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Abstract

This paper investigates managers' hedging incentives against currency risk within the principal-agent framework. Its theoretical basis lies in the existence of informational asymmetry between managers and owners regarding managers' hedging efforts, which causes disutility to managers. The theory suggests that under the condition that managers are risk-averse, hedging efforts by managers might be inefficiently low from the perspective of owners because managers' efforts are not fully observable. Empirical results conducted under the assumption that each currency risk exposure coefficient is linearly related to a variable that is considered to capture the degree of informational asymmetry basically favor this theoretical implication. In particular, the hypothesis of no informational asymmetry is more likely rejected for the currency risk exposure stemming from exports than that from other sources including overseas production and/or imported primary materials. This result is consistent with the view that investing in overseas production itself is a means of reducing the currency risk exposure.

Key words: Risk management; Hedging incentive;
Informational Asymmetry; Currency risk exposure;
Principal-agent framework

JEL classification: D82; F23; G39

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I. Introduction

According to classical finance theory, a firm is generally owned by numerous investors, each of whom bears only a tiny fraction of the total risk pertaining to the firm. The modern corporate form of organization was in fact developed to enable entrepreneurs to disperse risk among many investors, which suggests that it is hard to see why firms themselves also need to reduce risk exposure[1], since investors can manage risk on their own[2].

This line of logic can be recognized as a variant of the Modigliani and Miller (1958) theorem (henceforth, the M&M theorem). The key insight of the M&M theorem is that the value of a firm is created on the left-hand side of the balance sheet when the firm makes investments, which ultimately increase operating cash flow. How the firm finances those investments on the right-hand side of the balance sheet is irrelevant. Decisions about financial policy can affect only the way in which the value created by the firm's real investments is divided among shareholders. But, in an efficient and perfect capital market, they cannot affect the overall value of those investments. If one accepts this viewpoint, risk management is of no consequence to firms. Risk management consists of financial transactions that do not affect the value of a firm's operating cash flows.

Contrary to the prediction of the classical arguments mentioned above, today, more and more firms use hedging technologies. For example, the Bank for International Settlements (BIS) reports that the total estimated notional amount of outstanding global over-the-counter (OTC) derivatives contracts of major banks and dealers in the G10 countries stood at $70 trillion at end-June 1998. This is 47% higher than the estimate for end-March 1995.

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[1] Put differently, hedging transactions at the firm level sometimes lose money and sometimes make money, but on average they break even. Thus firms cannot systematically make money by hedging.
[2] This argument is called the Homemade Coverage theorem. For more details, see Appendix.

So, why would a firm want to hedge against future uncertainty? A number of potential rationales for hedging have been developed recently. For example, Froot, Scharfstein, and Stein (1993) develop a general framework for corporate risk management policies. They begin by observing that if external sources of finance are more costly to firms than internally generated funds, there will typically be a benefit to be obtained from hedging. That is, hedging adds value to the extent that it helps ensure that the firm has sufficient internal funds available to take advantage of attractive investment opportunities.

They seem to give us a solid rationale for risk management. But does this view explain the experience of Japanese firms, for example, in 1995? In that period, many of the stock price indices of Japanese firms moved up and down in line with large exchange rate fluctuations, suggesting that Japanese firms were subject to a high degree of currency risk exposure despite the well-recognized potential benefits from hedging policies.

In order to address this question, I think it important to introduce a principal-agent framework based on informational asymmetry between managers and owners because most of the existing rationales for risk management presume that managers seek to maximize the value of firms, that is, their objective is the same as owners'. In reality, however, managers' objective might be different from owners' due to the existence of informational asymmetry between them[3]. In the principal-agent type framework, even if a perfect hedge is potentially an optimal strategy to owners, under the condition that managers are risk-averse, one can show that the non-observability of managers' efforts for collecting information about currency risk exposure[4] and hedging unnecessary risk raises the cost of implementing the hedging strategy. Hence it can lead to an inefficiently

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[3] In fact, Tufano (1996) finds no evidence that firms in the U.S. gold mining industry hedge in order to maximize shareholders' value.

[4] As in Baba and Fukao (2000), my focus in this paper is operating exposure, which is based on the extent to which the value of the firm as measured by the present discounted value of its expected cash flows will change when exchange rates change.

low level of hedging efforts being implemented by managers. This consequence allows exchange rate variations to influence the values of firms.

To take a classic example, in 1976 when the Financial Accounting Standards Board adopted a rule called FASB 8 requiring U. S. firms to translate their overseas earnings in terms of dollars at the current exchange rate, many firms suddenly altered their hedging behavior in order to reduce exposure in foreign currencies. They knew that such exposure would show up on their annual reports as earnings that were highly variable in terms of dollars. While some hedging might always be prudent for a firm with large overseas operations, in this case, the significant change in managers' behavior in response to FASB 8 can be perceived as a sign that the degree of informational asymmetry between managers and owners is far from negligible[5]. Although this episode occurred more than 20 years ago and did not involve Japanese firms, it suggests to us the importance of asymmetric information about managers' hedging efforts between shareholders and managers in considering currency risk exposure.

Motivated by a wish to understand this question, in this paper I formally analyze the role of informational asymmetry between managers and owners in the degree of currency risk exposure of the firm. Empirically, I use a variant of the currency exposure estimation model used in Baba and Fukao (2000) under the assumption that currency risk exposure coefficients are linearly related to a variable that captures the degree of informational asymmetry.

The paper is organized as follows. Section II briefly reviews the basic theoretical rationales for risk management and the empirical results obtained. Section III considers risk management within an established principal-agent framework. Section IV explains the estimation method, and then reports empirical results. Section V concludes the paper.

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[5] This example is taken from Caves, Frankel, and Jones (1996). For more details, see Revey (1981).

II. Basic Rationales for Hedging Policy: A Brief Survey[6]

As mentioned in Introduction, the M&M theorem suggests that in a imaginary world with no taxes, no transaction costs and a fixed investment policy, investors can perform their own home-made risk management by holding diversified portfolios. So what would be a necessary condition for firms to hedge uncertainty? The most convincing answer lies in concavity of the value (or profit) function, which implies that a perfect hedge of uncertain cash flows leads to a higher value than would be the case with no hedging. In what follows, let us briefly review some basic cases, which create concavity of the value function.

