NEGOTIATION ANALYSIS OF RISK ALLOCATION FOR PFI PROJECTS

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Private Finance Initiative (PFI) is characterized by complex negotiations regarding risk allocation. Unlike most previous investigations, this paper approaches the investigation of the risk allocation negotiation in a consistent manner. It explores theoretical implications of risk allocation negotiations for PFI projects between the government client and the private PFI promoter within the framework of negotiation analysis. The investigation focuses on the effect of stakeholders' risk attitude on the negotiation space by applying a risk allocation model to obtain the negotiation space. The investigation identifies that the stakeholders may become contradictory in revealing information on their respective levels of risk aversion before and during the negotiation. Negotiation analysis with a theoretical model provides practical implications for risk allocation negotiations in PFI projects.

Keywords: decision analysis, negotiation, private finance initiative, risk allocation.

INTRODUCTION

This paper explores theoretical implications of risk allocation negotiations for PFI projects between the government client and the private promoter, commonly referred to as the special purpose vehicle (SPV), within the framework of negotiation analysis. The SPV is an organization that has contracted with the client to provide services using the PFI method of delivery.

Risk allocation among stakeholders involved in a construction contract is complex particularly when the PFI method is used. The PFI method of delivery has gained popularity in recent years as an effective vehicle for delivering infrastructure projects in a partnership between the government and the private sector. The PFI method requires the private promoter or SPV not only to build the facility but also design it, finance its development and operate it for a fixed period of time. Clearly, effective allocation of risk to the stakeholders is crucial to the success of the project. Such risk allocation involves a complex process of negotiations. Previous studies have largely focused on the mechanics of risk allocation in both qualitative and quantitative manner as evident by the work of Erikson (1980), Kangari (1995), Snelgrove (1994), Arndt (1998), Arioka (1997) in the former case and Ashley (1977 and 1980), Porter (1981), McKim (1990), Levitt *et al.* (1979 and 1980), Suijis (1999) and Suijis *et al.* (1999) in the latter case. There is a gap in our knowledge of risk allocation negotiations particularly with regard to the PFI method.

Negotiations have been investigated within theories of interactive decision-making such as game theory and social psychology (Young, 1975; Kleindorfer *et al.*, 1993). Game theory assumes fully rational characters of the interaction by abstracting away various descriptive characters. Social psychology focuses on investigations of such

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descriptive characters in decision-making. The emerging framework of negotiation analysis explained by Sebenius (1992) brings those two theories together. Its main focus is on cooperative decision-making with a bounded rational view to the interaction, and on the negotiation space.

A risk allocation model proposed by Yamaguchi *et al.* (2001) defines the negotiation space. This paper applies the Yamaguchi model to investigate effects of stakeholders' risk attitudes on the negotiation space. It will attempt to extract theoretical implications of risk allocation negotiations in PFI projects on both the government client and the SPV.

THE THEORETICAL MODEL

The model proposed by Yamaguchi *et al.* (2001) is an extension of the Ashley (1977) model, which in turn is based on the Borch (1962, 1979, 1990) insurance theory. Table 1 summarizes risk allocation between the client and the SPV during the construction, and operation and maintenance (O&M) phases.

Table 1 Costs and profits after risk allocation

Stakeholder	Wealth	Phase	Cost	Net profit
Government client	w_g	Constr.	$(1-\alpha)\tilde{x}\lfloor\sigma_g\rfloor + P$	-
		O&M	G	$(1-\beta)(R+\tilde{y}\lfloor\delta_g\rfloor)$
SPV	w_p	Constr.	$m + \alpha\tilde{x}\lfloor\sigma_p\rfloor$	P
		O&M	-	$\beta(R+\tilde{y}\lfloor\delta_p\rfloor) + G$

where:

