance that must be answered before the establishment of any reserve stock scheme are: (1) the size of the stock; (2) the rules by which stocks will be bought and sold; (3) the location of stocks; and (4) the way in which costs will be shared among program participants.

This study is focused on the second question and the clarification of the tradeoffs that exist between alternative types of storage rules and between the variables that are affected by the rules. No attempt has been made to consider the questions of cost sharing and the location of reserve except to measure costs and benefits, for Canada and the rest of the world (ROW), assuming Canada will hold a fraction of a world reserve stock. Similarly, the question of the optimal size for a world reserve stock is not addressed because the question cannot be answered satisfactorily until the storage rule has been specified.

The first section of the paper discusses the general theoretical setting of alternative storage policies and the second section briefly discusses the stochastic simulation model of the wheat industry. Later sections outline several policies which were evaluated, firstly assuming that Canada attempts to establish an independent storage policy with no change in the stock holding policies of the ROW and secondly, assuming that Canada cooperates in a world storage policy.

2.0 Analysis of Reserve Schemes

Although research on the optimal level and resultant welfare gains from commodity reserve programs has been developed for some time [4], [8],

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[6], [17], recent policy proposals have resulted in economists developing more specific alternatives [2], [12]. These have been developed to consider a wider range of variables as well as their time paths. The wider range of variables studied include the stability and levels of consumer surplus, producer revenue, costs of holding reserves and levels of reserves.

Various models have evaluated specific storage rules using synthetic supply and demand relationships for future time periods and storage rules which have generally attempted to stabilize either price or supply within prespecified limits. These policies although possibly realistic in that they specify a strict procedure for acquiring and releasing stocks, make it more difficult for policymakers, as they must decide on the appropriate parameters to define the rule. For example they must decide on the target or desirable levels of supply and/or price as well as the ranges or bounds within which these variables will be allowed to fluctuate. A further complication is in determining whether the storage rule should be triggered by price or quantity changes.

Price changes would appear to be the most obvious trigger to use in releasing or accumulating stocks. In a perfect market, changes in the world price would reflect altered conditions in both the supply and demand side of the market and summarize the impact of a wide number of exogenous factors which shift these relationships [3]. Such a trigger would be completely adequate if the overriding objective of such a scheme was price stabilization, but if we are concerned also with the problem of stability of supplies in the world market then a quantity trigger would be more useful. Quantity storage rules, as suggested in the recent U.S. proposal for a grain reserve agreement [19], are probably easier to administer as the relevant information on grain production is known early in the crop year. Thus it is possible to determine if production is above or below the target and to make public the level of reserve activity. While such a policy may be beneficial in smoothing the supply of product it may be of little assistance in providing reserves in periods when demand fluctuates and prices rise even though supply is normal.

The policy experiments in this study evaluate 3 basic storage rules. The first two rules are those suggested above, i.e., a price triggered stock policy, and a storage level based on the level of production. The third rule is a mixed strategy where the change in carryover stocks in any year is dependent on the price in that year and the level of production. This strategy should combine the effects of the other two alternatives with some possible advantages. In years when the price quantity relationship in the market place is not reliable, i.e. prices increasing when supply is above normal, the opposing effects of the two triggers would act to counter balance each other while in years when the two triggers move together, say reduced supply and increasing prices, the rules would compliment each other.

The form of the particular rules used in this analysis are also different from those considered in the previous studies. Rather than specifying target levels and bands within which the variables must fall, continuous rules are used which specify the level of closing stocks for any crop year as a function of prices and the availability of wheat. While this is different than the usual form of suggested storage rules it does away with the need for comparing a wide range of target values and width of bands for the alternative rules. In addition the use of continuous storage rules should remove the opportunities for speculation, by countries or private grain traders, near the limits of price or quantity bands. These storage rules are also intuitively appealing in that they have comparable counterparts already existing in the market place. It is possible as is shown in the following section to estimate stock demand relationships which explain a large part of the stockholding activities of the major countries in the wheat market. Although these were not deliberate stockholding rules practised by the Commodity Credit Corporation or the Canadian Wheat Board, a consistent behaviour in stockholding did aid in stabilizing the price of wheat through the 1950's and 1960's. It is thus possible to compare the policies analyzed in this study with those that have existed in the past. The following section briefly presents the results of an econometric model in which the supply demand relationships in the world wheat economy, including the existing storage rules are estimated.

3.0 The Econometric Model

The model contains fourteen endogenous and ten exogenous variables.[1] Variables explained by the model are: acreage and production in Canada and the ROW, food demand in Canada, farm and export prices in Canada, stock demand in Canada and the ROW, Canadian exports, demand in the ROW, gross and net revenue from Canadian wheat sales, and storage costs. The predetermined variables in the model are: Canadian price of barley lagged one year, wheat yield in Canada and the ROW, Canadian disposable income, the United States loan rate on wheat, residual wheat use in Canada, the value of total world exports and dummy variables for the Lower Inventory for Tomorrow (LIFT) and the Temporary Wheat Reserves (TWR) programs.

The fourteen equations in the model include seven behavioral equations and seven identities. All of the behavioral equations in the model were estimated using ordinary least squares and three stage least squares (3SLS) with crop year data from 1950/51 through 1974/75.

Table 1 presents the (3SLS equation estimates with "t" values given in parenthesis and elasticities at mean values in brackets below the estimated coefficients. Complete variable definitions are also given in Table 1.

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[1] This model is basically a modified and expanded version of the model developed by MacLaren [10].

