Flexible Design in Public Private Partnerships:

A PFI case study in the National Health Service

PFI Development at Royal Victoria Infirmary in Newcastle-upon-Tyne

ABSTRACT

The focus of this paper is improving individual Private Finance Initiative (PFI) projects to deliver better value for the benefit of the partners in PFI. Signing long term contracts of 20 to 30 years with the private sector typically enlarges demand risks in PFI. Subsequently, this report seeks a way to deliver more valuable PFI projects by the effective management of demand risks. Incorporation of flexibilities in design is found to be a promising solution to deal with greater demand risks. Flexibility can add a significant value to the project as it allows actively reacting to the unforeseen circumstances in the future. Consequently, it will enable to cut losses in downside scenarios and amplify gains in upside scenarios.

In order to benefit from the use of flexibilities in PFI project, it is essential for the public sector to structure flexibilities into the contract at the start of the project. This paper proposes managerial ways of considering the flexibilities systematically and structurally by an illustrative process using matrices called "OUF Matrices": Operational Matrix, Uncertain Event Matrix and Flexibility Matrix. The process is designed in a way to help the partners to consider a sufficient number of scenarios and to look at the possibility of using flexibility.

This paper also makes a contribution to the financial valuation of flexibilities in design to deal with demand risks using a case study of a PFI development in National Health Service in the UK. The financial model built for the case study suggests that the incorporation of flexibilities can substantially increase the value of the project only for the public sector who is responsible for taking demand risks. However, the fact that the private sector owns the asset limits the public sector's interests in adopting flexibilities. It is thus desirable to develop a way of sharing the added value of flexibility in order to motivate the private sector to create and exercise flexibilities in the project. An approach by introducing the "option fee" in the contract is suggested in this paper, which the public sector pays to the private sector in terms of an additional unitary payment over the concession period. In this way, both partners in PFI can take advantages from incorporating flexibilities in the project.

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1. INTRODUCTION

Since May 1997, Private Finance Initiative (PFI) has been a dominant procurement process in the National Health Service (NHS) in the UK. It has been developed to ensure modern, efficient and cost effective facilities by placing responsibility for their provision with private sector firms who are experts in their provision. There are generally three main components which drive the financial value of the projects: construction cost, operational cost and revenue during the operational period, and each component faces risks and uncertainties. PFI does more to improve the management of risks in construction costs and operating costs than other public sector procurement schemes in the UK. However, PFI is less concerned with the certainties of demand risks, which can lead to greater revenue uncertainty than more traditional public procurement. The first objective of this paper lies in finding management tools to deal with the highly volatile demands associated with PFI projects.

A key to handling demand uncertainty lies in flexible design. Unlike the traditional public investment process, the public sector under PFI should explicitly spell out the flexibilities and scenarios under which they will be exercised in the contract to avoid financial penalties. This necessitates structuring flexibilities in the early stage of design before the financial close is made. The second objective of this paper then involves discovering a process to systematically and structurally consider flexibilities in the operation of the hospital and associated uncertain events in the early design process.

Once flexible designs to be included in the project are identified, it will be necessary to examine the value of these flexibilities to the partners in the contract. In this paper, the value of flexibility is examined through a case study of PFI development at the Freeman Hospital and Royal Victoria Infirmary in Newcastle-upon-Tyne. The case will illustrate that flexibilities in design to deal with market risk can increase the overall value of the project, but the added value of flexibility is not shared between the partners. The only partner who gains an advantage from flexibility will be the public sector who is exposed to market risks. This paper then seeks to develop a way of sharing the benefits of increased value in order to motivate the private sector firms to create and exercise flexibilities in the project. In addition, effective ways of managing flexibility in order to maximise its use are discussed.

This report aims to bring benefits at two different points of time in the PFI procurement process: during the bidding process and after the selection of a final bidder. In the bidding process, a private sector firm can produce a solution with flexibilities in design rather than one which merely minimizes costs. It will be necessary for the firm to provide evidence to the client that the added value of flexibility exceeds its costs. This evidence can be provided using the financial analysis developed in this paper. This will help to increase the chance for the private sector firm to be selected as a preferred bidder. After the selection of a final bidder, partners will develop the design further in order to produce a final business case. Here, they can produce flexible solutions more effectively according to a proposed process using the matrices. This will help to deliver more valuable PFI projects, and benefits from flexibilities will eventually brought to both partners.

The rest of the paper is divided into five chapters. The next chapter explores PFI in the NHS with descriptions of key risks which drive the value of the project. Then we will illustrate how we can deal with the risks under PFI by incorporating flexibilities in design. Chapter 3 looks at the possible flexibilities in design of a hospital. Chapter 4 explains why the flexible designs should be considered in the early stage under PFI, and subsequently explores an illustrative process to consider flexibilities in a systematic way as means of delivering more valuable PFI projects. Chapter 5 examines the case study and illustrates the effect of uncertainty and flexibility on the value of a contract for two partners. We also suggest an approach to share the added value of flexibility between them. Chapter 6 illustrates a detailed methodology for constructing financial valuation models. The final section reflects on general lessons on incorporating flexibilities in design under PFI, and outlines areas for future work.

2. RELEVANCE

2.1. PFI in NHS

Private Finance Initiative (PFI) has been one of the innovations in public sector management in the UK. The private sector signs a contract with the public sector to design, finance, build and operate assets in requiring the supply of public services over periods of 20 to 30 years. The rationale underlying PFI is that enhanced value for money and cost-effectiveness will result from allowing partners in the contract to concentrate on what they each do best (Gallimore and Woodward, 1997).

Particularly in the National Health Service (NHS) in the UK, 80 major PFI hospital developments have been agreed since May 1997, making up a total projected capital value of more than £60 billion (Department of Health, 2007). The main contractual relationship in PFI in the health sector is between a public authority, the NHS Trust, and a private consortium, often a Special Purpose Vehicle Company (SPV)[1] created for the project in question. Under PFI, the public sector obtains a service rather than an asset and the NHS Trust will thus continue to be responsible for providing high quality clinical care to patients. The private sector provides the required asset by designing, building and financing, and also operates the facility during the lifetime of the asset. In return, the Trust agrees to make regular payments, which can be thought of as a type of rent, to the private consortium over the term of the concession period. This single payment is known as the Unitary Payment (UP). No payments are made by the NHS until services are provided to the agreed standard required by the consortium.

2.2. Evaluation of Key Risks under PFI: Construction Risk, Operating Risk & Demand Risk

There are three key risk areas which are related to the value drivers of the project: construction risk, operating risk, and demand risk which drive upfront investment costs, operational costs, and revenue/social benefits during the operational period. Let us examine how these key risks are handled under PFI compared to traditional public procurement.

[1] For a large scheme, the private partner will be a consortium of construction companies, bankers and service providers. This consortium is often referred to as SPV.

First of all, PFI improves construction performance by transferring design and construction risk to the private sector. The National Audit Office (NAO) reported in 2003 that the vast majority of PFI projects are delivered on time and to budget compared to those under public sector procurement[2]. This could be achieved because the private sector takes on the financial risk of the project being late as well as over-budgeting in construction. Namely, they will not be paid until the building is completed, and over-budget in building the asset is a direct cost incurred by the private sector. Furthermore, a PFI project can avoid cost escalation in the upfront investment by preventing the design changes instigated by NHS managers or medical staffs which are considered to be the main factors in the cost and time overruns in publicly financed hospital construction schemes (Sussex, 2003).

Transfer of operating risk to the private sector is another clear area where PFI brings more benefits than publicly financed procurement (Sussex, 2003). The private sector takes on the risk of any unforeseen costs involved in maintaining the building and operating the services. The payment to them is fixed throughout the course of the contract so any unforeseen costs which arise will be met from their own resources. Furthermore, it is perceived that the private sector can operate the services more cheaply than local authorities (Rowland & Pollock, 2002). Another benefit under PFI can be achieved by design, construction and maintenance of the hospital all being the responsibility of the same consortium. The private sector will be more careful about design and building quality since they will not only constructing the hospital buildings but also be responsible for maintaining them (Broadbent and Gill, 2003).

So far, PFI improves the way to deal with risks associated with two key cost components of the project: upfront investment cost and operating cost. However, PFI is in general not so well positioned to cope with demand risks, which drive the revenue of the public partner, since PFI projects are inherently subject to greater demand risks compared to the traditional procurement process. There are three characteristics of PFI which explain why PFI is exposed to greater demand risks.

The first distinct reason is the long contract period, which can last up to 60 years. Many public sector organisations are certain of their sources of income only on a short term

[2] Typically in 2001, 76% of PFI projects were delivered on time and 79% within budget, compared with 30% on time and 27% within budget using conventional procurement (McKee at al., 2006).

basis and cannot anticipate what the demand will be in 20 to 30 years (Froud, 2003) due to changes in demographics, medical technology, and government policy, which can all be highly volatile. Demand is very sensitive to variations in the catchments' population, including natural demographic change and migration pattern change. Medical technology has rapidly advanced in the past 30 years and similar progress, possibly even at a faster rate, is anticipated over the lifetime of the PFI project. As a result, the pattern of hospital activity may change dramatically. For instance, between 1982 and 1999, the NHS was able to increase the number of patients it treated as inpatients or day cases by over two thirds while reducing the number of beds by two fifths (Hensher and Edwards, 1999). There is also a distinct possibility that government policy on health care will be changed over the concession period of 20-30 years and can subsequently affect the future demand. For example, the government recently announced an intention to increase the volume of elective work being undertaken in the Independent Sector, which may result in a reduction of outpatient activities.

As a result of uncertainties associated with the demand risk, it will be very difficult to produce "future-proof" facilities. Indeed, the Treasury has warned that PFI assets may not be well suited for what is required in the later years of the project due to the presence of high market risk: "The assumption that any asset created now will be suitable in its present form to deliver a further contract after some 25 years is questionable. The client's operational needs will change" (Private Finance Panel, 1996).

