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EXPORT CREDIT GUARANTEES:

A WELFARE AND STRATEGIC ANALYSIS

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1. Introduction

Export credit programs are increasingly recognized as a tool of strategic trade policy (Eaton). In international grain markets, export credit (or credit guarantee) programs are offered by most major exporters, including the United States, France, Canada, and Australia. These programs provide credit to countries that are considered poor risks (by commercial lenders) to stimulate exports of wheat and other commodities.

Two factors have raised the visibility of export credit programs for agricultural commodities. First, defaults by Russia, one of the world's major wheat buyers, have demonstrated the potential for substantial losses under the Commodity Credit Corporation's (CCC) GSM programs[1], which provide U.S. government guarantees for approved export credits. Second, while the General Agreement on Tariffs and Trade (GATT) has imposed discipline on export subsidies, export credit programs (such as GSM-102) fall outside its purview. With GATT-imposed limits on direct price subsidies, governments may have greater incentive to use credit programs to gain or protect international market shares.

Little research has been published on export credit programs for agricultural commodities. U.S. Department of Agriculture economists (Skully and Hyberg, et al.) have quantified the implicit subsidy that GSM programs provide to importers of U.S. commodities. This stems from lower interest rates charged by lenders on GSM credits. Yang and Wilson conducted an econometric analysis of U.S. and competitor export credit programs. They analyzed the factors that influence allocations of credit by major wheat exporting countries. One of the most important factors, they determined, was the provision of credit (in given import markets) by competitor countries. Wilson and Yang assessed the effectiveness of credit allocations (versus direct price subsidies and other trade policies) as an instrument for capturing market share. Dahl, et al. provide background on export credit programs and an overview of current policy issues.

The question of *additionality* is critical to informed policy discussions: To what extent do export credit programs like GSM contribute to the volume of commodity exports? To provide a credible answer, the possibility of strategic interactions between exporting countries must be considered. (Does the extension of credit by the United States induce similar offers by competing countries, such Canada or France?) The welfare effects of export credit programs, from the exporter's perspective, hinge on additionality. These have not been adequately addressed in previous research, although some of the literature (Bohman, Carter and Dorfman) on targeted export subsidies (e.g., as provided under the Export Enhancement Program, EEP) is suggestive. Anania, Bohman and Carter concluded that EEP cannot be welfare-enhancing for the United States, even considering strategic trade theory. Indeed, much of the strategic trade literature has been developed from a perspective of imperfect competition (e.g., Brander and Spencer) that does not accord with the actual performance of U.S. commodity trade (i.e., competitive, price-taking behavior by firms).

This paper presents a simple analytical model of export credit guarantees. The model is normative in the sense that it can be used to study "optimal" allocations of credit guarantees by an exporting country to an importing country, conditional on actions by a competing exporter. It allows explicit consideration of strategic interactions between exporting countries and provides a basis for analyzing welfare effects of credit programs in a complex, multi-market environment.

The plan of the paper is as follows. Section 2 presents a simple graphical analysis of export credit guarantees. Section 3 presents the analytical model. In Section 4, properties of the model are illustrated through numerical simulations. Strategic implications (from a game-theory perspective) are developed in Section 5. The paper concludes with a summary and discussion.

2. Graphical Analysis

To gain perspective on the problem, it is useful to begin with a simple graphical analysis. Consider the case of an individual wheat importing country (Figure 1). The import demand schedule is represented as line *ak*. We assume that the importing country is large in the sense that it faces an upward sloping supply schedule, line *ej*. The price received by exporting countries is positively related to trade volume. In the absence of distortions, q1 would be the import volume, and p1 would be the price paid by importers to exporters.

Assume that the importer is considered a poor risk by international lenders and has limited access to trade credit on commercial terms. To the left of the curved, dashed line in Figure 1 are all price-quantity pairs that are affordable, given the credit constraint.[2] The free-trade equilibrium, lying to the right of the constraint, is unattainable. The effective export supply schedule is *ehf*; the vertical segment reflects the unwillingness of exporters to supply wheat above the importer's borrowing capacity.

The diagram is similar to the case of export quota (Houck, pp. 125-129). With exports constrained to be no more than q2, a wedge is driven between the importer's domestic price (p3) and the world price (p2). The rectangle *bfhd* represents the value of rents associated with the constraint. *A priori*, it is not clear whether these rents are captured by the importer or the exporter (or their respective governments). It depends on how quota rights are allocated. In the case of a binding credit constraint, if there are competitive conditions among export firms and no explicit export controls, then it is plausible that *bfhd* would accrue to the importing country (i.e., firms or tax authorities). In that case, p2 is the price received by exporters, and *cihd* represents a loss of exporter surplus that can be attributed to the credit constraint.

Figure 2 illustrates the impact of an export credit guarantee program, such as GSM 102, on trade volume and welfare. Initially, the importer faces a binding credit constraint, limiting its imports to q2; the effective export supply schedule is *dgf*. Provision of an export credit guarantee will have two effects. First, international lenders will be able to extend a larger volume of loans to the importer with no increase in their country exposure. Second, the guarantee allows lenders to charge a lower interest rate. Because 98% of the principal on GSM loans is guaranteed, banks are subjected to less risk for these loans and can offer better terms, i.e., lower interest spread over the London Interbank Offer Rate (LIBOR). These features cause the effective export supply schedule (as seen by the importer) to shift to *elknm*. The vertical segment of the schedule has shifted to *nm* because of the credit expansion effect. The segment *el* reflects the lower interest rate charged on guaranteed loans. This is equivalent to an *ad valorem* export subsidy with quantity limit. At point *l*, the exporter's allocation of subsidized credit is fully utilized; the segment *kn* represents exports financed on commercial terms with no interest subsidy. For exports beyond point *n*, the commercial credit constraint is again binding.

In Figure 2, the effective supply schedule intersects the import demand schedule at point *j*. This corresponds to point *i* on the schedule *dn*, which gives prices received by exporters. The difference between prices paid by the importer and received by the exporter, multiplied by trade volume, gives the cost of the interest subsidy (rectangle *abji*) borne by taxpayers in the exporting country.[3] As a result of the credit guarantee, exporter surplus--the area below price received and above marginal cost--increases by the area *acgi*. If this increase is larger than the cost borne by taxpayers, there is a net increase in welfare in the exporting country. This requires that area *bcgh* exceed area *hij*.

Two sources of additionality (trade creation) are displayed in Figure 2. Recall that q2 is the trade volume in the absence of a credit guarantee program. As a result of the credit guarantee, trade volume increases to q3. The expansion from q2 to q1 is due to relaxation of the credit constraint, while the expansion from q1 to q3 is due to the price effect of the interest subsidy.

Variants of Figure 2 can be conceived with different trade and welfare effects. For example, the import demand schedule could intersect the export supply schedule along segment *kn*. In that case, the importer exhausts its GSM allocation and purchases some wheat on commercial terms. Additionality is entirely due to relaxation of the credit constraint. In another variant, the import demand schedule intersects the export supply schedule at a quantity less than q2 (the free-trade equilibrium). The original credit constraint is not binding in that case; the interest subsidy can expand export volume, but gains to exporter surplus are outweighed by costs to taxpayers.