(i) Taxes[7]

The structure of the tax schedule can make it beneficial for firms to hedge their risk. If the effective marginal tax rate is an increasing function of the firm's pre-tax value, then the after-tax value of the firm is a concave function of its pre-tax value. If hedging reduces the uncertainty of the pre-tax value of the firm, then the expected corporation tax liability is reduced and the expected post-tax value of the firm is increased, as long as the cost of the hedge is not too large.

To formally analyze the effect of hedging on the present after-tax value of the firm, let us use a state-preference model of the value of the firm. Assume that there are s states of the world, with V_i defined as the pre-tax value of the firm in state i. Possible states are numbered such that $V_i \leq V_J$, if $i < j$. Let P_i denote the price today of one dollar to be delivered in state i, and $T(V_i)$ be the tax rate if the pre-tax value of the firm is V_i. In the absence of leverage, the post-tax value of the firm, $V(0)$, is given by

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[6] Smithson (1996) provides an excellent compact survey on this issue.
[7] The explanation here is based on Smith and Stultz (1985).

$$V(0)=\sum_{i=1}^{s} P_i\left[V_i - T(V_i)V_i\right]. \tag{1}$$

Hedging can increase the value of the firm if there are two states, j and k, such that $T(V_j) < T(V_k)$. To illustrate this argument, suppose that the firm holds a hedge portfolio such that $V_j + H_j = V_k + H_k$, and that the hedge portfolio is self-financing in the sense that $P_j H_j + P_k H_j = 0$[8]. Now let $V^H(0)$ be the value of the hedged firm. This setting leads to

$$\begin{aligned} V^H(0) - V(0) = P_j&\left[T(V_j)V_j - T(V_j + H_j)(V_j + H_j)\right] \\ &+ P_k\left[T(V_k)V_k - T(V_k + H_k)(V_k + H_k)\right] > 0 \end{aligned} \qquad (2)^9$$

Thus, hedging can increase the value of the hedged firm. This analysis also implies that incomplete hedging also raises the value of the firm.

The above analysis must be applied if hedging is costly, that is, as long as transaction costs of hedging do not exceed the benefits identified in equation (2). The amount of hedging undertaken by the firm depends on the transactions cost of hedging. If transaction costs exhibit scale economies, then the firm either hedges completely, in the case in which the cost is low enough, or does not hedges at all.

(ii) Costs of Financial Distress (Bankruptcy Costs)[10]

Among others, Mayers and Smith (1982) and Smith and Stultz (1985) argue that hedging reduces the probability that the firm will encounter financial distress (bankruptcy) by decreasing the variance of the net after-tax value of the firm, and thereby

[8] Such a portfolio is feasible if it is possible to create a portfolio that pays one dollar in state *j* and a portfolio that pays one dollar in state *k*.
[9] The inequality is implied by the definition of a concave function.
[10] Explanation here is based on Smith and Stultz (1985).

reducing the expected costs of financial distress[11]. Below, let us describe this mechanism briefly.

Consider a levered firm that pays taxes on its cash flow net of interest payments to the creditors. Let F be the face value of the debt. If the value of the firm is below F at maturity, the creditors receive F minus the transaction costs of bankruptcy[12]. Otherwise, the shareholders receive firm value minus both taxes paid and the creditors' payment, F. The lower are expected bankruptcy costs, the higher the expected payoffs to the firm's claimholders. By reducing the uncertainty of the future value of the firm, hedging lowers the probability of incurring bankruptcy costs. This decrease in expected bankruptcy costs benefits shareholders. If the transaction costs of bankruptcy are a decreasing function of the value of the firm, and the tax rate is either constant or an increasing function of the value of the firm, the expected after-tax value of the firm net of bankruptcy costs is higher if the firm can hedge without substantial costs.

Now consider a simple case in which a firm issues debt to create a tax shield. In the absence of leverage, the after-tax value of the firm is $V(0)$. Let us assume a firm issues pure discount bonds with face value F, and pays taxes on its before-tax value net of its payment to the creditors. The after-tax value of a leveraged firm with the same investment policy as the unlevered firm is $V(F)$. For simplicity, assume that $V_j < F < V_k$. If $V_i < F$, bankruptcy costs are given by $C(V_i) \le V_i$. The difference in the value of the levered and the unlevered firm is given by

$$V(F) - V(0) = \sum_{i=1}^{j} P_i\left[T(V_i)V_i - C(V_i)\right] + \sum_{i=k}^{S} P_i T(V_i) F \ . \tag{3}$$

[11] Diamond (1984) also argues that bankruptcy costs lead to hedging. In his model of financial intermediaries, financial intermediaries hedge all systemic risks, that is, all risks that have no incentive effects. His conclusion is stronger than that here since in his model there are no cases in which it does not pay to hedge, either because of transaction costs or for other reasons discussed in this paper.

[12] The costs of bankruptcy includes direct costs (for example, legal and administrative fees) as well as indirect costs. The indirect costs reflect difficulties of running a company (e.g., decreased product-market competitiveness and underinvestment).

By inspection, the value of the levered firm equals the value of the unlevered firm minus the present value of bankruptcy costs plus the present value of the tax shield from interest payments. Equation (3) suggests that the value of the levered firm increases with decreases in the present value of expected bankruptcy costs.

To analyze the effects of hedging on expected bankruptcy costs, let us examine an unlevered firm whose shareholders plan to issue debt. Let us also assume that investment policy is fixed and that any proceeds of a debt issue are distributed to the shareholders as a dividend.

The firm can reduce bankruptcy costs by holding a hedge portfolio that pays positive amounts when the firm would be bankrupt without hedging. To analyze the benefits of hedging, consider a hedge portfolio that pays $H_g < 0$ in state g and $H_m > 0$ in state m. Now assume that the hedge portfolio involves no current cash flows ($P_g H_g + P_m H_m = 0$) and that $V_g + H_g > F$ and $V_m + H_m > F$. By construction, $V_g < F$ follows. Further, let $V^H(F)$ be the value of the levered firm if the firm hedges. Then, assuming a constant tax rate T yields

$$V^H(F) - V(F) = P_g C(V_g) + P_g T(F - V_g). \tag{4}$$

Since $C(V_g) > 0$ and $V_g < F$, $V^H(F) - V(F)$ is always positive. Thus, hedging decreases the present value of bankruptcy costs, which increases the present value of the tax shield of debt. Shareholders can benefit from hedging only because bankruptcy involves real costs to shareholders and creditors-—the direct costs and the loss associated with debt tax shields. Again, even with costly hedging it is still generally profitable to hedge. However, shareholders must take account of hedging costs when they decide among alternative hedging strategies.