w_g	Initial wealth of the government client
w_p	Initial wealth and the fee without risk allocation for the SPV
m	Cost estimate (assuming both parties have agreed on the same estimate)
α	Allocation ratio of the risk of construction costs
β	Allocation ratio of the risk of O&M net profit
P	Government client's contribution to the contractor for the O&M service, including risk premium or contingency cost for risk allocation (α) of costs
G	Government contributions to the contractor for the O&M service
R	O&M net revenue estimate (assuming both parties have agreed the same estimate)
$\tilde{x}[\sigma_i]$	Cost variation evaluated by stakeholder *i* with $N(0,\sigma_i)$
σ_i	Standard deviation of stakeholder *i*'s risk evaluation of construction costs after the allocation α
$\tilde{y}[\delta_i]$	Profit variation evaluated by stakeholder *i* with $N(0,\delta_i)$
δ_i	Standard deviation of stakeholder *i*'s risk evaluation of O&M net revenue after the allocation β

Note that the method of risk allocation or profit sharing during the O&M phase assumes the simplest method where the risk allocation ratio (β) applies to the agreed estimate of profit (R) as well as to the variation ($\tilde{y}$) from R.

The most problematic aspect of risk allocation is the determination of risk allocation ratios (α and β) and the risk premium including the government contributions ($P + G$). The condition for the government client and the SPV can be represented as:

$$\iint U_g\left(w_g-\left(m+\tilde{x}[\sigma_g]\right)+R+\tilde{y}[\delta_g]\right)f_g(x)g_g(y)dxdy$$
$$\leq \iint U_g\left(w_g-\left((1-\alpha)\tilde{x}[\sigma_g]+P\right)+(1-\beta)\left(R+\tilde{y}\left[\delta_g\right]\right)-G\right)f_g(x)g_g(x)dxdy \qquad (1)$$

and

$$\iint U_p\left(w_p+P-\left(m+\alpha\tilde{x}[\sigma_p]\right)\right.$$
$$\left.+\beta R+\beta\tilde{y}\left[\delta_p\right]+G\right)f_p(x)f_p(y)dxdy \geq U_p\left(w_p\right) \qquad (2)$$

respectively, where U_i is the utility function of stakeholder i ($i = g, p$; where g = government client, and p = SPV), $f_i(x)$ and $g_i(y)$ is the probability density function (PDF) of stakeholder i before the risk allocation of the construction costs and the O&M net revenue, respectively. Both expressions indicate that the situation after risk allocation is preferred to that before risk allocation according to the utility theory.

Note that the risk during construction is independent of the risk during O&M. This is so because the model solely considers monetary variations of construction costs and O&M profits. It also assumes predetermined specifications at the completion of construction and at the start of O&M. Given the predetermined specifications, construction costs and O&M profits are estimated. Whatever cost variations may occur, an asset is built with the specifications, and the O&M service will be provided with the specifications. Effects of non-monetary variations such as quality during construction on the O&M revenue and risk are incorporated in the estimates of construction cost and O&M revenue as exogenous variables.

FRAMEWORK OF NEGOTIATION ANALYSIS

This paper supposes a hypothetical project described in Table 2 as a base case for comparison purpose.

Table 2 Assumed values for the negotiation space

	Variables	**Client ($i = g$)**	**SPV ($i = p$)**
Initial wealth		0 $\therefore w_g - m = 0$	0 $\therefore w_p = 0$ + (fixed fee) = 5% of the cost
Risk attitude	a_i	0.1	0.3
Assessment of construction risk	σ_i	15	10
Assessment of O&M risk	δ_i	20	15
Agreed cost estimate	m	50	50
Agreed profit estimate	R	60	60

Assuming that each of the stakeholders utility function is expressed as:

$U_i = -Exp(-a_i x)$ ($i = g, p$),

and that the PDF for construction costs and net profits are normally distributed as:

$f_i(x) = \frac{1}{\sigma_i\sqrt{2\pi}}Exp[-\frac{1}{2}(\frac{x}{\sigma_i})^2]$ and $g_i(y) = \frac{1}{\delta_i\sqrt{2\pi}}Exp[-\frac{1}{2}(\frac{y}{\delta_i})^2]$ ($i = g, p$),

respectively, feasible combinations of risk allocation are represented by:

$$P + G = (1-\theta)P_{\min} + \theta P_{\max}\left(= P_\theta\right) \quad \left(0 \leq \theta \leq 1\right) \qquad (3)$$

where:

$$P_{\min} = \frac{a_p\left(\alpha^2\sigma_p^2 + \beta^2\delta_p^2\right)}{2} + m - \beta R \quad (4)$$

and

$$P_{\max} = \frac{a_g\left\{(2-\alpha)\alpha\sigma_g^2 + (2-\beta)\beta\delta_g^2\right\}}{2} + m - \beta R \ . \qquad (5)$$