As other features are added to the problem, it becomes more difficult to assess the implications of credit guarantees through graphical analysis. In Section 3, an analytical model is developed in which an importing country buys wheat from two exporting countries. Wheat from these two sources is not perfectly substitutable in demand, and both exporters are able to extend credit guarantees. This allows consideration of strategic decisions by exporters (or program administrators) and offers a way to examine additionality and welfare effects in a more complex, multi-market setting.

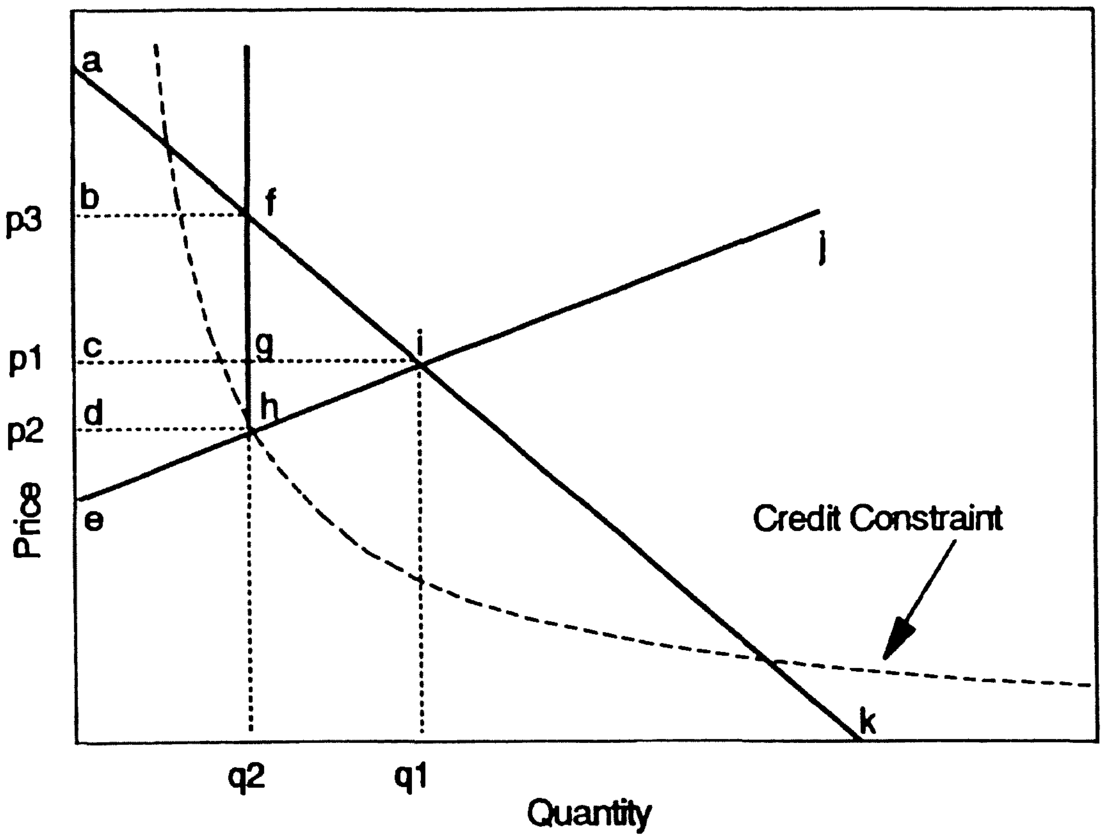


Figure 1. Imports with Binding Credit Constraint

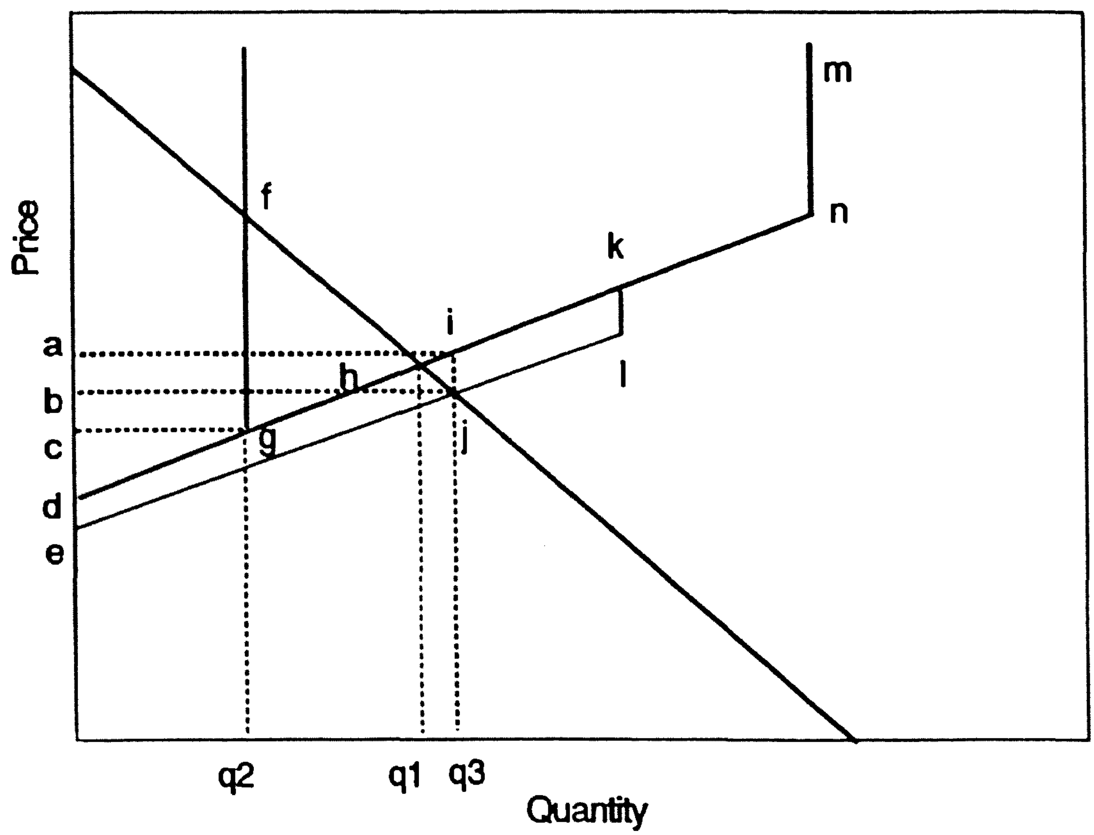


Figure 2. Impact of Credit Guarantee on Trade Volume, Prices and Welfare

3. Model Formulation

The analytical model is developed as a nonlinear programming problem. The objective is to maximize the sum of importer and exporter surplus subject to credit constraints. The objective function is quadratic, in keeping with a well-known formulation by Takayama and Judge (applied to spatial equilibrium). However, in this model, nonlinearities also occur in the constraints.

Assume two wheat exporting countries (i=1,2) and one importer. The two exporters supply different types of wheat, which are imperfect substitutes. In addition, both exporters have export credit programs, which provide credits for wheat purchases at subsidized rates. The terms of these programs may differ between exporting countries, but are taken as given by the importer. Program parameters include the credit allocation (value of qualifying imports), the fraction of credit that is guaranteed, and the subsidy value (associated with lower interest rates).