(iii) Avoiding Underinvestment

Froot, Scharfstein, and Stein (1993) generalized the so-called underinvestmnent problem proposed by Smith and Stulz (1985) by noting that firms simultaneously choose the optimal levels of investment and financing subject to an expected profit constraint.

Now, consider a firm that faces a decision of a two-period investment and financing problem. In the first period, the firm has an amount of assets, a, which is assumed to be liquid. In this period the firm must choose its investment expenditures and external financing needs. In the second period, the output from the investment is realized and outside investors are repaid.

On the investment side, let the net present value of investment to be

$$F(I) = f(I) - I, \tag{5}$$

where I is investment, $f(I)$ is the expected level of output, which satisfy $\partial f/\partial I \equiv f_I > 0$ and $\partial^2 f/\partial I^2 \equiv f_{II} < 0$. For simplicity, it is assumed that the discount rate is zero.

As will become clear below, the firm prefers to finance the investment with internal funds first before turning to external sources. Thus, the amount of external financing x is determined such that

$$I = a + x. \tag{6}$$

Assumption of a zero discount rate implies that outside investors require an expected repayment of x in the second period.

Let us assume, further, that there are additional costs to the external finance, denoted C. These costs could arise from various sources. First, they could stem from the costs of financial distress (bankruptcy) as mentioned before. Second, they could arise from informational asymmetries between managers and outside investors[13]. Consider, for example, the situation in which the firm would decide to raise funds from its internal

[13] In this regard, see Myers and Majluf (1984), and Jensen and Meckling (1976).

funds or from equity financing. The thrust of the problem here is that it is difficult for investors in the stock market to assess the real value of the firm's assets. They might get it right on average, but sometimes they value the stock too high and sometimes they do it too low. As a matter of course. firms will be reluctant to raise funds by selling stock when they think that their equity is undervalued. Thus, issuing equity will send a strong signal to the stock market investors that the firms think their shares are overvalued. The result is that most firms perceive equity to be a costly source of financing.

Whatever the rationale one chooses, the costs associated with external financing will be an increasing function of the amount of external finance. Let these costs be $C = C(x)$, with the property $\partial C/\partial x \equiv C_x \geq 0$.

Hedging is important when the first period cash flow, a, is random. To explore the impact of hedging on optimal financing and investment decisions, let us solve the model backwards, starting with the firm's first-period investment decision. The firm's maximization problem can be stated as follows:

$$P(a) \equiv \underset{I}{Max} \;\; F(I) - C(x). \tag{7}$$

The first-order condition is

$$F_I = f_I - 1 = C_x, \tag{8}$$

where $\partial F/\partial I \equiv F_I$ and I have used the fact that in the second period, $dx/dI = 1$ holds. Equation (8) implies that there is underinvestment, that is, optimal investment is below the first-best level, which would satisfy $f_I = 1$.

Now let us turn to the first period. The firm chooses its hedging policy to maximize its expected profits. Using the first-order condition in equation (8), the second derivative of profits denoted P_{aa} can be written as

$$P_{aa} \equiv f_{II}\left(\frac{dI^*}{da}\right)^2 - C_{xx}\left(\frac{dI^*}{da} - 1\right)^2, \tag{9}$$

where f_{II} and C_{xx} are evaluated at the optimum, $I = I^*$. If this expression is negative, then hedging can raise expected profits. Equation (9) can be rewritten by applying the implicit function theorem to equation (8), which yields

$$P_{aa} \equiv f_{II} \frac{dI^*}{da}. \tag{10}$$

Equation (10) explains the essence that hedging policy is determined as the interaction between investment and financing decisions. If hedging is beneficial, the following two conditions must be satisfied: (i) marginal returns on investment are decreasing, and (ii) the level of internal cash flow has a positive impact on the level of investment plan. Regarding the second condition, there is substantial empirical evidence suggesting that corporate investment is sensitive to levels of internal cash flow[14].

(iv) Empirical Evidence regarding Japanese Corporations

Unlike the case of U.S. multinational corporations, unfortunately, there have been very few studies that empirically analyze the hedging incentives for Japanese counterparts[15]. To my knowledge, that of He and Ng (1998) is the only such empirical study. Of the hedging incentives reviewed above, they examine the second and the third, that is, avoiding the costs of financial distress and underinvestment. They use a firm's long-term debt ratio to measure its probability of financial distress and the ratio of a firm's book to market value of equity as a proxy for a firm's growth opportunities[16].

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[14] See, for example, Fazzari, Hubbard, and Petersen (1988), and Hoshi, Kashyap, and Scharfstein (1991).

[15] In fact, in the case of U.S. corporations, we can find many empirical studies. For example, Dolde (1995) reports a positive relationship between tax loss carry forwards and the use of risk management instruments, indicating that taxes provide a significant incentive for corporations. Second, Dolde (1995) and Samant (1996) both find a significantly positive relationship between the use of risk management and leverage, which is consistent with the financial distress argument. Lastly, Nance, Smith, and Smithson (1993) and Dolde (1995) find a significantly positive relationship between the firm's R & D expenditure and hedging behavior, which is consistent with the prediction by Froot, Scharfstein, and Stein (1993).

[16] Note that the underinvestment hypothesis suggests that both the interaction between growth opportunities and costly external financing, and their predicted relationship should be negative.

By running a cross-sectional regression between the pre-obtained exchange rate beta and each proxy variable, they obtained the predicted signs on both variables. The coefficient of the ratio of a firm's book to market value of equity, however, is not adequately significant. This result suggests that avoiding the costs of financial distress is likely to explain the hedging incentives for Japanese multinationals.

It should be noted that these rationales indicate how managers should behave if they want to increase shareholder value via risk management. That is, they only hold under the condition that there is no principal-agent problem. In the next section, I will explore the testable implication in the case in which this crucial assumption fails.

III. Risk Management within a Principal-Agent Framework: Theoretical Basis

Shareholders try to hire managers since the managers own specialized resources that can increase the value of the firm. Unless offered proper incentives, however, managers might not have the same objective as shareholders, that is, to maximize the value of the firm. This is a typical principal-agent problem.

