Pricing Method Based on Service-portfolio Approach to Equipment-providing Services

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Abstract: In recent years, the uncertainty surrounding corporate management has increased for several reasons, and investments in enterprise and equipment have become increasingly risky in terms of future profitability. As a result, many businesses now prefer to keep such investments at arm's length by obtaining equipment through equipment-providing services, where the provider makes the investment, and his/her profits depend on how much and/or how long each user operates the provided equipment. A provider must be able to accurately determine the amount of risk related to providing such equipment and then price its services accordingly to operate profitably. Contracts have conventionally been priced based on the amount of risk associated with each contract. We describe an approach to lease pricing that takes into account the diversification effect that comes from providing equipment to users in various types of industries and in various geographical regions. The diversification reduces the overall risk, enabling the provider to profitably lease equipment at lower prices. Evaluation of this portfolio approach using actual industry data showed that the maximum diversification effect is about a 55% reduction in risk.

Keywords: risk, price, portfolio, risk premium, risk reduction rate

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1. Introduction

The uncertainty surrounding corporate management has increased for several reasons in recent years, and investments in enterprise and equipment have become increasingly risky in terms of future profitability. As a result, many businesses now prefer to obtain equipment through equipment-providing services. Through such services, the provider, rather than the actual user, owns the equipment and receives rental fees based on how much and how long the user operates the equipment. The user thus bears none of the risk of equipment ownership [5]. There are many examples of such services, including utility computing companies and energy service companies.

These service businesses differ from businesses selling equipment outright. They purchase and retain ownership of the equipment and provide it on a lease basis to the actual users. The profits they earn on the equipment depend on how much and how long each user operates the provided equipment. This means that the provider also takes on some of the user's operating risk; this is a major change from similar services that have been offered in the past. An equipment provider must be able to accurately determine the amount of risk related to providing its equipment and then price its services accordingly to operate profitably.

We have developed an approach to service pricing that takes into account the diversification effect that comes from providing equipment to users in various types of industries and in various geographical regions. The service price can then be set based on the cost of providing the equipment and the risk premium, which is calculated based on a predicted range of profitability and the provider's experience with the user, the provider's intuition and strategy, and the reliability of the equipment.

A user who actually owns the equipment it uses accepts the risk of whether it produces a profit or not, and the user cannot reduce this risk. In contrast, an equipment provider does reduce the risk by diversifying its investments. By taking these lower estimated risks into account, it can reduce its service prices and increase its price competitiveness. Setting too high a price will reduce the number of orders received, so the provider should estimate the risk as accurately as possible so that the risk premium is not overstated. This can be done by considering the risk premium for each user, which is determined by various factors, and taking into account the effect investment diversification has on the entire portfolio.

Various researchers have investigated the effect of stock portfolio diversification on risk [3][4][7][8]. These researches target the stocks, and the problem how the investor selects the brand has been taken up. When a service supplier cannot freely select its customers, like an equipment provider can, it is necessary not to select user's combination, and it measures and to control the amount of the risk in the user combination. Because it is difficult for a service supplier to control the effect of a more diversified investment, it is useful to establish the relationship between the number of contracts and the effect that diversified investment has on expanding services. The service price is set based on the cost of providing the service and the risk premium. The service price should be lower due to the lower risk resulting from the service portfolio diversification.

We have developed a method for an approach to calculating the effect of service portfolio diversification on the risk premium. In Section 2 we describe the approach generally used by equipment-providing services and the inherent problems. In Section 3, we explain the portfolio effect and how it should be reflected in service pricing. Section 4 discusses our evaluation of the effectiveness of our method. We conclude in Section 5 with a brief summary.

2. Traditional Approach

2.1. Business Model

The traditional business model for equipment-providing services, where an equipment provider rather than the user owns the equipment, is outlined in Fig. 1. Equipment-providers supply various types of equipment such as information technology (IT) hardware and charge a fee that depends on, for example, the amount of equipment usage, the length of time it is used, or its effect. The set of equipment is, for example, energy-saving equipment, disk, printers etc. However, since the provider's profitability, i.e. the user's cost, depends on how the user operates the equipment, an important characteristic of an equipment-providing service is that the user and the provider share the uncertainty (risk) regarding future returns on investment. The sources of risk for the equipment provider and for the user are, for example, fluctuation of amount of production, demand of customer, etc. For an equipment provider to avoid taking on excessive risk and ensure long-term profitability, the provider must accurately determine the amount of risk it can accept for each service offer and price the offer accordingly.