Table 1: Econometric Relationships for the World Wheat Model

1. CANADIAN WHEAT ACREAGE

$$CA_t = 14.86 + 5.86\ CPW_{t-1} - 9.86\ PB_{t-1} - 10.51\ LIFT - .238\ DSC_{t-1} + .592\ CA_{t-1}$$

(1.86) (-2.08) (-5.75) (-2.37) (7.13)

[.45] [-.49] [-.14]

2. CANADIAN WHEAT PRODUCTION

$$CP_t = (CA_t)\ (CY_t)$$

3. CANADIAN STOCK DEMAND FOR WHEAT

$$DSC_t = -5.91 - .0176\ PW_t + .637\ CP_t + .866\ DSC_{t-1}$$

(-1.14) (5.42) (8.93)

[-.09] [.64]

4. CANADIAN FOOD DEMAND FOR WHEAT

$$DCH_t = 1.367 - .00124\ PW_t + .00815\ CINC_t$$

(-2.92) (11.46)

[-.06] [.19]

5. CANADIAN FARM PRICE FOR WHEAT

$$CPW_t = 1.713 + .00390\ PW_t + .0176\ DPW_t - 1.384\ D_t - .0117\ DSC_{t-1}$$

(1.00) (4.44) (-4.97) (-1.92)

[.14] [.93] [-.09]

6. WORLD (CANADIAN EXPORT) PRICE FOR WHEAT

$$PW_t = 150.4 + .285\ WEX_t - .531\ DRW_t$$

(13.23) (-7.16)

[.82] [-1.75]

7. REST OF WORLD ACREAGE

$$ARW_t = 40.45 + .0620\ PW_{t-1} - .167\ DSRW_{t-1} + .927\ ARW_{t-1}$$

(.73) (-.72) (15.26)

[.01] [-.01]

8. REST OF THE WORLD PRODUCTION

$$PRW_t = (ARW_t)\ (YRW_t)$$

9. REST OF WORLD STOCK DEMAND FOR WHEAT

$$DSRW_t = -43.86 - .120\ PW_t + 17.93\ LR_t + .149\ PRW_t + .577\ DSRW_{t-1}$$

(-2.67) (3.42) (3.30) (5.45)

[-.29] [.93] [1.14]

10. CANADIAN EXPORTS OF WHEAT

$$CEX_t = CP_t + DSC_{t-1} - DCH - DSC_t - RES_t$$

11. REST OF WORLD DEMAND FOR WHEAT

$$DRW_t = PRW_t + DSRW_{t-1} + CEY_t - DSRW_t$$

12. CANADIAN GROSS SALES REVENUE

$$GR_t = PW_t\ (CEX_t + DCH_t)$$

13. CANADIAN WHEAT STORAGE COSTS

$$SC_t = 5.51\ ((DSC_t + DSC_{t-1})/2) + .07\ (PW_t\ (DSC_t + DSC_{t-1})/2)$$

14. CANADIAN NET SALES REVENUE

$$NR_t = GR_t - SC_t$$

TABLE 1 continued

Variable definitions:

CA = Canadian wheat acreage (mil. acres) [14]

YC = Yield of Canadian wheat (metric tons/acre) [14]

CP = Canadian wheat production (mil. metric tons) [14]

ARW = Acreage in world (incl. China and U.S.S.R.) excluding Canada (mil. acres) [5]

YRW = Yield of wheat in world excluding Canada (metric tons/acre) [5]

PRW = Wheat production in world excluding Canada (mil. metric tons) [5]

DCH = Consumption of food wheat in Canada (mil. metric tons) [14]

CPW = Total realized price (farm price) for No. 1 Northern Wheat in store Thunder Bay or Vancouver (dol./bu.) [1]

DSC = End of crop year stocks of wheat in Canada (mil. metric tons) [1]

PW = Canadian f.o.b. export price of No. 1 Northern Manitoba wheat from 1949/50 to 1963/64, of CWRS 14.5 percent until 1972/73 and of CWRS 13.5 percent in 1973/75 (dol./metric ton) [5]

DSRW = End of crop year stocks of wheat in world excluding Canada (mil. metric tons) [5]

CEX = Canadian wheat and flour exports (mil. metric tons) [1]

DRW = Consumption of wheat in world excluding Canada (mil. metric tons) [1], [5]

GR = Canadian gross sales revenue (mil. dol.)

SC = Carrying charges for Canadian wheat (mil. dol.)

NR = Canadian net sales revenue (mil. dol.)

PB = Total realized price (farm price) for No. 3 Canadian Western 6 Row barley in store Thunder Bay (dol./bu.) [1]

LIFT = A zero-one dummy variable equal to one for 1970/71 and zero for all others

CINC = Canadian total personal disposable income from July to June in current dollars (mil. dol.) [15]

D = A zero-one dummy variable equal to one for the years when there was no Temporary Wheat Reserves program and zero otherwise

WEX = The value of total world exports at current prices (bil. dol.) [18]

LR = Loan rate for United States wheat (dol./bu.) [20]

RES = A residual of Canadian wheat disposition representing the difference between total dispositions and food use (mil. metric tons) [1], [14]

t = time periods

In equation (1) Canadian acreage is specified as a function of the farm price of Canadian wheat and barley and stocks of wheat all lagged one year. Barley represents the major substitute for wheat in the Prairie Provinces and stocks are a proxy for Wheat Board quota policies. A zero-one dummy variable equal to one in 1970/71 is included to account for the LIFT program [11]. Canadian wheat production is obtained by multiplying acreage by yield in equation (2).

The demand for stocks in Canada (equation 3) is represented as a function of the Canadian export price of wheat and total production. These variables act as proxies for the quota and sales strategies of the Canadian Wheat Board, with the complete relationship describing a stock-holding or sales strategy. Stock levels in Canada have been more closely related to production changes than to price changes as indicated by elasticities of 0.64 and -0.09 respectfully.

The demand for wheat consumed as food in Canada is related to the price of wheat and Canadian disposable income. The income variable in equation (4) picks up the demand shifting influence of both income and population and has an estimated elasticity of 0.19. As expected the price elasticity of food demand is very inelastic at -0.06.[2]

Equation (5) explains the Canadian farm price of wheat as a function of the export price of wheat, the level of stocks lagged one year and slope and intercept dummy variables for the TWR program. The TWR program was in effect between crop years 1956/57 and 1972/73. Under this program the federal government paid the storage cost for wheat stocks in excess of 178 million bushels, which we would expect to influence the relationship between farm and export prices. Equation (5) indicates that farm and export prices were closely related during the period when the TWR program was not in effect, i.e. a one percent increase in the export price resulted in a 0.93 percent increase in the farm price. The low elasticity estimate (0.14) during the years in which the TWR program was operative is due to three factors: (1) a lack of export price variation; (2) data problems; and, (3) cost factors. The major data problem involves the use of a simple (unweighted) average of quoted monthly selling prices by the Canadian Wheat Board as the export price variable, which may not be representative of the actual weighted selling prices.