Smith and Stultz (1985) show that if the managers' compensation scheme is a concave function of the firm's payoffs, then the optimal hedging strategy for the managers is to hedge perfectly. On the other hand, if the managers' compensation is a convex function of the firm's payoffs, then even risk-averse managers might not prefer to hedge.

In reality, however, their assumption that the form of the managers' compensation schedule is taken as given seems problematic. It is more natural to think that shareholders can choose the managers' compensation schedule and thereby can affect the hedging strategies that managers take. Also, in their framework, the managers' expected utility depends solely on the distribution of the firm's payoffs. But, in reality, it is also more natural to think that hedging efforts by managers entail greater difficulty, which should cause them disutility. In what follows, let us augment the model by incorporating these points. In this section, I prefer just to apply the simple established principal-agent framework[17] to the aspect of risk management instead of creating a brand-new model.

(i) Basic Setting

Suppose that the representative owner[18] of a firm (the principal) wishes to make a contract to an incumbent manager (the agent) for a one-time project involving currency risk. The project's revenues are affected by the representative manager's hedging efforts. If these efforts were fully observable to the owner, the contract would not cause a headache to the owner. It should simply specify the exact hedging efforts that the owner desires the manager to make and the compensation (wage) that the owner is to provide in return. When the manager's efforts are not fully observable, however, the contract can no longer specify them efficiently. The reason is that there is simply no way to verify whether or not the manager has fulfilled his or her duty. In this situation, the owner has an incentive to design the manager's compensation scheme in a way that induces him or her to make the desirable actions.

Now, let v denote the project's revenues, and let e denote the manager's effort choice. Also, although the project's revenues are affected by the choice of e, it is not fully determined by e. For example, imagine a manufacturing firm that is engaged in exports. Revenues from exports depend on numerous factors including shifts of tastes and income conditions of customers as well as unexpected exchange rates movement. The

[17] The description of the basic model in this section follows Mas-Colell, Whinston, and Green (1995). Also, DeMarzo and Duffie (1995) explore the information effect of financial risk management within a similar framework. They show that financial hedging improves the informativeness of corporate earnings as a signal of management ability and project quality by eliminating extraneous noise. Also they show that managerial and shareholder incentives regarding information transmission may differ, leading to conflicts regarding the choice of an optimal hedging policy.

[18] Throughout the paper, I ignore the existence of foreign shareholders. As emphasized by French and Poterba (1990) and Tesar and Werner (1991), domestic residents tend to hold a very large proportion of

discussion in the last section implies that under the condition of concavity of the value function, whatever the reason is, hedging the currency risk exposure can raise expected cash flows from exports. In the discussion below, let us restrict our attention to a situation in which the manager has only two possible effort choices, e_H and e_L. e_H is a high-effort choice that leads to a higher expected revenue level for the firm than e_L, but entails greater difficulty for the manager. To be more specific, for proper hedging, the manager must grasp all the risk exposure that the firm faces at every moment. Since I assume that proper hedging leads to higher expected revenues, e_H corresponds to a perfect hedge whereas e_L corresponds to no hedge.

Further, let us assume that the distribution of v conditional on e_H dominates the distribution conditional on e_L in a first-order stochastic sense, which implies that the distribution functions $F(v \mid e_H)$ and $F(v \mid e_L)$ satisfy $F(v \mid e_H) \leq F(v \mid e_L)$ at all $v \in [\underline{v}, \bar{v}]$. This assumption suggests that the level of expected revenues when the manager chooses e_H is larger than that from e_L, that is, $\int_{\underline{v}}^{\bar{v}} vf(v \mid e_H)dv > \int_{\underline{v}}^{\bar{v}} vf(v \mid e_L)dv$.

The manager is assumed to maximize his or her expected Bernoulli utility function $u(w,e)$ that has his or her wage w and effort level e as its arguments. The utility function is assumed to satisfy $\partial u(w,e)/\partial w > 0$, $\partial^2 u(w,e)/\partial w^2 \leq 0$ and $u(w,e_H) < u(w,e_L)$ at all w. In plain words, the manager prefers more income to less and is weakly risk averse over uncertainty stemming from wage variability. For simplicity, let us focus on a special case of the form: $u(w,e) = h(w) - g(e)$ that satisfies $\partial h(w)/\partial w > 0$, $\partial^2 h(w)/\partial w^2 \leq 0$ and $g(e_H) > g(e_L)$.

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their wealth in domestic assets alone. This is often called a "Home Bias" phenomenon in portfolio investment.

On the other hand, the owner's profits are defined as the project's revenues minus wage payments made to the manager. I assume that the owner is risk neutral and hence his or her objective is to maximize his or her expected profits.

(ii) The Case in which the Manager's Effort Level is Observable

Suppose the situation in which the owner cannot change the incumbent manager, so the owner is willing to make the incumbent manager an offer that he or she will accept. In such a case, the optimal contract for the owner can be specified as the following expected profit maximization problem:

$$\underset{e\in\{e_L,e_H\},w(v)}{Max}\int_{\underline{v}}^{\bar{v}}[v-w(v)]f(v\mid e)dv \tag{11}$$

$$\text{s.t.}\qquad \int_{\underline{v}}^{\bar{v}}h[w(v)]f(v\mid e)dv-g(e)\geq\bar{u}\ , \tag{12}$$

where $\bar{u}$ is the reservation (subsistence) utility level for the manager.

The usual way to solve this kind of problem is to divide it into two steps. The first step is to determine the optimal compensation scheme $w(v)$ for each choice of e. The second step is to determine the optimal choice of e given the outcome of the first stage.

The problem of the first step can be written as

$$\underset{w(v)}{Min}\int_{\underline{v}}^{\bar{v}}w(v)f(v\mid e)dv\ . \tag{13}$$

The first-order condition can be written as

$$\frac{1}{h'[w(v)]}=\lambda\ , \tag{14}$$

where λ is the Lagrangian multiplier on the constraint (12).

If the manager is strictly risk averse, the optimal compensation scheme $w(v)$ turns out to be a constant. That is, the owner should provide the manager with a fixed wage. This result is nothing but a form of risk-sharing in which the owner offers a fixed wage w^* such that the manager receives exactly his or her reservation utility level:

$$h(w^*) - g(e) = \bar{u} . \tag{15}$$

On the other hand, in the case in which the manager is risk neutral, the first-order condition is always satisfied for any compensation function. In this case, any compensation function $w(v)$ that gives the manager an expected wage equal to $\bar{u} + g(e)$ is also optimal.