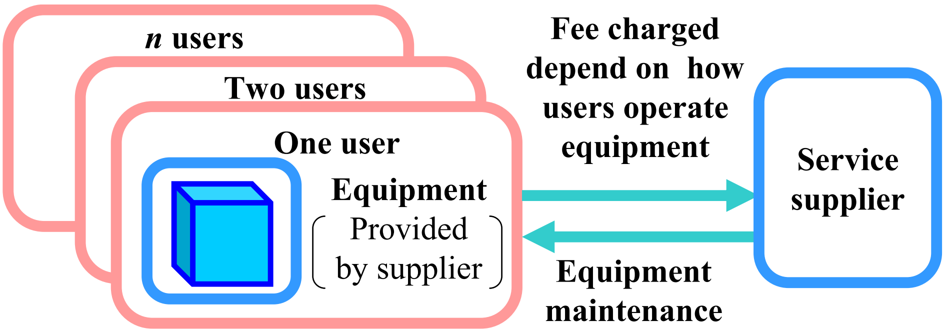

Figure 1: Traditional Business Model for Equipment-providing Service

The amount of risk is defined by the area within the predicted profit range, as shown in Fig. 2. Past operation data and benchmark data are used to predict profits. More specifically, if the standard deviation for the profit of a certain service, *i*, is σ_i, the amount of risk for *i* is given by

$$P(i) = a_i \sigma_i \quad (1)$$

Where a_i is a constant set for each *i*. a_i is necessary to think whether to prepare the preparation cost to the risk how much. In a word, the provider compares *P(i)* with the investment standard of the risk. Service *i* include equipment components $E_{i1}, E_{i2}, ..., E_{im_i}$. A normal distribution is assumed here for simplicity although the values will differ when the distribution is not normal.

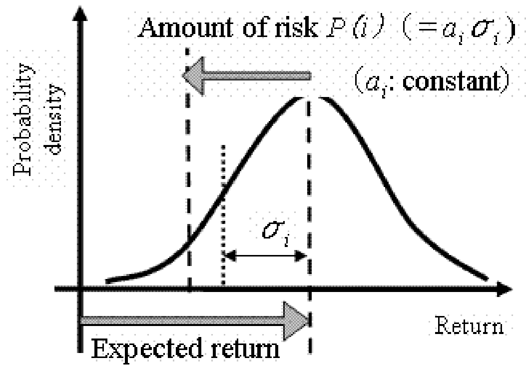

Figure 2: Definition of Amount of Risk

2.2. Problems

One problem with the traditional approach is that the equipment provider must estimate constant a_i for each user. This is done based on the provider's experience with the user, the provider's intuition and strategy, and the reliability of the equipment. The service price is determined based on the amount of risk and the cost of the equipment being provided.

Another problem is that, although the risk is quantified and taken into account, the effect of diversification through servicing to different users is not. Moreover, there is no way of reflecting the service price when the risk premium is changed by a_i. Quantifying the total amount of risk using portfolio theory solves the problem of determining the service price. Moreover, lower estimates for the risk enable the provider to reduce the price and still retain profitability, which would improve price competitiveness. Here, the variance and covariance are determined before pricing the service. The purpose of the paper is to make a proposal for a risk premium.

A further problem is that, even if the user wants to extend the contract due to a favorable risk premium, the provider may not agree. This is because the provider would have to update all of its contracts to reflect the change.

In addition, the best portfolio cannot be selected. The price is decided from the combination of customers for whom service is provided.

3. Portfolio Approach

3.1. Quantification of Portfolio Effect

A portfolio is a combination of various assets owned by an investor. By investing in various assets with different risk characteristics, an investor can reduce the overall risk. An equipment provider holds a portfolio of service contracts, and each contract can be considered an asset. The risk associated with each contract can be reduced by combining many contracts for which the profitability depends on various factors, such as the type of industry and geographic region. The degree of risk reduction achieved through such diversification can be quantified.

The overall risk of a portfolio is computed using the variance and covariance of the returns generated by the contracts therein. In this way, a linear relationship between the portfolio return and effective risk can be established. The expected portfolio return is the linear sum of the expected return for each random variables X_i $(i=1,2,...,n)$:

$$E(X) = \sum_i c_i E(X_i) \tag{2}$$

where $c_1, c_2, ..., c_n$ are constants and $E(X_i)$ is the return on service i.