Export Supply and Import Demand

Let x_i denote a sale of wheat under a subsidized export credit program (exporter i), and let y_i denote a sale under commercial terms. For each exporter, trade volume is given by the sum of subsidized and commercial sales:

$$q_i = x_i + y_i \qquad (i=1,2) \tag{1}$$

Linear functions are specified for the exporters' (inverse) supply:

$$p_{si} = c_i + d_i\, q_i \qquad (i=1,2) \tag{2}$$

where p_{si} is the wheat price received by exporter i and c_i and d_i are parameters. The importer is assumed to be large enough to affect world prices, so that $d_i > 0$ (i=1,2).

For the importer, the inverse wheat demand functions are given by

$$p_{di} = a_i + b_{ii}q_i + b_{ij}q_j \qquad (i=1,2;\ j \neq i) \tag{3}$$

where p_{di} is the demand price for wheat i, q_i and q_j are wheat quantities consumed, and a_i and b_{ij} are parameters ($b_{ij} < 0$; i,j = 1,2). It is assumed that cross-partial derivatives are equal, i.e., $b_{ij} = b_{ji}$ ($i \neq j$). This ensures that measurement of the importer's consumer surplus in two wheat markets does not depend on the order of integration.[4]

In addition to wheat supply and demand, the model includes demand for a composite, nonwheat import. Demand for the nonwheat import is important because if constraints on commercial trade credit are binding, then provision of credits for wheat (under GSM or similar programs) may also change nonwheat purchases--by allowing the importer to reallocate borrowed funds. Importer demand for the nonwheat commodity is given by

$$p_{zd} = a_z + b_z z \tag{4}$$

where p_{zd} is the demand price, a_z (>0) and b_z (<0) are parameters, and z is quantity (e.g., a fixed-weight index of nonwheat imports). For simplicity, assume that the international supply of z is perfectly elastic, with supply price fixed at p_{zs}.

Objective Function

The objective to be maximized is the sum of exporter and importer surplus--the area lying below importer demand schedules and above exporter supply schedules, plus subsidy values:

$$W = \sum_{i=1}^{2}\sum_{j=1}^{2}\left[a_i q_i + \frac{1}{2}b_{ij}q_i q_j\right] - \sum_{i=1}^{2}\left[c_i q_i + \frac{1}{2}d_i q_i^2\right] + \sum_{i=1}^{2} s_i[c_i + d_i q_i]x_i + \left[a_z z + \frac{1}{2}b_z z^2 - p_{zs}z\right] \tag{5}$$

The first term represents the sum of areas under two wheat demand functions. Second is the area beneath two wheat supply functions (cumulation of exporters' variable costs). Third is the value of subsidies received by the importer through credit programs, where s_i is a discount parameter ($0 \le s_i \le 1$).[5] Fourth is the surplus associated with nonwheat imports.

Inequality Constraints

The maximization is subject to credit constraints on imports and pricing constraints. Credit constraints are of two types: constraints on subsidized wheat imports under exporter credit programs, and a constraint on other import expenditures (financed on commercial terms).

Let G_i denote the credit allocation by exporter i (under GSM or similar program) for wheat purchases by the importer. G_i is the maximum value of import expenditures under the exporter's program:

$$p_{si}(1 - s_i)x_i \le G_i \qquad (i=1,2) \tag{6}$$

Note that the importer's effective purchase price, $(1-s_i)p_{si}$, is lower than the price received by wheat exporting firms because of an implicit interest subsidy, measured as a fraction of p_{si}.

Let V denote the importer's total commercial borrowing capacity, i.e., the maximum amount of credit that foreign lenders will extend to the importer without GSM or similar guarantees, given their assessment of country risk. Imports under commercial credit terms are constrained as follows:

$$\sum_{i=1}^{2} p_{si}y_i + p_{zs}z + \sum_{i=1}^{2}[(1-h_i)p_{si}(1-s_i)x_i] \leq V \tag{7}$$

On the left-hand side are nonsubsidized wheat purchases, purchases of nonwheat commodities, and a (small) fraction of the value of subsidized wheat purchases. Recall that under GSM, only part of the value of loan principal is guaranteed. In constraint (7), h_i denotes the fraction of qualifying loans covered by government guarantee. The uncovered part of subsidized loans, $(1-h_i)p_{si}(1-s_i)x_i$, adds to the country risk exposure of private lenders.

Pricing constraints are also imposed:

$$p_{si}(1-s_i) - p_{di} \leq 0 \qquad (i=1,2) \tag{8}$$

In each wheat market, demand price cannot be lower than the landed value of imports (inclusive of subsidy). This rules out solutions that are loss-making for firms importing wheat.

<u>First-order Conditions and Solution Procedures</u>

After appropriate substitutions, the constrained maximization problem can be expressed in Lagrangian form as a function of ten variables: subsidized wheat imports (x_1 and x_2); nonsubsidized wheat imports (y_1 and y_2); nonwheat imports (z); and five multipliers associated with inequality constraints. Let λ_1 and λ_2 denote, respectively, the multipliers for credit guarantee constraints (6) for exporters 1 and 2. Let λ_c denote the multiplier for the commercial credit constraint (7). Let θ_1 and θ_2 denote the multipliers for pricing constraints (8) in the two wheat import markets.

The Kuhn-Tucker necessary conditions for maximization are reproduced in equations (9) through (20). All variables are nonnegative.

$$
\begin{aligned}
\partial L/\partial x_i \;=\; & a_i - c_i(1-s_i) + (b_{ii} - d_i + 2d_i s_i)x_i \\
& + b_{ij}(x_j + y_j) + [b_{jj} - d_i(1-s_i)]y_i \\
& - \lambda_i[(1-s_i)(c_i + 2d_i x_i + d_i y_i)] \\
& - \lambda_c[d_i y_i + (1-h_i)(1-s_i)(c_i + 2d_i(x_i + y_i))] \\
& - \theta_i[(1-s_i)d_i - b_{ii}] - \theta_j(-b_{ij}) \le 0 \\
& \qquad (i=1,2;\ j \ne i)
\end{aligned}
\tag{9}
$$

$$
x_i \partial L/\partial x_i = 0 \qquad (i=1,2)
\tag{10}
$$

$$
\begin{aligned}
\partial L/\partial y_i \;=\; & (a_i - c_i) + (b_{ii} - d_i)y_i + b_{ij}y_j \\
& + (b_{ij} - d_i(1-s_i))x_i - \lambda_i[d_i(1-s_i)x_i] \\
& - \lambda_c[c_1 + 2d_i y_i + (d_i + (1-h_i)(1-s_i)d_i)x_i] \\
& - \theta_i[d_i(1-s_i) - b_{ii}] - \theta_j[-b_{ij}] \le 0 \\
& \qquad (i=1,2;\ j \ne i)
\end{aligned}
\tag{11}
$$

$$
y_i \partial L/\partial y_i = 0 \qquad (i=1,2)
\tag{12}
$$

$$
\partial L/\partial z = a_z + b_z z - p_{zs} \le 0
\tag{13}
$$

$$
z \partial L/\partial z = 0
\tag{14}
$$

$$\partial L/\partial \lambda_1 = G_i - [c_i(1-s_i)x_i + d_i(1-s_i)x_i^2 + d_i(1-s_i)x_i y_i] \geq 0 \qquad (i=1,2)$$

