Export Credit Insurance and
Moral Hazard*

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1. Introduction

The author [Funatsu (1985)] recently studied the fundamental role of export credit insurance in a theoretical framework which was based on the expected utility maximization approach. Among other things, the paper showed that export credit insurance is a useful device to protect domestic exporting firms against various political risks and default risk in the foreign market; under a certain type of the reimbursement method, export credit insurance can make the exporting firm's production decision independent of the risk and the attitude toward risk. However, all the results were derived under the assumption that the probability distribution function of export credit risk would not be affected by the behavior of the firm or the presence of export credit insurance. The purpose of this paper is to modify the analysis by assuming that the probability distribution of the loss of revenues can be affected by certain self-protective activities on the part of the firm. Such activities, for example, may make it possible for the firm to identify importers with a lower risk of default. When we incorporate this feature into the model, we are essentially dealing with the

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so-called "moral hazard" problem.

The problem of moral hazard has long been recognized in the literature of insurance. According to Dionne (1981), there exist two types of moral hazard in the economic literature on insurance. The first type is defined as the reduction of self-protection by the insured due to the difficulty on the part of the insurer in observing this type of activity, and in using this information for the selection of an appropriate premium. Since the insurance premium does not vary with the effort to prevent loss, the insured has less incentive to undertake preventive activities. The studies of Ehrlich and Becker (1972), Pauly (1974), Helpman and Laffont (1975), Marshall (1976), and Shavell (1979) belong to this type. The second type of moral hazard is defined as the increase in the consumption of insured services due to a decrease in the price paid by the insured for these services. The insured is subsidized by the insurance coverage and continues to spend for the services after the marginal benefit falls below marginal cost. In that case, the insurer can observe the amount of loss, but cannot verify, in a costless fashion, the state of the world that has created this expense. This interpretation of moral hazard was first proposed by Pauly (1968) in a comment on a paper by Arrow (1963).

The analysis in this paper is more closely related to the first type of moral hazard. Introducing self-protection behavior by exporting firms into the model, the present paper studies its effect on the demand for export credit insurance. A careful attention is paid to the effects of changes in various parameters on the optimal level of self-protection and the demand for insurance. Ehrlich and Becker showed that, contrary to the moral hazard argument, market insurance and self-protection could be complements not only in the sense that the availability of the former could increase the demand for the latter, but also in the sense that an
increase in the productivity of self-protection or a decrease in the real cost of market insurance would increase the demand for both. We investigate whether their assertion holds in our model or not.

From the point of view of a policy maker, the problem of moral hazard is important. If the presence of export credit insurance severely discourages the firm from spending on self-protection, the expected insurance payment may exceed the premium revenue. If the deficit is paid from the government budget, the government explicitly subsidizes the exporting firms.

This paper is organized as follows: Section 2 presents the basic model and assumptions; Section 3 examines the boundary conditions for self-protection and the demand for export credit insurance; Section 4 studies the separation property and comparative statics with respect to various parameters in the model; and finally, a summary is presented in Section 5.

2. The Model and Assumptions

When self-protecting behavior is explicitly introduced into the model, the analysis becomes considerably more complex. In order to make the analysis tractable and to derive meaningful conclusions, this paper must make several simplifying assumptions. First, the firm is assumed to export all its product to a foreign market as was the case in Funatsu (1985). In this way the number of endogenous variables is reduced and it will be easier to investigate the effect of self-protecting behavior on the level of export and the demand for insurance. Second, it is assumed that during any specified time interval, total sales will either be completely lost with probability \( \gamma \), or the firm will suffer no loss at all with probability \( 1 - \gamma \). In other words, it is assumed that only two states of the world are possible. This kind of simplifying assumption has been made in
previous studies of moral hazard [Ehlich and Becker, and Shavell]. The probability of loss \( r \) is assumed to be a decreasing function of self-protecting activity.