The standard deviation is expressed by

$$S(X) = \sqrt{\sum_{\mathrm{i}} \sum_{\mathrm{j}} c_i c_j \sigma_{ij}} \tag{3}$$

where X is the portfolio, c_i is the investment rate for asset i, σ_{ii} denotes the variance in the return for asset i, and σ_{ij} denotes the covariance between the returns for assets i and j [6]. Equation (3) is generally used for calculating the return on a portfolio of stocks when assets are distributed to each brand. However, since an equipment provider cannot distribute the services it provides, we consider the sum of service by assuming that $c_i = 1$ $(i = 1, 2,..., n)$. That is,

$$S(X) = \sqrt{\sum_{\mathrm{i}} \sum_{\mathrm{j}} \sigma_{ij}} \tag{4}$$

The amount of risk is defined using Eq. (4). Here we define the amount of risk for a portfolio using $S(X)$ and an arbitrary constant, a:

$$Q = aS(X) \tag{5}$$

Constant a is adjusted based on the service supplier's experience, intuition, and strategy; it can also be determined using a value at risk (VaR) approach. VaR is a risk index that indicates the maximum amount of potential loss statistically determined for a fixed confidence interval when financial assets are held for a fixed period. If we assume that the returns from each contract follow a normal distribution for an equipment-providing service and that the period of equipment usage is fixed, a can be determined by setting a confidence interval. For example, for a 95% confidence interval, a is 1.96 [1]. Constant a can be determined from a normal distribution table. The above-mentioned approach is one example of the idea. Here we simply assume $a=1$. When agreeing to a contract, an equipment provider should ensure that the amount of risk, Q, associated with that contract does not exceed the permitted amount of potential loss.

3.2 Pricing of Portfolios

We explained how the total risk taken on by an equipment provider can be computed in Section 3.1. Because of diversification, the total risk is less than the simple sum of the risks for the contracts since the returns from the contracts will have less than perfect correlation. Denoting the standard deviation of the return for each contract as σ_i, we can express the effectiveness of diversified investment as

$$S(X) \le \sum_i \sigma_i \tag{6}$$

Given the lower risk to which it is then exposed, the provider can reduce the pricing of a contract. By accurately calculating the risk, the provider can determine the minimum value of a contract, for example, and use this as a basis for negotiating the contract. The provider controls the risk by changing the price, whereas a stock investor controls it by changing the number of shares held. With the conventional approach, each risk premium is based solely on the risk of the contract, and the price is determined based on the premium and the cost of providing the equipment. However, since the total risk to which a provider is exposed also depends on the effect of diversification, each contract price can reflect the savings achieved through diversification. Moreover, since the amount of risk differs with the type of business in which each equipment user is engaged, the price reflects this source of risk. When the risk associated with a contract is specifically expressed as Eq. (1), the risk premium for service *i* is expressed based on the amount of portfolio risk, *Q*:

$$P'(i) = Q \frac{a_i \sigma_i}{\sum a_i \sigma_i} \tag{7}$$

That is, P'(i) is calculated based on the proportional division of the total risk for all contracts, thereby taking the amount of risk for each contract into account in each contract.

3.3 Risk Reduction Rate

The provider can better negotiate the service price during negotiations by using the results of Eq. (7). Risk premium *P'(i)* is determined by multiplying the amount of risk for each contract, $a_i \sigma_i$, by risk reduction rate *R*. This rate is the ratio of the total amount of risk calculated using the proposed approach to that calculated using the conventional one:

$$R = \frac{Q}{\sum a_i \sigma_i} \tag{8}$$

We defined *R* by equation (8). *R* can determine equation (8) or from the following experiment results. From Eqs. (1) and (8), we can see that risk premium *P'(i) = RP(i)*. We can simplify the calculation of *P'(i)* by calculating the risk reduction rate as follows. The price for service *i* is $E = C_i + RP(i)$, i.e. the cost plus the risk premium. The risk premium is *RP(i)*. Because the risk premium is smaller the smaller the *R*, it is important to reduce *R*. If variation is the relation between reverse-correlation and the variations in all service fees are the same, the variations in service fees for two customers is counterbalanced. In other words, the correlation coefficient for two services should ideally be -1. The same holds for more than two customers. There are actually variations in the fees, and if the number of customers increases, it becomes difficult to combine services that will create a mutual relation between reverse-correlations. From Eqs. (4) and (5), the risk reduction rate in Eq. (8) can thus be calculated using