Expressions (4) and (5) constitute the negotiation space represented by the government contributions and risk allocation ratios as shown in the Edgeworth box in Figure 1. P_{min} is the minimum contribution required by the SPV for the given allocation ratios, and P_{max} is the maximum contribution acceptable for the client for the given allocation ratios. Figure 1 shows the government contributions ($P + G$) and the allocation ratio of construction risk (α) for the base case, given the allocation ratio of O&M profit and risk (β) as 0.5. The two curves, given by Expressions (4) and (5), are the borders that constitute the negotiation space (hatched area).

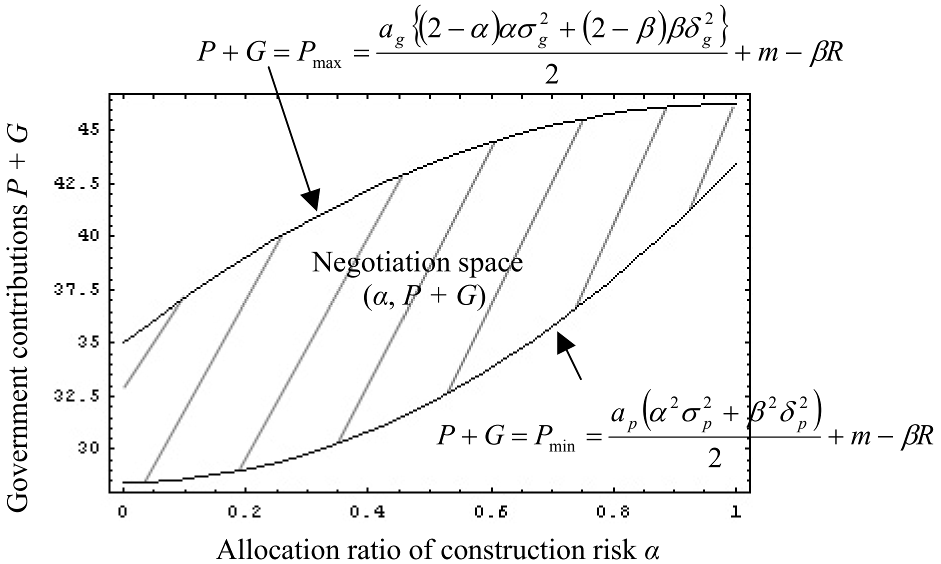

Figure 1 The Edgeworth box for the base case at $\beta = 0.5$

The negotiation space can also be drawn in the parametric utility space (EU_g, EU_p), each of which is represented by:

$$EU_g = -Exp\left[\frac{a_g}{2}\left[2(G + P - R + \beta R) - 2W_g + a_g\left\{(\beta-1)^2\delta_g^2 + (\alpha-1)^2\sigma_g^2\right\}\right]\right] \quad (6)$$

and

$$EU_p = -Exp\left[\frac{a_p}{2}\left\{2(G + P + \beta R - m) - 2W_p + a_p\left(\beta^2\delta_p^2 + \alpha^2\sigma_p^2\right)\right\}\right], \quad (7)$$

for feasible combinations of risk allocation ($\alpha, \beta, P + G$), which is represented by Expressions (3) to (5). Figure 2 illustrates the example of the negotiation space for the base case. The hatched area represents the negotiation space bordered by the two lines, representing the minimum level of expected utility for each stakeholder, and the curve, representing the efficiency frontier, which is defined as any allocation where one party cannot improve its utility without reducing that of the other party. Optimal solutions can be found on the efficiency frontier. Additional axioms or solution concepts are required to identify such a specific solution (Raiffa, 1968).