(15)

$$\lambda_i \partial L/\partial \lambda_i = 0 \qquad (i=1,2)$$

(16)

$$\partial L/\partial \lambda_c = V - \left[\sum_{i=1}^{2} [c_i + d_i(x_i + y_i)y_i] + p_{zs}z + \sum_{i=1}^{2} (1-h_i)[c_i + d_i(x_i + y_i)](1-s_i)x_i \right] \geq 0$$

(17)

$$\lambda_c \partial L/\partial \lambda_c = 0$$

(18)

$$\partial L/\partial \theta_i = [c_i + d_i(x_i + y_i)](1-s_i) - [a_i + b_{ii}(x_i + y_i) + b_{ij}(x_j + y_j)] \geq 0 \qquad (i=1,2;\ j \neq i)$$

(19)

$$\theta_i \partial L/\partial \theta_i = 0 \qquad (i=1,2)$$

(20)

With restrictions on demand parameters and subsidy values, the objective function is necessarily concave.[6] However, because the commercial credit constraint (7) is not convex, the Kuhn-Tucker conditions are not sufficient for global maximization (Chiang, pp. 728-743). This argues against using the first-order conditions (with specific assumptions about nonzero variables and binding constraints) to derive analytical solutions. Instead, we use numerical solutions to study properties of the model.

The model was written for GAMS/MINOS, a general nonlinear solver (Brooke et al.). Because the feasible region is not convex, there is no assurance that a local optimum (identified by the solver) is actually global. One way to deal with this problem is to solve the model with different starting values and check that the same solution is obtained. That was the procedure used here. Based on experimentation with different starting values for x_i and y_i (i=1,2), the solution identified by GAMS/MINOS does not appear to be sensitive to initial conditions.

4. Base-case Results and Parametric Analysis

In this section, numerical solutions are presented and discussed. Supply and demand parameters are shown in Table 1. These are not derived from empirical data, but are chosen for the (arbitrary) base case. Deviations from these parameter assumptions will be noted as appropriate.

Table 1. Base-Case Supply and Demand Parameters

Parameter	Wheat		Non-wheat
	Exporter 1	Exporter 2	
a_i	300	300	n.a.
b_{i1}	-2.5	-1.5	n.a.
b_{i2}	-1.5	-2.5	n.a.
c_i	80	80	n.a.
d_i	0.2	0.2	n.a.
a_z	n.a.	n.a.	150
b_z	n.a.	n.a.	-1.0
p_{zs}	n.a.	n.a.	100

n.a. not applicable.

The maximum country exposure for commercial lenders (V) is fixed at $3,000. In addition, the importer buys wheat through two credit guarantee programs. For both exporters (i=1,2), the implicit subsidy value of export credits is set equal to 5 percent (s_i = .05), and 98 percent of approved credits are guaranteed (h_i = .98).

Alternative assumptions are made with respect to G_i, the maximum sales under credit guarantees. For exporter 2, G_2 is fixed at $1,000. For exporter 1, G_1 is fixed at two different levels--$2,000 and $6,000--to illustrate the effects of exporter credit allocations on trade volumes and welfare.

Results of parametric analysis are shown in Tables 2 and 3. Table 2 shows results with a small credit allocation by exporter 1 (G_1 = 2000), while Table 3 shows results with a large credit allocation (G_1 = 6000). The first column in each table corresponds to the base case. Other columns show the effects of changing individual model parameters. Welfare measures are displayed at the bottom of each table. For each of the exporting countries, *net surplus* is defined as the area above the wheat supply function and below the supply price less the subsidy value provided to the importer under credit programs. If the subsidy value (a cost borne by taxpayers) is sufficiently large, exporter net surplus is negative. Lagrange multipliers are also shown; nonzero values indicate that the associated constraint is binding.

Under base-case assumptions with G_1=2000 (Table 2, column 1), the importer divides its wheat purchases equally between the two exporters. Exporter 2 has a smaller credit program (G_2=1000) under the base case and therefore incurs smaller subsidy costs. As a result, exporter 2 has a larger net surplus than exporter 1. In the alternative base case with G_1=6000 (Table 3, column 1), exporter 1 has a larger trade volume than exporter 2, and a substantially larger net surplus. Comparing the two base case results, exporter 2 appears to fare better when exporter 1 has a "small" credit program. (However, this is conditional on the size of G_2).

The second and third columns (Tables 2 and 3) show model results with alternative demand parameters. When the importer's demand for type-1 wheat is more price elastic (b_{11} = -2.0), trade volume expands, and the credit allocation is more advantageous to exporter 1 (relative to the base case). When cross-effects are larger (b_{12} = -2.25), there are pronounced effects on exporter welfare when G_1 is "large." In particular, exporter 2 suffers a welfare loss (Table 3) due to sharply reduced trade volumes. This illustrates that the welfare effects of credit programs depend on program size and on the substitutability of wheat offered by competing exporters.

Table 2. Parametric Analysis: Model Results With Small G_1 Allocation

Variable	Parameter Values				
	Base Case: G_1 = 2000	b_{11} = -2.0	$b_{12} = b_{21}$ = -2.25	V = 5000	s_i = .10 (i=1,2)
Trade Volumes and Prices					
Exporter 1 trade volume (q_1)	35.04	41.64	34.98	42.27	35.97
Subsidized exports (x_1)	24.20	23.84	24.20	23.80	25.49
Commercial exports (y_1)	10.85	17.80	10.78	18.47	10.49
Export supply price (p_{s1})	87.01	88.32	87.00	88.46	87.20
Import demand price (p_{d1})	159.83	174.34	133.87	130.91	156.11
Exporter 2 trade volume (q_2)	35.04	28.26	34.98	42.27	35.97
Subsidized exports (x_2)	12.10	12.29	12.10	11.90	12.74
Commercial exports (y_2)	22.94	15.97	22.88	30.37	23.23
Export supply price (p_{s2})	87.01	85.65	87.00	88.46	87.20
Import demand price (p_{d2})	159.83	166.90	133.87	130.91	156.11
Nonwheat imports (z)	0	0	.13	6.19	0
Nonwheat demand price (p_{dz})	150.00	150.00	149.87	143.81	150.00
Lagrange Multipliers					
Exporter 1 credit (λ_1)	0.852	0.972	0.568	0.505	0.908
Exporter 2 credit (λ_2)	0.852	0.972	0.568	0.505	0.908
Commercial credit (λ_c)	0.775	0.890	0.499	0.438	0.730
Competitive pricing (θ_1)	0.000	0.000	0.000	0.000	0.000
Competitive pricing (θ_2)	0.000	0.000	0.000	0.000	0.000
Welfare Measures					
Importer surplus	10,173.43	10,531.6 0	9,253.45	11,185.71	10,467.62
Exporter 1 net surplus	17.53	68.10	17.06	73.44	-92.82
Exporter 2 net surplus	70.13	27.21	69.69	126.07	18.30