$$R = \frac{a\sqrt{\sum_i \sum_j \sigma_{ij}}}{\sum a_i \sigma_i} = \frac{a\sqrt{\sum_i \sigma_{\mathrm{i}}^2 + \sum_{i \ne j} \sigma_{ij}}}{\sum a_i \sigma_i} \tag{9}$$

where $\sigma_{ii} = \sigma_i^2$. Assuming that the standard deviation of each service is the same, that is $\sigma_i = \sigma$, Eq. (9) is can be expanded to

$$R=\frac{\sqrt{n\sigma^2+\sum\sigma_{ij}}}{\text{n}\sigma\sum\frac{a_i}{a}}=\frac{1}{\sum\frac{a_i}{a}}\sqrt{\frac{1}{\text{n}}+\frac{\sum\sigma_{ij}}{n^2\sigma^2}} \tag{10}$$

From Eq. (10), if the standard deviations of all services are the same, the rate of risk is smaller, and the more service objects and variations there are, the smaller the covariance.

We can also write Eq. (9) as

$$R=\frac{a\sqrt{n\overline{V}+n(n-1)\overline{C}}}{n\overline{D}}=\frac{a}{\overline{D}}\sqrt{\frac{\overline{\text{V}}}{\text{n}}+(1-\frac{1}{n})\overline{C}} \tag{11}$$

where the mean value for the amount of risk, $a_i\sigma_i$, for each service is $\overline{D}$, the mean value for variance σ_i^2 is $\overline{V}$, the mean value for covariance σ_{ij} is $\overline{C}$, $\overline{D}=\frac{\sum a_i\sigma_i}{n}$, $\overline{V}=\frac{\sum\sigma_i^2}{n}$, and $\overline{C}=\frac{\sum\sigma_{ij}}{n(n-1)}$.

4. Evaluation

4.1 Method

We evaluated the effectiveness of our proposed method based on a study of an actual equipment-providing service. The users are provided with equipment (primarily a motor and inverter) and the lease fee is based on a fixed rate and the amount of the equipment is used. We evaluated the service's effectiveness by comparing the service fees against fictitious data based on the mining and manufacturing index published by the Ministry of Economy, Trade and Industry in Japan [2]. Because the fee is partially determined by the amount of equipment usage, there is a high correlation between the value of production and the extent to which the equipment had been used. A constant is multiplied by the value of production to determine the charge. The fictitious data was prepared as follows.

1. Various types of business data were extracted from the mining and manufacturing index for a 60-month period (January 1998 to December 2002).
2. The constant was multiplied by the value of production for each type of business. The result was assumed to be the fee charged by the provider.
3. For each month, 104 fees were calculated.

The fees for five example services are plotted in Fig. 3, and the average fee is plotted in Fig. 4. The standard deviations and average for the five-year period are listed in Table 1; the covariances for each service are listed in Table 2. As shown in Fig. 4, the overall risk is reduced by combining the five services into one portfolio.

Calculation of *R* using the prepared fee data showed that combining services into one portfolio reduces the amount of risk. The calculation was done as follows.

1. The constants were assumed to be 1, and the number of customers, *n*, was *5, 10, 20, 30,* or *50.*
2. The data for the n customers was randomly extracted from the prepared data, and $\sum a_i\sigma_i$ and *Q* were calculated.
3. The mean values of $\sum a_i\sigma_i$ and *Q* were repeatedly calculated 50 times.
4. Each mean value in Step 3 was substituted into Eq. (8), and *R* was calculated.