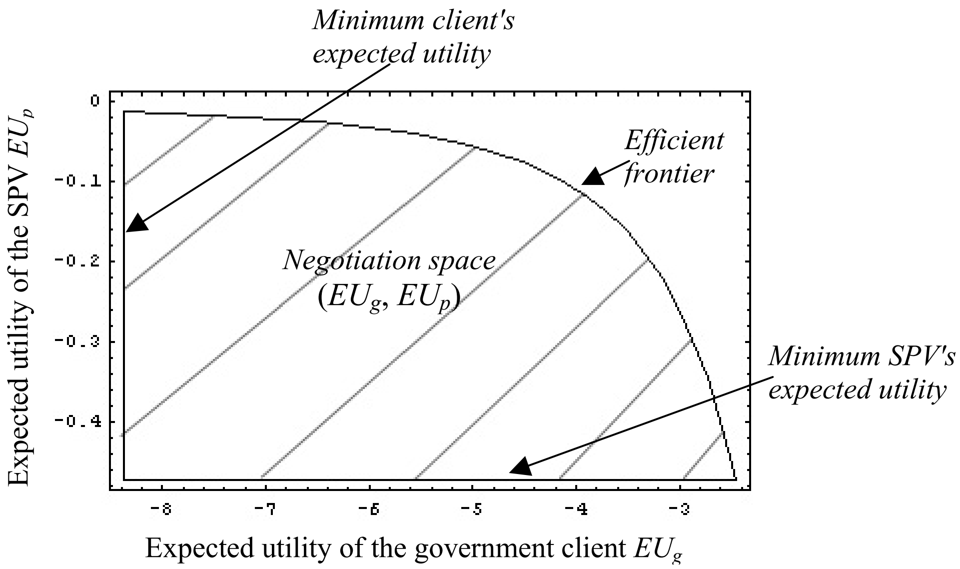

Figure 2 Negotiation space in parametric utility space

ANALYSES OF EFFECTS OF CHANGES IN THE LEVEL OF RISK AVERSION

This section explores effects of the changes in the level of risk aversion. The level of risk aversion is expressed in the form of the utility function. The exponential form of utility function assumed in Expression (1) represents the level of risk aversion by a_i ($i = g, p$): the larger the value is, the more risk averse the stakeholder is.

This paper considers two cases in comparison with the base case: (i) both stakeholders become less risk averse to the level of 0.05 (Case 1); and (ii) only the SPV becomes less risk averse to the level of 0.1 while the client's level remains unchanged (Case 2). Table 3 summarizes these cases. Other variables remain unchanged from the base case.

Table 3 Cases of changing the level of risk aversion

	Client a_g	**SPV a_p**
Base case	0.1	0.3
Case 1	0.05	0.05
Case 2	0.1	0.1

Results and analyses with the Edgeworth box

Figure 3 shows the Edgeworth box between the government contributions ($P + G$) and the allocation ratio of construction risk (α) for the base case and Case 1, given the allocation ratio of O&M profit and risk (β) as 0.5. The negotiation space of each case is represented by two curves, one for each stakeholder at the respective level of risk aversion. The two thick curves represent the negotiation space for the base case.