Table 3. Parametric Analysis: Model Results With Large G_1 Allocation

Variable	Parameter Values				
	Base Case: G_1 = 6000	b_{11} = -2.0	$b_{12} = b_{21}$ = -2.25	V = 5000	s_i = .10 (i=1,2)
Trade Volumes and Prices					
Exporter 1 trade volume (q_1)	65.42	67.54	67.54	61.83	67.68
Subsidized exports (x_1)	65.42	67.54	67.54	61.83	67.68
Commercial exports (y_1)	0.00	0.00	0.00	0.00	0.00
Export supply price (p_{s1})	88.55	93.51	93.51	92.37	93.54
Import demand price (p_{d1})	93.08	118.32	92.65	87.75	84.18
Exporter 2 trade volume (q_2)	31.94	31.07	17.11	38.46	31.08
Subsidized exports (x_2)	12.19	12.21	12.62	12.00	12.89
Commercial exports (y_2)	19.75	18.86	4.49	26.45	18.19
Export supply price (p_{s2})	86.39	86.21	83.42	87.69	86.22
Import demand price (p_{d2})	122.03	121.02	105.26	111.12	120.79
Nonwheat imports (z)	11.58	12.34	24.85	25.52	12.98
Nonwheat demand price (p_{dz})	138.42	137.66	125.15	124.48	137.02
Lagrange Multipliers					
Exporter 1 credit (λ_1)	ε	0.289	0.039	ε	ε
Exporter 2 credit (λ_2)	0.449	0.441	0.312	0.305	0.515
Commercial credit (λ_c)	0.384	0.377	0.251	0.245	0.370
Competitive pricing (θ_1)	ε	0.000	ε	-0.049	-0.239
Competitive pricing (θ_2)	0.000	0.000	0.000	0.000	0.000
Welfare Measures					
Importer surplus	11,469.01	12,582.08	10,286.20	12,097.23	11,838.23
Exporter 1 net surplus	123.48	140.41	140.41	96.72	-174.99
Exporter 2 net surplus	49.36	43.88	-23.36	95.27	-14.55

ε: nonzero but infinitesimal

The fourth column shows the effect of a larger commercial credit limit (V=5000). This is advantageous to both exporters when program allocations are small (Table 2). However, when exporter 1 makes a large credit allocation (Table 3), an expansion of commercial credit has the effect of reducing exporter surplus (relative to the base case). Relaxing the commercial credit constraint, in this case, creates room for additional imports of type-2 wheat, which depresses demand for type-1 wheat.

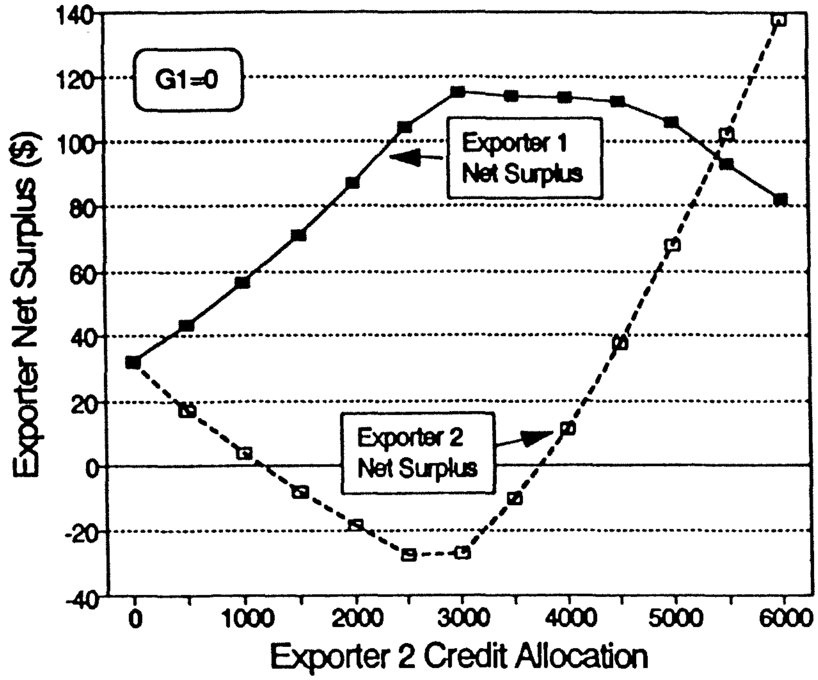
Effects of higher subsidy values (s_i = .10) are shown in the fifth column (Tables 2 and 3). For both exporters, net surplus is substantially reduced relative to the base case. Large negative values are recorded for exporter 1, as taxpayer costs exceed any welfare gain from higher trade volume.

The importance of program size (G_1) is evident from comparisons of results in Tables 2 and 3. However, these assume a fixed program size for exporter 2. It is natural to ask how the results would change if G_2 were also allowed to vary. To provide some insight, additional simulations were performed. Results are displayed in Figures 3 and 4. In each figure, a fixed value of G_1 is specified, but G_2 is varied incrementally. Net welfare measures for the two exporters are shown to depend on the amounts of credit provided by each.

In Figure 3-A, exporter 1 provides no credit (G_1=0). Payoffs to the two exporters are identical when G_2=0. As G_2 is raised to 3000, the payoff for exporter 1 increases. This demonstrates that (over some range) credit programs can be welfare-enhancing for a competing exporter--exporter 1 in this case. This is due to the fungibility of credit: with the expansion of "tied" credits, the importer's overall credit constraint is also relaxed, permitting larger purchases (e.g., of type-1 wheat) on commercial terms. Exporter 2 does not gain from the provision of credit until G_2 exceeds 4,500. Beyond that level, successive increases in G_2 reduce the payoff for exporter 1.

Figure 3-B (G_1=2000) has a similar interpretation. Figures 4-A (G_1=4000) and 4-B (G_1=6000) have markedly different payoff functions for the two exporters. In the latter case, the payoff for exporter 1 decreases with each successive increase in G_2. However, the payoff for exporter 2 is maximized at G_2=0. In the parlance of game theory, G_2=0 is the "best response" by exporter 2 to the action of exporter 1 (i.e., G_1=6000).

A.



B.