Secondly, the public sector becomes 'locked in' with the private sector partner for the entire contract period under PFI. The fact that the private sector owns the asset restricts the public sector in its response to a dynamic environment. In a December 2005 public interest report into Queen Elizabeth Hospital NHS Trust on behalf of the Audit Commission, PricewaterhouseCoopers stated that "the Trust has a high level of fixed costs under PFI scheme which are fixed under the contract and cannot be reduced, even if activity levels fall significantly".

Lastly, demand risks are entirely retained by the public sector under PFI. The main source of income for the public sector entirely depends on how demand develops in the future and the public sector financially suffers if they failed to anticipate future market conditions reasonably accurately despite of the highly unpredictable future of healthcare. The first PFI development of a museum, the Royal Armouries in Leeds, which was signed in 1993 shows the negative consequences of retaining high market risks. The gap between the projected demand made at the financial close and the realised demand in the new museum was significant. The museum could never raise enough money to meet its operating costs and the servicing of debts. For instance, in 1999, realised visitor rates were only 400,000 per year against projections of 750,000 and this overestimate of demand consequently led to the financial collapse of the museum (NAO, 2001). This case illustrated a need for management tools to help dealing with high market risks in PFI projects.

2.3. Managing Demand Risk

To overcome the problem of market risk typically due to long lock-in period, short term contracts with a lifetime of only 5-10 years could be introduced. However, such a short term contract will be hard to attract private investors since it will not be adequate to allow the private sector to raise the money for capital investment at favourable rates, which in turn will result in lower expected profits at any given level of risk (Atun and McKee, 2005; Sussex, 2003). As it seems infeasible to reduce market risk by shortening the terms of the contract, this report will focus on managerial strategies for projects which cannot inherently avoid high market risks.

There are essentially two tools to manage risks and uncertainties: diversification and flexibility. Firstly, diversification spreads the investments in order to reduce the risk of returns; “Don’t put all your eggs in one basket”. It is a passive risk management tool and does not directly influence the management of individual projects (Savva, 2006a). Diversification is therefore particularly relevant to investors and to some extent also to the government. Since the focus of this paper lies in improving individual PFI projects to deliver better value for the benefit of the partners in the PFI project, diversification is not relevant for our setting. Even for the government, the effect from diversification is not significant, since similar projects such as hospital PFI projects are positively correlated and for diversification to work the component assets must not be perfectly correlated. We will therefore focus on the second risk management tool, flexibility.

Flexibility can be introduced to the project to stress the importance of proactive risk and opportunity management. It improves a system manager’s capability to react to changing circumstances, and thereby increases the expected value of the project. Flexibility analysis, also known as “real options analysis”, moves the focus of the design from meeting fixed specifications toward the active management of uncertainty. De Neufville and Scholtes (2006) explain that flexibility in a project is like a switch; it provides the capacity to adapt to new circumstances. This switch can be designed to deal with downside risks which can allow the managers to minimize their losses and to avoid unpleasant outcomes, and this is linked to a "put" option[3] in the financial market-place. Another type of switch can be introduced to deal with upside scenarios when a project is proven to be unexpectedly beneficial and profitable, and this is linked to a "call" option[4] in finance. By having an appropriate provision for the downside and upside opportunities, managers can take advantage of unfolding uncertainties, e.g. avoiding a financial crisis by downsizing the system or capitalizing on success by extending the system in a quick and cost efficient manner. These switches will consequently shift the distribution of possible outcomes towards more beneficial outcomes. System studies by de Neufville indicate that "real options approach can lead to major increases in performance over traditional practice, easily on the order of 25%".

3. FLEXIBILITY IN THE DESIGN OF A HOSPITAL

Typically in partnership contracts, the concepts of real options have been successfully adapted in terms of incorporating flexibilities in "contract". For example, Savva (2006b) has looked at the value of options to opt-out and buy back in the co-development partnership contract in the pharmaceutical industry. In contrast, our paper focuses on flexibilities in "design", which may require technical design modifications to enable flexibility exercisable. Flexibility in design can be differentiated into three categories depending on its level and effect: Strategic, Tactical and Operational Flexibilities. In this chapter, characteristics and examples of flexible designs in each category are discussed.

Strategic flexibility is responsible for long term changes by altering the size or the usage of the hospital. When the managers exercise this flexibility with the right decision, it can add the most significant value to the project. It enables future expansion and down sizing

[3] Options in the finance industry can be thought of as bets on stock prices. A "put" option gives its owner the right but not the obligation to sell a stock for a fixed price at a fixed point in time ("European" option) or over a fixed period ("American" option). It is worth more if the stock price goes down as it enables the owner to shelter the project from downside risks (De Neufville and Scholtes, 2006).

[4] A "call" option gives its owner the right but not the obligation to buy a stock for a fixed price at a fixed point in time or over a fixed period. It is worth more if the stock price goes up as it enables the owner to capitalize on upside opportunities (De Neufville and Scholtes, 2006).

of the hospital to interact with changes in demand, diagnostics, technology, and staffing trends. For instance, a hospital can be designed in a way that the expansion of the hospital can take place incrementally, by leaving sufficient space in the site as needs demand. A hospital can also be expanded in height by providing sufficient size of structural elements to withstand higher loadings in the future. In contrast to upside scenarios of the demand, PFI hospital projects may face affordability problems when the demand has been less than anticipated. In this case, a part of hospital can be turned into the space for secondary usages such as the office block, pharmaceutical production, pharmaceutical trials, and plastic surgery possibly by subletting it to the private company. The design can also include the wings of the hospital which can be easily demolished when downside scenario kicks in.

On a tactical level, future uncertainties are accommodated by flexibility in design of the proposed facilities without altering the overall size and the functionality of a hospital building. Tactical flexibility often enables easy modification of the facilities and changes made could be in effect for some time but probably not permanently. Examples of tactical flexibility include 'shell space', flexible design of footprints and operating theatres, and the use of demountable blocks for linear accelerator bunkers (table 3.1).

'Shell Space'	A 'Shell space' can be introduced to the building without any service built in. The use of this space can be determined by the Trust at a future date and the space could include operating theatres, offices, or expansion of the adjacency departments.
Design of flexible footprint	Extra footprint can be designed to cope with additional operating theatre in the future.
Flexible design of room arrangements	Adjacency of the rooms can be designed by leaving spaces in the form of storage rooms next to the functional rooms for their possible expansions. In addition, risers can be regularly spaced in strategic locations in the building with the spare capacity, typically 25%.

Demountable 'Ledite' blocks for linear accelerator bunkers	Room arrangements for the cancer treatment are designed under great concerns due to limited footprint and potential change in the treatment process. 'Ledite' blocks can be used instead of concrete blocks for linear accelerator bunkers as they are easily demountable compared to concrete blocks in the case when the radiation treatment is replaced by other technology in the future. However, use of 'Ledite' blocks typically increases the cost by approximately 150%.

Table 3.1: Tactical flexibility in design of a hospital

Operational flexibility involves in designing the engineering services which are efficient and adaptable. Thus, the systems can incorporate the spare capacity and are easily expandable to meet the future needs. For example, mechanical and electrical main distribution can have spare capacity, typically an extra 25%.

The redevelopment of West Middlesex University Hospital is an example which has attempted to overcome potential problems related to the demand risk by a flexible design. According to the National Audit Office (NAO), West Middlesex addressed this as follows: "Long term planning is difficult in the health service because healthcare is changing over time and the local demography may also change. In the West Middlesex deal there is some flexibility to accommodate these uncertainties. Up to six additional wards can be provided or alternatively bed numbers could be decreased. The Trust believes the contract provides sufficient flexibility to address future uncertainties in long-term healthcare (Paragraph 5 of the Executive Summary of NAO, 2002)."

An eye clinic at Royal Victoria Infirmary, Newcastle-upon-Tyne is another example to illustrate the successful design of hospital with flexibilities to amplify gains in the upside scenarios. In 1996, an eye clinic comprising a three storeys building was built under traditional procurement process at Royal Victoria Infirmary in Newcastle-upon-Tyne[5]. This building was designed in very flexible ways which are driven and technically suggested by the eye surgeons. Firstly, an additional shell floor was introduced by the clients in design. Secondly, design was flexible with size of day units versus inpatient units according to the unforeseeable patterns of the out-patient ratio and length of stay.

[5] The capital value and the size of the project were approximately £ 5M and 9000m^2.

Finally, footprints of extra operating theatre were built which were initially used as instrument sterilisation units. As a consequence of flexible designs, the Trust has gained a significant economical gain by exercising first two flexibilities. Although, the last flexibility has not yet been exercised, the NHS Trust expects the high potential use of it.

4. ILLUSTRATIVE PROCESS TO INTRODUCE FLEXIBLE DESIGN INTO THE CONTRACT

Under a traditional public investment project, the public sector has control over the assets as well as the provision of service. Hence, there is noticeably more flexibility to make changes either temporarily or on a long-term basis (Froud, 2003). However, under PFI, the public sector must explicitly spell out the flexibilities and scenarios under which they will be exercised in the contract. Otherwise, it will be difficult to negotiate contractual changes, and more importantly, penalties will be levied for even minor changes. The main reason for this is that under PFI it is the private consortium who owns the asset and therefore the public sector does not have a right to change the asset in response to the realised demand without an agreement from the private partner. Another distinct reason is that the bond finance is based on the original usage of the building and it can be a very expensive process to re-rate the bonds in respond to the change in risk profile after the financial close.

The PFI development at Royal Victoria Infirmary in Newcastle-upon-Tyne illustrates the importance of structuring flexibilities in the early stages of design. The Trust proposed to build the project scheme using a possible expansive area as office accommodation instead of the usage as an additional ward space agreed on at the financial close. Since the use as an office space was not explicitly stated in the contract, the Trust could not get the agreement from the SPV to exercise this flexibility at a reasonable cost at the time.

So how can we effectively structure flexibilities into the contract at an early stage of the project? The main interest of this paper is developing flexibilities in the design of a hospital to deal with market risks which are responsible for a wide range of project outcomes, from failure to great success. Traditional strategic planning approaches often fail to effectively incorporate uncertainty since they approached it in a “binary” way of thinking, that is to say, considering the world either as entirely predictable or unpredictable. However, neither approach is valid in dealing with the dynamic and uncertain environment of the healthcare sector (Jennings, 2000). To develop strategic planning approaches towards the flexible design of the hospital, it is important to understand its basic sources of uncertainties.