Next, let us move to the second step, that is, the determination of the optimal choice of e. The owner's problem can be written as

$$\underset{e \in \{e_L, e_H\}}{Max} \int_{\underline{v}}^{\bar{v}} v f(v \mid e) dv - h^{-1}[\bar{u} + g(e)] . \tag{16}$$

Thus, whether e_H or e_L is optimal depends on the incremental increase in expected profits from e_H over e_L compared with the monetary cost of the incremental disutility.

(iii) The Case in which the Manager's Effort is not Observable

First, consider the case in which the manager is risk-neutral, that is, for example, $h(w) = w$. The optimal effort level e^* when effort is observable solves

$$\underset{e \in \{e_L, e_H\}}{Max} \int_{\underline{v}}^{\bar{v}} v f(v \mid e) dv - g(e) - \bar{u} . \tag{17}$$

Now suppose that the owner offers a compensation scheme of the form $w(v) = v - \vartheta$, where ϑ is some constant. If the manager accepts the contract, he or she must choose e so as to solve

$$\underset{e \in \{e_L, e_H\}}{Max} \int_{\underline{v}}^{\bar{v}} w(v) f(v \mid e) dv - g(e) = \int_{\underline{v}}^{\bar{v}} v f(v \mid e) dv - \vartheta - g(e) . \tag{18}$$

Comparing equations (17) and (18), one can see that e^* also maximizes the problem (18). Hence, this contract gives the first-best (full observability) effort level e^*.

Next, consider the case in which the manager is strictly risk averse. Incentives for high effort can be provided only at the cost of having the manager face risk. The optimal incentive scheme for implementing a specific effort level e must solve

$$\underset{w(v)}{Min} \int_{\underline{v}}^{\bar{v}} w(v) f(v \mid e) dv \tag{19}$$

$$\text{s.t.} \qquad \int_{\underline{v}}^{\bar{v}} h[w(v)] f(v \mid e) dv - g(e) \geq \bar{u} \tag{20}$$

$$e = \underset{e}{argmax} \int_{\underline{v}}^{\bar{v}} h[w(v)] f(v \mid e) dv - g(e), \tag{21}$$

where constraint (21) is called an incentive constraint.

If the optimal effort level for the owner is e_L, the owner optimally offers the manager the fixed wage $w^* = h^{-1}[\bar{u} + g(e_L)]$. This is the same as the payment he offers the manager in the case of contractually specifying effort e_L when the manager's effort is observable.

On the other hand, if the optimal effort level for the owner is e_H, constraint (21) of the maximization problem (19) can be rewritten as

$$\int_{\underline{v}}^{\bar{v}} h[w(v)] f(v \mid e_H) dv - g(e_H) \geq \int_{\underline{v}}^{\bar{v}} h[w(v)] f(v \mid e_L) dv - g(e_L). \tag{22}$$

Thus, in this case, the Kuhn-Tucker first-order condition[19] can be written as

$$\frac{1}{h'[w(v)]} = \lambda + \mu\left[1 - \frac{f(v \mid e_L)}{f(v \mid e_H)}\right]. \tag{23}$$

In this case, one can easily check that both constraints (20) and (21) bind when $e = e_H$. Also it should be noted that the compensation scheme is not necessarily a monotonically increasing function of profits. For the optimal compensation scheme to be monotonically increasing, it must be the case that the likelihood ratio $f(v \mid e_L)/f(v \mid e_H)$ is decreasing in v.

Furthermore, it should be noticed that the expected value of the manager's wage must be strictly greater than his or her fixed wage in the observable case. Intuitively,

[19] As easily shown, in the case in which the owner is risk averse over $v - w(v)$, the Kuhn-Tucker first-order condition becomes $\frac{u'[v - w(v)]}{h'[w(v)]} = \lambda + \mu[1 - f(v \mid e_L)/f(v \mid e_H)]$, where $u(\cdot)$ denotes the owner's utility function. Note that, in this case, the incentive constraint may not bind, i.e., it may be optimal for the manager to have sufficient risk for the incentive constraint not to be binding.

since the manager must be assured an expected utility level of $\bar{u}$, the owner must compensate him or her through a higher average wage for any risks he or she bears.

Given the preceding analysis, which effort should the owner make? To determine it, the owner compares the incremental change in expected profits from the two effort levels $\int_{\underline{v}}^{\bar{v}} vf(v \mid e_H)dv - \int_{\underline{v}}^{\bar{v}} vf(v \mid e_L)dv$ with the difference in expected wage payment in the contracts. We already know that the wage payment when implementing e_L is exactly the same as in the case in which the manager's effort is observable, whereas the expected wage payment when implementing e_H under the non-observability is strictly larger than his or her payment in the observable case.

The most important implication of the discussion above is that the non-observability of the manager's effort can lead to an inefficiently low level of the manager's effort from the perspective of the owner. When e_L is the optimal effort level for the owner if effort were observable, then it still is when effort is not observable. On the other hand, when e_H is optimal if effort is observable, then one of the following two consequences can follow: (i) it is optimal to implement e_H using an incentive scheme that faces the manager with risk, or (ii) the risk-bearing costs are so high that the owner decides that it is better to implement e_L instead of e_H. In sum, the existence of informational asymmetry can lead to an inefficiently low level of hedging effort by the manager.

(iv) Testable Implication

From the analysis above, one can derive the following implications regarding the hedging policies of multinational firms. Remember the case of the manufacturing firm that exports its products. The main uncertainty this firm faces is the amount of revenues it will receive from foreign sales. The firm can forecast its foreign sales volume quite accurately, but the yen value of those sales is hard to pin down due to the uncertainty inherent in exchange rates.

In this setting, consider the case in which owners can observe managers' efforts to collect information about exchange rate exposure and hedging risks without additional costs, that is, information regarding the managers' efforts is symmetric between owners and managers. In such circumstances, if the gross expected profit from hedging is large enough, then the owner's choice will be hedging, and the owners can successfully impose on the managers an optimal contract that specifies the effort being implemented by the managers and the corresponding fixed compensation.

In a situation in which the owners cannot fully observe the managers' efforts, and the managers are risk-averse, however, even if the gross profit that comes purely from hedging is large, hedging might not be implemented. This is because in that case (i) the contract must involve a larger expected compensation payment than is required when effort is observable, and/or (ii) due to high risk-bearing costs, the owners do not prefer hedging after all.