The Canadian export price for wheat was assumed to be representative of the world price for wheat. In equation (6) the export price of wheat is expressed as a function of the demand for wheat in the ROW and the value of total world exports. This is the same specification used by MacLaren [10] except in this model the equation is estimated in a price dependent form rather than quantity dependent, as the former approach resulted in a predicted price series which was more variable than the actual price

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[2] The food wheat subsidy schemes in existence since 1969/70 were not taken into account in estimating equation (4).

series, and at times fell to unreasonably low levels. By estimating a price dependent function this problem is avoided and demand in the ROW is calculated from the supply-demand identity (equation 11). Although stock levels are generally assumed to be an important determinant of price levels several different specifications of equation (6), including stock variables, failed to improve the fit, and the stock variables consistently had small t ratios [12].

Acreage in the ROW is expressed in equation (7) as a function of price, world stocks and lagged acreage. World acreage is dominated by a strong trend which is picked up by the lagged dependent variable. The lagged price and stock variables while having the correct signs have small "t" ratios and estimated elasticities. Production in the ROW is obtained by multiplying ROW acreage by ROW yield in equation (8). The demand for stocks in the ROW is assumed to be a function of price, ROW production, the loan rate on United States wheat, and lagged stocks. All of the variables have the expected signs and large "t" ratios. Price appears to play more of a role in determining ROW stocks than Canadian stocks with an estimated elasticity of -0.29.

Canada's exports of wheat are defined to equal the difference between domestic supply and domestic demand (equation (10) . Similarly consumption demand in the ROW is obtained from the ROW supply-demand equilibrium condition (equation (11) . Equations (12), (13) and (14) are accounting identities and need little explanation except to say that no value is placed on the residual wheat use in Canada and storage costs are assumed to be 15 cents per bushel per year, representing the physical cost of storage, plus seven percent of the value of the average ending inventory which represents the opportunity cost of the wheat held in inventory in any particular year.

3.1 Validation

Both stochastic and deterministic validations of the model were carried out by simulating the model over the 24 year period 1951/52 to 1974/75. Three summary measures of the deterministic validation, (1) mean absolute percentage error (M.A.P.E.), (2) R^2 obtained from regressing predicted on actual values, and (3) Theil inequality coefficients, are given in Table 2. The validation was performed using both the model generated lagged endogenous variables and the actual lagged endogenous variables.

Large M.A.P.E.'s were obtained for several variables in the model validation: (1) stocks in Canada and the ROW; (2) Canadian acreage; and, (3) Canadian exports. With regard to stocks the error was caused by the model failing to build and deplete stocks as quickly as the real world, which resulted in the problem of predicting acreage because of the influence of the lagged stock variable in equations (1) and (5). Most of the error in the Canadian acreage function is removed when actual values are used for the lagged endogenous variables. The error made in predicting Canadian exports was to be expected since it is obtained from an identity

TABLE 2: Deterministic Validation of World Wheat Model 1950-1974

Variables	Using Model Generated Lagged Endogenous Variables			Using Actual Values of Lagged Endogenous Variables		
	M.A.P.E.	R^2	Theil U	M.A.P.E.	R^2	Theil U
ARW	1.8	.89	.81	1.5	.92	1.11
PRW	1.8	.99	.25	1.5	.99	.34
CA	15.7	.08	.85	5.1	.86	.58
CP	15.6	.50	.40	5.3	.93	.29
PW	9.8	.91	.74	9.6	.92	.68
DSRW	20.6	.44	.90	16.6	.68	.99
DCH	2.6	.87	1.03	2.6	.88	1.03
CPW	8.4	.90	.62	6.6	.93	.54
DSC	20.2	.39	.85	14.1	.72	.90
CEX	20.8	.13	.97	19.6	.18	.95
DRW	2.2	.99	.47	2.3	.98	.52
GR	18.3	.88	.69	18.4	.85	.80
SC	16.3	.43	.85	10.8	.79	1.08
NR	25.3	.85	.71	24.0	.85	.79

M.A.P.E. = Mean Absolute Percentage Error

R^2 = R^2 from regressing predicted on actual values.

$$\text{Theil U} = \sqrt{\left(\frac{\Sigma\ [(\hat{Y} - \hat{Y}_{-1}) \div (Y - Y_{-1})]^2}{\Sigma\ (Y - Y_{-1})^2}\right)}$$

and includes the errors made in forecasting production and stocks.

Impact, interim and final multipliers were calculated for all of the exogenous variables in the model. The magnitude of the multipliers seemed reasonable and final multipliers were stable by about 50 periods. Unfortunately model validation is always somewhat of a subjective exercise. We feel the simple model of the wheat economy presented in this study provides a useful although imperfect representation of the world wheat economy. In the next section the model is modified slightly and used to evaluate several different stockholding schemes.

4.0 The Policy Analysis

4.1 Model Modifications and Assumptions

The above model was used to conduct stochastic simulation experiments with alternative storage rules for a 12 year period from 1974/75 - 1985/86. The stochastic elements were included in the model through the error terms in the demand, price, and acreage equations. Yields were made endogenous to the complete model using time trends through the past observations and the calculated error terms of these regressions. Each policy simulation was replicated 50 times using a procedure developed by McCarthy [9] to select sets of random errors which maintain the variance-covariance structure of the estimated equations. Although it could be argued that 50 replications is insufficient sampling to derive adequate distributions in the results, the fact that the same 50 samples of error terms were used in each policy simulation does allow reasonable comparisons between policies.