This paper thus proposes an illustrative process to systematically consider flexibilities to be included and to specify the use of the flexibilities in the contract by identifying the main sources of uncertainties in market risk. This process can be carried out by a team of clinicians and designers, who are more open to the use of flexibilities than the public client managers, to complement the usual process of producing an adjacency matrix[6] at the initial design stage. An integrated partnering system between clinicians and designers is essential in the process as these two groups bring different benefits to the system. Clinicians are the most knowledgeable about the future of medical technology and the barriers to efficient delivery in the circumstances of the hospital whereas designers can help to develop innovative flexible designs and evaluate whether a particular design is structurally possible to be built or not.

In the case of a complex socio-technical engineering system, Bartolomei et al. (2006) looked at the use of Design Matrices to screen for flexibilities which avoid downside consequences or exploit upside opportunities. In the context of building a hospital, which is relatively less complex but larger in size, this report proposes to build three matrices as an approach to develop flexible designs of the hospital: "OUF Matrices" for Operational Matrix, Uncertain Event Matrix and Flexibility Matrix. The process is designed in a way to help the partners to consider a sufficient number of scenarios and to look at the possibility of using flexibility. The descriptions of the main steps in using the "OUF Matrices" are outlined as below. The process eventually develops flexibilities in the capacity of a hospital (i.e. the overall size of the hospital) and the design of hospital facilities.

STEP 1: Develop Flexibilities in the Capacity of a Hospital

STEP 1-1: Determine the components which make up the matrices

The Operational Matrix contains the components describing the patient activities such as the number of inpatients, length of stay and the number of outpatients, which determine the capacity of a hospital. Key uncertain events which may affect the

[6] A design of room arrangements in a hospital is achieved by building adjacency matrix and is highly influenced by clinicians to achieve efficient footprints of a hospital.

elements of the patient activities are then identified and entered in the Uncertain Event Matrix. For example, events associated with changes in demographics, medical technology and government policy will be appropriate to form this matrix. Finally, the flexible designs to deal with changes in the patient activities are developed and they become the components making up the Flexibility Matrix. Flexibilities to expand and downsize the hospital are relevant here. Possible flexibilities identified in Chapter 3 could be used as a basic guide to start with.

STEP 1-2: Find the correlations between the components entered in each matrix

The impact of each key uncertain event on each element of patient activities is revised by looking at the correlation between them. Positive and negative correlation can be represented by '+' and '-' signs and a stronger correlation can be represented by multiple weighted signs. The next step is to determine the correlation between the components in the Operational Matrix and the Flexibility Matrix. If a particular flexibility allows the expansion of a hospital as the patient activity increases, '+' is entered into the matrix and vice versa. An example of the outcome of Step 1 is illustrated in figure 4.1.

Uncertain Events Matrix	**Operational Matrix**		
	No. of Inpatients	Length of Stay	No. of Outpatients
Immigrations of middle-aged population	+	-	+
Increase in population aged 65 and over	++	+	++
Development of new Treatment	+	--	+
Expansion of hospital in height	+	+	+
Subletting hospital for secondary usages	-	-	-
'Shell' space	+/-	+/-	+/-
Flexibility Matrix			

Figure 4.1: Example of "OUF Matrices" in developing flexibilities in the capacity of a hospital

STEP 2: Develop Flexibilities in the Design of Hospital Facilities

STEP 2-1: Determine the components which make up the matrices

The Operational Matrix now contains the components accounting for the individual hospital facilities to cope with a chosen capacity such as clinical departments, operating theatre and treatment rooms. The uncertain events and possible flexible designs associated with the components in the Operational Matrix are identified and entered into the Uncertain Event Matrix and the Flexibility Matrix.

STEP 2-2: Find the correlations between the components entered in each matrix

The impact of each key uncertain event on the design of each proposed facility is revised by examining whether a particular event will require a design alteration of the facility or not. When a particular event requires changing design, ‘o’ is entered into the matrix and when an event does not require the alteration of design, ‘x’ is entered. Subsequently, the correlation between the components in the Operational Matrix and the Flexibility Matrix is determined by ‘+/-‘ signs depending on whether flexibility helps the alteration of design or not. An example of the outcome of Step 2 is illustrated in figure 4.2.

Uncertain Events Matrix	**Operational Matrix**		
	Department Arrangement	Operating Theatre	Treatment Room
Development of new treatment	O	O	O
Introduction of new disease	O	O	O
Demountable walls and ceilings	+	.	.
Footprint of extra operating theatre	.	+	.
Demountable blocks for linear accelerator bunkers	.	.	+
Flexibility Matrix			

Figure 4.2: Example of “OUF” Matrices in developing flexibilities in design of hospital facilities

Once possible flexibilities are identified, it is necessary to classify the flexibilities into strategic, tactical and operational levels. Flexibilities to deal with the patient activities are generally expected to be on a strategic level and those to deal with designs of facilities are expected to be on a tactical and an operational level. As flexibilities on a strategic level can enhance the value of the project most significantly, they should be considered for a detailed simulation model. The case study of financial valuation of typical flexibilities in a strategic level is illustrated in the next chapter.

5. FINANCIAL VALUATION OF FLEXIBILITY

A case study is used to illustrate the effect of uncertainty and flexibility on the value of a contract for the partners. The financial value of flexibility on a strategic level, which can alter the value of the project most significantly, is assessed in dealing with market risks and uncertainties. This will give insights of how the project can be improved financially by incorporating flexibilities in the PFI project.

5.1. Introduction to the case: PFI Development at the Freeman Hospital and Royal Victoria Infirmary in Newcastle

The contract was signed between the Newcastle upon Tyne Hospitals NHS Trust and the private concessionaire led by Equion plc[7] in May 2005 as a PFI deal to develop the Freeman Hospital and Royal Victoria Infirmary (RVI) in Newcastle. It was to ensure a more efficient delivery of clinical services in Newcastle as well as providing long-term benefits for the Trust by moving all acute hospital services from the Newcastle General Hospital site and reproviding them in modern state of the art facilities at the Freeman Hospital and the RVI site[8]. A description of the deal is illustrated in figure 5.1.

[7] Equion plc, a division of John Laing plc, is a specialist provider of facilities in PFI and PPP markets with a long-term perspective and approach. Equion won the Infrastructure Journal PPP developer of the Year Award in 2002 and 2003 and the award for Global Developer of the Year in 2004 (John Laing, 2004).

[8] The Freeman Hospital (20,000m^2) site will contain cancer and renal services centre, and new multi storey car park (Newcastle upon Tyne Hospitals NHS Trust, 2005). The RVI site (60,000m^2) equipped with operating theatre, outpatient clinics will benefit from a new accident & emergency department, with all the clinical support services required, such as neurosciences, infectious diseases, traumatic orthopaedics, dermatology and critical care. Additionally, children's services will be integrated into a purpose-built facility adjoining the main development (Newcastle upon Tyne Hospitals NHS Trust, 2005).

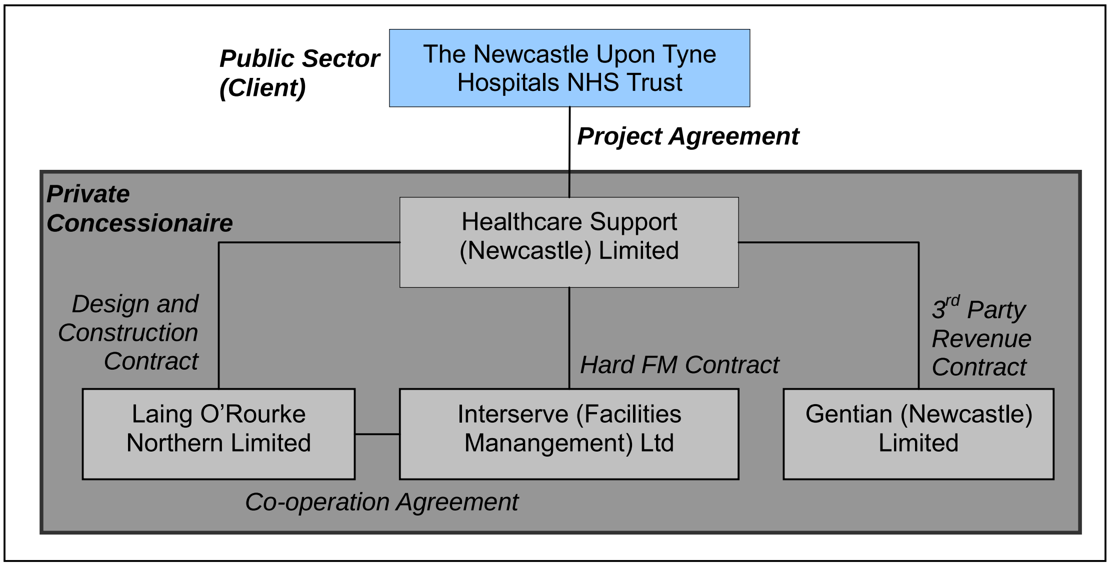

Figure 5.1: A description of a PFI deal to develop the Freeman Hospital and Royal Victoria Infirmary (RVI) in Newcastle

Total capital of the project amounts to £301.5M[9] which involves a combination of new buildings, repair and refurbishment of existing facilities. Consequently, the sum of £24.6M p.a. is agreed to be the unitary payment over the term of the 38-year life of the concession. The PFI solution has the benefit of a £5.8M series of enabling works that will be undertaken by the private sector, which accelerate the program by two years. It also can result in a more innovative solution compared to a publicly-funded scheme which effectively provides a greater scope of new build accommodation (Newcastle upon Tyne Hospitals NHS Trust, 2005).

The project's promoter is the Newcastle-upon-Tyne Hospitals NHS Trust. It currently provides healthcare services for a local population of around 300,000 in Newcastle and the surrounding area and specialist tertiary services to around three million people in the North East. It is one of the largest NHS Trusts in the UK and has a turnover of more than £0.5 billion. The activity profile for 2003/04 was 101,654 inpatients; 73,200 day cases; and 769,284 outpatients, which delivered an income of around £530M (Newcastle upon Tyne Hospitals NHS Trust, 2005).

