The pricing method of the purchase option by the book value for equipment service

Shigeyuki Tani, Tadasuke Nakagawa, and Norihisa Komoda

***Abstract*—**In the equipment service some users appear who want to buy the equipment. But, the equipments which users want to buy are high performance. Venders want to sale by the time value, but users want to buy by the book value. So the problem occurs that the price negotiation becomes a rough. To this problem we service the purchase option by book value. In this paper we propose the pricing method of the purchase option using the real option evaluation. And we evaluated the value of the purchase option for the energy sercie by this method. By our method the price negotiation becomes unnecessary, and the profitability of vender can be saved by the right sales.

***Keywords*—** Equipment service, Real option, Book value, Time value, Price negotiation

I. Introduction

RECENTLY in Japan the investment in equipment is often kept at a distance. Because the risk is expected by earnings in the future, the equipment service increases. Equipment service is the service in which venders do not sell out equipments but they offer users equipments free of charge and collect the charge from the advantage by operation of equipments. The examples of such services are the outsourcing service and the ESCO (Energy Service Company) serivice, etc.

The features of equipment services for users compared with equipment sales are that investment risk is not owed because initial cost is unnecessary, and operation risk is not owe because of pey-par-use.[1] By these features users who cannot buy the equipment by feeling the uncertainty in the effect. However, when users use the equipment through service, they can experience the effect and confirm it. Then uncertainty which obstructs purchase is excluded, and users appear who want to buy the equipment.

The equipments which users want to buy are always high effective equipments. So the equipments are high profitable equipments for venders because of pay-par-use. Therefore, if venders do not sell the equipments by high price, then the profitability of venders decreases. For this problem the pricing method based on the time value in bought point is proposed.[2] But users always think equipment price by the book value which is unrelated to the size of effect. So they cannot consent to buy it by high price even if effect is large. Actually, the problem occurs that the price negotiation becomes a rough, and at the end the equipment is bought by the book value.

To this problem, we service the right to buy the equipment by the book value. And in this paper we propose the pricing method of the purchase option for equipment service. By this method the price negotiation becomes unnecessary and the profitability of service portfolio can be saved by the right sales.

Manuscript received xxxx x, 2011: Revised version received xxxx x, 2011.

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II. Equipment Service

Equipment service is the service in which venders do not sell out equipments but they offer users equipments free of charge and collect the charge from the advantage by operations of equipments.

By these service, venders excavate equipment effect that has been buried in user's factory. Venders can offer users these equipments without debt.

A. *Energy saving service by motor drive*

In the energy saving service by motor drive venders do not sell out inverters. The inverter is the energy saving equipment. Venders offer inverters free and collect the energy saving advantage by operations of inverters.By this service venders excavate energy saving resource that has been buried in user's factory.

Fig. 1 shows the outline of the energy saving service by motor drive. First of all, a vender sells off an inverter to a leasing company. And the vender offers a user the inverter free while paying for the leasing company the lease charge.

Here, inverters are equipments that control rotational speed of motors. The power consumption of motors change according to rotational speed of them. Therefore when users srive moters with inverters the power consumption can be saved more than when users drive only motors.

Based on the power saving advantage by the inverter that the vender offered, both the user and the vender receive the difference between the cash in and the cash out which is shown in Table 1. The cash in of users is an energy saving advantage by the equipment operation. And the cash out of users is a service charge calculated from an energy saving advantage.

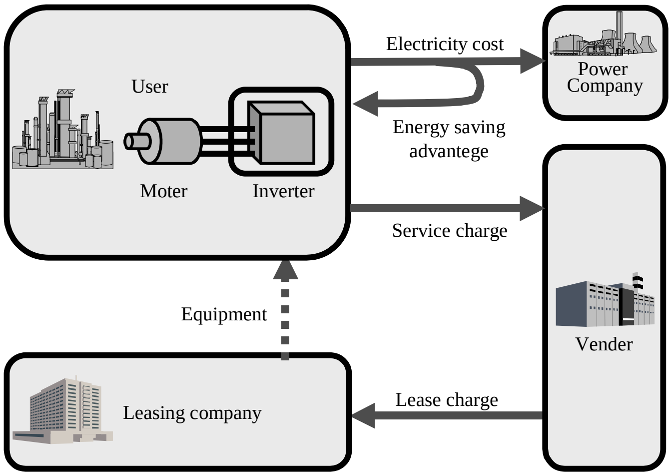


Fig. 1 Conservation of energy service by motor drive

Table 1 list of Cash flow

player		item
User	cash in	conservation of energy advantage
	cash out	service charge
Vender	cash in	service charge
		lease charge
		maintenance expense
		construction expense

On the other hand, the cash in of venders is a service charge calculated from an energy saving advantage. The cash out of venders are “lease charge", "maintenance expense", and "construction expense". These are the costs that users bear in generally.