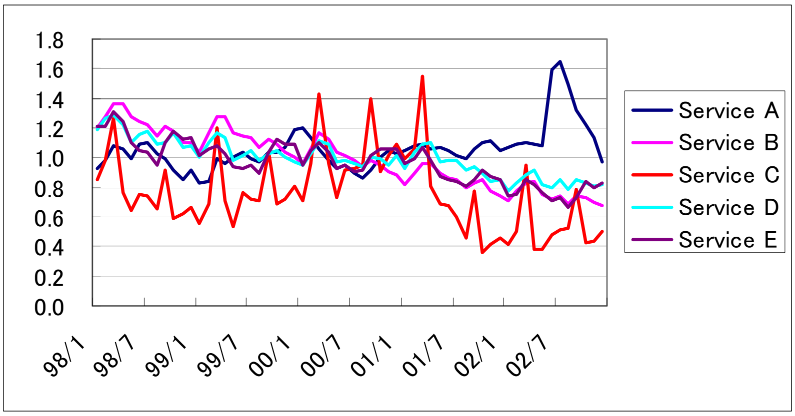

Figure 3: Example fee Data

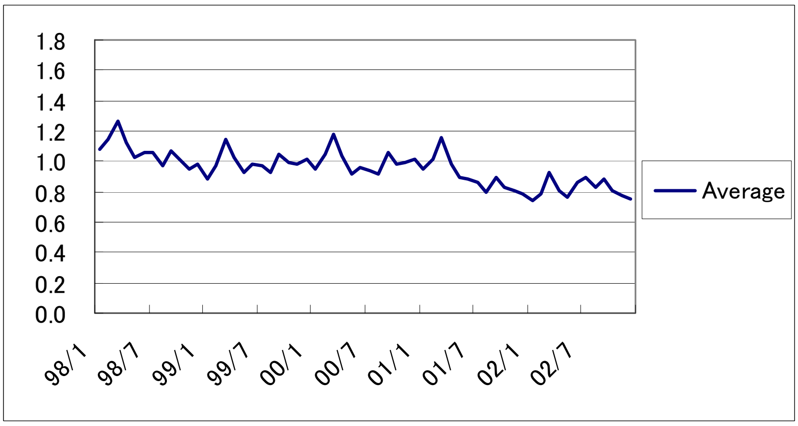

Figure 4: Average for Example fee Data

Table 1: Standard Deviations for fee Data

Service	A	B	C	D	E	Average
Standard deviation ($\times 10^5$)	1.53	1.92	2.69	1.24	1.44	1.15

Table 2: Covariances for fee Data

Service	A	B	C	D	E
A	23.2	-13.7	-9.1	-8.5	-11.0
B	-13.7	37.0	21.9	22.2	23.3
C	-9.1	21.9	72.4	17.9	21.1
D	-8.5	22.2	17.9	15.5	15.9
E	-11.0	23.3	21.1	15.9	20.8

4.2 Results

Table 3 lists the risk reduction rate calculated using the procedure described above. It shows that the service charges can be reduced by using the proposed method. The effect increases as the number of users increases; however, it eventually saturates at about 50 users.

Table 3: Amount of Risk and Risk Reduction Rate

n	$\sum a_i \sigma_i$	Q	R
5	599319	437715	73.0
10	1206627	794528	65.8
20	2675378	1650169	61.7
30	3950569	2325690	58.9
50	6378055	3623491	56.8

4.3. Effect of Variance and Covariance

We further investigated the relationship between the number of customers and the average risk reduction rate, which decreases as the number of customer increases. The mean obtained from the 50 calculations differed depending on the combination of services. We calculated the standard deviations for the risk reduction rate for these 50 calculations. Figure 5 plots the average rate and the standard deviations against the number of customers.