[9] It will be financed by receiving a combination of £238M senior bonds and £115M loan facility provided by European Investment Bank, together with junior subordinate loan stock and ordinary shares.

The PFI deal was made in a way that the Trust will be responsible for clinical care for patients as well as Soft FM services, the maintenance of any existing estate (over 180,000 m^2), 'Big Ticket' equipment such as linear accelerators, and car park management. The private concessionaire, Healthcare Support (Newcastle) Limited, led by Equion will through its sub-contractors provide the designing and constructing facilities, non-clinical services and maintenance required over the 38-year life of the concession.

5.2. Methodology

Three financial models are built to achieve a goal of finding the value of flexible design in dealing with demand risks: a Static Model, a Model Recognising Uncertainty and a Model Recognising Uncertainty and Flexibility. This chapter describes the models in broader terms by mainly focusing on the intuition of the models. The detailed description of each model can be referred to Chapter 6.

First of all, a model is built to calculate a static Net Present Value (NPV) of the project for public and private sectors using standard Discounted Cash Flow analysis (DCF). This model is referred to a Static Model and it assumes deterministic projection of the cash flow from a single demand scenario, which is expressed in terms of patient activities (i.e. inpatient/daycase activity and outpatient activity). However, this will result in the "flaw of averages" where average value of uncertain investment cannot be reliably predicted using an average value of uncertain inputs and can consequence a financial crisis from ignoring the range of uncertainties. In addition, a single demand scenario does not allow us to demonstrate the value of flexibility. Calculations of the value of flexibility have to allow for different scenarios in which they would be exercised (de Neufville and Scholtes, 2006).

Therefore, a second model which incorporates different demand scenarios instead of a single scenario is developed. In order to build different demand scenarios, key sources of demand risks are identified and are assumed to be from the changes in demographics, medical technology and government policy. Representative demand scenarios from each source are outlined as following.

There are two main components of demographic patterns which affect patient activities: demographic ageing and immigration pattern. As the population aged 65 and over is increasing, the number of patients as well as length of stay are expected to rise. For example, as people live longer, more of the NHS's work will be treating long-term conditions such as diabetes and heart diseases. In contrast, increased immigration of middle-aged people into the catchments could relatively decrease the inpatient length of stay but increase the number of potential patients.

Changes in medical technology will also impact significantly on the future demand. First of all, let us look at how the medial technology influenced patient activities up to the present day. The development in medical technology has dramatically improved productivity and has substantially increased hospital capacity for treating patients and providing interventions. Diseases that would have almost certainly killed in the immediate post-war period are now usually treatable, and in many instances curable (Jennings, 2000). As a result, it has increased the number of treated inpatients/daycases and outpatients whereas it has reduced the inpatient length of stay. Since the early 1980s, inpatient activity has grown by over two thirds and outpatient activity has increased steadily by over a quarter. On the other hand, inpatient length of stay has shown a downward trend for nearly 50 years: mean length of stay was 49.3 days in 1949; 19.8 days in 1979, and currently mean length of stay of approximately 4.92 days is recorded [10](Hensher and Edwards, 1999).

A similar pattern is expected in the future. As the medical technology changes at a fast rate, more surgical procedures could be done on an out-patient basis, and consequently fewer hospital beds are needed for convalescence and a greater percentage need to be equipped for intensive and acute (de Neufville and Scholtes, 2006). For example, Biotechnology companies are developing products that will prevent, modify or treat a variety of cancers, breast cancer being one of the first treated (Wilson, 1999). The development of pharmaceutical products will thus decrease the need for admission to hospital by replacing some procedures. Another example can be found in the way of performing surgery. The most common operation in cardiac surgery can now be done robotically through pencil sized openings in the chest and this minimally invasive surgery will reduce hospital stay and promote outpatient operations (Wilson, 1999).

In addition, government policy in the health sector can affect the patient activity. For instance, government recently intends to increase the volume of elective work being undertaken in the Independent Sector which may result in a reduction of the outpatient

[10] As a result of a reduction in length of stay, the number of hospital bed in England fell by 31 percent, from 211,617 to 145,218 between 1984 and 2004 (Department of Health, 2006).

activities. Work in the Northumberland, Tyne and Wear Strategic Health Authority indicates that there is a threat to £8.4 M worth of Trust elective business from the government's drive to transfer up to 15 per cent of elective work to the Independent Sector. Similar scenario due change in government policy is assumed in the financial model.

Once the main sources of demand risks are identified, a model which is referred to a Model Recognising Uncertainty is built by incorporating a range of demand scenarios which is generated by combining effects from each source of uncertainties with different probabilities. Here, expectation consistency is ensured so that the average demand increment under the assumptions which make up for different demand scenarios will coincide with that for the original single demand scenario. This enables us to compare the outcome from a single scenario with a range of outcomes from using a model with different scenarios. In order to build a more accurate model recognising uncertainty in practice, the Trust can investigate the errors in the initial demand projection in previous hospital projects: i.e. by how far off the initial projection was made compared to the realised demand. This could then act as a reference point to assign the degree of the uncertainty in the model.

Lastly, flexibilities in the strategic level are introduced into the model to respond to different demand scenarios; a Model Recognising Uncertainty and Flexibility. Flexibilities considered in the analysis include expansion of the hospital in height (Flexibility 1) and that by turning the existing car parks into the new hospital blocks (Flexibility 2) as the means of amplifying gains in upside scenarios. Although it is not rare to find this kind of expansion options in design, most of the hospital design does not consider the flexible way to deal with downside scenarios. Thus, the option which enables to sublet a part of a hospital to the private company as a secondary usage (Flexibility 3) is also included in the analysis to find out whether it effectively helps to cut losses in downside scenarios. The next step is then to decide when a particular flexibility should be exercised as the demand projection moves from a high to a low demand forecast according to the relationship between capacity and demand. For example, if the demand increases significantly, flexibility whose ability is to expand the hospital can be exercised thereby increasing its capacity. Subsequently, the model will enable us to evaluate the added value of flexibility compared to its related costs (i.e. initial and exercise flexibility costs) on a scenario by scenario basis.

5.3. Value of Flexibility to Deal with Demand Risk

Static Net Present Value (NPV) for the Trust is obtained to be £3300M[11] using one deterministic demand scenario with a 4% annual increase in patient activities. When uncertainties are introduced to the demand prediction, the Trust expects to have a lower NPV of £2865M on average. A distribution of NPV rather than a single value is obtained as an outcome of the model recognising uncertainty and it can vary from the minimum of £380M to the maximum of £4275M. This large variation is due to the fact that the PFI projects especially in the healthcare are inherently subject to greater demand risks which drive the income of the Trust. Indeed, the variation of NPV is very sensitive to the chosen degree of uncertainty in the model. By increasing the level of uncertainty by a factor of 1.5, the NPV for the Trust can be as low as -£500M, indicating that the Trust can go bankrupt in some of the extreme downside scenarios. This illustrates the serious implication of ignoring uncertainties in the financial analysis.

Let us see what happens to the value of the contract for the Trust as we introduce flexibility in the project. The Trust has the option to react to new information regarding the patient activities, and hence increased uncertainty is not necessarily detrimental to the value of the project for them. Instead, flexibility becomes more valuable with higher volatility which provides the Trust more opportunities to exercise flexibilities to respond to different demand scenarios. If the downside scenario unfolds, the client can sublet the part of a hospital to the private sector for secondary usages therefore limiting its losses (i.e. exercise flexibility 3). In the upside, the client has an option to expand the hospital and the value increases with this volatility (i.e. exercise flexibility 1&2).

Overall, flexibilities can add on an average of £200M to the value of the project for the Trust and always shift the distribution of possible outcomes beneficially (figure 5.2). This indicates the value of flexibility exceeds its costs in both downside and upside scenarios. The option to expand the hospital can amplify gains in upside scenarios by as much as £600M whereas the option to sublet a part of the hospital (i.e. downsizing the capacity of

[11] The activity profile for 2003/04 for Newcastle upon Tyne Hospitals NHS Trust was 101,654 inpatients; 73,200 day cases; and 769,284 outpatients, which delivered an income of around £530M (Newcastle upon Tyne Hospitals NHS Trust, 2005). Based on this data, average income per 1000 spells and per 1000 attendances in the start year of the PFI project (i.e. 2004) are assumed to be £1.4M and £1.0M. Thus, in the first year of the operational period (i.e. 2011), an incremental income of £220.7M from the new development is assumed using static expected demands of 52,640spells and 118,43 attendances, and inflation rate of 2%.

the hospital) can cut loses which amount up to £300M.

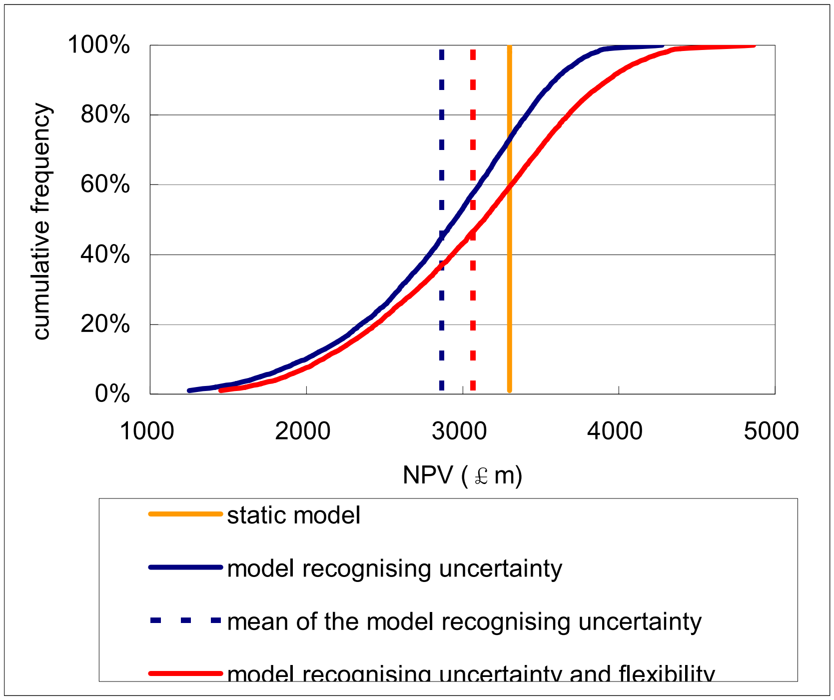

Figure 5.2: Value of flexibility for the Trust to deal with demand risk

Value At Risk and Gain (VARG) Curve using a model recognising uncertainty and flexibility is also obtained with a 25% threshold percentage as in figure 5.3. This is informative to the Trust looking for the average NPV from upside scenarios and that from downside scenarios. The figure indicates a quarter of chance of having NPV smaller than £2525M (Value at Risk, VAR), a quarter of chance of having NPV higher than £3638M (Value at Gain, VAG), and finally having the average NPV of £3067M compared the average NPV of £2865M from the case without flexibilities.