B. Risk factors of the service

The difference of power consumption between the case of the inverter is introduced and the case of the inveter does not introduce is a energy saving advantage. And this energy saving advantage is an effect of the equipment introduction. And power consumption changes by the rotational speed of moters, so the effect of the equipment changes by the rotational speed of motors.

Fig. 2 shows the relation of the rotational speed and power consumption in the case of the inverter is introduced and in the case of the inverter is not introduced. The black-bold line shows the case of the inverter is not introduced, and the gray-bold line shows the case of the inverter is introduced. The difference between the black-bold line and the gray-bold line shows the energy saving advantage. If the rotational speed is low, the energy saving is large, and if the rotational speed is high, the energy saving is small.

Fig. 3 shows the one example of the distribution of a moter rotational speed for one year. The equipment effect changes by the user’s operation of the moter, for instance, the moter operation time in one year and the rotational speed of motor in the period of service. Therefore, the income of venders becomes unstable by user's operation, because the income of venders changes by the effect of equipments. Venders bear user’s operation risk with users.

As shown in Table 2, there are risk items of specializing in user's industry and product, for instance, (1) the change risk of rotational speed of motor and (2) the change risk of motor operation time.

In addition, there are risk items concerning changes in the market which influence the electricity cost and the lease cost, for instance, (3) the change risk of power price and (4) the change risk of interest rate.

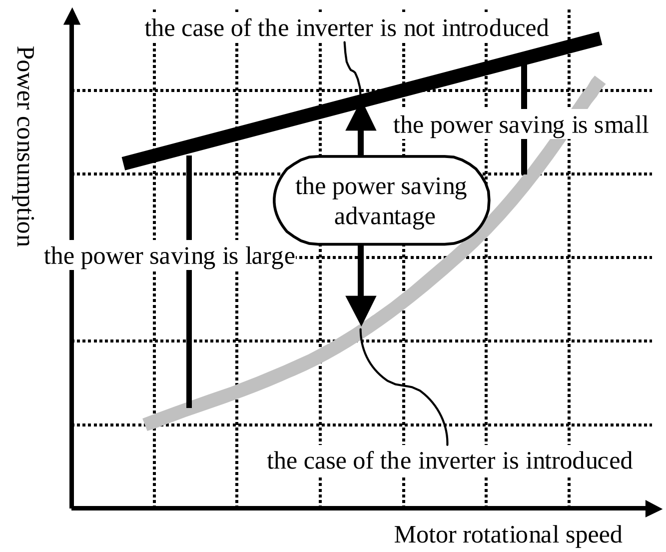


Fig. 2 Motor rotational speed vs. power consumption

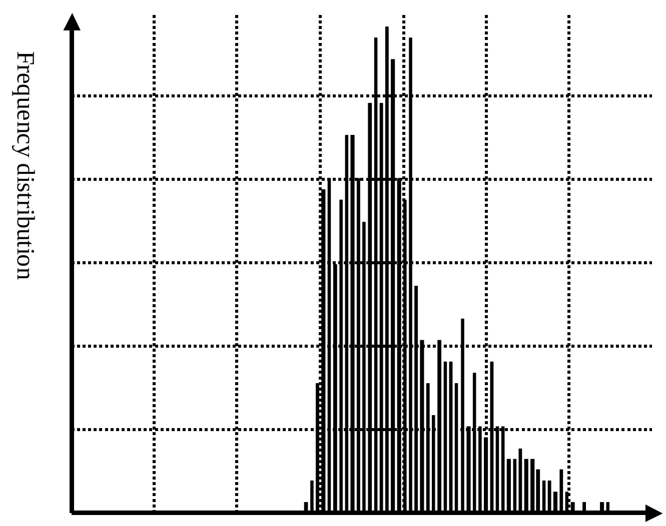


Fig. 3 Distribution of the motor rotational speed for one year

Table 2 list of risk

Risk item	Type of risk
the change risk of rotational speed of motor	Risk of specializing in user's product
the change risk of motor operation time	Risk of specializing in user's industry
the change risk of power price	Risk concerning changes in the market
the change risk of interest rate	Risk concerning changes in the market

C. Risk factors of the service

Fig. 4 shows time series of vender's accumulation cash flow for ten years. And Fig. 5 shows time series of user's accumulation cash flow for ten years. Three time series are shown, maximum series, minimum series, and average series.