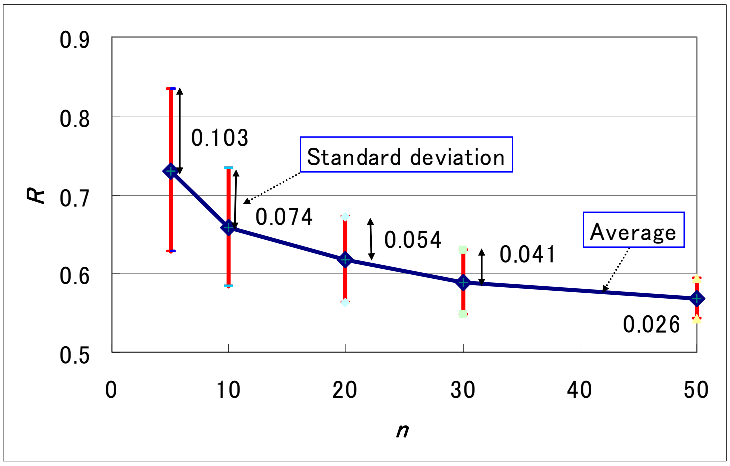

Figure 5: Average Risk Reduction Rate vs. Number of Customers

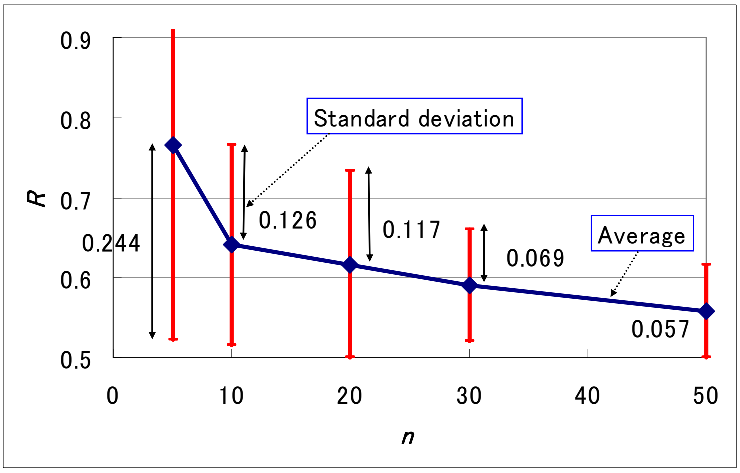

Figure 6: Average Risk Reduction Rate vs. Number of Customers $(0.5 \leq a_i \leq 2)$

As shown in Fig. 5, when the number of service customer increases, the average risk reduction rate drops. In other words, by increasing the number of customers, a supplier obtains rates of risk approaching those in Table 3, no matter which services are combined. It is thus important to increase the number of service customers in order to stabilize services. We also calculated the D'Agostino-Pearson and Jarque-Bera statistics for the data. Both follow a χ^2 distribution with two degrees of freedom with a significance level of 5%; 82 of the 104 distributions were close to normal. If all the data in Fig. 5 were assumed to have a normal distribution, the probability from the expected value to a value 1.96 times the standard deviation would be 95%, i.e. $51.7\% \leq R \leq 61.9\%$ for $n = 50$. This means that $R = 61.9\%$ can be determined for $n = 50$ even when user fee data is unavailable.

We then randomly selected values from 0.5 to 2 for a_i; a was assumed to be the mean of a_i for all services. Figure 6 shows that the rate of risk decreases as the number of customers increases and settles at about *55%*. Moreover, because the rate of risk increases if a is much larger than the mean of a_i, the rate of risk is determined by the relationship between a and a_i.

Let us now consider why the rate of risk does not fall below a certain value even when the number of customers increases. When n increases, Eq. (11) can be approximated as

$$R = \frac{a\sqrt{\overline{C}}}{\overline{D}} (n \to \infty) \tag{13}$$

(A) A precise solution with Eq. (11) and (B) an approximate solution with Eq. (13) were obtained for 50 repeated calculations using the procedure in 4.1 for $n = 10, 20, 30,$ and 50, and the means are listed in Table 4. The margin of error between the precise and approximate solutions was *8.3%* for $n = 50$, and this was small with an increase in n. When n is large, risk reduction rate R is determined by the mean for covariance $\overline{C}$ and the mean amount of risk for each service, $\overline{D}$, and constant a.

Table 4: Risk Reduction Rate

N	(A)	(B)	((B)-(A)) / (A)
10	65.8	46.8	-28.9%
20	61.7	49.6	-19.6%
30	58.9	50.8	-13.8%
50	56.8	52.1	-8.3%

Calculation of the rate of reduced risk using the procedure in 4.1 showed that the amount of risk for each service, $\overline{D}$, was within the range 0.9×10^5 to 1.7×10^5. Figure 7 plots the relationship between the risk reduction rate and the mean of covariance $\overline{C}$, assuming that $\overline{D}$ and constant a are fixed. If $\overline{D}$ and $\overline{C}$ change, R changes as shown by the curves in Fig. 7. However, R is actually almost constant (*50–60%*). Therefore, $\overline{D}$ and $\overline{C}$ have specific values.

Figure 8 plots the relationship between the risk reduction rate and the mean for the amount of risk, $\overline{D}$. Figure 9 plots the relationship between R, and the mean for covariance $\overline{C}$. There is a tendency for both value to settle as the number of customers increases.

It is thus possible to reduce the amount of risk to a maximum of *55%* by comparing past risk premiums with the increase in n.