Based on the preceding discussion, I will empirically access the role played by asymmetric information in exchange rate exposure of the firms by using a proxy that captures the degree of asymmetric information.

IV. Empirical Analysis

(i) Equations for Estimation

As for equations for an empirical assessment, let us use the following types of equation, which I converted from the equations used in Baba and Fukao (2000) on the assumption that each exposure coefficient is linearly related to a variable that captures the degree of informational asymmetry of each firm:

$$\left.\frac{d\Omega_{it}^*}{\Omega_{it-1}^*}\right|_g = \alpha_i + \left(\gamma_1^g + \gamma_2^g I_i\right)\sum_{n\in N}\frac{A_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_3^g + \gamma_4^g I_i\right)\sum_{n\in N}\frac{B_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_5^g + \gamma_6^g I_i\right)\sum_{n\in N}\frac{C_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^{US}}{\Pi_{t-1}^{US}} + \varepsilon_{it} \tag{24}$$

$$\left.\frac{d\Omega_{it}^*}{\Omega_{it-1}^*}\right|_n = \alpha_i + \left(\gamma_1^n + \gamma_2^n I\right)\sum_{n\in N}\frac{A_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_3^n + \gamma_4^n I\right)\sum_{n\in N}\frac{B_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_5^n + \gamma_5^n I\right)\sum_{n\in N}\frac{C_i}{\Omega_{it-1}^*}\frac{d\Pi_t^{US}}{\Pi_{t-1}^{US}} + \varepsilon_{it}\ , \tag{25}$$

where $\left.\frac{d\Omega_{it}^*}{\Omega_{it-1}^*}\right|_g = \frac{dV_{it}^*}{V_{it-1}^*} - Const_i - \sum_{j\in R}\theta_j D_j\ ,$ (26)

and $\left.\frac{d\Omega_{it}^*}{\Omega_{it-1}^*}\right|_n = \frac{dV_{it}^*}{V_{it-1}^*} - Const_i - \sum_{j\in R}\theta_j D_j - \beta_i\frac{dV_{mt}}{V_{mt-1}}\ .$ (27)

Here, on the right-hand side of equations (24) and (25), A_i^n denotes exports to the area n by firm i, B_i^n the number of employees that firm i employs in area n, C_i^n the amount of the U.S. dollar-denominated (internationally-mobile) primary materials that firm i uses in the area n, and Π_t^n the exchange rate of the Japanese yen against the currency of n (Π_t^{US} is the yen-U.S. dollar rate). As shown by Baba and Fukao (2000), the first term (excluding the constant term) in equations (24) and (25) captures currency risk exposure via the dependency on exports, the second term via the dependency on overseas production, and the last term via the dependency on the internationally-mobile primary materials.

In equations (26) and (27), V_m is the value of the sum of all the firms in the market, which corresponds to the market portfolio in the CAPM (Capital Assets Pricing Model) . D_j is a dummy variable that is equal to 1 if the day is j and 0 otherwise. Equation (24) is meant to capture the “gross” measure of currency risk exposure, while equation (25) captures its “net” measure.

One of the most important merits of using this type of specification is that one can evaluate the quantitative as well as the qualitative impact of informational asymmetry in terms of three different sources of currency risk exposure, that is, the dependency on exports, overseas production and imported primary materials. This point is thought to be very important because, in reality, owners might prefer hedging the currency exposure arising from exports and imports rather than to hedging that the exposure arising from overseas production, since overseas production itself is sometimes considered to be a means of risk management[20].

For the proxy variable I_i, I use the ratio of the stocks owned by the 10 largest shareholders to all the existing stocks[21] as of fiscal year 1995. The rationale of this choice is that large shareholders are generally considered to enjoy the great advantage of being able to monitor the managers' efforts to collect information about the exchange rate exposure of their firms and to hedge the risk. This measure of shareholders' ratio includes the managers who own large portions of the stocks of their company.

(ii) Hypothesis Testing

In a joint form, the hypothesis can be written as

$$H_0: \ \hat{\gamma}_1 \le 0, \hat{\gamma}_2 \ge 0, \hat{\gamma}_3 \ge 0, \hat{\gamma}_4 \le 0, \textit{ and } \hat{\gamma}_5 \ge 0, \hat{\gamma}_6 \le 0$$

$$H_1: \ \hat{\gamma}_1 > 0, \hat{\gamma}_2 < 0, \hat{\gamma}_3 < 0, \hat{\gamma}_4 > 0, \textit{ and } \hat{\gamma}_5 < 0, \hat{\gamma}_6 > 0 . \tag{28}$$

The joint null hypothesis is rejected if informational asymmetry causes managers a downward bias in implementing risk management. That is, as the ratio of large shareholders becomes higher, the smaller the firm's currency risk exposure is, due to the close monitoring of managers' efforts by owners. Thus, if the null hypothesis cannot be rejected, then the role of the asymmetric information between owners and managers about exchange rate exposure and hedging behavior by managers is confirmed.

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[20] As emphasized by Baba and Fukao (2000), this type of hedging is sometimes termed "natural hedging"

[21] The source of the data is Japan Company Handbook, summer edition of 1996, published by *Toyo Keizai*, inc.

As I mentioned earlier, my main interest also lies in the separate sets of exposure coefficients stemming from different sources of currency risk. In particular, Japanese manufacturers are generally highly dependent on exports, so whether or not managers hedge exports revenues has an especially big impact on the shareholders' value.

(iii) Econometric Issues

Baba and Fukao (2000) report that this type of estimation might suffer from endogeneity and measurement errors of regressors. Thus, in this paper, I use the same instrumental variables technique in a panel data setting as in Baba and Fukao (2000). Concretely, I use a linear combination of such instrumental variables as (up to five-day) lagged values of each regressors as well as the first difference in the return on the 10-year Japanese government bond.

(iv) Sample Periods and Firms

As in Baba and Fukao (2000), both long and short periods were checked using daily data[22] to judge whether informational asymmetry plays a role in company's currency risk exposure. It is because there is an important trade-off with regard to sample size. One consideration is that choosing relatively short periods (for example, 30 business days) during which the exchange rates changed significantly in one direction enables us to regard the exchange rate shock as a primary source of uncertainty. The use of relatively short periods, however, has potentially a large cost in that the estimator obtained in this way might not have desirable large-sample properties. Hence, I pick 30, 60, and to 90-business day periods during which the Japanese yen/U.S. dollar exchange rate significantly changed in one direction as well as a whole sample period, which covers

[22] For more details concerning the data set, see Baba and Fukao (2000).

from January 18 to December 29 in 1995 after using the first several days' data as instrumental variables.