In our model, the risk is divided into two types; exogenous and endogenous risk. Examples of the former type are political risks such as war, coup d'etat, and import restrictions, which are usually beyond the control of a private company. On the other hand, certain risks can be reduced by the exporting firm's effort. The risk of default by an importer is a good example. The firm can minimize such a risk by engaging in market research and information gathering. Let \( w \) denote the amount of such self-protecting activity. Now write the probability of total loss \( r \) in two terms as follows:

\[
r = \phi(w) + \lambda, \tag{1}
\]

where \( \phi \) is endogenous risk and \( \lambda \) is exogenous risk. Further assume that the function \( \phi \) is positively valued, decreasing, convex, and bounded by \( 1 - \lambda \), that is,

\[
\phi(w) > 0, \, \phi' < 0, \, \phi'' > 0, \text{ and } \phi(w) < 1 - \lambda. \tag{2}
\]

The insurance arrangement in this model is relatively simple. The exporting firm can choose the amount of coverage, \( y \), which should not exceed the value of total sales, \( px \). In case of total loss, the firm receives the amount of \( y \) from the insurance agency. In order to receive this insurance service, the firm must pay a premium payment of \( qy \), where \( q \) is the premium rate per dollar of coverage.

Let \( f \) and \( b \) denote variable and fixed costs of producing one unit of output, respectively. Then, the random profit function is written as follows:
\[
\pi = \begin{cases} 
\pi_1 = px - f(x) - b - qy - rw & \text{with probability } 1 - r \\
\pi_2 = y - f(x) - b - qy - rw & \text{with probability } r,
\end{cases}
\]

where \( r \) denotes the price per unit of self-protecting activity. If the exporting firm maximizes the expected utility of profit, then the optimization problem is described as follows:

\[
\begin{align*}
\text{Max } V(x, y, w) = & \quad E u(x) = [1 - \phi(w) - \lambda] \cdot u(\pi_1) + [\phi(w) + \lambda] \cdot u(\pi_2), \\
\text{subject to } & \quad 0 \leq w \text{ and } 0 \leq y \leq px.
\end{align*}
\]

(3)

3. Boundary Conditions

Suppose that the firm produces some output. We are interested in the boundary conditions for self-protection and the demand for insurance coverage.

First, we investigate the conditions under which the exporting firm chooses no insurance coverage. Differentiating the objective function (3) twice with respect to \( y \) yields

\[
\begin{align*}
V_y &= -q \left( 1 - \phi(w) - \lambda \right) u'_1 + (1 - q) \left( \phi(w) + \lambda \right) u'_2, \\
V_{yy} &= q^2 \left( 1 - \phi(w) - \lambda \right) u''_1 + (1 - q)^2 \left( \phi(w) + \lambda \right) u''_2 < 0,
\end{align*}
\]

where \( u'_1 \) and \( u''_1 \) are \( u'(\pi_1) \) and \( u''(\pi_1) \), respectively. Since the objective function is concave with respect to \( y \), the necessary and sufficient condition for the firm to choose no insurance coverage requires the first partial derivative evaluated at \( y = 0 \) to be non-positive, that is,

\[
V_y |_{y=0} = -q \left( 1 - \phi(w) - \lambda \right) u'(\pi_3) + (1 - q) \left( \phi(w) + \lambda \right) u'(\pi_4) \leq 0,
\]

(6)

where \( \pi_3 \) is \( px - f(x) - b - rw \) and \( \pi_4 \) is \( -f(x) - b - rw \).

Solving (6) for \( q \) yields
Let $\theta$ denote the left-hand side of (7). The expression $\theta$ is the highest value for the premium rate which can induce the firm to purchase insurance. We are now interested in how the value of $\theta$ is affected by changes in the amount of self-protection. Differentiating $\theta$ with respect to $w$ gives

$$\frac{d\theta}{dw} = u'_s \cdot [\phi'(w) + u'_s \cdot \phi(w) + \lambda \cdot [1 - \phi(w) - \lambda] R - \pi_r - R(\pi_r)]$$

where $R = \frac{u''}{u'}$ denotes the Arrow-Pratt measure of absolute risk aversion.

Since $\pi_r < \pi_3$, it follows that $R(\pi_3) < R(\pi_r)$ under the usual assumption of decreasing absolute risk aversion. Thus, the sign of $\frac{d\theta}{dw}$ is ambiguous.

In the special case of constant absolute risk aversion, it is strictly negative, which means that the likelihood of condition (7) being satisfied increases as the amount of self-protection increases. In this case, one might say that self-protection and the demand for insurance coverage are substitutes in the sense that a larger amount of self-protection reduced the likelihood of purchasing some amount of insurance coverage. However, under the assumption of decreasing absolute risk aversion, the sign of $\frac{d\theta}{dw}$ can be positive. Insurance purchase and self-protection might increase the likelihood for the firm to purchase some insurance coverage.