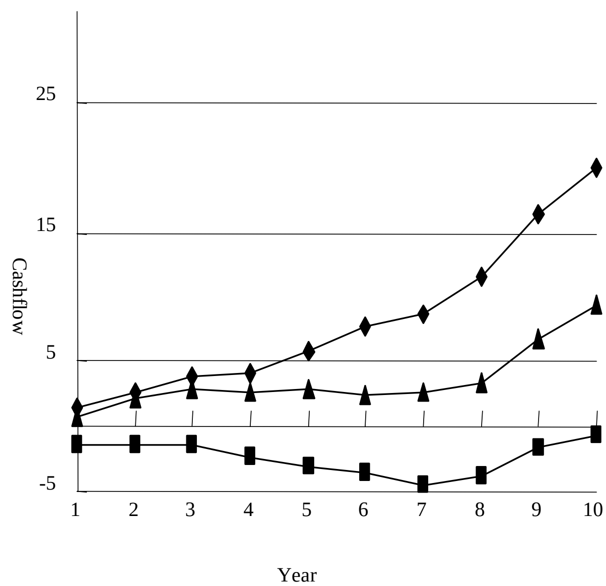


Fig. 4 Time series of Vender's accumulation cash flow

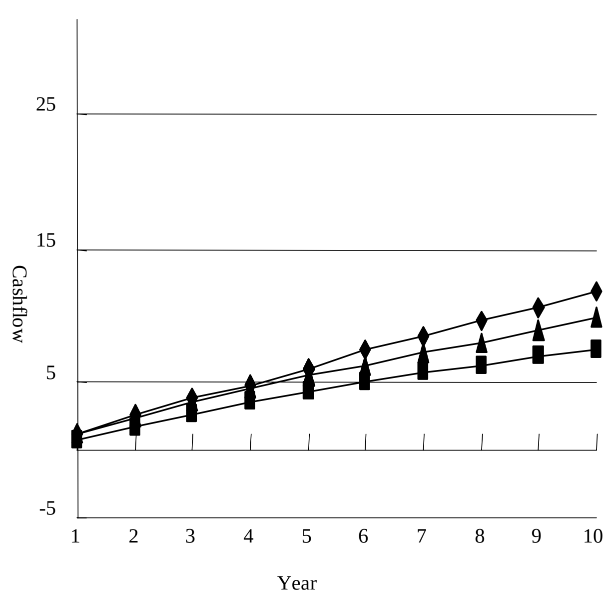


Fig. 5 Time series of User's accumulation cash flow

In Fig. 4 and Fig. 5, the service charge is set that the average of accumulation cash flow after ten years becomes same by the vender and the user.

Therefore, when the service charge is set that the average of accumulation cash flow becomes same, the vender is influenced from energy saving advantage change compared with the user who doesn't pay an initial cost.

Fig. 6 shows distribution of vender's accumulation cash flow after ten years. And Fig. 7 shows distribution of user's accumulation cash flow after ten years. Vender's range of the earnings forecast is larger than user's range of the earnings forecast. The vender should collect fixed costs, lease expense, maintenance expense, and construction expense by the energy saving advantage.