A major problem in analyzing stabilization policies is to determine which sources of instability should be considered. Many authors have argued that instability arising from shifts in exogenous economic variables should not be stabilized as it is these variables which allow for major structural changes, and adjustments between sectors of an economy [3], [16]. For this reason the exogenous variables are assumed to be predetermined with fixed values throughout the policy experiments.

The barley price and U.S. loan rate variables were fixed at their actual values through the 1975/76 crop year and then at $3.00 per bu. and $1.50 per bu. respectively thereafter. Predicting the future values of the world exports (WEX) and Canadian income (CINC) variables presented more of a problem. Both of these variables had relatively low and stable growth rates until 1971/72 followed by rapid increases in the last three years. The assumption was made that the expected growth in these variables could best be represented by the growth in the earlier period. Hence the values through to 1985 were predicted to increase starting from the 1975/76 values at the pre 1971/72 rate. This choice of high level slow growth for demand variables represents an important assumption about the future of the market but the use of fixed values rather than stochastic exogenous variables means that the assumption should not affect the analysis of stability in the market.

Stability of the endogenous variables is measured not as the distribution of the variables over time periods but rather as the standard deviation of a variable around its expected value in any period. The results thus provide an estimate of the stability of each endogenous variable for each period of the simulation. To reduce the number of variables only the average of these standard deviation estimates are reported. The measure of the levels of the endogenous variables presented in the results represents the average of the expected values over the time periods.[3]

Constraints were placed on the model to ensure that stocks and exports from Canada remained positive in each period. These constraints are necessary as very flexible policies could force stocks to be negative or alternatively force Canada to import wheat to meet the desired demand for stocks. The possibility of this occurring can be determined by comparing the expected values of these variables with their standard deviation.

The estimated acreage equations, for both Canada and the ROW, include the lagged level of stocks as independent variables to account for the negative impact of large stock levels on production. These variables act as proxies for complex domestic agricultural policies such as U.S. diversion payments, land banks, and Wheat Board quota practices that resulted in producers reducing production as stocks increased during the estimation period. Including the response of acreage to stock levels in the policy experiments led to considerable cut-backs in production in both Canada and the ROW, thereby reducing the effectiveness of the buffer stock schemes. This reduction in production had considerable impact on consumer welfare and producer revenues making them more costly in comparison with a no stock policy. The impact of stocks and stabilization policies on producer responses are far from clear. In fact, some studies suggest that the existence of stocks which produce stable market prices and returns will increase production as risk is reduced [7]. The uncertainty as to the sign and magnitude of these affects led to the exclusion of the lagged stock response in the policy simulations.

The reserve policy experiments conducted were broken into two possible situations. The first set of experiments consider the impacts of alternative storage rules for stocks held in Canada assuming that the Rest of World storage policy is the same as that estimated in the original

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[3] Although the results were estimated for each of the 12 periods the reported results cover only the last 9 periods. This was done so that the costs of starting the program, i.e., building initial stock levels would not influence the evaluation of the policy. For an analysis that includes starting costs see Cochrane [2].

model. To conduct this experiment the only change in the basic model is to replace the Canadian demand for stock relationship (equation 3) with a synthetic stock relationship or storage rule. The second set of policy experiments consider the impacts on Canada and the ROW of an international reserve policy. In this case the world demand for stocks relationship (equation 9) is replaced with the synthetic storage rule and Canadian stocks are specified as a fraction of the total world stock.

The following sections briefly outline the policy rules considered in the experiments.

5.0 The Storage Rules

The econometric model described above estimated demand for stock relationships for Canada and the ROW in the following general form;

$$DS_t = a - bPW_t + dS_t + dDS_{t-1}.$$

where, DS_t is the closing level of stocks in crop year t, PW_t is the world price of wheat, S_t is the level of production, and DS_{t-1} is the opening level of stocks in period t.

Starting from this basic storage rule it is possible to define alternatives which represent different strategies for holding reserves.

5.1 The Price Rule

This rule has the following general form,

$$DS_t = \alpha - \beta PW_t,$$

and simply states that in periods when market price is high the closing level of stocks will be low with the reverse true in low price periods. Obviously the β parameter assumed in the rule influences the stability of the stock levels as it determines the rate at which stocks are accumulated or depleted. The α parameter is important in determining the average level of stocks held over the analysis period. In the experiments the level of α was selected and set at such a level as to give a mean stock of 6 m.m.t. for the Canadian policy and 20 m.m.t. for the world storage rules. At these levels of α and the selected levels of β which represent inflexible and flexible rules the elasticity of changes in stock in relation to price changes are approximately 1.3 and 7.6 respectively. The inflexible and flexible rules are represented by policies 1 and 2 in Table 3.

5.2 The Quantity Rule

The synthetic demand for stock rule in this case specifies the closing level of stocks to be a function of the availability of grain in that particular year where availability is defined as a function of current production and opening stocks. The function has the general form;

$$DS_t = \alpha + \gamma(cS_t + dDS_{t-1}).$$

In the range of policies considered the α and γ parameters are varied and the c and d parameters are kept constant at the values estimated in the econometric demand for stocks functions. This mechanism provides for a more constant level of stocks in the short run and yet an ability for stock levels to change with longer run changes in production. The short run elasticity of stock changes with respect to production variations were calculated for the inflexible and flexible stock rules to be .95 and 1.93 respectively for the Canadian policy experiments and 1.49 and 2.66 for the World policy analysis. Again the values of α were chosen to allow average stocks of 6 m.m.t. in Canada and a total of 20 m.m.t. in the World policy. Policy number 3 (Table 3) is the inflexible quantity rule ($\gamma = \frac{1}{2}$) and policy number 4 is the flexible quantity rule ($\gamma = 1$).

5.3 The Mixed Policy Rule

The mixed rules evaluated have the following general form;

$$DS_t = \alpha - \beta PW_t + \gamma(cS_t + dDS_{t-1})$$

where the β and γ values are the same coefficients used in the high and low flexibility price and quantity rules. In this case there are four alternative policies to evaluate for Canada and the World respectively. Policies 5, 6, 7 and 8 in Table 3 represent the mixed rules which are combinations of flexible and inflexible quantity and price rules.