Similarly, the necessary and sufficient condition for full coverage is the first derivative evaluated at $y = px$ is non-negative:

$$V_y|_{y=px} = [\phi(w) + \lambda - q] \cdot u'(\pi_5) \geq 0,$$
where $\pi_5=(1-q)p x - f(x) - b - rw$. Since $u' > 0$, the condition is reduced to the following:

$$\phi(w) + \lambda \geq q.$$  

(8)

Condition (8) is similar to the one studied in Funatsu; that is, the firm takes full coverage if and only if the premium is fair or more than fair. However, the probability of total loss here is a function of self-protection, while in the previous analysis it was completely exogenous. Therefore, whether the premium is fair or not depends in part on the firm's choice of $w$. We can consider two polar cases. If the exogenous risk $\lambda$ is greater than $q$, condition (8) holds irrespective of the level of self-protection. Therefore, $\lambda > q$ is a sufficient condition for the firm to purchase full coverage. On the other hand, if $\phi(0) + \lambda < q$, then the firm never purchases full coverage. Thus, $\phi(0) + \lambda \geq q$ is a necessary condition for full coverage.

Next, we investigate the condition for no self-protection. Differentiating the objective function (3) partially with respect to $w$ yields

$$V_w = \phi'(u_2 - u_1) - r[1 - \phi(w) - y]u_1 - [\phi(w) + y]u_2,$$

(9)

$$V_{ww} = -\phi''(u_1 - u_2) + 2r\phi'(u_1 - u_2) + r^2[1 - \phi(w) - y]u_1 + [\phi(w) + \lambda]u_2,$$

(10)

where $u_i$ is $u(\pi_i)$. The second partial derivative is not necessarily negative. Assume that the magnitudes of the negative terms dominate that of the positive term, which guarantees that $V_{ww} < 0$, and the necessary and sufficient condition for no self-protection is as follows:

$$V_w|_{w=0} = -\phi'(0) \cdot (u_5 - u_6) - ru'_6 + r(\phi(0) + \lambda)(u'_5 - u'_6) \leq 0,$$

(11)

where $\pi_5 = px - f(x) - b - qy$ and $\pi_6 = y - f(x) - b - qy$. 
Solving (11) for \( r \) yields

\[
-\phi'(0) \cdot (u_5 - u_6) / (u_5 - (\phi(0) + \lambda)(u_5' - u_6')) \leq r
\]

(11')

The assumptions of \( u' > 0 \) and \( u'' < 0 \) imply that \( u_5 > u_6 \), and \( u_5' < u_6' \) since \( \pi_5 < \pi_6 \). Therefore the left-hand-side of (11') is always a positive number. If the firm purchases full coverage, i.e., \( y = px \), then \( \pi_5 = \pi_6 = (1 - q) px - f(x) - b \), in which case the left-hand-side of (11') is zero. Thus, the condition for no self-protection is always satisfied. The above discussion can be summarized in the following proposition.

**Proposition 1.** If the premium rate of export credit insurance is less than the exogenous risk, the firm chooses full coverage and no self-protection.

The proposition illustrates the extreme case of moral hazard. Without the availability of export credit insurance, it would be optimal for the firm to engage in some self-protective activities. But the presence of export credit insurance at a low premium rate works as a disincensive for taking self-protection. The point has a significant implication for the operation of an export credit insurance program. In order to promote exports, the government agency must set the premium rate as low as possible. If the agency underestimates the negative side effect of the insurance in the form of a reduced self-protection, it might incur an unexpected deficit in the account of export credit insurance.

### 4. The Separation Property and Comparative Statics

In the absence of moral hazard, the author's earlier paper has shown that the firm's production decision is separated from the risk management when export credit insurance is available with the proportional
reimbursement method. This section investigates whether this separation property still holds in the model with self-protection and also conducts comparative static analyses on the various parameters in the model.

If the objective function in (3) has a regular interior maximum, the first-order conditions are written as follows:

\[
V_x = [1 - \phi(w) - \lambda] u'_1 (p - f') - [\phi'(w) + \lambda] u'_2 f' = 0, \\
V_y = -q [1 - \phi(w) - \lambda] u'_1 + (1 - q)[\phi(w) + \lambda] u'_2 = 0, \\
V_w = \phi'(u'_2 - u_1) - r \{ [1 - \phi(w) - \lambda] u'_1 + [\phi(w) + \lambda] u'_2 \} = 0.
\]

The second-order conditions can be stated as follows:

\[
V_{xx} < 0, \quad \begin{vmatrix} V_{xx} & V_{xy} \\ V_{yx} & V_{yy} \end{vmatrix} > 0, \quad \begin{vmatrix} V_{xx} & V_{xy} & V_{xz} \\ V_{yx} & V_{yy} & V_{yz} \\ V_{xz} & V_{yz} & V_{zz} \end{vmatrix} < 0.
\]

In the case of risk neutrality, both the 2×2 and 3×3 determinants are always positive, so that an interior maximum does not exist. Even under the assumption of risk aversion the 3×3 determinant may be positive. However, the conditions in (15) are assumed to be satisfied.