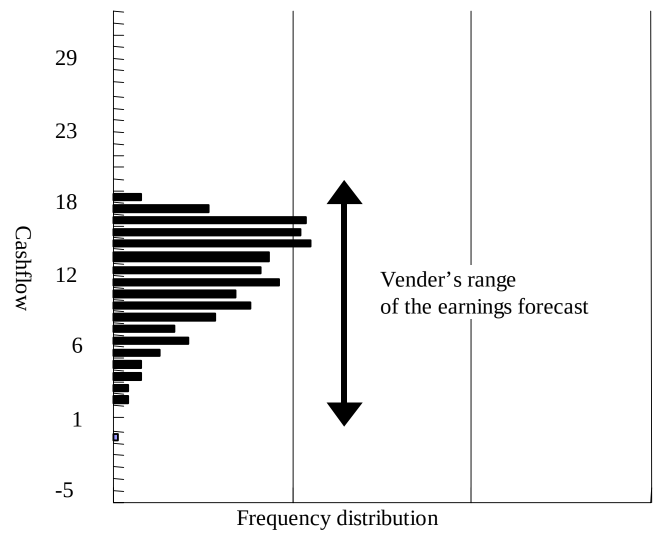


Fig. 6 Distribution of vender's accumulation cash flow after ten years

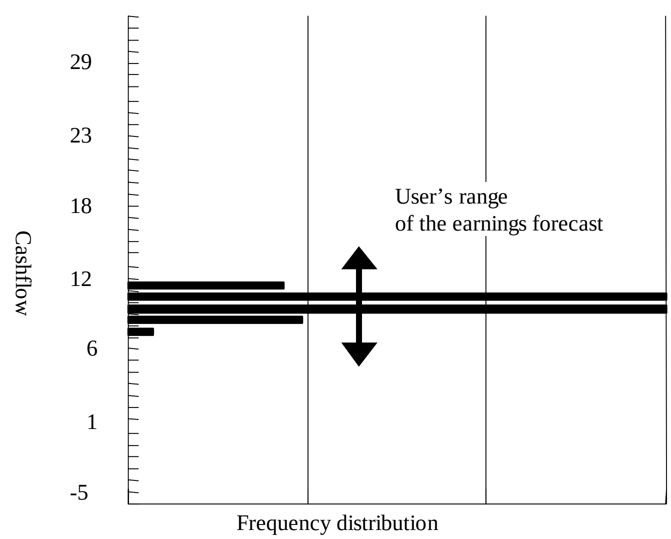


Fig. 7 Distribution of user's accumulation cash flow after ten years

III. TRADITIONAL METHOD

In equipment services, equipments that user become to wants to buy are high performance equipments. So they are high profitable equipment for venders. To prevent profit decrease in the service portfolio, venders should sell them in higher price than the book value. For this problem, the traditional pricing method is general based on the effect of use at purchase timing (=time value).

A. Traditional evaluation method

As the evaluation method of time value at the purchase timing, for example in the M&A, the method based on stock prices are proposed.[3] Moreover in the IT property, the evaluation method which convert the value of IT equipment into the financial numerical value is proposed.[4] In the method, at first the value index is defined and the improvement value before and after use equipment is set, and finally financial numerical value is calculated. A general expression of the time value is (1).

$$TV = AP \times (UY - PY) \tag{1}$$

$TV\,[Yen]$: Time Value

$AP\,[Yen/year] = \dfrac{\sum_{i=1}^{PY} \mathrm{Pr}\,ofit(i)}{PY}$: Year's Average Performance

$UY\,[year]$: Statutory useful life years

$PY\,[year]$: Possesion years = purchase timing

B. Problem of the traditional method

On the other hand there is cost redemption method which calculates value on corporate accounting. The book value by the cost redemption method is uniquely calculated at the purchase price and the possession years. A general expression of the book value is (2).

$$BV = PP \times \left(1 - \frac{PY}{UY}\right) \tag{2}$$

$BV\,[Yen]$: Book Value

$PP\,[Yen]$: Purchase Price

And the book value is unrelated to the performance of equipment. Even the equipment with high performance, users cannot consent with purchasing by a high price compared with the book value.

As shown in Fig. 8, in the traditional evaluation method, two values of the book value and the time value are calculated at purchase timing. Therefore, even if the calculated time value is appropriate, user's agreement is not obtained in price negotiation. Because the time value is higher than the book value in the case of the high performance equipment, as shown in Fig. 9.

IV. THE NEW METHODS

To this problem, we propose the method to sell users the right to buy equipments by the book value (=the purchase option) at service beginning.

As a result, at begging we answer the hope of users who want to buy the equipment by the book value. Secondarily, the price negotiation can be evaded at the purchase timing.