The policies selected for evaluation in this study are not intended to be optimal. Rather they are an attempt to determine the effect of different types of storage rules on the level and stability of the endogenous variables. Initially attempts were made to determine continuous relationships between variables and parameter levels but the computational costs and complexity of resultant relationships led to reporting only a subset of results which suggest some general relationships and useful areas for the development of further policy experiments.

6.0 Canadian Policies

This section presents the results of simulating the existing, and 9 alternative storage rules for the ROW and Canada to 1985. Policy simulation 9 in each case shows the effects of a zero stock policy, to provide benchmark levels with which to compare alternatives and to determine the social payoffs for any policy, while policy 10 is the historically estimated storage rule.

Table 3 provides a description of the individual policy experiments and Table 4 presents the results of the experiments in terms of the

TABLE 3: Stock Rules Used in Policy Experiments

Policy No.	Type of Rule	Stock Demand Elasticities With Respect To: Canadian Experiments Price	Canadian Experiments Quantity	World Experiments Price	World Experiments Quantity
(1)	price rule: inflexible	-1.28		-1.28	
(2)	price rule: flexible	-7.70		-7.59	
(3)	quantity rule: inflexible		.95		1.49
(4)	quantity rule: flexible		1.93		2.66
(5)	mixed rule: price inflexible quantity inflexible	-1.28	.95	-1.21	1.49
(6)	mixed rule: price flexible quantity inflexible	-7.46	.92	-7.17	1.48
(7)	mixed rule: price inflexible quantity flexible	-1.30	1.92	-1.07	2.65
(8)	mixed rule: price flexible quantity flexible	-7.71	1.91	-6.33	2.61
(9)	No stock	-	-	-	-
(10)	Actual	-.39	1.16	-.79	1.98

TABLE 4: Estimated Impacts of Alternative Canadian Stockholding Policies

	Policies									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean Value Of:										
Can. Stock (m.m.t.)	6.0	6.0	6.0	5.9	6.0	6.2	6.0	6.0	0.0	9.9
Price ($/m.t.)	217.8	217.7	217.8	217.9	217.8	217.7	217.8	217.7	217.8	217.9
Can. Exports (m.m.t.)	13.1	13.3	13.0	12.9	13.0	13.3	13.0	13.3	13.1	12.7
Row Consumer Sur. (mil. dol.)	49079.0	49104.0	49053.0	49027.0	49060.0	49099.0	49060.0	49098.0	49051.0	48993.0
Can. Total Rev. (mil. dol.)	3302.0	3353.0	3278.2	3262.0	3291.4	3355.4	3283.3	3358.0	3289.1	3218.0
Can. Net Rev. (mil. dol.)	3178.2	3227.7	3155.0	3141.0	3168.8	3226.2	3160.2	3233.6	3289.1	3018.0
Within Year Std. Dev. Of:										
Can. Stock	.4	2.3	1.1	3.4	1.2	2.9	.8	4.2	0.0	3.6
Price	11.5	10.7	11.6	11.5	11.4	10.6	11.6	10.6	11.7	11.4
Can. Exports	2.9	3.2	2.3	1.4	2.1	2.6	2.5	2.3	3.1	1.3
Row Consumer Sur.	4026.6	3836.0	4011.0	3957.0	3962.3	3766.1	4027.4	3725.0	4071.0	3926.5
Can. Total Rev.	629.2	777.6	487.1	331.8	487.7	680.7	529.0	626.2	645.2	321.8
Can. Net Rev.	630.5	784.6	471.7	295.9	476.2	687.9	518.3	642.4	645.2	288.3
Economic Benefits (mil. dol.):										
Gain to Row Consumers	28.0	53.0	2.0	-24.0	9.0	48.0	-10.0	47.0	0.0	-58.0
Gain to Can. Producers	13.0	64.0	-11.0	-28.0	2.0	66.0	-8.0	69.0	0.0	-71.0
Gain to Row Producers	-9.5	-44.9	11.3	34.2	6.7	-42.9	19.6	-46.4	0.0	82.7
Storage Cost	124.4	125.0	123.0	121.0	123.4	128.8	123.7	124.7	0.0	200.0
Net Gain or Loss	-92.9	-52.9	-120.7	-138.8	-105.7	-57.7	-122.1	-55.1		-246.3

expected values and stability of selected variables. The economic benefits presented at the end of Table 4 measure the expected gains or losses for producers in Canada, consumers in the ROW and producers in the ROW. In the following discussion gains or losses resulting from a specific policy are calculated as deviations from the no stock policy, measured in terms of producer revenue and consumers surplus. The costs reported are the calculated storage costs for each policy, made up of a physical storage cost and an interest cost for the capital value of the wheat reserve.

Perhaps the best way to visualize the expected impacts of the alternative storage rules on the endogenous variables is to consider their impact on Canada's excess supply of wheat to the ROW. With no storage policy the excess supply is almost perfectly inelastic in any year with a stochastic element caused by fluctuations in production and domestic demand. The introduction of a price responsive storage rule causes the excess supply to have a positive relationship with the world price although it is still stochastic. A quantity triggered rule which is responsive to Canadian production changes will retain the inelastic excess supply but the variance of exports will be reduced as major production changes which would otherwise be exported are retained in stocks. These different impacts on the Canadian export supply relationship can be seen in the impacts on producers and consumers.

6.1 Effects on Canadian Producers

As the world price of wheat in this model is not greatly dependent on Canadian exports, i.e., there is a high excess demand elasticity, the change in the excess supply resulting from a price triggered rule does not affect the world price to any great extent. It does however, have some impact on Canadian wheat producers' sales revenue as they sell more in high priced periods and less in low price periods. It also has an impact on the stability of revenue because as a price storage rule becomes more flexible (more elastic with respect to price) expected revenue increases but the stability of revenue decreases. In moving from a no stock to a high price flexibility policy Canadian wheat producers have an expected gain of $64.0 million per year which represents a 2.7% increase in revenue but at the same time the standard deviation of this revenue increases by 20.0%.