In contrast, there is no effect of uncertainty and flexibility on the value for the private sector which amounts to £59M since the private sector does not take any demand risk. Thus, in PFI projects, flexibilities are exercised unilaterally in the interest of only the public sector's payoffs. More detailed statistics of NPV for different partners in the contract are summarised in Appendix I.

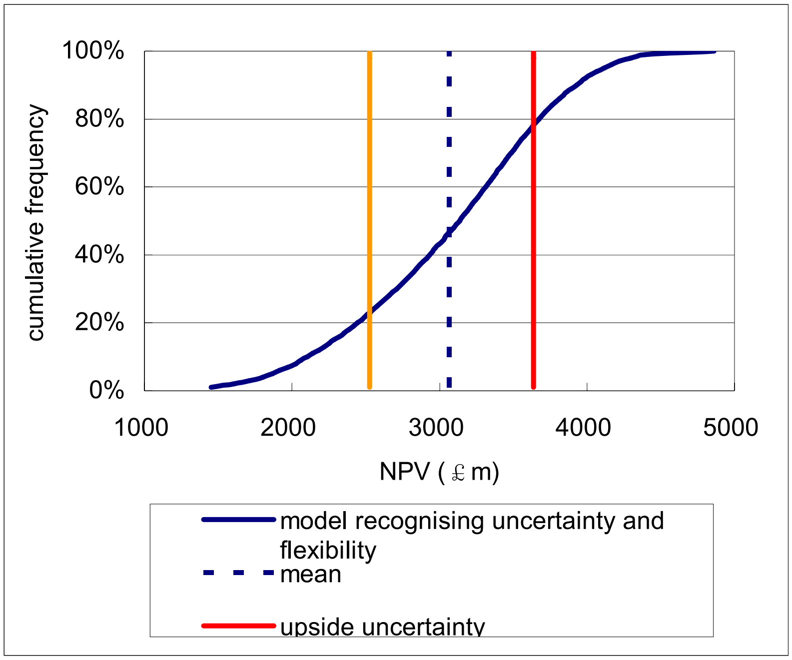

Figure 5.3: Value At Risk and Gain (VARG) curve for the Trust

5.4. Option Fee, an Approach to Share the Benefits of Flexibility

It is discovered that the added value of flexibility is not shared between the partners in the PFI contract. Instead, incorporation of flexibility is only beneficial to the public sector who has the right but not obligation to exercise options from taking demand risks. Hence, it will be hard for the Trust to negotiate with the private sector to include flexibilities in the contract. In fact, the private sector, the "owner of the asset", has few incentives to build in flexible design solutions since they can charge the public sector for the higher cost of future modifications which fall on the public sector. It is thus necessary to develop a way to share the added value of flexibility so that both partners agree to incorporate flexibilities in the project.

This paper proposes that the public sector pays "option fee" to the private sector in order to gain the private partner's willingness to implement the option for them. This fee is recognised in terms of an additional unitary payment which is fixed over the concession period. Consequently, the Trust will have different risk contents of the benefit compared to the private sector. The public sector faces uncertainties in the added value of flexibility which will depend on whether a particular flexibility is exercised or not (figure 5.4). On the other hand, the private sector can benefit from the increased unitary payment throughout the concession period without any risk associated with the benefit. This unbalanced sharing of risks between the partners is assumed since the private partner who is the owner of the asset, has higher negotiating power in adopting flexibilities in the contract.

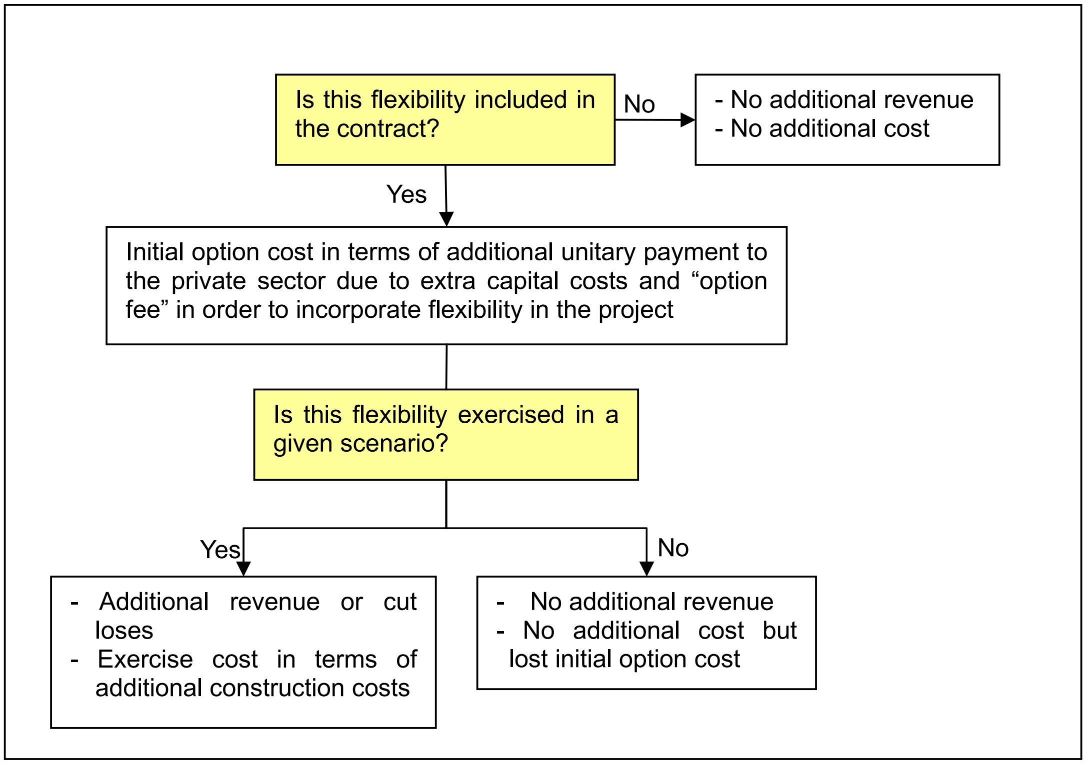

Figure 5.4: A flow chart to illustrate the value of flexibility when “option fee” is introduced in the contract

The next question concerns by how much the public sector should be prepared to increase the unitary payment. Figure 5.4 represents how the value of the real option changes with the option fee for each player typically by employing flexibility 1 whose ability is to expand the hospital in height. It indicates that the introduction of the option fee at the contract makes the added value of flexibility start to be shared between the partners. Namely, if the value of flexibility goes up for one player, that for the other player goes down. In addition, due to the risk associated with the added value of flexibility for the Trust, a range of the benefit is expected. When flexibility to expand the hospital in height is exercised, the value of the project can be augmented indicating the positive benefit of flexibility. In contrast, the Trust loses the initial option cost including the option fee when flexibility is not exercised. This particular flexibility is then expected to bring the added value which lies between the dotted lines observed in figure 5.5 with 95% confidence. As long as the average value of flexibility is positive, the Trust should then be prepared to pay “option fee” which lies within the positive side of this range. Similarly, the ranges of possible option fees for flexibility 2 and 3 are obtained in Appendix 2.

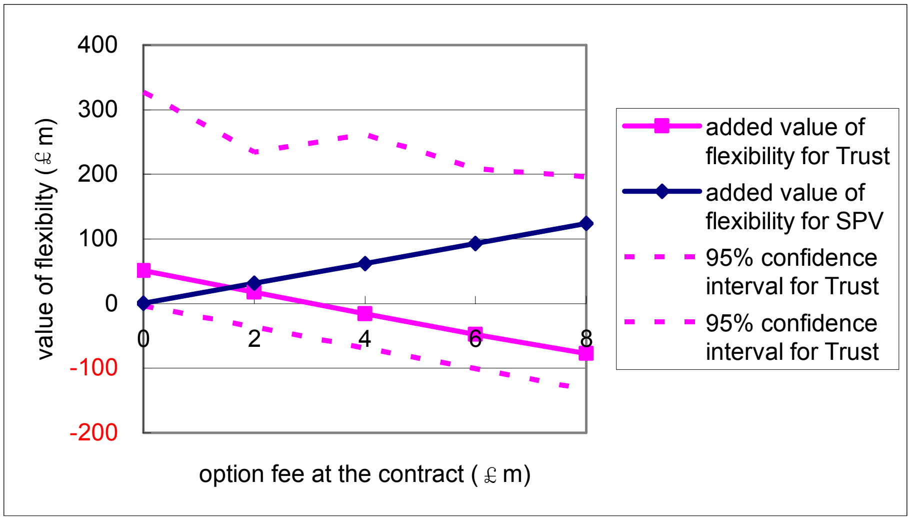

Figure 5.5: Obtaining a range of possible option fees at the contract for flexibility 1

5.5. Value of Flexibility with Introduction of Option Fee in the Contract

Both public and private sector can now take benefits from incorporating flexibility with an introduction of option fee in the contract. As an indication to illustrate the outcome of this approach in sharing the benefits, the option fee for each flexibility is determined at the intersection between the profiles of value of flexibility for different players (i.e. when the benefit is shared equally between the players on average); £2M for flexibility 1 and 2, and £3M for flexibility 3. In this setting, it is assumed that the private sector has more negotiating power in choosing the value of the option fee. This is because the incorporation of flexibility to deal with demand risks is the interest of only the public sector but the private sector owns the asset. Thus, the public sector is assumed to bear the risks associated with introducing flexibilities into the project. In addition, both partners in the contract are assumed to agree on the level of uncertainty anticipated in the future.