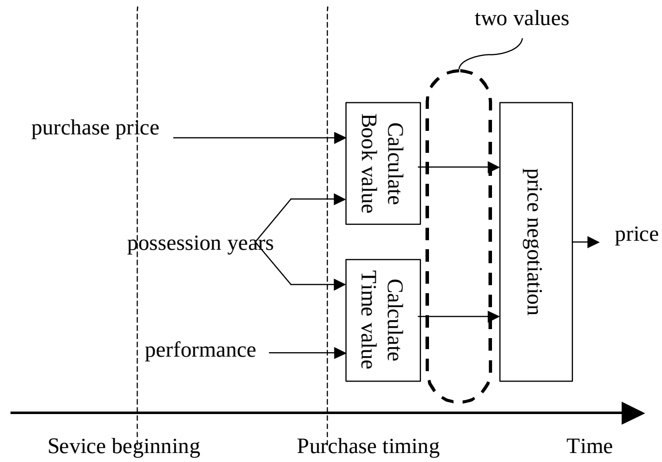


Fig. 8 the traditional pricing process

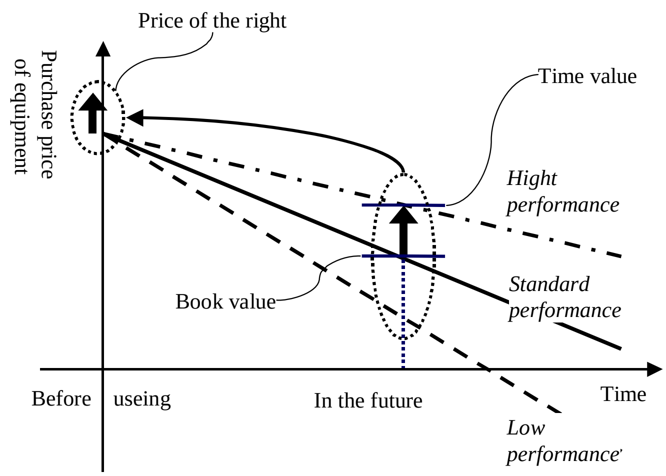


Fig. 9 Relation between book value and time value

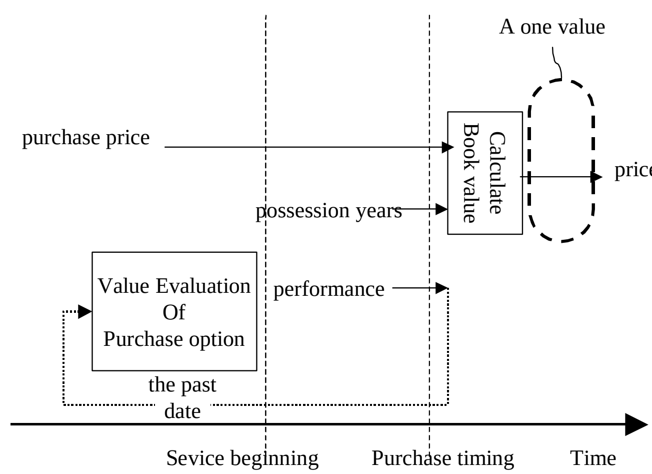


Fig. 10 The new pricing process

Furthermore, by the right sales the profitability of the service portfolio is kept. In this paper to achieve the purchase option sales we propose the method of evaluating the value of the option before using service. By this method the value index at the purchase timing becomes only the book value (Fig. 10).

A. Real option evaluation method

In the situation with uncertainty in the future and the decision making that cannot go back, real options are right that can be chosen after certainty in the future goes up.

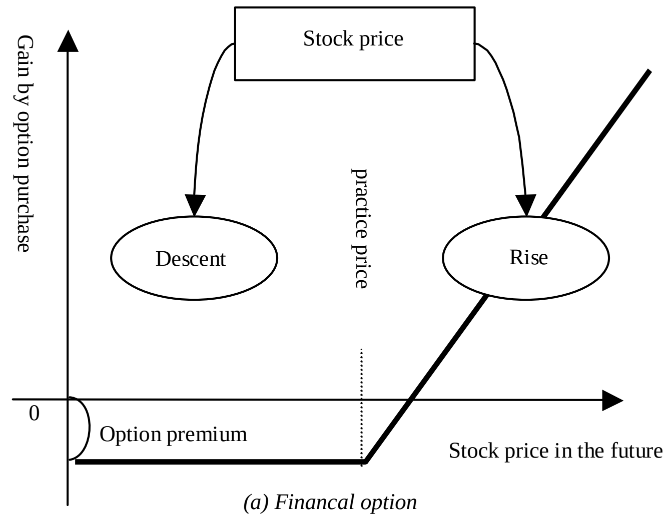
The degree of freedom of decision making goes up with these options. This improvement of degree of freedom has value, the method of quantitatively evaluating the value has been researched.[5][6][7] Because the gain variation of these options against uncertainty are similar to financial options, they are called real options. The method of quantitatively evaluating value of real options is called real option evaluation method.

Fig. 11 (a) shows the characteristic of the gain variation in financial options. Financal options are right to buy or to sell stocks in the future by decided price (practice price).

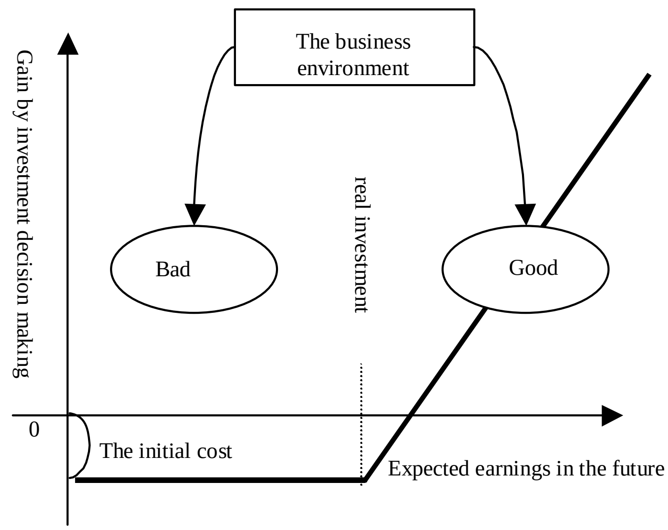
As shown in Figure 11(a), when stock prices rise the gain is received by exercising the option. On the other hand, when stock prices descend the loss is stopped in the option premium because the option is not exercised. For these reasons, the loss can be decreased comparing with keeping only stocks.