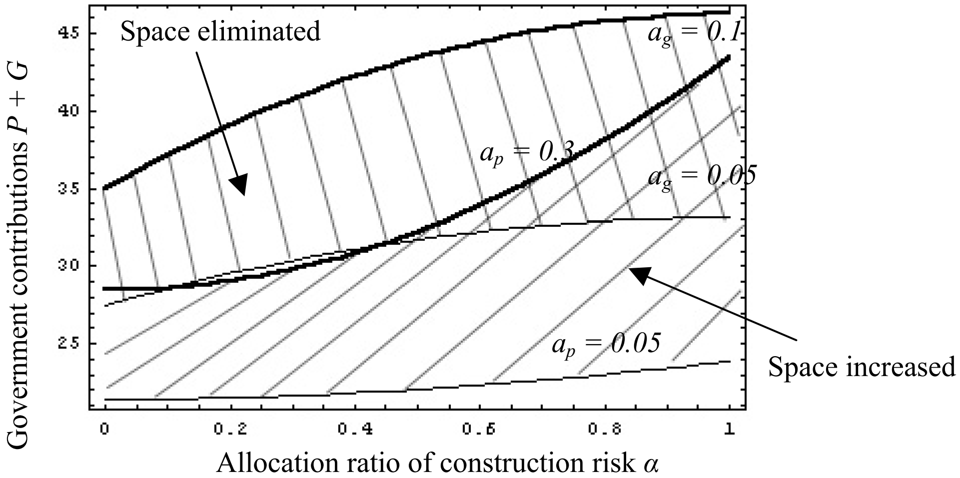

Figure 3 Edgeworth box for the base case and Case 1 at $\beta = 0.5$

The decrease in the client's level of risk aversion shifts the client's curve downward and eliminates the area where the client may have paid more contributions at the same level of the risk allocation ratio. Similarly, the decrease in the SPV's level of risk aversion shifts the SPV's curve downward and increases the area where the SPV may receive less contribution at the same level of the risk allocation ratio. In Case 1 compared with the base case, the SPV is perceived to be able to take more risk with less payment from the client, while the client is perceived to be able to retain more risk with less payment to the SPV.

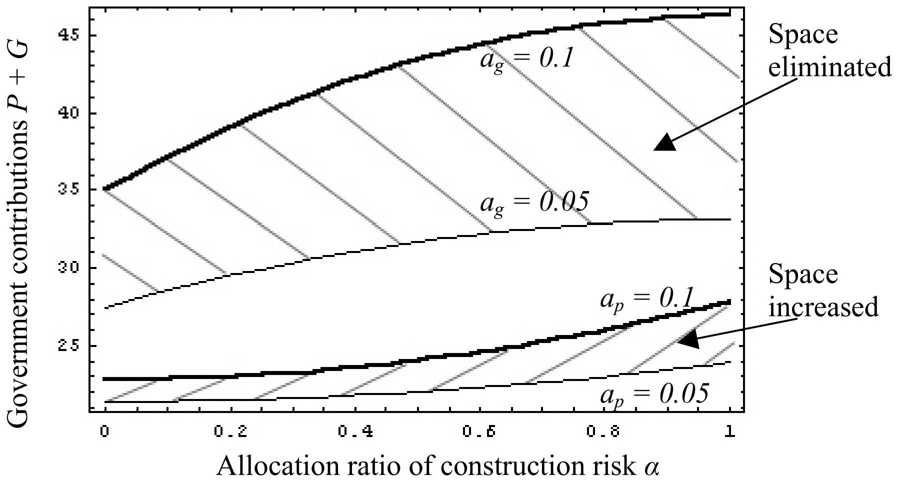

Figure 4 The Edgeworth box for Case 1 and Case 2 at $\beta = 0.5$

Figure 4 shows negotiation spaces for Case 1 and Case 2, given the allocation ratio of O&M profit and risk (β) as 0.5. The two thick curves represent the negotiation space for Case 2. Similarly as observed in Figure 3, the decrease in the level of risk aversion shifts both curves downward, resulting in the elimination of the upper space where the client may have paid more contributions and the increase in the lower space where the SPV may receive less contribution. The negotiation space for Case 1 eventually becomes smaller, favoring the client paying less contribution at the same risk allocation ratio.

The risk attitude represented by the level of risk aversion affects all elements of risk allocation including allocation ratios and the government contributions. The decrease in the level of risk aversion shifts the risk-contribution curve downward. Regardless of the type of risk, both stakeholders are perceived to be able to take more risk.

Results and analyses with the utility-based negotiation space

The negotiation space on the parametric utility space is depicted in Figure 5 based on the expected utility. Comparing Case 2 with the base case shows the expansion of the negotiation space in favor of the client. The maximum level of the client's expected utility increases while the minimum level remains unchanged. On the other hand, both the maximum and minimum levels of the SPV's level of expected utility decrease. Case 1 further moves the negotiation space to the right and in the downward direction where the client can achieve higher utility while the SPV's utility decreases further. Case 1 also shows that the client's minimum level of utility increases. This is caused by the decrease in the client's level of risk aversion.