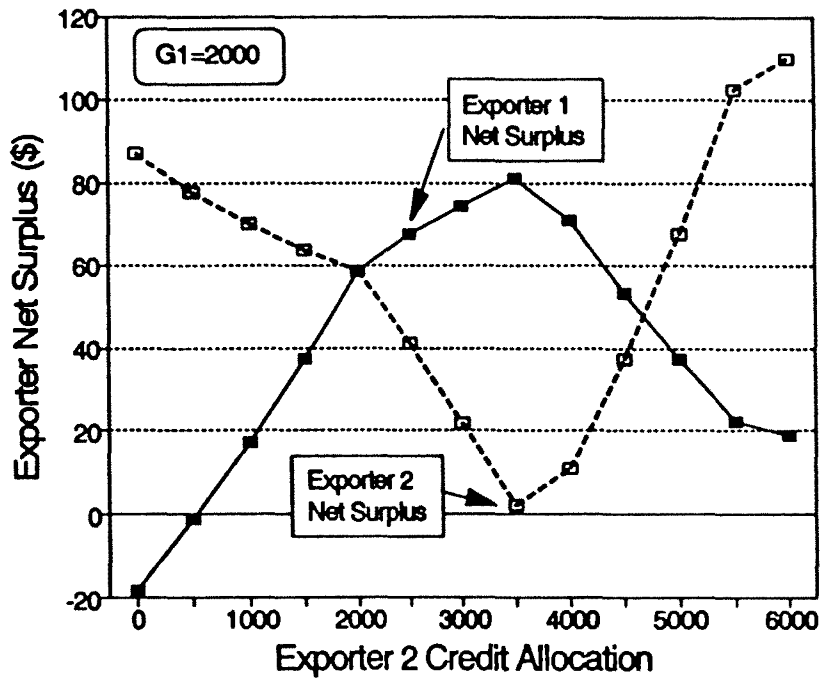
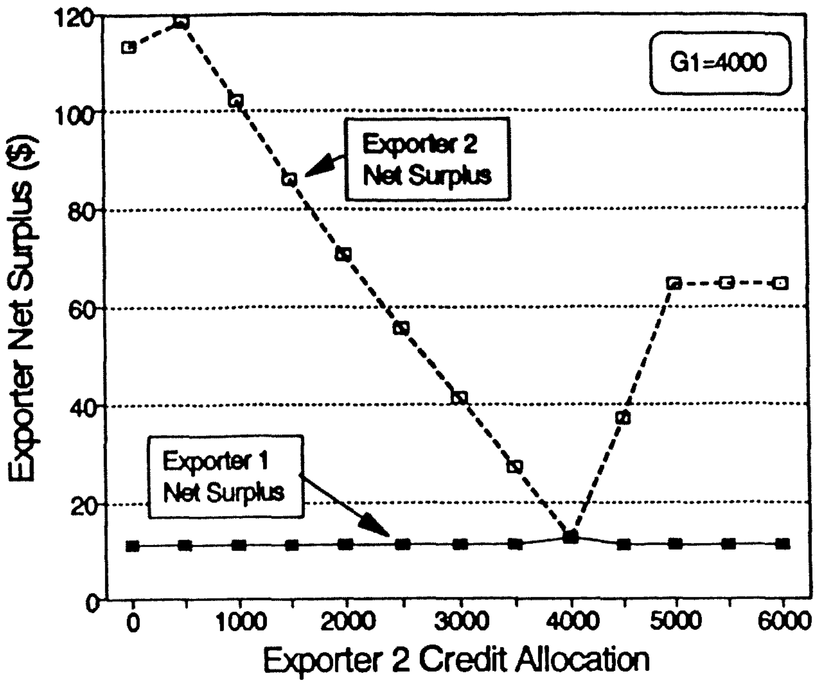


Figure 3. Sensitivity of Exporter Welfare to Credit Allocations

A.



B.

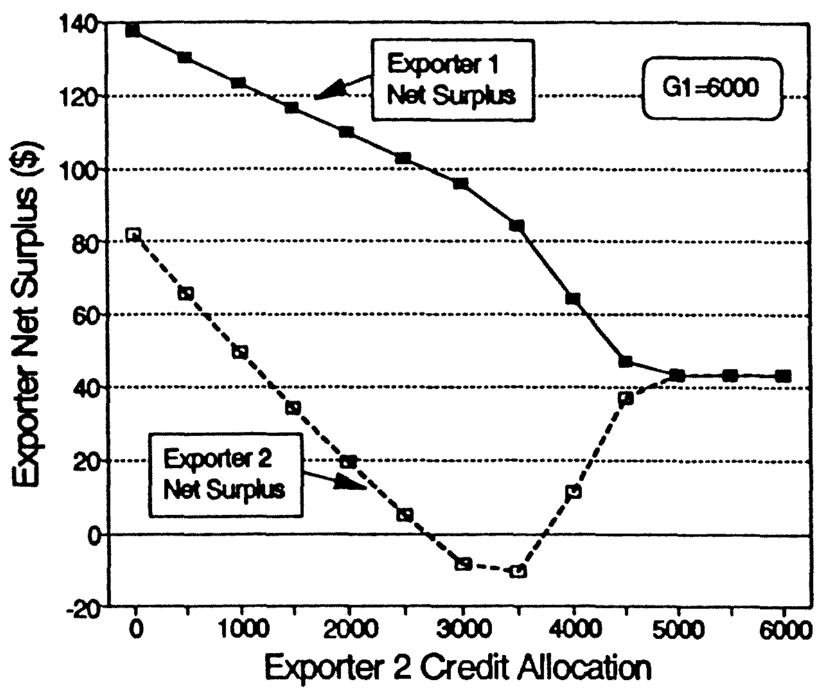


Figure 4. Sensitivity of Exporter Welfare to Credit Allocations

5. Strategic Aspects of Export Credit Programs

In this section, model simulations are used to study strategic interactions between exporters. Two cases are considered. The first is a direct extension of the analysis presented thus far: in both exporting countries, trade is conducted on a competitive basis with firms acting as "price takers." Governments can influence export volume through credit programs, but export prices are set equal to marginal cost, and any quota rents accrue to the importing country. The second case pits a country with competitive export firms (e.g., the United States) against a "single-seller agency" (e.g., the Canadian Wheat Board). Both exporters have credit programs, but the single seller is able to practice price discrimination.

In both cases, interest centers on identifying actions that are optimal from the perspective of each exporter and mutually consistent. For simplicity, assume that exporting countries each have one decision variable: G_i, the value of guaranteed export credits. (Other program parameters, s_i and h_i, are the same for both exporters, as in the base case.)

The analysis draws upon two equilibrium concepts from noncooperative game theory. In a *Nash* equilibrium, the action of each player is a best response (yielding highest payoff), given the other's action. This is intuitively appealing, since neither player has an incentive to deviate unilaterally. Formally, let $R_i(G_j)$ denote the best response of exporter i to G_j, the credit allocation of exporter j:

$$R_i(G_j) \equiv \underset{G_i}{\text{argmax}}\; U_i(G_i,G_j)$$

where $U_i(\cdot)$ is the payoff function for exporter i. In our (2-player) case, a Nash equilibrium is a strategy pair satisfying $(G_i,G_j) = (R_i(G_j),R_j(G_i))$, i.e., both credit allocations are best responses. In a *Stackelberg* equilibrium, it is assumed that one player (the "leader") moves first, but anticipates the best response of the second player (the "follower"). The Stackelberg leader solves

$$\max_{G_i}\; U_i(G_i\;,\; R_j(G_i))$$

where $R_j(G_i)$ is the follower's best response. In our context, the Stackelberg concept provides a way to evaluate first-mover advantages, i.e., for the country that provides export credit first.

As formulated, the model includes credit allocations G_i as parameters, rather than decision variables. For given allocations by the two exporters, the solution is consistent with (credit-constrained) market equilibrium. However, exporter strategies can be studied through numerical simulations. In particular, the model is solved with ranges of values for G_1 and G_2, and equilibria are identified through grid search.

Case 1: Two Competitive Exporters

The first case assumes competitive, price-taking behavior by firms in both exporting countries. With wheat exports priced at marginal cost (given by export supply functions), the importing country captures any quota rent arising from constraints on credit. For each exporting country, net exporter surplus (NES_i) is represented by the area below the supply price and above the export supply function, less the subsidy value of sales under credit programs:

$$NES_i = p_{si}q_i - \int_0^{q_i} p_{si}(Q)dQ - p_{si}s_ix_i \qquad (i=1,2) \tag{23}$$

where $p_{si}(\cdot)$ is the (inverse) supply function. This is the "payoff" for each exporting country. Payoffs are linked through the effects of their respective credit programs on trade volume.