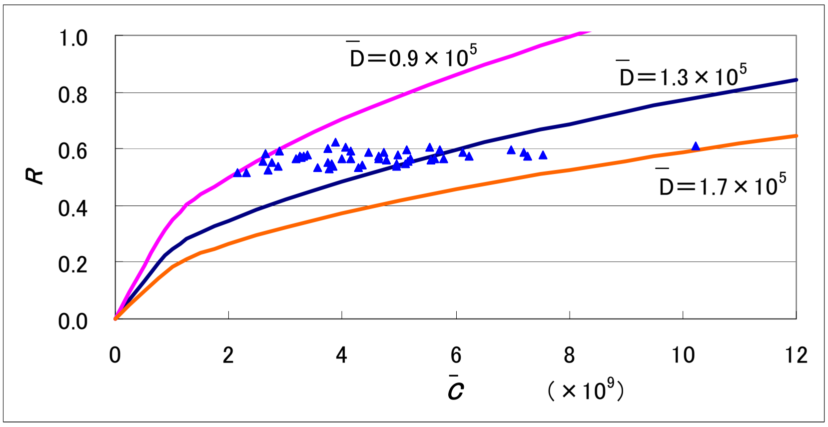

Figure7: Relationship Between Average Covariance and Risk Reduction Rate

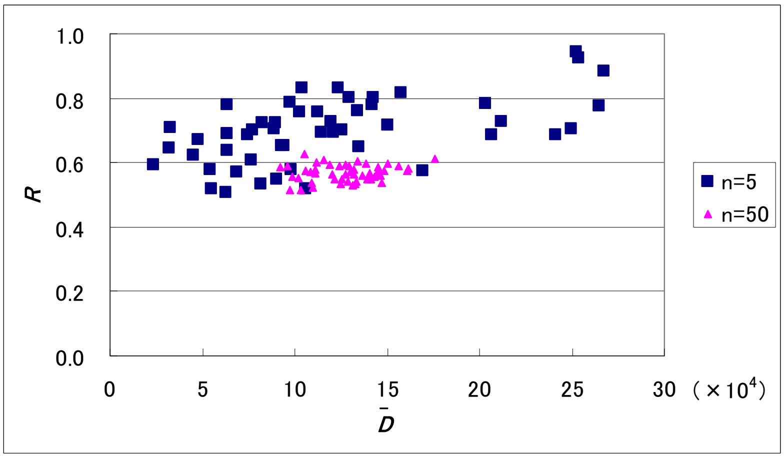

Figure 8: Distribution of Average Amount of Risk

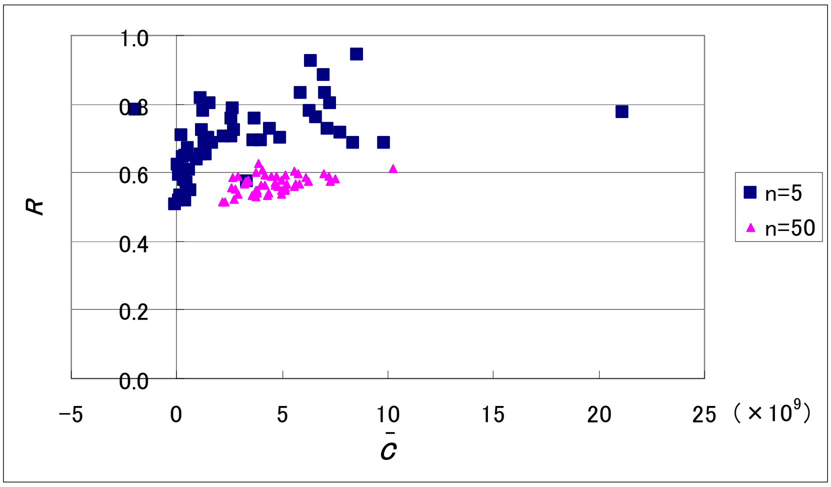

Figure 9: Distribution of Average Covariance

4.4. Research contribution

Our finding that it is possible to reduce the amount of risk to a maximum of *55%* by comparing past risk premiums with the increase in n was based on production amount data provided by the Ministry of Economy, Trade and Industry in Japan. Equipment-providing services as a whole can use this value because there is a high correlation between the amount of equipment usage and the amount of production, and equipment-providing services generally base their fees on the amount of usage and/or the length of time the equipment is used. An equipment-providing service expanding its business should thus find our 55% risk decrease rate useful.

5. Conclusion

We have shown that an equipment provider holding a portfolio of contracts can lower its service prices by taking into account the risk reduction achieved through the diversification effect of its portfolio of services.

Using industry data obtained from the Ministry of Economy, Trade and Industry, we showed that the maximum effect is about a 55% reduction in risk.

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