With a quantity triggered stock rule there is a small reduction in producer revenue but also a reduction in the standard deviation of this revenue. The increased stability is caused by a more constant level of exports from Canada. In moving from a zero stock policy to a flexible quantity rule the expected value of producer revenue decreases by $28 million per year but the standard deviation of this revenue is likewise decreased by almost 50%. The two basic types of policies discussed above have very different impacts on the level and stability of producer revenue, with price rules increasing but destabilizing expected revenues and quantity rules decreasing but stabilizing revenues. The range of mixed rules analyzed present alternatives between these two extremes. For example, policy 5, a low price flexibility and low quantity flexibility rule results in almost no gain in expected value but does give a 24% reduction in the standard deviation of Canadian producer revenue.

6.1.1 Effects on Consumers in the Rest of the World[4]

The different storage rules have very different impacts on consumers in the ROW. In considering the price rules, the injection of Canadian exports into the world market in high price years causes the expected value of consumer surplus to increase and to become more stable. In moving from a no stock policy (policy 9) to a price flexible rule (policy 2) consumer surplus is increased by $53 million (0.11 percent) per year while the expected standard deviation is reduced 5.8 percent. In comparison a quantity rule (policy 4) causes a small decrease (0.04 percent) in the expected value and a 3 percent decrease in the standard deviation of consumer surplus, again compared with the no stock policy. The change in expected values for both the price and quantity rules is negligible but the impact on the stability of consumers surplus is substantial.

In the mixed rules where increasing quantity response is combined with different levels of price responsiveness the gain in stability is reduced and in the case of policies 5 and 7 becomes destabilizing. Gains in the stability of ROW consumer surplus will occur with a quantity trigger if stable Canadian exports are less destabilizing on world demand than random exports.

6.1.2 The Trade-offs

This brief description of the results has shown that there are several trade-offs to be made in selecting a storage rule. These are not only between variables, such as the stability of Canadian producer revenue or the stability of world consumer surplus, but also between the expected value and stability of any variable as is the case of producer revenue. It is possible however to draw some conclusions from the experiments which show major trade-offs.

Firstly, the policies considered have very small impacts on the expected values of the endogenous variables. Over the range of policies considered the greatest change is a 4.7% change (policy 4 and policy 8) in the net revenue of Canadian producers. There is very little change in the level of world demand, consumer surplus and world price. If changes in the opening and closing stocks over the 9 year evaluation period were accounted for these effects would be even further reduced as revenues

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4 This analysis has not considered the impact of the alternatives on Canadian consumers of wheat as they represent such a small useage of wheat from Canadian production. Thus it is felt that the major consuming impacts of the policies would be on importing countries or consumers in the Rest of the World.

would be increased for policies which accumulate stocks and reduced for policies which run down stocks. The policies do however have substantial impacts on the stability of the variables. Over the policies considered there was a potential 135% range (policies 4 and 9) in the standard deviation of Canadian exports and a 165% change (policies 2 and 4) in the standard deviation of Canadian producers' revenue. The policies have a potential impact of approximately a 10% change on the stability of world prices, demand levels and consumer surplus.

Secondly, because of the small impact of the policies on expected revenues, none of the policies considered show a gain to Canadian producers sufficient to cover the cost of storage, i.e., the no stock policy has a higher net revenue than any other policy. The most beneficial policies from this point of view are the high price response policies (policies 2, 6, 8) and even these policies cover less than one half the costs of the program. Even when the potential gains (losses) to ROW consumers and producers are accounted for none of the policies generate sufficient welfare to cover storage costs. The best policy in this regard is policy 2 where Canadian producers benefit by 64 million dollars, ROW consumers by 53.0 million dollars, while ROW producers lose 44.9 million dollars leaving a net loss of 52.9 million dollars for the storage activity.

It should be noted that gains and losses to ROW producers tend to be approximately equal and opposite in sign to the benefits of Canadian producers. This was to be expected since Canadian gains come from increased exports, during high priced periods, which have a depressing effect on world price levels.

In general the stability impacts of the policies are more important than changes in the expected values of the variables. Viewing the results in this context the major trade-offs facing decision makers are more apparent. The policies which give the maximum stability to Canadian wheat producers net and gross revenues are the high quantity - low price response rules which stabilize export levels. Importing countries or world consumers however would derive the most stability from Canada following a high price response rule with probably the high price response, high quantity response rule (policy 8) being the most preferable. From a cost efficiency point of view the policies which generate the most stability for Canadian producers are the most inefficient compared with the rules which generate the most stability for the world. Comparing the theoretical rules with the extension of the actual rule would suggest that in the past the aim of the Canadian Wheat Industry has been to reduce the instability of producers' revenue. While this has been accomplished it is seen to be a relatively expensive policy. The need for policy makers to consider more global policy objectives in determining future reserve policies or sales strategies may make more price responsive mixed rules a viable alternative to the present strategy.

6.2 World Policies

Nine policies representing similar storage strategies to those used in the Canadian experiment were analyzed for an international wheat reserve scheme. It was assumed that changes in the stock levels in the world were dependent on the world price, total production and total stocks in the world, and in order to evaluate the impact of each policy on the Canadian wheat industry it was assumed that Canada holds one third of the world stock in any year. Although this is a very high proportion considering Canada's production in relation to world production it is not unrealistic considering past levels of stocks. In selecting the policies an attempt was made to derive a total world stock of 20 m.m.t. of which Canada would hold approximately 7 m.m.t. on average with stocks again constrained to be positive.

A further modification to the storage rule was required to account for the trend in world production over the base simulation period. As the elasticity of response in the quantity rules is relatively high any increase in world production resulted in a large increase in stocks. To overcome this problem of rapid stock build up the demand for stock function was modified by adjusting stocks only in response to movements of production away from a trend of 10 m.m.t. per year. The effect of this modification was to bring the growth rate of average stocks into line with the growth rate of world production and yet still allow more elastic stock responses to short run production changes.