Now the production decision is shown to be indeed separated from the risk management in this model.

From (13),

\[
[\phi(w) + \lambda] u'_2 = \frac{q [1 - \phi(w) - \lambda] u'_1}{1 - q}
\] (13')

Since \(\frac{1 - \phi(w) - \lambda}{1 - q} u'_1\) is positive, substituting (13') into (12) must imply

\[(1 - q) p - f' = 0.\]

The expression in (17) is exactly the same as the one derived in Funatsu.
(1985) in which export credit insurance is available with the proportional payment method. The production decision is clearly separated from the risk management. The optimal level of export is independent of the attitude toward risk, the probability of total loss, prices of insurance and self-protection, and the fixed costs. One must also note that the level of export is larger as the premium rate becomes lower. The government agency can promote exports by reducing the premium rate.

Next, let us conduct comparative static analyses with respect to various parameters in the model. From (17), it is quite obvious that the optimal level of export is negatively related to the level of the premium rate and positively related to the commodity price. The other parameters of the model do not affect the optimal level of export. Therefore, our main task is to find out the effect of a small change in each parameter on the optimal level of self-protection and the optimal amount of insurance coverage.

Solve (17) for the optimal value of $x$;

$$x = g^x(p, q), \quad g^x_p > 0, \quad \text{and} \quad g^x_q < 0,$$

(18)

where $g^x_i$ denotes the partial derivative with respect to parameter $i$, $i = p, q, b, r, \lambda$. Substituting the optimal value of $x$ into (13) and (14) solves for the optimal values of $y$ and $w$. They are expressed as functions of the parameters of the model as follows:

$$y = g^y(b, r, \lambda, p, q),$$

(19)

$$w = g^w(b, r, \lambda, p, q).$$

(20)

Write (13) and (14) in the reduced form as follows:

$$V_y(x, y, w; b, r, \lambda, p, q) = 0,$$

(13')

$$V_w(x, y, w; b, r, \lambda, p, q) = 0.$$  

(14')
Substituting (18), (19), and (20) into (13') and (14') yields
\[
V_y[g^x(\cdot), g^y(\cdot), g^w(\cdot); b, r, \lambda, p, q] = 0 \quad (13')
\]
\[
V_w[g^x(\cdot), g^y(\cdot), g^w(\cdot); b, r, \lambda, p, q] = 0. \quad (14')
\]

**Fixed Costs**

Differentiating (13'') and (14'') with respect to \( b \) obtains the following system of equations:
\[
\begin{bmatrix}
V_{yy} & V_{yw} \\
V_{wy} & V_{ww}
\end{bmatrix}
\begin{bmatrix}
g_{y'} \\
g_{w'}
\end{bmatrix}
= \begin{bmatrix}
-V_{yb} \\
-V_{wb}
\end{bmatrix}. \quad (21)
\]

From the second-order conditions, \( V_{yy} < 0, V_{ww} < 0, \) and \( D = V_{yy}V_{ww} - V_{yw}V_{wy} > 0 \). \( V_{yw} \) is explicitly written as follows:
\[
V_{yw} = V_{wy} = \phi' [qu_1^i + (1 - q)u_2^i] + r\{q[1 - \phi(w) - \lambda]u_1^i - (1 - q)[\phi(w) + \lambda]u_2^i\}. \quad (22)
\]

From (13'),
\[
(1 - q)[\phi(w) + \lambda] = q[1 - \phi(w) - \lambda] \frac{u_1^i}{u_2^i}. \quad (13'')
\]

Substituting (13'') into (22) yields
\[
V_{yw} = V_{wy} = \phi' [qu_1^i + (1 - q)u_2^i] + rq[1 - \phi(w) - \lambda]u_1^i(R_2 - R_1). \quad (22')
\]

where \( R \) denotes the Arrow-Pratt measure of absolute risk aversion. In the special case of constant absolute risk aversion, the second term of the right-hand side in (22') is zero, so that the sign of \( V_{yw} \) is negative. In general, under the usual assumption of decreasing absolute risk aversion, the sign is ambiguous because \( R_2 > R_1 \) implies that the second term in (22') is positive.