Similar patterns in the Trust’s NPV distribution are observed as in the case without option fee in the contract: flexibility minimizes their exposure to bad outcomes, and maximizes their opportunities. However, the added value of flexibilities is reduced from £200M to £91M on average (i.e. a reduction of £109M) by implementing the option fee. This reduction is directly transferred to gains for the private sector. Namely, the NPV for the private sector now increases from £59M to £168M, and there is no uncertainty associated with this NPV as the private sector benefits from the option fee regardless whether flexibility is exercised or not. More summary statistics on the outcomes are presented in Appendix I.

5.6. Portfolio Thinking

The Trust needs a way to discriminate between flexibilities to decide which flexibility is worth of implementation. Therefore, the performance of combination of several flexibilities can be analysed incorporating a 'portfolio thinking'; flexibility is regarded as an investment option in the portfolio design. The client will choose a "portfolio" of flexibilities which maximises the value of the project. Risk vs Return Chart for different portfolios of flexibilities in table 5.1 is obtained as in figure 5.6. It shows that the individual value of different flexibilities is not necessarily additive due to interactions between them.

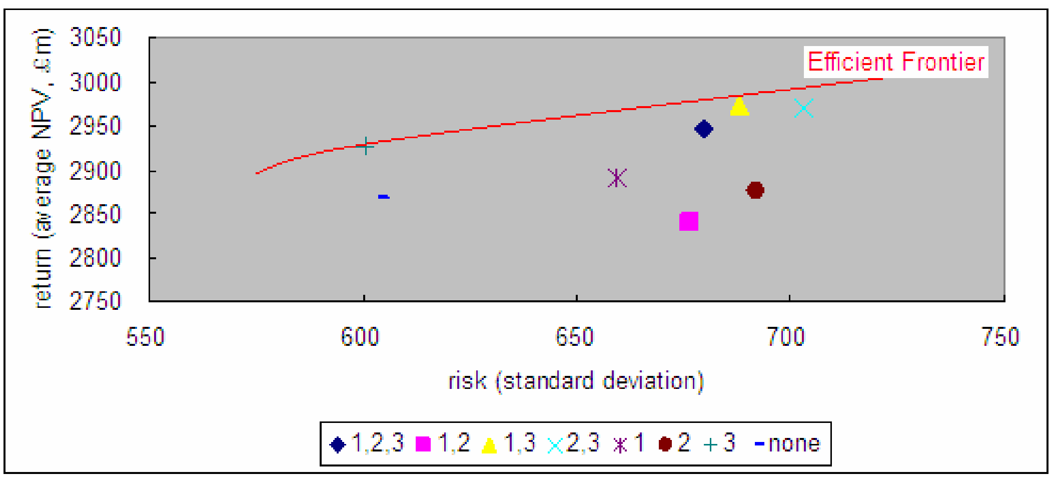

Figure 5.6: Risk vs Return Chart for the Trust with the total option fee of £7M

Flexibility 1	Expanding the hospital in height
Flexibility 2	Expanding the hospital by building additional hospital blocks
Flexibility 3	Downsizing the hospital by subletting for secondary usages

Table 5.1: Flexibilities in the financial analysis

A portfolio is called efficient with respect to a set of performance metrics if no other portfolio exists within the budget which improves on one metric without deteriorating in any of the others (Brealey and Myers, 2003). The collection of efficient portfolios is then called the efficient frontier. In this PFI project, only two portfolios are observed on the efficient frontier (figure 5.5) and they are summarised in table 5.2. The choice of a portfolio among the ones on the efficient frontier really depends on the risk preference since a portfolio design with a higher average NPV has to be in general compromised with a higher risk as well as a higher investment cost. For example, a risk-averse client will choose to incorporate only one option with the lowest risk, which is to sublet the part of a hospital for private usages in the project. In order to maximise their NPV, the client can include flexibilities whose abilities are to expand the hospital by building additional hospital blocks and to sublet a part of hospital to the private sector for a secondary usage. However, the Trust should be aware of greater risks and higher investment costs underlying this portfolio choice.

Efficient Portfolio	Return average NPV (£ M)	Risk std dev	Investment cost (£ M)
Flexibility 3	2925.93	600.76	300.3
Flexibility 1 & 3	2973.63	688.07	302.7

Table 5.2: Efficient portfolios with the total option fee of £ 7M

General comments can be made from this portfolio analysis. The project can benefit from a higher NPV when it contains both the option to expand and the option to downsize the hospital capacity. This is the most effective way to cut losses in the downside as well as to amplify gains in the upside scenario. In addition, it is not proposed to include more than one option whose ability is to expand a hospital since there is little chance to exercise both flexibilities so that there is a higher chance of losing initial investment for flexibility.

5.7. Value Drivers of the Option

Six levers which control an option's value are identified by Leslie and Michaels (1997) and the applications of each lever to a PFI hospital project are identified as in table 5.3. Sensitivity analysis of the option value by pulling the levers enables the Trust to carry out the proactive management; they can make initial decisions which optimise the use of flexibility. Here, change in option value arising from a 10% change in each lever identified in table 5.3 is examined (figure 5.7).

Lever	Definition	Application to a PFI hospital project
Lever 1	Present value of expected cashflows	Average annual revenue per patient activity
Lever 2	Present value of fixed costs	Average annual cost
Lever 3	Uncertainty of expected cashflows	Uncertainty in demand projection
Lever 4	Duration of option	Length of concession period
Lever 5	Value lost over duration of option	Initial capacity decision
Lever 6	Risk-free interest rate	Interest rate

Table 5.3: Value drivers of the option (Leslie and Michaels, 1997)

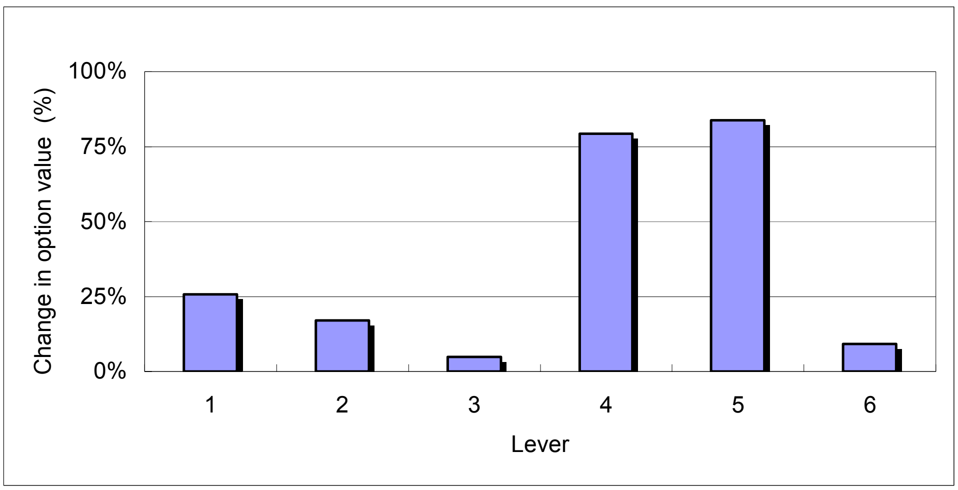

Figure 5.7: Sensitivity analysis of option value with the total option fee of £7M

Changes in the concession period and initial capacity decision have the greatest impact on the change in option value. They are also the only levers which can be pulled or altered by negotiations between the partners in a typical PFI hospital contract. Let us look at the way that the concession period and initial capacity decisions should be negotiated in the contract to maximise the value of the option.

Flexibilities can add more values to the project by increasing the contract period which will in turn increase uncertainties in the future. This is because flexibility becomes more valuable with higher volatility which provides more opportunities to exercise flexibilities to respond to different demand scenarios. Furthermore, if the height of a hospital is restricted at 8 storeys, flexibility can add more value to the project with the lower initial height decision (figure 5.8). This is because the lower capacity decision enables to increase or decrease the capacity in a more effective way in response to the realised demand. The maximum average NPV is reached when the hospital is designed with the initial height of 4 storeys and the added value of flexibility with this decision covers the its costs in almost 70% of cases. The initial capacity of more than five storeys would not bring any merits to the client as it is too large to sink the project, and at the same time there are higher chances when the added value of flexibility cannot cover its cost. Summary statistics of the outcome for different initial capacity decisions can be referred to Appendix I.

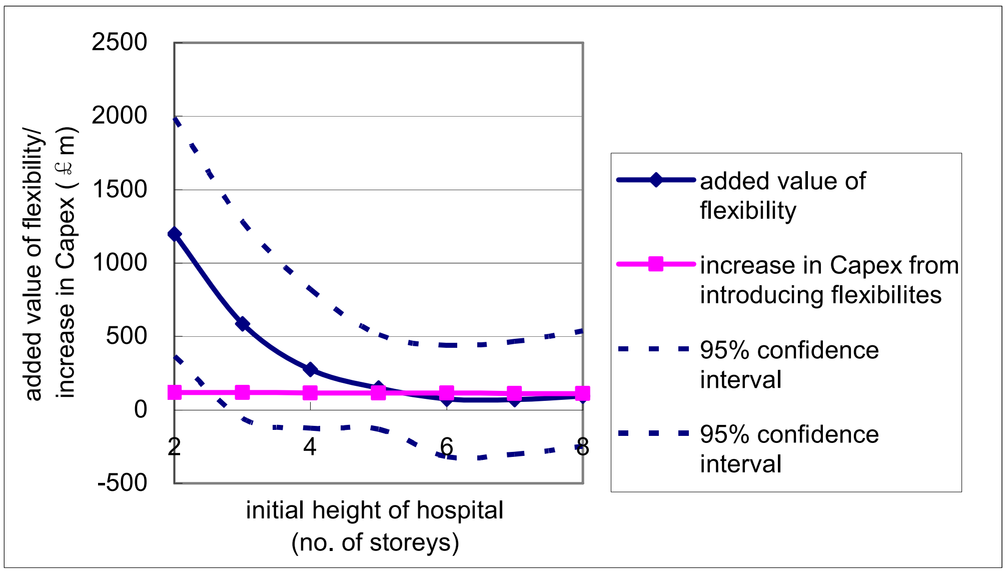

Figure 5.8: Effect of changing the initial capacity decision on the value of flexibility for the Trust with the total option fee of £7M

6. DETAILED EXPLANATION OF METHODOLOGY FOR FINANCIAL VALUATION

The methodology to assess the value of flexibility in dealing with demand risks is based on Monte Carlo simulations and Real Options Analysis. It involves building three models: Static Model (SM), Model Recognising Uncertainty (MU) and Model Recognising Uncertainty and Flexibility (MUF).