Table 5 presents the results of the world stock policy analysis. The total stock in the world is the sum of the stock level in Canada and the Rest of the World. In this analysis total revenue is calculated for wheat producers in the world and for Canadian producers separately while the net revenue calculation is for all producers.

The effects of the different types of storage rules can again be seen in their impacts on the supply of grains. In these experiments, however, the relevant supply is the world supply and the demand facing this supply is the total world demand for wheat rather than the excess demand for Canadian exports. This difference means that the demand is much less elastic than in the Canadian experiments but nonetheless the effects of the different storage rules are similar. An increase in the flexibility of the price rule makes the supply function more elastic and a quantity rule makes the supply function more stable.

6.2.1 Effects on Producers

The results show in this experiment that increasing the price responsiveness of a storage rule increases the level of total revenue and at the same time increases the stability of total revenue. This conclusion is different from the Canadian experiments where increasing price responsiveness decreased the stability of Canadian total revenue. The cause of this difference is the inelastic world demand curve which means that attempts to increase sales in high priced markets causes substantial drops in price which reduces the instability in revenue and at the same time reduces the gain in expected revenue. In the Canadian experiment moving to a more flexible price policy caused a 1.6% increase in Canadian revenue

TABLE 5: Estimated Impact of Alternative World Reserve Stock Policies

	Policies (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean Value Of:										
Can. Stock (m.m.t.)	6.7	6.7	7.1	7.9	7.1	7.1	8.0	8.1	0.0	10.8
Row Stock (m.m.t.)	13.4	13.5	14.1	15.9	14.1	14.3	15.9	16.2	0.0	21.6
Price ($/m.m.t.)	213.3	213.2	213.4	213.6	213.3	213.3	213.5	213.5	213.4	213.6
Can. Exports (m.m.t.)	12.4	12.5	12.4	12.3	12.4	12.4	12.3	12.3	12.4	12.2
Row Consumer Sur. (mil. dol.)	51122.5	51119.9	51067.9	50971.1	51072.3	51066.5	50971.5	50962.5	51050.9	50941.3
World Total Rev. (mil. dol.)	93516.9	93591.5	93528.3	93556.0	93540.7	93612.5	93571.5	93639.0	93509.0	93570.9
World Net Rev. (mil. dol.)	93112.4	93181.9	93117.2	93086.8	93111.9	93181.8	93091.3	93156.2	93509.0	92918.9
Can. Total Rev. (mil. dol.)	3092.2	3114.4	3081.4	3062.7	3086.0	3106.0	3067.2	3084.8	3079.0	3058.1
Within Year Std. Dev. Of:										
Can. Stock	.5	2.4	.6	1.8	1.1	3.3	2.4	5.1	0.0	2.4
Row Stock	1.0	4.9	1.2	3.5	2.2	6.6	4.7	10.1	0.0	4.7
Price	12.3	10.2	12.5	12.1	11.9	9.7	11.4	9.2	12.9	11.4
Can. Exports	2.9	3.1	2.9	2.8	2.7	3.1	2.7	3.2	3.1	2.7
Row Consumer Sur.	4857.6	4339.6	4752.0	4435.0	4577.3	4076.1	4262.4	3779.4	5035.1	4262.5
World Total Rev.	3973.7	3916.0	3993.0	3994.0	3978.5	3917.3	3979.4	3914.3	3988.4	3978.6
World Net Rev.	3973.5	3958.9	3979.0	3979.9	3978.4	3964.9	3981.9	3973.0	3988.4	3976.7
Can. Total Rev.	634.2	733.9	617.0	609.4	614.5	730.9	620.8	755.0	649.9	621.8
Economic Benefits (mil. dol.):										
Gain to Row Consumers	71.0	69.0	17.0	-80.0	21.0	15.0	-80.0	-89.0	0.0	-110.0
Gain to World Producers	8.0	82.0	19.0	47.0	31.0	103.0	62.0	130.0	0.0	61.0
Storage Cost	409.2	411.1	430.3	478.8	430.7	432.6	478.9	485.0	0.0	650.5
Net Gain or Loss	-330.2	-260.1	-394.3	-511.8	-378.7	-314.6	-460.9	-444.0	0.0	-699.5

and a 23% increase in the standard deviation of total revenue while in the world experiment a similar policy change results in only a 0.1% increase in world revenue while the standard deviation of world revenue falls by 1.5%.

Increasing the flexibility of the quantity rule increases the expected value of total revenue to producers in the world but has little impact on the stability except in the case where the quantity mechanism is combined with a high price response rule in which case stability is increased (policy 8). The quantity rules do give a more stable revenue than a no stock policy but their effect is limited in the world model because the coefficient of variation of world production is considerably less than that in Canada. Thus for the world as a whole, price stability is more important than supply stability in determining revenue stability. A further important point to note is that in the base simulation period from 1974-85 the world elasticity of demand is considerably different from that calculated in the estimating period. Given the changes in income and price from the base period the estimated elasticity of demand over the 1974-1985 period is approximately -0.9 which means that changes in supply levels cause very little revenue instability. This can be seen from the fact that over the whole range of experiments the maximum change in the stability of total revenue was only 2.0%, (policies 8 and 9).

6.2.2 Effects on Consumers

From the consumers point of view moving from a no stock policy to a price flexible policy (number 2) would provide a 0.1% increase in expected value and a 14% reduction in the standard deviation of consumer surplus. In a similar manner, moving to a flexible quantity rule (number 4) would reduce the standard deviation by 12%, but with a .1% decrease in expected value. Obviously these policies have very little impact on the expected value of consumer surplus with the greatest difference between all the policies being a 0.3% change (policies 8 and 1). There is however a 33% change in the standard deviation with the most unstable being the no stock policy and the most stable being the high price flexibility and high quantity flexibility rule (policy 8). The mixed policy rules show very little impact on the expected values but the compounding of price and quantity rules has very large impacts on stability. Combining policy 2 and policy 4 to give the very responsive policy 8 results in a 33% reduction in the standard deviation at a cost of a 0.17% reduction in expected value.