Also for the data of attributes of firms, I use the same data set as in Baba and Fukao (2000), which includes 84 companies classified as in industries of electricity machinery and precision instruments. The most important reason for this choice is that these firms are particularly dependent on overseas operations, which implies that they face a high degree of currency risk exposure.

(v) Empirical Results

Table 1 reports the parameter estimates by the pooling IV technique. The result for the whole sample period indicates that in a case in which the gross measure of the value of the firm is used, the set of coefficients concerning currency exposure arising from exports significantly satisfy the signs required by the hypothesis of informational asymmetry, while others related to other source of currency risk also satisfy the required signs, but less significantly.

Dividing the sample periods into short sub-periods yields a much more significant result. There is considerable asymmetry in the performance of the model between appreciation and depreciation periods. In the appreciation period, generally speaking, currency exposure coefficients stemming from imported primary materials satisfy the sign requirement, sometimes significantly. Few coefficients of other sources of currency risk, however, do not satisfy it in most cases. On the other hand, in the depreciation period, in all the cases, regardless of which measure of the value of the firm is used, the sign requirement of the role of informational asymmetry is satisfied. In particular, except for one case where gross measure is used in a 90-day period, the set of exposure coefficients arising from exports is found to be significant. Further, if a 60-day period is used, all the coefficients are found to be significant in both the gross and net measures that are used.

To evaluate the estimated coefficients in economic terms, let us perform a simulation of the role of informational asymmetry in currency risk exposure that stems from exports in the case in which the Japanese yen changes by 10% uniformly against every other currency. Table 2 reports the main result based on the regression result using the gross measure of the value of the firm and whole sample periods. The simulation is conducted by using the ratio of the stocks owned by the 10 largest shareholders to all the existing stocks I_i with different values and evaluating the economic significance in terms of the average value of exports and current profits of 84 sample firms. The result shows that for the baseline case where I_i=1 (0), a 10% change in the Japanese yen increases currency risk exposure from exports by 47.3 (-9.9) billion yen, which corresponds to 7.3 (-1.5) times the total of average current profits. For the sample average of I_i=0.46, one can estimate the change in currency risk exposure from exports as 20.9 billion yen, which corresponds to 3.2 times the total of average current profits. Thus, as far as this simulation is concerned, the role of informational asymmetry in currency risk exposure does not seem small in terms of economic significance.

V. Concluding Remarks

This paper analyzes the role of informational asymmetry between owners and managers in hedging policy against unanticipated fluctuations in foreign exchange rates. Theoretically, in the principal-agent type framework, even if a perfect hedge is potentially an optimal strategy to owners, on condition that managers are risk-averse, one can show that the non-observability of the managers' efforts for hedging currency risk raises the cost of implementing the hedging strategy to owners. Hence it can lead to an inefficiently low level of hedging efforts being implemented by managers. This consequence naturally allows exchange rate variations to influence the values of firms.

Empirically, within the framework and the data set used by Baba and Fukao (2000), by assuming that each currency risk exposure coefficient is linearly related to a variable that captures the degree of informational asymmetry, I conducted a regression analysis, which shows that, especially for currency risk exposure that stems from exports, the role of informational asymmetry is large in terms of both statistical and economic significance.

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Table 1: Parameter Estimates by the Pooling IV (Instrumental Variables) Method

(a) Gross Measure:

$$\left.\frac{d\Omega_{it}^*}{\Omega_{it-1}^*}\right|_g = \gamma_0 + \left(\gamma_1^g + \gamma_2^g I_i\right)\sum_{n\in N}\frac{A_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_3^g + \gamma_4^g I_i\right)\sum_{n\in N}\frac{B_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^n}{\Pi_{t-1}^n} + \left(\gamma_5^g + \gamma_6^g I_i\right)\sum_{n\in N}\frac{C_i^n}{\Omega_{it-1}^*}\frac{d\Pi_t^{US}}{\Pi_{t-1}^{US}} + \varepsilon_{it}$$

[Regression Result]

(i) Whole Period (January 18-December 29: Number of Observations=20,160)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.375E-04	8.584	-10.423	-65.940	83.112	-20.640	17.231
(0.210)	(3.104)***	(-1.843)*	(-2.174)**	(1.123)	(-0.821)	(0.405)

(ii) Appreciation Periods

a. 30-day Period (February 28-April 11: Number of bservations=2,520)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.295E-02	-0.830	0.357	15.719	-39.169	-18.793	23.810
(-5.038)***	(-0.862)	(0.189)	(1.434)	(-1.495)	(-2.317)**	(1.818)*

b. 60-day Period (January 24-April 18: Number of Observations=5,040)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.251E-02	1.004	-2.523	-4.733	6.394	-13.030	17.633
(-6.342)***	(1.061)	(-1.377)	(-0.404)	(0.227)	(-1.630)*	(1.365)

c. 90-day Period (February 1-June 12: Number of Observations=7,560)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.218E-02	-0.357	1.760	22.490	-62.100	-12.606	19.454
(-8.357)***	(-0.324)	(0.771)	(1.492)	(-1.722)*	(-1.405)	(1.307)

(iii) Depreciation Periods

a. 30-day Period (July 6-August 16: Number of Observations=2,520)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.635E-02	3.351	-4.890	-23.566	37.808	-12.848	12.409
(10.265)***	(3.305)***	(-2.548)**	(-1.624)	(1.057)	(-1.511)	(0.904)

b. 60-day Period (June 26-September 13: Number of Observations=5,040)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.476E-02	2.522	-3.857	-29.151	56.564	-22.365	26.091
(11.319)***	(2.541)**	(-2.073)**	(-2.211)**	(1.748)*	(-2.646)***	(1.920)*

c. 90-day Period (June 29-November 2: Number of Observations=7,560)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.310E-04	1.694	-2.674	-24.992	46.080	-19.814	22.672
(9.491)***	(1.592)	(-1.349)	(-1.574)	(1.172)	(-2.074)**	(1.458)

Notes: 1. I use a linear combination of (up to 5-day) lagged 10-year government bond yields (first difference form) and each regressor as instrumental variables.
2. Figures in parentheses are *t*-values in two-tail tests.
(*: significant at 10% level **: significant at 5% level ***: significant at 1% level)
3. The *t*-values are computed based on heteroscedasticity–corrected standard error estimators obtained by the method proposed by White (1980).