Credit allocations were varied for each exporter between 0 and 6000, using increments[7] of 500. This produced 13^2 combinations for analysis. (Numerical results of the grid search are provided in the Appendix). Results indicate two Nash equilibria (Table 4). Both of the Nash solutions are "all or nothing": exporters either provide no credit, or they provide the maximum allowed (so that the credit constraint becomes nonbinding). The payoff is higher for the exporter who does provide credit. This indicates a first-mover advantage: if an importer does not initially receive credit from either source, the exporter acting first stands to gain. The Stackelberg equilibria (contained within the Nash set) confirm this result.

Table 4. Strategic Outcomes: Two Competitive Exporters

	Equilibrium Strategy Pairs (G_1,G_2)	Exporter Payoffs (NES_1,NES_2)
Nash Equilibria	(0,6000)	(82,138)
	(6000,0)	(138,82)
Stackelberg (1=Leader)	(6000,0)	(138,82)
Stackelberg (2=Leader)	(0,6000)	(82,138)

Figures 3-A and 4-B provide perspective on these strategic outcomes. If exporter 2 acts as a Stackelberg leader, selecting G_2=6000, its payoff is 138 and that of exporter 2 is 82: these are points furthest to the right in Figure 3-A. If exporter 1 acts as leader, the payoffs are reversed: that outcome is represented in Figure 4-B by points furthest to the left. Payoffs for both exporters are higher in a Stackelberg solution (with either acting as leader) than when neither country provides export credit (a situation shown at far left in Figure 3-A).

Case 2: Competitive Exporter vs. Single-Seller Agency

Thus far, we have assumed that exporters are unable to extract any of the rents arising out of importer credit constraints. That is an inappropriate assumption when one of the exporters is a single-seller agency. In the following analysis, exporter 2 is assumed to behave as a discriminating monopolist. The price received by exporter 2 will equal the importer's demand price for type-2 wheat, and credit will be allocated to satisfy a set of marginal revenue conditions:

$$p_{d2} + b_{22}x_2 - s_2[p_{d2} + b_{22}x_2] \geq p_{s2} \tag{24}$$

$$p_{d2} + b_{22}y_2 - s_2 b_{22}y_2 \geq p_{s2} \tag{25}$$

Marginal revenue from subsidized sales (24) and unsubsidized sales (25) must be no less than marginal costs. In addition, credit constraints are adjusted to reflect the higher price received by exporter 2:

$$p_{d2}(1 - s_2)x_2 \leq G_2 \tag{26}$$

$$p_{s1}y_1 + p_{d2}y_2 + p_{zs}z + (1-h_1)p_{s1}(1-s_1)x_1 + (1-h_2)p_{d2}(1-s_2)x_2 \leq V \tag{27}$$

The payoff for exporter 2 now reflects the importer's demand price:

$$NES_2 = p_{d2}q_2 - \int_0^{q_2} p_{s2}(Q)dQ \tag{28}$$

With these changes in specifications, the model was again solved for 13^2 combinations of exporter credit allocations. Strategic outcomes are listed in Table 5. (Detailed results are in the Appendix).

Table 5. Strategic Outcomes: Competitive Exporter vs. Single-seller Agency

	Equilibrium Strategy Pairs (G_1,G_2)	Exporter Payoffs (NES_1,NES_2)
Nash Equilibria	(500,5000), (500, 5500), (500,6000)	(115,2315)
Stackelberg (1=Leader)	(500,5000), (500, 5500), (500,6000)	(115,2315)
Stackelberg (2=Leader)	(500,5000), (500, 5500), (500,6000)	(115,2315)

Although 3 Nash equilibria are listed, they are really equivalent because the credit constraint (26) is not binding at G_2 levels above 5000 (so that additional amounts of credit do not change trade volumes or exporter payoffs). The set of Nash equilibria is also identical to the Stackelberg, whichever exporter acts as "leader."

Two conclusions emerge from these results. First, strategic outcomes differ from the first case (with two competitive exporters). Exporter 1 extends a small amount of credit and exporter 2 a large amount. Second, there is no first-mover advantage, as there is only one Stackelberg solution. The presence of a single-seller agency, in this case, removes any incentive for "preemptive" extension of credit by exporter 1. Of course, further experimentation would be necessary to establish the sensitivity of these results to individual model parameters.

6. Summary and Discussion

Export credit programs are viewed as an alternative means for stimulating commodity exports. Unlike other forms of targeted subsidies (such as EEP), export credit programs are not subject to international disciplines. Further, they appear to hold some potential for enhancing welfare in the exporting country. The putative welfare gains arise because of importers' limited access to credit on commercial terms. By providing credit guarantees, the exporting country relaxes the importer's credit constraint, allowing a larger volume of imports. This effect has not been adequately addressed in previous studies of credit programs--many of which have focussed on the implicit subsidy (through lower interest rate) provided to importers (Skully; Hyberg, et al.).

A simple analytical model was developed to illustrate the effects of credit programs on prices, trade volumes, and welfare. Parameter values were invented, rather than derived from empirical data. Nevertheless, the results of numerical simulations provide insight into the economic and strategic dimensions of this problem. Following are some of the results:

1. Provided that the importer has a binding credit constraint, credit guarantee programs can be welfare enhancing for the exporting country. This contrasts with the usual conclusion about export subsidy programs, i.e., that they detract from exporter welfare (except under conditions of imperfect competition).

2. Credit programs are not *necessarily* welfare enhancing for the exporting country. Much depends on the size of the implicit interest subsidy (measured in price equivalent). If wheat importers are not constrained by credit, the provision of credit at subsidized rates is essentially a net transfer to the importer, implying a net welfare loss to the subsidizing exporter. Also, credit allocations to a "small" importing country (i.e., too small to affect international prices) cannot enhance exporter welfare.

3. Provision of credit by one exporter can actually help competing exporters. Even though credits are "tied" to purchases of commodities from particular countries, they relax the importer's overall credit constraint. Wheat purchases under GSM (or similar programs) reduce the importer's demand for commercial credit, creating room for other purchases on commercial terms--including wheat from competing exporters.

4. This effect can be mitigated, to some extent, by cross-price effects. As an importer buys more U.S. wheat, its demand for substitutes (e.g., European or Canadian wheat) shifts to the left. Results of parametric analysis suggest that larger cross-price effects would enhance the "additionality" of U.S. credit programs. In other words, additionality should be greater when U.S. wheat competes against a close substitute.

5. There are two direct sources of additionality. First (but probably less important) is the price-subsidy effect (measured in Skully and Hyberg, et al.). GSM provides importers with an interest subsidy, similar in concept to a price subsidy. Graphically, this can be represented by a downward shift of the export supply schedule--lowering the price paid by the importer. Second is the credit-expansion effect. When imports are credit constrained, the export supply schedule is "kinked"--i.e., becomes vertical at the quantity associated with a binding credit constraint. GSM relaxes the constraint, pushing the vertical segment further to the right. If the import demand schedule intersected the original vertical segment, then this rightward shift will raise import volume. There can be additionality from GSM even if some imports of U.S. wheat are purchased on commercial terms.

6. Measuring additionality--or evaluating welfare effects--is less straightforward when there are competing exporters with credit programs. In that case, it is necessary to make assumptions about strategic interactions. Based on results from numerical simulations, it seems clear that strategic outcomes in a two-player game depend on whether their respective export industries are organized on a competitive basis or as a single-seller agency.