In consumer theory, one of the usual definitions of subsitutability or
complementarity of two commodities is given by the sign of the cross substitution term of the Slutsky equation. Since insurance and self-protection are different from ordinary commodities in the sense that both of them serve as a device for dealing with an uncertain situation, it will be justifiable to introduce the following definition.

**Definition 1.** (a) If \( V_{yw} \leq 0 \), then insurance coverage and self-protection are weak stochastic substitutes. (b) If \( V_{yw} > 0 \), then insurance coverage and self-protection are stochastic complements.

The terminology of stochastic substitutes (or complements) was used by Hiebert (1983) in the context of production uncertainty. Definition 1 plays an important role in the determination of the comparative static results.

Differentiating (13) and (14) with respect to \( b \), and using (13'), \( V_{yb} \) and \( V_{wb} \) are explicitly written as follows:

\[
V_{yb} = q [1 - \phi(w) - \lambda] u'_i - (1 - q)[\phi(w) + \lambda] u'_z
= q [1 - \phi(w) - \lambda] u'_i (R_2 - R_1),
\]

\[
V_{wb} = \phi'(u'_i - u'_z) + r \{ [1 - \phi(w) - \lambda] u'_i + [\phi(w) + \lambda] u'_z \}. \tag{24}
\]

The sign of \( V_{yb} \) is positive under the assumption of decreasing absolute risk aversion, while the sign of \( V_{wb} \) is ambiguous in general. However, if the firm purchases an amount of insurance coverage which is close to total sales (which might usually be the case), then the difference between \( u'_i \) and \( u'_z \) will be relatively small, so the effect of the second term in (24) will be dominant. We will assume that \( V_{wb} \) is negative.

Solve (21) for \( g_b^y \) and \( g_b^w \), and

\[
g_b^y = \frac{1}{D} (V_{yw} V_{wb} - V_{yb} V_{ww}), \tag{25}
\]
If the sign of $V_{yw}$ is negative, determinate results are obtained as stated in the following proposition.

**Proposition 2.** If insurance coverage and self-protection are weak stochastic substitutes, then an increase in fixed costs increases the optimal amount of insurance coverage and reduces the optimal level of self-protection.

**Price of Self-Protection**

Differentiating (13”) and (14”) with respect to $r$, we have the following system of equations:

\[
\begin{bmatrix}
V_{yy} & V_{y\gamma} & g_w^y \\
V_{w\gamma} & V_{ww} & g_w^w
\end{bmatrix}
\begin{bmatrix}
g_w^y \\
g_w^w
\end{bmatrix}
= \begin{bmatrix}
-V_{yr} \\
-V_{wr}
\end{bmatrix}.
\]

(27)

Differentiating (13) and (14) with respect to $r$, and using (13’), we have

\[
V_{yr} = w\{q[1-\phi(w)-\lambda]u^*_i - (1-q)(\phi(w)+\lambda)u^*_j\}
= wq[1-\phi(w)-\lambda]u^*_i(R_2-R_1),
\]

\[
V_{wr} = \phi' w(u^*_i-u^*_j) - [1-\phi(w)-\lambda]u^*_i - [\phi(w)+\lambda]u^*_j
+ rw[1-\phi(w)-\lambda]u^*_i + rw[\phi(w)+\lambda]u^*_j.
\]

(29)

Under the assumption of decreasing absolute risk aversion, $V_{yr} > 0$. After rearranging some of the terms, we can rewrite (29) as follows:

\[
V_{wr} = \phi' w u^*_i - [\phi(w)(1-\epsilon_w)+\lambda]u^*_j - [1-\phi(w)-\lambda]u^*_i
+ rw[1-\phi(w)-\lambda]u^*_i + rw[\phi(w)+\lambda]u^*_j,
\]

where $\epsilon_w = -\frac{\phi' w}{\phi}$ which is the elasticity of the endogenous risk with
respect to self-protection. If \( \varepsilon_w < 1 \), then the sign of \( V_{wr} \) is unambiguously negative.