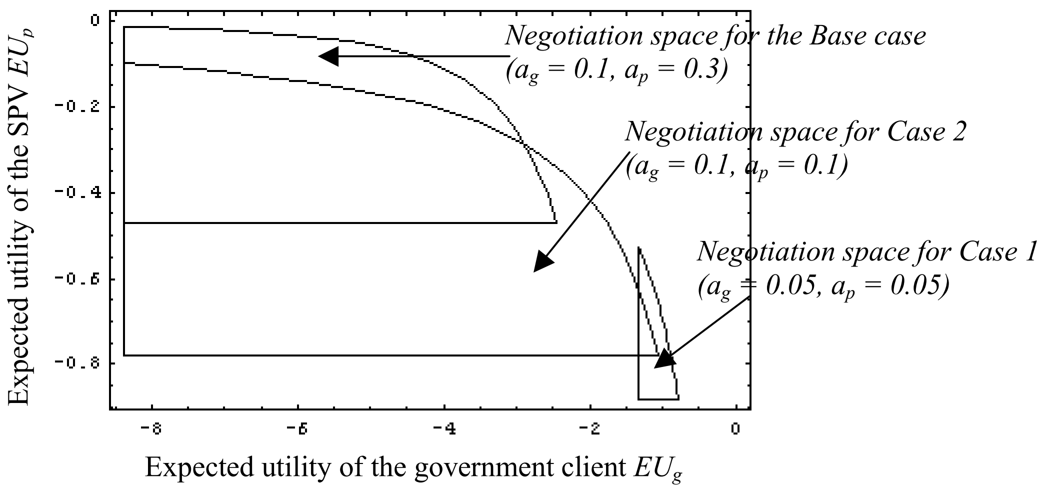

Figure 5 Negotiation space by case

Figure 5 may be interpreted as indicating that prior to any negotiation (say in tendering), the client prefers to deal with a SPV who is willing to take more risk. On the other hand the SPV prefers to work with a client who is more risk averse.

However, in general decision-making (also evident in Figure 5) a SPV would normally need to demonstrate a higher level of risk averseness to realize higher expected utility (to be in a stronger position in negotiation) while a client would need to demonstrate willingness to accept more risk.

There appears to be a contradiction between how the client and the SPV perceive risk and respond to it in negotiations. The knowledge of the client's preference for risk, say in tendering, would help the SPV to alter the perception of risk in line with that of the client in formulating a tender. If selected as a winning bidder, the SPV would then attempt to revert back to the SPV's original position in negotiations with the client. Similarly, the client's preference for risk may be influenced by the knowledge of the SPV's preference in negotiations.

Whether or not the changes in the level of preference for risk by the client and the SPV before and after negotiations is deliberate is not clear. But the fact that they do occur may prevent the stakeholders from developing an appropriate level of trust which is necessary in cooperative risk allocation.

Effects on the optimal solution

The optimal ratios of risk allocation were calculated (Yamaguchi *et al.*, 2001) as:

$$\alpha^* = \frac{a_g \sigma_g^2}{a_g \sigma_g^2 + a_p \sigma_p^2} \text{ and } \beta^* = \frac{a_g \delta_g^2}{a_g \delta_g^2 + a_p \delta_p^2}. \quad (8)$$

An optimal level of the government contributions can be obtained by assuming a solution concept. For example, the Nash cooperative axioms (Nash, 1953) give the optimal solution that maximizes the product of utility gains from the disagreement point (d_g, d_p). For the case of the risk allocation model in this paper, the optimal solution $GC^* = (P + G)^*$ satisfies:

$$\max\ (EU_g - d_g)(EU_p - d_p) \text{ s.t. } \alpha = \alpha^* \text{ and } \beta = \beta^*$$

Table 4 summarizes the optimal risk allocation for all cases for the Nash cooperative solution. The expected rate of return for the SPV is also calculated. Comparing Case 1 with the base case indicates that a more risk-prone SPV will take more risk of the construction and O&M phases with less government contributions. As indicated in Expression (8), comparing Cases 1 and 2 shows that the level of risk aversion does not affect optimal allocation ratios when the level of risk aversion is the same for both stakeholders and that more government contributions will be paid and a higher rate of return is expected for the more risk-averse case (Case 2).