6.1. Static Model

This model is built to calculate a static NPV of the project for the public and private sectors and this corresponds to a standard Discounted Cash Flow analysis (DCF). A typical timeline for each partner in the PFI contract in the NHS is illustrated in figure 6.1. Based on this timeline, a cash flow model is built with the main assumptions outlined as following:

- Cash flow is modelled for 38 years of concession period after the financial close.
- Revenue from the patient activity is the only source of the Trust's income (i.e. there is no secondary revenue involved in the project).
- Trust takes responsibility for providing soft Facility Management and 'Big Ticket' equipment (e.g. linear accelerators).
- The project is mainly financed by bond funding, EIB (European Investment Bank) bond debt and UK Government bond debt, and repayments start at the beginning of the operational period.
- Initial capacity decision in terms of the height of a hospital is assumed to be 6 storeys which enable it to serve 90 spells/year and 240 attendances/year.
- Demand and capacity are expressed in terms of spells/year [12] and attendances/year to represent inpatient/daycase activity and outpatient activity respectively. A 4% annual increase in patient activity is chosen to represent a deterministic scenario.

[12] Spell is the total continuous stay of a patient in a hospital from admission to discharge. Spell/year is then found by
$Spell / year = (Total\ number\ of\ inpatients) \times (Average\ length\ of\ stay)$.

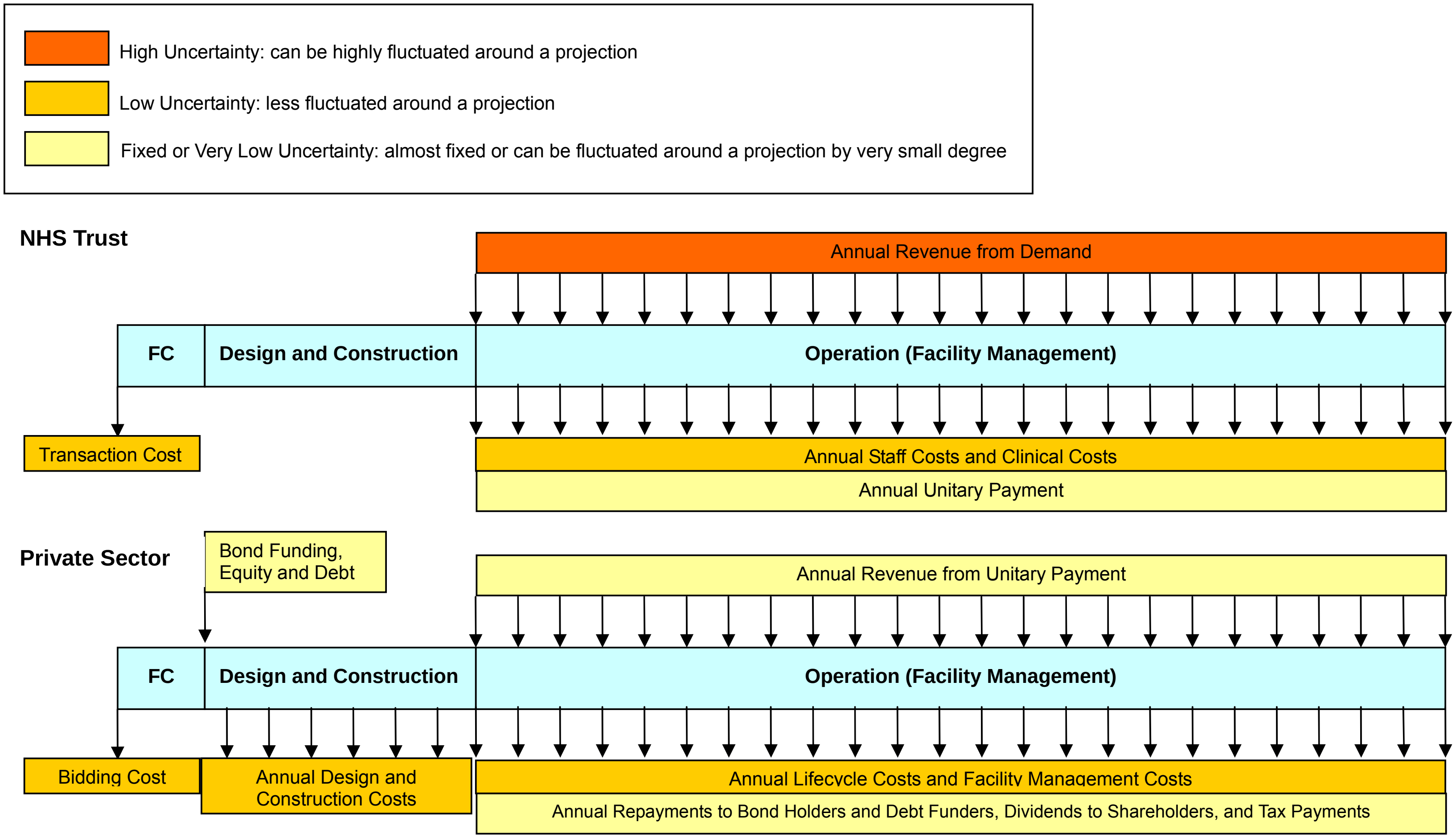

Figure 6.1: A typical timeline for a PFI hospital project

6.2. Model Recognising Uncertainty

In the model recognising uncertainty, future demand is modelled by three random variables which describe the annual growth of components of patient activities, namely the number of inpatients, length of stay and the number of outpatients. First of all, key sources of the uncertainties related to the future patient activities are identified such as changes in demographics, medical technology and government policy. Annual growth of each patient activity due to each source i is assumed to be normal distributed with mean μ_i and variance var_i (Table 6.1), and it is also assumed to be independent from one source to another. Further assumptions in the government policy change are made so that there is a certain probability of change in government policy in any given year within a specified term, $term_1$, and once the change takes place, it will last for the rest of the contract period. The random variable for each component of patient activities is then obtained from a flow chart in figure 6.2.

By Monte Carlo simulations[13], the model can simulate samples from the defined random variable distribution chosen by figure 6.2 to represent the demand scenario and in turn produce one NPV for each sample. By running several simulations, a distribution of NPVs corresponding to a chosen distribution of input values can be obtained and consequently statistics such as mean NPV and standard deviation are calculated.

	% of happening	Annual growth of patient activity (%)		
		mean	volatility	distribution
change in demographics		μ_1	var_1	$N(\mu_1,var_1)$
change in medical technology		μ_2	var_2	$N(\mu_2,var_2)$
change in government policy	P_1, $term_1$	μ_3	var_3	$N(\mu_3,var_3)$

Table 6.1: Inputs to model an annual growth of patient activity

[13] Monte Carlo simulation is a variation of scenario analysis, based on sophisticated mathematical tools and software. It consists of isolating a number of the project's key variables or value drivers and allocating a probability distribution to each. All the assumptions about distributions of possible outcomes are entered into a spreadsheet. The model then randomly samples from a table of pre-determined probability distributions in order to identify the probability of each result (Vernimmen et al. 2005).

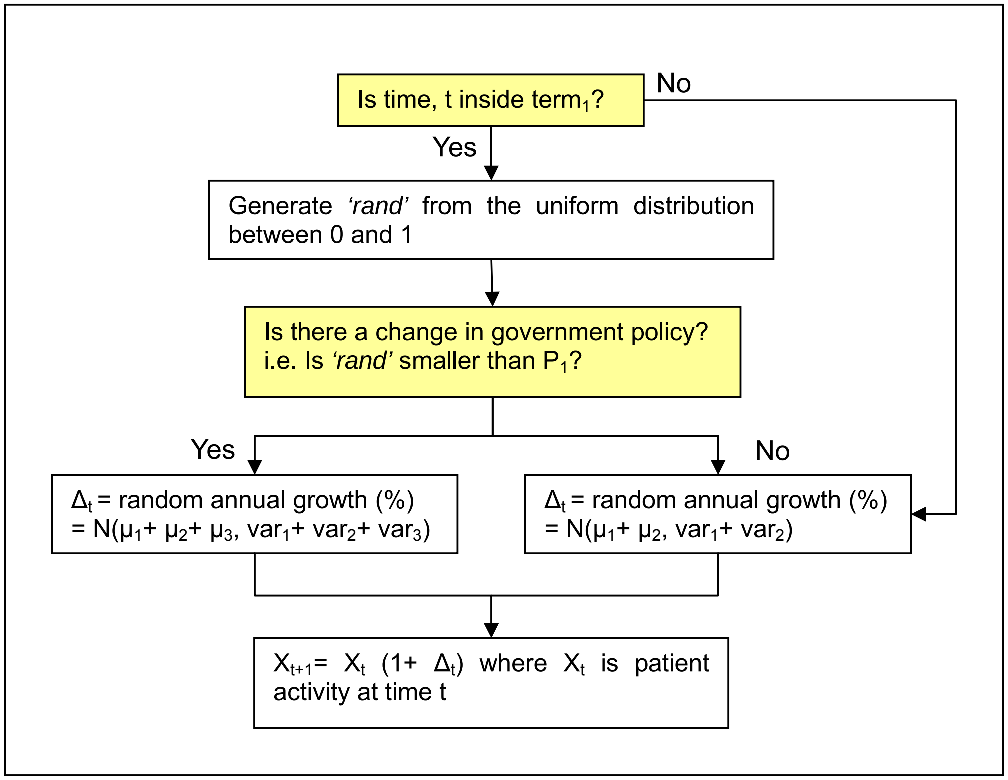

Figure 6.2: A flow chart to model patient activity at time t

6.3. Model Recognising Uncertainty and Flexibility

Random model with flexibility introduces the use of flexibility in the model. The flexibilities introduced in the financial analysis are in the strategic level as this has the most significant effect on the overall performance of the project. Three strategic flexibilities considered in the financial valuation are outlined below.