Fig. 11 (b) shows the characteristic of the gain variation of real options. The real options are right that decision making of canceling business or expansion of business according to change in business environment.

As shown in Figure 11(b), when the business environment is good the business earnings more than the real investment are obtained by the business expansion. On the other hand, when the business environment is bad the loss can be stopped only in the initial cost by the canceling business. The gain variation is similar to the gain variation of financial options in which the downside loss is limited and the upside profit is keeped.



(a) Financal option



(b)Real option

Fig. 11 Real option and financial option

B. New Evaluation method

The performance of the equipment in the future is uncertain, it becomes low or high, by the using of the equipment.

There are the following characteristics with purchase options in the equipment service. When seeing from users' side, in the case of high performance equipment, users receive the gain between the boid line and one point short dashed line as shown in Fig. 9 because they exercise the option. On the other hand, in the case of low performance equipment, users do not receive the loss because they do not exercise the option. When seeing from venders' side, sales increase by the right sales. On the other hand, a part of the expectation sales of the service portfolio is lost because the right are exercised to the high performance equipments.

Then in evaluation method of the value of the purchase option, as shown in Fig. 12, is composed 1) the option value evaluation part that calculates user's value and 2) the service portfolio evaluation part where vender's sales trade-off is evaluated.

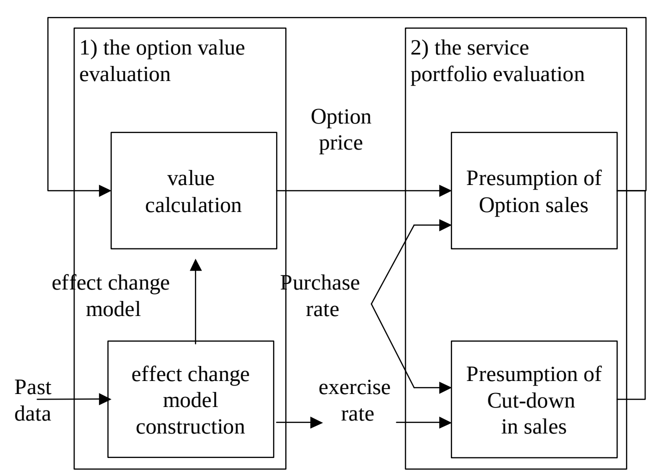


Fig. 12 Value evaluation method of purchase option

1) The option value evaluation part

The option value evaluation part is composed with the effect change model statistically presumed from past operation data, the book value calculation model based on depreciation and the option model by which the payoff characteristic is shown.

a) The effect change model

The effect generation is assumed to be a random walk. The effect change model after time of Δt is defined as (3).

$$\Delta E(t) = \mu\Delta t + \sigma\Delta z \tag{3}$$

μ : Trend of the effect change

σ : Volatility of the effect change

Δz : Increment of standard Weiner process (Average : 0 , Decentrali zation : Δt)

The effect of the equipment use in t=k is presumed to be (4) in the future.

$$E(k) = E(0) + \sum_{i=1}^{k} \Delta E(t) \tag{4}$$

b) The book value calculation model

The book value in t=k is calculated by (5) at the time (= possesion years) in the future.

$$V(k) = \left(1 - \frac{k}{n}\right) V(0) \tag{5}$$

k : Possesion years

n : Statutory useful life years

$V(0)$: Purchase Price

The depreciation ratio rt is defined as (6).

$$rt = \frac{\left(1 - \frac{V(n)}{V(0)}\right)}{n} \tag{6}$$

c) The option model

The payoff of the option is shown in Fig. 13. In the future t=k, the payoff for E(k)-V(k) is obtained by the exercise, when performance E(k) is larger than book value V(k) as (7).

$$\max(0, E(k) - V(k)) \tag{7}$$

d) The option value evaluation

Here, as shown in Fig. 14 (b), the effect change model is a stochastic process generated according to probability distributions. As shown in Fig. 15, probability distribution features are presumed from past operation datas of user's equipments. The solid line is past results distribution, and the boid line is presumption distribution in Fig. 15.

When the optional model is given as shown in Fig. 14 (a), the probability distributions of payoff are presumed according to an optional model as shown in Fig. 14 (c). The option price P is calculated from the center of these probability distributions.