Solving (27) for \( g_r^y \) and \( g_r^w \) yields

\[
g_r^y = \frac{1}{D} (V_{wr} V_{yw} - V_{yr} V_{w w}),
\]

\[
g_r^w = \frac{1}{D} (V_{w y} V_{yr} - V_{yy} V_{w r}).
\]

The condition \( V_{yw} < 0 \) implies that \( g_r^w > 0 \) and \( g_r^w < 0 \), and the following proposition has been established.

**Proposition 3.** If insurance coverage and self-protection are weak stochastic substitutes, then an increase in the price of self-protection increases the optimal amount of insurance coverage, and reduces the optimal level of self-protection, provided that \( \varepsilon_w < 1 \).

In this case, substitutability according to Definition 1 implies that insurance is a gross substitute for self-protection according to the usual definition in consumer theory. However, if insurance and self-protection are stochastic complements, the signs of \( g_r^y \) and \( g_r^w \) are ambiguous in general. Therefore, there is no one-to-one relation between Definition 1 and the conventional definition.

**Exogenous Risk**

Differentiating (13") and (14") with respect to \( \lambda \) obtains the following system of equations:

\[
\begin{bmatrix}
V_{yy} & V_{yw} \\
V_{yw} & V_{ww}
\end{bmatrix}
\begin{bmatrix}
g_1^y \\
g_1^w
\end{bmatrix}
=
\begin{bmatrix}
-V_y \\
-V_w
\end{bmatrix}.
\] (30)

From the original expressions in (13) and (14),
Solving (30) for $g^y_1$ and $g^w_1$, we have

$$g^y_1 = \frac{1}{D} (V_{wy} V_{yw} - V_{yy} V_{ww}),$$

$$g^w_1 = \frac{1}{D} (V_{wy} V_{ycl} - V_{yy} V_{wl}).$$

The condition $V_{yw} < 0$ implies that $g^y_1 > 0$ and $g^w_1 < 0$, and the following proposition has been established.

**Proposition 4.** If insurance coverage and self-protection are weak stochastic substitutes, an increase in the exogenous risk increases the optimal amount of insurance coverage and reduces the optimal level for self-protection.

This result is consistent with our intuition. If there is an increase in the political risk such as war, coup d'etat, or nationalization which an exporting firm cannot control, the firm will increase the insurance coverage, and reduce the expenditure on self-protection. However, one must remember that this result also depends on stochastic substitutability between insurance and self-protection. If they are complements, a perverse case might arise.

**The Commodity Price**

Differentiating (13") and (14") with respect to $p$ obtains the following system of equations:

$$
\begin{bmatrix}
V_{yy} & V_{yw} \\
V_{wy} & V_{ww}
\end{bmatrix}
\begin{bmatrix}
g^y_p \\
g^w_p
\end{bmatrix}
=
\begin{bmatrix}
-V_{yx} g^y_p & -V_{yp} \\
-V_{wx} g^w_p & -V_{wp}
\end{bmatrix}
\tag{31}
$$
Differentiating (13) and (14), $V_{yx}, V_{wx}, V_{yp}$ and $V_{wp}$ can be explicitly written as follows:

$$V_{yx} = -q[1 - \phi(w) - \lambda](p - f')u_1^*(1 - q)[\phi(w) + \lambda]f'u_2^* > 0, \quad (32)$$

$$V_{wx} = -\phi'(p - f')u_1^* - \phi'f'u_2^* - r[1 - \phi(w) - \lambda](p - f')u_1^* + r[\phi(w) + \lambda]f'u_2^*, \quad (33)$$

$$V_{yp} = -q[1 - \phi(w) - \lambda]u_1^* x > 0, \quad (34)$$

$$V_{wp} = -\phi'u_1^* x - r[1 - \phi(w) - \lambda]u_1^* x > 0. \quad (35)$$

The sign of $V_{wx}$ is indeterminate in general. The first three terms on the right-hand side of (33) are positive, and the last term is negative. We will assume that the positive terms always dominate the negative terms.

Solving (31) for $g_p^y$ and $g_p^w$ yields

$$g_p^y = \frac{1}{D} \left[ (V_{wx} g_p^x + V_{wp}) V_{yw} - (V_{yx} g_p^x + V_{yp}) V_{ww} \right], \quad (+) (+) (+) (+) (-)$$

$$g_p^w = \frac{1}{D} \left[ V_{yx} g_p^x + V_{yp} \right] V_{ww} - (V_{wx} g_p^x + V_{wp}) V_{yy} \right], \quad (+) (+) (+) (+) (-)$$

If insurance coverage and self-protection are stochastic substitutes, the signs of $g_p^y$ and $g_p^w$ are indeterminate. However, if they are stochastic complements, both of them are positive. If insurance and self-protection are combined to serve for the same purpose, the demands for both insurance and self-protection increase as a result of a rise in the commodity price.