(b) Net Measure:

$$\left.\frac{d\Omega_{it}^{*}}{\Omega_{it-1}^{*}}\right|_{n}=\gamma_0+\left(\gamma_1^n+\gamma_2^n I_i\right)\sum_{n\in N}\frac{A_i^n}{\Omega_{it-1}^{*}}\frac{d\Pi_t^n}{\Pi_{t-1}^n}+\left(\gamma_3^n+\gamma_4^n I_i\right)\sum_{n\in N}\frac{B_i^n}{\Omega_{it-1}^{*}}\frac{d\Pi_t^n}{\Pi_{t-1}^n}+\left(\gamma_5^n+\gamma_6^n I_i\right)\sum_{n\in N}\frac{C_i^n}{\Omega_{it-1}^{*}}\frac{d\Pi_t^{US}}{\Pi_{t-1}^{US}}+\varepsilon_{it}$$

[Regression Result]

(i) Whole Period (January 18-December 29: Number of Observations=20,160)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.195E-04	5.192	-7.179	-36.881	55.240	-21.754	27.080
(-0.138)	(2.373)**	(-1.604)	(-1.537)	(0.943)	(-1.093)	(0.804)

(ii) Appreciation Periods

a. 30-day Period (February 28-April 11: Number of Observations=2,520)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.185E-02	-0.744	0.638	15.272	-36.129	-8.227	11.123
(-3.810)***	(-0.935)	(0.408)	(1.685)*	(-1.669)*	(-1.227)	(1.028)

b. 60-day Period (January 24-April 18: Number of Observations=5,040)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.157E-02	0.476	-1.860	1.247	-2.920	-12.469	19.205
(-4.447)***	(0.564)	(-1.140)	(0.120)	(-0.117)	(-1.752)*	(1.670)*

c. 90-day Period (February 1-June 12: Number of Observations=7,560)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
-0.546E-02	0.653	1.049	19.356	-52.950	-15.691	23.648
(-2.368)**	(0.067)	(0.519)	(1.451)	(-1.659)*	(-1.977)*	(1.795)*

(iii) Depreciation Periods

a. 30-day Period (July 6-August 16: Number of Observations=2,520)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.212E-02	2.923	-4.730	-22.254	41.268	-14.943	17.982
(3.948)***	(3.362)***	(-2.835)***	(-1.764)*	(1.327)	(-2.022)**	(1.507)

b. 60-day Period (June 26-September 13: Number of Observations=5,040)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.241E-02	1.863	-3.285	-22.432	47.679	-18.329	23.581
(6.430)***	(2.106)**	(-1.982)**	(-1.910)*	(1.653)*	(-2.434)***	(1.948)*

c. 90-day Period (June 29-November 2: Number of Observations=7,560)

γ_0	γ_1^g	γ_2^g	γ_3^g	γ_4^g	γ_5^g	γ_6^g
0.130E-04	1.923	-2.902	-28.796	61.572	-5.624	5.836
(4.503)***	(2.041)**	(-1.653)*	(-2.047)**	(1.767)*	(-0.656)	(0.424)

Notes:1. I use a linear combination of (up to 5-day) lagged 10-year government bond yields (first difference form) and each regressor as instrumental variables.
2. Figures in parentheses are *t*-values in two-tail tests.
(*: significant at 10% level **: significant at 5% level ***: significant at 1% level)
3. The *t*-values are computed based on heteroscedasticity–corrected standard error estimators obtained by the method proposed by White (1980).

Table 2: A Simulation on the Role of Informational Asymmetry in Currency Exposure from Exports in the Case in which the Japanese Yen Changes by 10% Uniformly against every other Currency

I_i	Exposure Coefficient ($\gamma_1 + \gamma_2 I_i$)	Average Change in Exposure (billion yen)	Δ Exposure/ Current Profits
0	8.6	47.3	7.3
1	-1.8	-9.9	-1.5
Sample Min (0.28)	5.7	31.4	4.8
Sample Ave (0.46)	3.8	20.9	3.2
Sample Max (0.75)	0.8	4.4	0.7

Note: This simulation is based on the regression result using the gross measure of the value of the firm in the whole sample period. Average change in exposure from exports is calculate based on the fact that average amount of exports of 84 sample firms is about 55 billion yen in the fiscal year 1995. Current profits are the average value of 84 sample firms in the fiscal year 1995.

Appendix: Proof of the Homemade Coverage Theorem

Suppose that there are two (twin) firms, each of which has the same cash flow of R U.S. dollars. One firm covers its cash flow by a forward contract and the other doesn't. Now let us call the covered firm C and the uncovered firm U (whose stock market values are V_C and V_U, respectively). Further, let r^f be the risk-free gross interest rate on the U.S. national bond, ρ the forward exchange rate of yen per dollar, Π the current spot exchange rate, and Π^e the future spot exchange rate. Here, the future cash flows of these two firms can be written as

$$v_C^e = \rho R \text{ and } v_U^e = \Pi^e R, \tag{A-1}$$

which also state the limits of dividends.

Now consider the following two portfolios. The first portfolio consists of $\alpha \times 100$ percent of the stocks of firm C and the U.S. national bonds of $\alpha R / r^f$ dollars. The second portfolio consists of $\alpha \times 100$ percent of the stocks of firm U and the U.S. national bonds of $\alpha R / r^f$ dollars. But, the U.S. bonds of the second portfolio are covered by a forward exchange rate contract. The future cash flow of the first portfolio is the same as the cash flow of the second one, namely, $\alpha R(\Pi^e + \rho)$. Accordingly, the market value of each portfolio in terms of the yen must be the same, which implies that

$$\alpha V_C + \frac{\Pi \alpha R}{r^f} = \alpha V_U + \frac{\Pi \alpha R}{r^f}. \tag{A-2}$$

From this, it is clear that $V_C = V_U$. In words, a shareholder can control his or her future cash flow freely. The shareholders' decisions concerning covering have nothing to with the decisions concerning covering by firms. For more formal proof see Baron (1976) and Tatsumi (1990)[23].

[23] The theorem holds, however, even if the existence of foreign shareholders is taken into consideration. In this regard, see Tatsumi (1990).