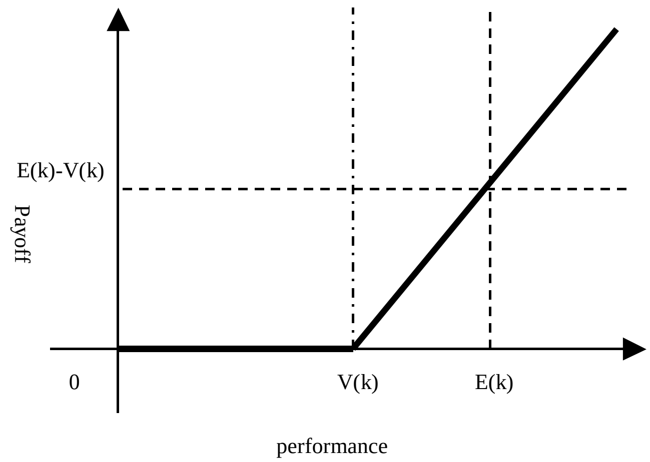


Fig. 13 Option model to performance risk

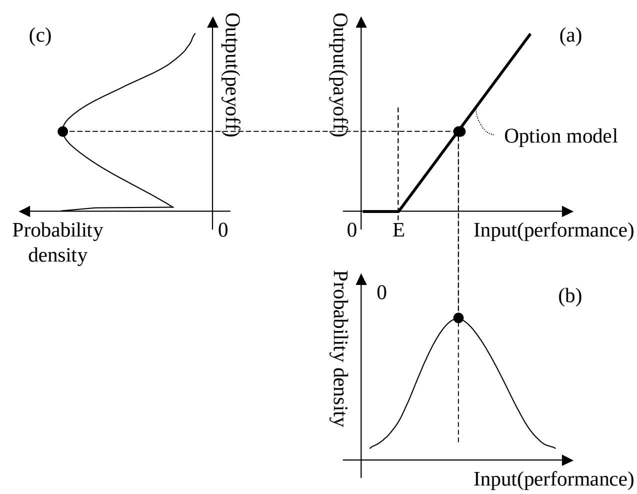


Fig. 14 Evaluation method of option value

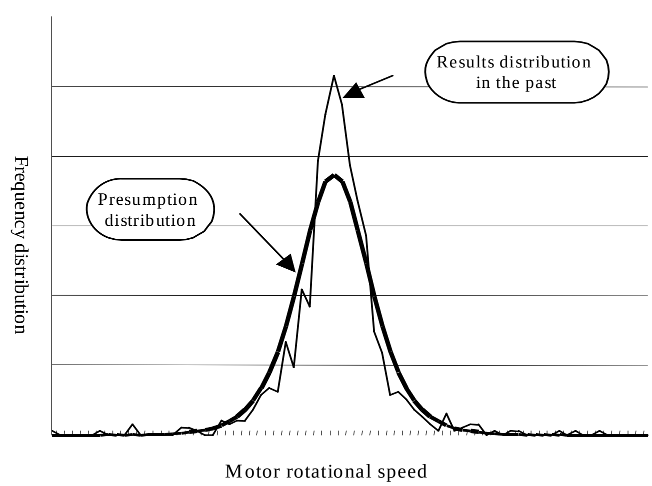


Fig. 15 Presumption of a probability-distributions model

2) The service portfolio evaluation part

The service portfolio evaluation part is composed with the sales increase presumption part by optional sales and the sales cut-down presumption part by the option exercise.

a) Presumption of option sales

At First, the increase of the option sales Ru is presumed as (8).

$$Ru = P \times U \times r \tag{8}$$

U : The number of users

r : The option purchase rate

b) Presumption of cut-down in sales

Moreover, from Fig. 14 (a) and (b), the number of users U' which a performance is higher than the book value appears is presumed. And The decrease of the service Rd is presumed as (9).

$$Rd = (R(k) - P) \times U' \times r \times b \tag{9}$$

U': The number of users who' s performanc e is higher tha n the book value

$R(k)$: The expectatio n performanc e of these users

b : The ratio of users that exercise the option

Here, to answer the following two requests, (1)to reduce the loss as much as possible (vender's request), (2)to be lowered the option price as much as possible (user's request), the option price P (=P_0+dP) is searched by the following objective function (10).

The objective finction :

$$\min(Ru - Rd) \tag{10}$$

$$condition : Ru - Rd \geq 0$$

By dP the payoff of Fig. 13 changes into the payoff of Fig. 16.

V. Evaluation

A. Condition of evaluation

We evaluated the method for the ESCO service in which venders offer the energy conservation equipments free. Here, the energy saving equipments are the inverters that control the rotational speed of the motor.

We assumed the oil maker, because they use a lot of high-pressure moters which we can introduce high-pressure inverters. And we also assumed the boiler ventilation equipment because there are chance to save a lot of energy by the inverters.