Table 4 Optimal risk allocation

		Base case	**Case 1**	**Case 2**
Risk allocation ratio	**Construction** α^*	0.43	0.69	0.69
	O&M β^*	0.37	0.64	0.64
Government contributions and expected rate of return[1]		40.0 (24.4%)	20.2 (17.2%)	28.9 (34.6%)

1) The unit of the amount of the government contributions is the same as that of cost and profit, e.g. 10 million dollars. The rate of return is calculated as $(P + G + \beta R - m) \times 100 / m$ (%) for the SPV.

Figure 6 plots the optimal solution on the negotiation space for each case. It also indicates that the base case realizes the highest utility for the SPV. However, Table 4 shows that the expected rate of return for the base case is not the highest among the three cases. The SPV may achieve a higher expected rate of return by accepting more risk than it can sustain. This implies that it is not appropriate for the SPV to evaluate viability of PFI projects solely on the basis of the expected rate of return. PFI projects should be evaluated in conjunction with the level of allocated risk.

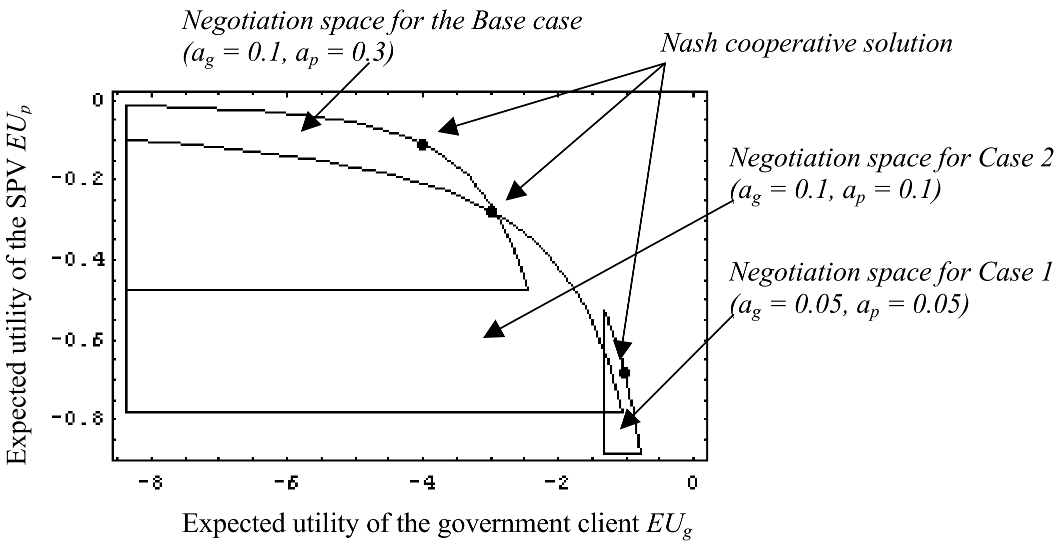

Figure 6 Negotiation space and an optimal solution by case

CONCLUSIONS

The purpose of this paper was to investigate the negotiation regarding risk allocation in PFI projects through the change in the negotiation space. The paper examined the effect of the change in the level of risk aversion of the key stakeholders on risk allocation negotiations.

The most important finding of this investigation was the realization that the stakeholders were contradictory in revealing information on their respective levels of risk aversion before and during the negotiation. This may or may not be a deliberate attempt of the stakeholders to place themselves in a more favorable position leading to contract negotiation. The analysis on the optimal solution suggested that the expected rate of return was not an appropriate indicator for the SPV to evaluate viability of PFI projects without consideration of the level of allocated risk.

The negotiation analysis based on the Yamaguchi model is suitable for analysing and understanding risk allocation negotiations involving PFI projects.

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