The analysis could be refined or extended in several ways. For example, the model could be expanded to include more than one importer, with different demand characteristics or credit worthiness. Alternative welfare criteria (from the exporters' perspective) could be used to evaluate strategic choices. Other features of the model, e.g., the informational assumptions, detract from its realism and are more difficult to address. In reality, the officials who administer credit programs make decisions on the basis of imperfect information--with respect to competitor programs and the characteristics of import demand. The allocation process is considerably more complex than allowed here, admitting political in addition to economic and financial considerations.

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Endnotes

1 U.S. export credit guarantee programs are administered by the Office of the General Sales Manager (GSM) within the Foreign Agricultural Service (FAS), U.S. Department of Agriculture. Two programs are currently operating: GSM-102 and GSM-103. Under GSM-102, the CCC acts as guarantor for private, commercial export credits with maturities of 3 years or less. GSM-103 provides guarantees for credits with longer maturities (3-10 years). See Dahl et al. for additional background.

2 Points on the curved, dashed line are solutions to V = pq, where V is the maximum value of imports that can be financed.

3 Hyberg, et al. calculated the implicit subsidy for U.S. wheat exports under GSM programs. During 1979-92, the average subsidy for all recipients was 4.3 percent. The authors argue that this overstates the true cost of GSM programs to U.S. taxpayers, given the history of claims paid relative to outstanding guarantees.

4 When integrability conditions are not satisfied, consumer surplus does not have a welfare interpretation. In that case, Takayama and Judge propose an alternative method for identifying a multi-market equilibrium in which "net social monetary gain" is maximized subject to a set of equilibrium price conditions. See pp. 250-273.

5 If $s_i = .05$, then the implicit subsidy (relative to supply price) is 5 percent.

6 It is sufficient to assume that direct price effects outweigh cross-price effects ($b_{11}b_{22} - b_{12}^2 > 0$); and subsidy levels are less than 50% ($s_i < .5$).

7 The increment is arbitrary, but sufficiently small for illustrative purposes. The maximum of 6000 is large enough that credit constraints (6) are not binding, with other model parameters fixed at base-case levels.

Appendix

Table 6. Payoffs for Exporter 1, Case 1.

	G_2: Exporter 2 Credit Allocation												
G_1	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
0	32	44	57	71	87	104*	115	114	113	113*	106*	93*	82*
500	17	30	45	61	78	96	116*	128*	118*	103	88	75	65
1000	4	18	34	52	70	90	111	120	102	86	71	57	49
1500	-8	8	25	44	64	85	94	101	86	70	54	39	34
2000	-18	-1	18	37	59	68	74	81	71	54	37	22	19
2500	-27	-9	11	32	41	48	55	62	56	38	21	5	5
3000	-27	-15	6	15	22	29	36	43	41	23	5	-8	-8
3500	-10	-10	-10	-5	2	9	16	24	27	8	-10	-10	-10
4000	11	11	11	11	11	11	11	11	13	11	11	11	11
4500	37	37	37	37	37	37	37	37	37	37	37	37	37
5000	68	68	68	68	68	68	68	68	65	47	43	43	43
5500	102	102	102	102	102	102	96	84	65	47	43	43	43
6000	138*	131*	123*	117*	110*	103	96	84	65	47	43	43	43

* $R_1(G_2)$: best response by exporter 1 to credit allocation of exporter 2.

Table 7. Payoffs for Exporter 2, Case 1.

		G₂: Exporter 2 Credit Allocation												
		0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
G_1	0	32	17	4	-8	-18	-27	-27	-10	11	37	68	102	138*
	500	44	30	18	8	-1	-9	-15	-10	11	37	68	102	131*
	1000	57	45	34	25	18	11	6	-10	11	37	68	102	123*
	1500	71	61	52	44	37	32	15	-5	11	37	68	102	117*
	2000	87	78	70	64	59	41	22	2	11	37	68	102	110*
	2500	104*	96	90	85	68	48	29	9	11	37	68	102	103
	3000	115	116*	111	94	74	55	36	16	11	37	68	96	96
	3500	114	128*	120	101	81	62	43	24	11	37	68	84	84
	4000	113	118*	102	86	71	56	41	27	11	37	65	65	65
	4500	113*	103	86	70	54	38	23	8	11	37	47	47	47
	5000	106*	88	71	54	37	21	5	-10	11	37	43	43	43
	5500	93*	75	57	39	22	5	-8	-10	11	37	43	43	43
	6000	82*	65	49	34	19	5	-8	-10	11	37	43	43	43

* $R_2(G_1)$: best response by exporter 2 to credit allocation of exporter 1.

Table 8. Payoffs for Exporter 1, Case 2.

		G_2: Exporter 2 Credit Allocation												
		0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
G_1	0	119	118	118	117	116	116	115	114	113	113	112	112	112
	500	133	133	132	131	130	129	128	128	127	126	115*	115*	115*
	1000	152	151	151	150	149	148	147	146	145	131*	101	101	101
	1500	176	175	174	173	172	171	170*	169*	160*	105	87	87	87
	2000	204*	203*	202*	200*	188*	174*	157	134	143	79	74	74	74
	2500	195	185	174	162	148	131	108	110	119	61	61	61	61
	3000	158	148	135	122	105	81	76	86	95	49	49	49	49
	3500	121	109	95	78	55	17	53	63	71	38	38	38	38
	4000	83	69	52	29	11	19	30	39	46	27	27	27	27
	4500	43	37	37	37	37	37	37	37	37	37	37	37	37
	5000	68	68	68	68	68	68	68	68	68	68	68	68	68
	5500	102	102	102	102	102	102	102	102	102	102	102	102	102
	6000	140	140	140	135	140	138	122	102	102	102	102	102	102

* $R_1(G_2)$: best response by exporter 1 to credit allocation of exporter 2.

Table 9. Payoffs for Exporter 2, Case 2.

		G₂: Exporter 2 Credit Allocation												
		0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
G_1	0	0	326	643	950	1244	1524	1786	2024	2233	2398	2494	2502*	2502*
	500	0	320	630	928	1212	1479	1724	1941	2119	2235	2315*	2315*	2315*
	1000	0	314	616	905	1177	1430	1656	1847	1984	2091	2248*	2248*	2248*
	1500	0	307	601	879	1140	1376	1580	1737	1852	2091	2181*	2181*	2181*
	2000	0	299	585	854	1159	1441	1688	1878	1817	2091	2114*	2114*	2114*
	2500	222	558	881	1186	1467	1714	1905	1866	1808	2049*	2049*	2049*	2049*
	3000	585	907	1212	1493	1740	1931	1883	1855	1799	1983*	1983*	1983*	1983*
	3500	933	1238	1519	1767	1957*	1945	1870	1844	1789	1918	1918	1918	1918
	4000	1265	1546	1793	1984*	1925	1846	1857	1832	1782	1854	1854	1854	1854
	4500	1572	1762	1855*	1809	1654	1701	1737	1738	1717	1717	1717	1717	1717
	5000	1518	1642	1664*	1549	1477	1535	1552	1535	1529	1529	1529	1529	1529
	5500	1425	1498*	1437	1353	1335	1373	1371	1358	1358	1358	1358	1358	1358
	6000	1318	1318	1259	1193	1196	1226	1277	1358*	1358*	1358*	1358*	1358*	1358*

* $R_2(G_1)$: best response by exporter 2 to credit allocation of exporter 1.