Table 3 shows the operational condition of the assumed boiler ventilation equipment. About energy saving, the average is 432Kyen/month, the maximum is 593Kyen/month and the minimum is 65Kyen/month. And the standerd deviation of eneryg saving is 1.06Myen/year. About boiler ventilation, the average is 52.8ton/hour, the maximum is 91.7ton/hour and the minimum is 31.5ton/hour.

B. Evaluation result

Table 4 shows the evaluation result. Fig. 17 shows the accumulation cash flow in the case without the purchase option. And Fig. 18 shows the accumulation cash flow in the case with the purchase option.

The average of payoff without the option is 14.3Myen. And the average of peyoff with the option is 16.4Myen.By compared with the case without the purchase option (Fig. 17) and the case with the option (Fig. 18), the average of peyoff in ten years has improved 2.03Myen. It improves about 14.6% to the average cash flow in the case without the option. And the purchase option price can be set within this margin.

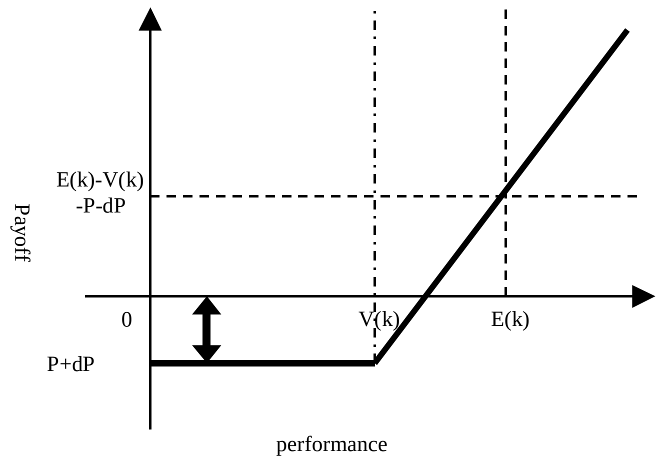


Fig. 16 Option model with Option Price

Table 3 Condition of the equipment

	Average	Maximum	Minimum
Energy saving	432K yen/month	593K yen/month	65K yen/month
Standard deviation	1.06M yen/year	-	-
Ventilation	52.8 ton/hour	91.7 ton/hour	31.5 ton/hour

Table 4 Evaluation result

	Without the option	With the option	Difference
Average of payoff	14.3Myen (100%)	16.4Myen (114.6%)	2.03Myen (14.6%)

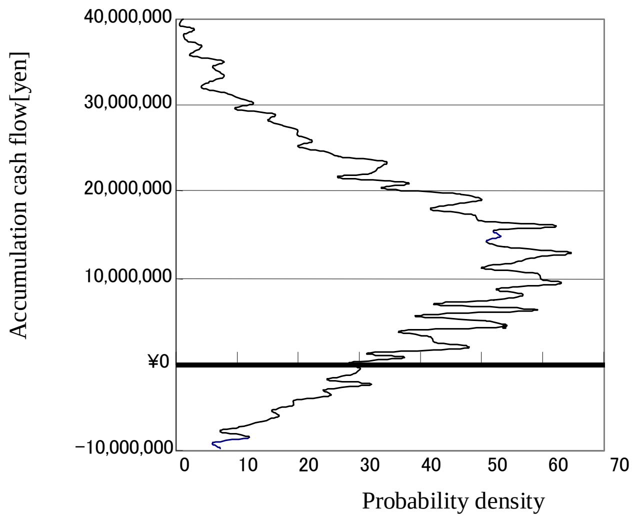


Fig. 17 The case without the purchase option

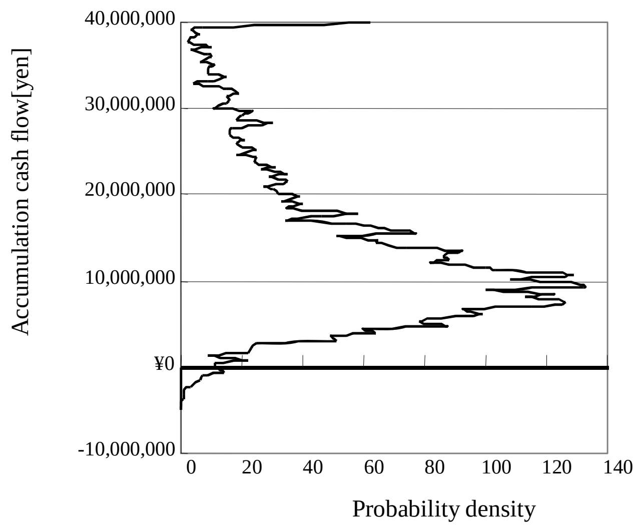


Fig. 18 The case with the purchase option

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