**The Premium Rate**

Differentiating (13") and (14") with respect to $q$ obtains the following system of equations:
\[
\begin{bmatrix}
V_{yy} & V_{yw} \\
V_{wy} & V_{ww}
\end{bmatrix}
\begin{bmatrix}
g_q^y \\
g_q^w
\end{bmatrix}
= 
\begin{bmatrix}
-V_{yx} g_q^x & -V_{yx} \\
-V_{wx} g_q^x & -V_{wx}
\end{bmatrix}.
\]  
(36)

Differentiating (13) and (14), \(V_{yq}\) and \(V_{wq}\) can be explicitly written as follows:

\[
V_{yq} = -[1 - \phi(w) - \lambda] u_1' - [\phi(w) + \lambda] u_2' + y[q[1 - \phi(w) - \lambda] u_1' - (1-q)[\phi(w) + \lambda] u_2'],
\]
\[
V_{wq} = y[\phi'(u_1' - u_2') + r[1 - \phi(w) - \lambda] u_1' + (\phi(w) + \lambda) u_2'].
\]

As it was done in Equation (22), we can rewrite (37) as follows:

\[
V_{yq} = -[1 - \phi(w) - \lambda] u_1' - [\phi(w) + \lambda] u_2' + yq[1 - \phi(w) - \lambda] u_1'(R_2 - R_1).
\]

Under the assumption of decreasing absolute risk aversion, the third term is positive while the first two terms are negative. The first two terms can be regarded as the price effect and the third term as the wealth effect. It will be assumed that the price effect dominates the wealth effect, so \(V_{yq}\) is negative.

From (24), we can write \(V_{wq} = yV_{wb}\). The sign of \(V_{wq}\) is the same as that of \(V_{wb}\) which was assumed to be negative before.

Solving (36) for \(g_q^y\) and \(g_q^w\) obtains

\[
g_q^y = \frac{1}{D} \left[ (V_{wx} g_q^x + V_{wq}) V_{yw} - (V_{yx} g_q^x + V_{yq}) V_{yw} \right],
\]

\[
g_q^w = \frac{1}{D} \left[ (V_{yx} g_q^x + V_{yq}) V_{wy} - (V_{wx} g_q^x + V_{wq}) V_{yx} \right].
\]

Once again, results are ambiguous if insurance coverage and self-protection are stochastic substitutes. If they are stochastic complements, we obtain that \(g_q^y < 0\), and \(g_q^w < 0\) which implies that insurance coverage and self-protection are gross complements according to the conventional
definition in consumer theory.

5. Summary

This paper has studied the role of export credit insurance in a model in which the self-protecting effort by the exporting firm, such as market research, can reduce the probability of sales loss in the foreign market. In a simplified setting of the nature of uncertainty (i.e., we assumed that only two states of the world are possible; either no loss or total loss), it was shown that export credit insurance can still separate the firm's production decision from the risk management and the decision on self-protection.

It was also demonstrated that the government agency can promote the level of export by quoting a relatively low premium rate. However, a lower premium rate tends to induce the exporting firm to purchase full coverage and not to engage in self-protection at all. One extreme case occurs when the premium rate is lower than the exogenous risk which is defined as the risk that self-protection cannot eliminate. In this case, the firm never engages in self-protection. Therefore, there exists a problem of moral hazard. The introduction of export credit insurance with a low premium rate would reduce the firm's incentive for self-protection.

Comparative static analyses were conducted with respect to various parameters in the model. In order to obtain determinate results, this paper had to introduce a definition of substitutability between insurance coverage and self-protection which is slightly different from the conventional definition in consumer theory. It turns out that insurance coverage and self-protection could also be complements in the conventional sense insofar as an increase in the price of insurance coverage might reduce the demand for self-protection and vice versa. The result confirms the assertion by
Ehlich and Becker that market insurance and self-protection could be complements. The effect of an increase in fixed costs or exogenous risk has the same impact on the optimal level of self-protection. It is likely to increase the demand for insurance and reduce the self-protecting activities.

References