6.2.3 Effects on Canadian Producers[5]

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[5] Unfortunately, the absolute levels of Canadian producers' revenue cannot be accurately compared between the Canadian and world policies, due to the fact that in the Canadian evaluation it was assumed that the Rest of the World held an average of 40 m.m.t. stock and that world acreage responded to lagged levels of stock. For this reason the overall production level in the world is higher and prices lower in the world evaluation. However the stability levels do remain comparable.

The impacts of the policies on Canadian producers show that a flexible price policy gives the highest expected value, as producers are building up stocks in low price years and selling in high priced years. The gain in expected revenue from increasing the flexibility of the rule is much more limited than in the Canadian model as the Rest of the World is behaving in the same manner causing world price changes when stocks are increased or decreased. As would be expected the pure price rule destabilizes Canadian revenue as changes in world prices have almost no correlation with changes in Canadian yields. This is the same result as the pure price policies of the Canadian experiments, where increasing the price flexibility of the policies makes revenue more unstable than the no stock policy. The quantity storage rules have a very small impact on the stability of Canadian revenue, but the pure quantity rule does generate more stable revenue than the no stock policy presumably because Canadian production is included in total world production and influences the variability of world production.

6.2.4 Summary of World Policies

The results of the world policy analysis show that in general the impacts of the policies on the expected values of the variables is minimal. Over the complete range of policies the greatest impact is on the level of Canadian exports and total revenue which vary by approximately 2.0%. Total world revenue varies by only 0.14% and consumer surplus by 0.32%. The stability of these variables however, is affected considerably by the choice of policy. The most sensitive variable is world price whose standard deviation varies by 40% over the range of experiments. Consumer surplus and demand in the world vary by 33.0% showing that the alternative policies have substantial effects on consumers, but the effects on producers' net and total revenue is very small. The standard deviation of total producer revenue varies by 2.0% and net revenue varies by only 0.75%. This is largely a reflection of the elasticity of demand generated by the model in the base period.

Because the policies have little effect on the expected values of the variables none of the policies cover the cost of operating the scheme. The most price elastic storage policy (number 2) has the greatest expected economic benefits with a $69 million gain to consumers and an $82 million gain to producers, but the total cost of storage for this policy is $411 million per year. The most cost inefficient policy is the high flexibility quantity rule which generates a gain to producers of $47 million and a loss to consumers of $80 million with associated program costs of $487 million.

It is clear that the international storage rules do not present the major trade-offs between consumers and producers that were evident in the Canadian policy simulations. Considering only the stability impacts of the policies would suggest that the group of price policies are better than pure quantity rules as they generate more stability for producers and are marginally better for consumers in the world as a whole, but mixed policies present opportunities for further gains in stability. The gain in stability resulting from the combination of price and quantity rules is most probably caused by the smaller stock changes in periods when the price and quantity triggers would independently suggest opposite changes in stocks. Perhaps the most interesting trade-off that results from the world policy analysis is that between the stability of revenue for Canadian producers and that for the producers in the world as a whole. This result suggests that a policy which may be satisfactory for the world as a whole or even for producers in the world need not be the best policy for an individual country participating in such a scheme.

7.0 Conclusions and Limitations

The evaluation of alternative wheat reserve strategies for an independent Canadian policy and a world-wide policy showed that in general the buffer stock activities would have little impact on the expected values of producer revenue and consumer surplus. In fact, in all of the policies considered the total benefits were insufficient to cover the assumed costs of the storage policies.

Although the net benefits of the policies are negative, this is not sufficient grounds to state that there should be no reserve policies. Certain policies do have a substantial impact on the stability of welfare which may be sufficient to justify the use of such policies. Unfortunately, economic theory does not provide us with a simple method of evaluating the benefits of stability or comparing the benefits of stability to individual groups such as producers and consumers or for individual regions. Perhaps the best the economist can attempt to do is evaluate different alternatives and point out the areas where the major trade-offs would occur.

The Canadian policy experiments showed that the different types of storage rules had very different impacts on Canadian producers, and consumers in the Rest of the World. A storage rule triggered by the availability of grain in Canada was shown to be the most stabilizing policy for Canadian wheat producers while highly price responsive policies were shown to provide the most price and consumption stability in the world.

The world policy experiments showed that highly price responsive policies were mutually beneficial for the stability of world producer revenue and consumer surplus but were in fact more unstable than no stock policy for Canadian wheat producers. This experiment, like the Canadian experiment, results in the conclusion that storage policies which may be stabilizing for the world as a whole need not be stabilizing for relatively small regions which participate in the policy.

It would seem appropriate at this stage of the paper to briefly review the most critical assumptions upon which these results and conclusions depend. Firstly, we have assumed in the structure and costing of the policy experiments that the stockholding authority does not pay wheat producers for grain that is stored until that grain is actually marketed. This assumption removes the need for financing a stockholding authority but it places more instability on producers. Secondly, the model does not include any response in demand or supply to high levels of stocks which could overhang the market. The estimated equations show a negative effect of increasing stocks on acreage of wheat in the world and other authors [3] have argued that increasing levels of stocks have large impacts on the demand elasticity for wheat. While we do not deny the existence of these effects they were excluded from the analysis under the assumption that a well managed reserve scheme with generally lower levels of stocks than in the past would minimize these effects. Thirdly, the extrapolation of the demand relationships until 1985 has resulted in a relatively high elasticity of demand for wheat in the world which may not be valid for this period. Lastly, the use of non-stochastic exogenous variables in the model has precluded their impact on stability of the exogenous variables which implies that the policies analyzed would not fully stabilize major exogenous, or structural changes in the market such as those seen in recent years.

Considerable further research is necessary to determine how critical these assumptions are. Better econometric estimates of responses are needed as well as further policy experiments to evaluate more flexible, and other types of policies before we can accurately determine the economics of reserve schemes.

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