- *Flexibility 1 - Expanding the Hospital in Height:*
  Flexibility to expand the hospital in height is feasible by designing for a stronger foundation, column, slab, etc. which could withstand heavier loadings from additional floors in the future. This option amplifies the upside scenario by increasing the capacity of the hospital whenever it is needed.

- *Flexibility 2 – Expanding the Hospital by Building Additional Hospital Blocks:*
  The arrangement of current buildings can be designed in a way that the long term development plan can take place by incrementally building additional hospital blocks

as need arises. As parking space is consumed by the new buildings, it will be necessary to build a new multi-storey car park when this flexibility is exercised. This is then another way to amplify the upside scenario.

- *Flexibility 3 – Downsizing the Hospital by Subletting for Secondary Usages:*

The part of a hospital can be sub-let to a private company for secondary usages such as office spaces, pharmaceutical production, pharmaceutical trials, and plastic surgery. In the model, it is assumed that subletting is a permanent decision for the concession period in consideration. This will enable the Trust to react with downside scenarios when they face difficulties from the overcapacity in its facility.

Let us now examine how the choice to exercise flexibility is modelled in the financial valuation. Flexibility will give the Trust the right but not the obligation to certain future actions and it is assumed that the Trust exercises flexibilities according to the relationship between capacity and demand at the option point. For example, if demand increases significantly, flexibility which has the ability to expand the hospital can be exercised to increase the capacity of the hospital. It is thus necessary to define the limit of the differences between the demand and capacity sufficient to exercise flexibility and also the maximum number to allow exercising it. Typically, it is assumed that the limit to expand the hospital by additional hospital blocks is higher than that to expand in height. A flow chart is built according to the limits and maximum allowances described in table 6.2 to decide when a particular flexibility should be exercised (i.e. option point) as the demand projection moves from a high to a low demand forecast and is obtained in figure 6.3.

	Limits for defined consecutive years	Maximum allowance
Flexibility 1: Expansion in height	(demand - capacity) > Limit 1	A1
Flexibility 2: Building additional hospital blocks	(demand - capacity) > Limit 2>Limit 1	A2
Flexibility 3: Subletting for secondary usages	(demand - capacity) < Limit 3	A3

Table 6.2: Inputs to model the option point

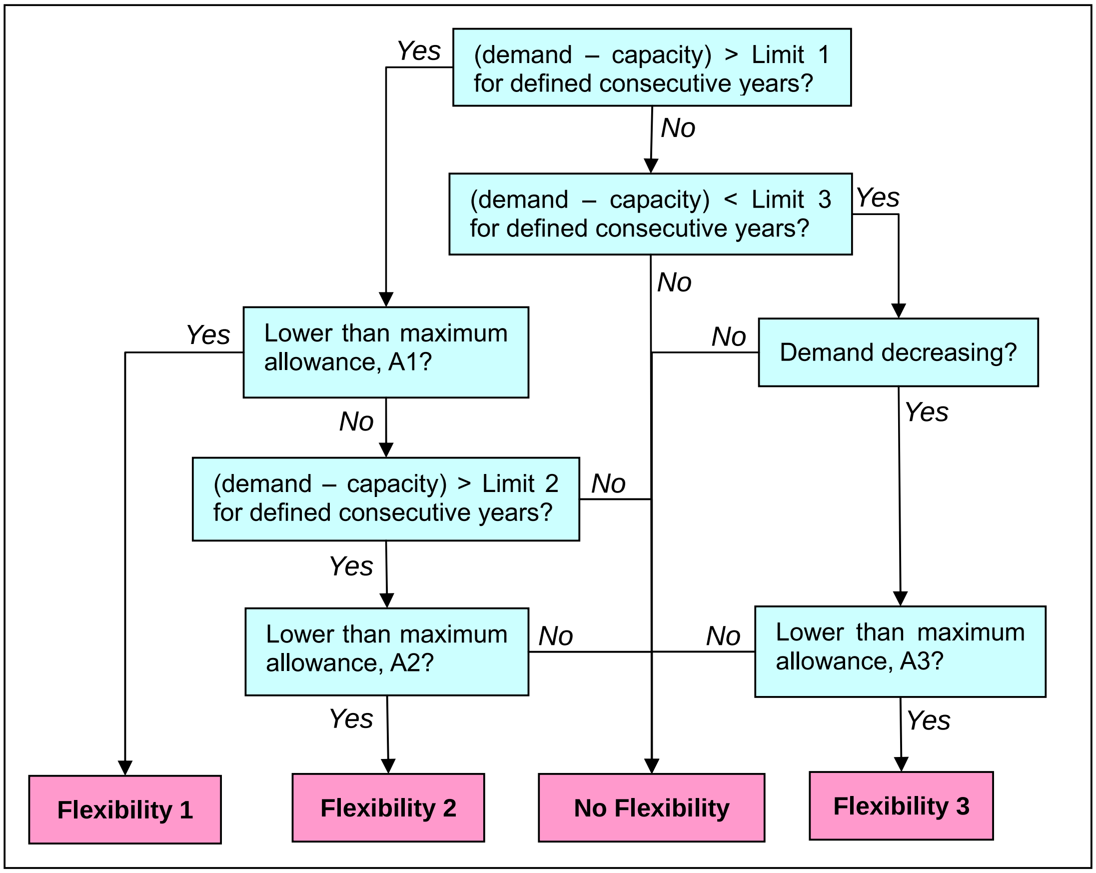

Figure 6.3: A flow chart to model the option point

7. CONCLUSION

7.1. Managerial Intuitions

Under PFI, the private sector owns the asset and therefore the public sector should explicitly spell out the flexibilities and scenarios under which they will be exercised in the contract to avoid financial penalties. This necessitates considering a way of structuring flexibilities in the contract before the financial close. We suggest an illustrative process using matrices called “OUF Matrices”: Operational Matrix, Uncertain Event Matrix and Flexibility Matrix. The process is designed in a way to help the partners to consider a sufficient number of scenarios and to look at the possibility of using flexibility through an integrated partnering system between clinicians and designers.

In addition, the financial models are developed in a way to capture many of the features relevant to an understanding of how value is affected by uncertainty and flexibility in PFI deals. They will allow managers to test their intuition during the procurement process by observing the effects of any change they make in the model.

The models suggest important managerial insights by analysing the value of flexibility in the design of a hospital PFI project. First of all, the public sector can substantially increase their expected Net Present Value (+ £ 200M on average) by incorporating flexibilities in the design of a hospital to deal with uncertain demands. However, the fact that the private sector owns the asset limits the public sector’s interest in adopting flexibilities. It is thus desirable to develop a way of sharing the added value of flexibility to motivate the private sector to create and exercise flexibilities in the project. Introducing an “option fee” in the contract, which the public sector pays to the private sector in terms of an additional unitary payment over the concession period, is suggested in this paper. In this way, both partners can take advantage of incorporating flexibilities in the design; the public sector can minimise their exposure to bad outcomes and maximise their opportunities and the private sector can benefit from the increased unitary payment throughout the contract period. Secondly, flexibility can be regarded as an investment option. By designing an effective portfolio of flexibilities, the client can either minimise the risk but with a relatively low return or maximise the return but with a relatively high risk. It is found that the value of a contract can be maximised by investing in a portfolio which contains both the option to expand and the option to downsize the hospital capacity. Lastly, sensitivity analyse for what drives the value of flexibilities can help to manage them proactively. It suggests that longer concession periods and the lower initial capacity decision can make the best use of flexibility.

7.2. Future work

This report focuses on evaluating the value of flexibility at the engineering and operations level, which requires modifications in design. Flexibility can also exist at the management decision level to increase a project's NPV. For example, Quiggin (2005) suggests that Public and Private Partnership (PPP) could be improved by the inclusion of put and call options which allow either party to terminate the contract after a predetermined period. He argues that "the inclusion of appropriately designed put and call options could render PPPs more robust and assist in the management of the risks associated with over-payments and contract failure." Hence, the next step towards improving PFI to deliver more value will be discovering and evaluating flexibilities at the management decision level which both partners in the contract can benefit from.

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APPENDIX I: OUTCOMES FROM FINANCIAL VALUATION

All amounts are in millions British Sterling.

		Static Model	Model recognising uncertainty	Model recognising uncertainty and flexibility
Trust's NPV	Average	3300.13	2865.71	3066.57
	Std Dev		614.39	688.95
	Std Err		6.14	6.89
	Max		4274.99	4861.94
	Min		380.49	679.38
Private Sector's NPV	Average	58.94	58.94	59.86
Initial Capacity Decision (no. of storeys)		6	6	6
Capex		300	300	304.7

Table AI.1: Value of flexibility to deal with demand risk using 10,000 Monte Carlo simulations

		Static Model	Model recognising uncertainty	Model recognising uncertainty and flexibility
Trust's NPV	Average	3300.13	2853.73	2936.32
	Std Dev		610.13	689.07
	Std Err		6.20	6.99
	Max		4092.28	4592.34
	Min		326.88	551.38
Private Sector's NPV	Average	58.94	58.94	168.06
Initial Capacity Decision (no. of storeys)		6	6	6
Capex		300	300	304.7

Table AI.2: Value of flexibility with the total option fee of £7M using 10,000 Monte Carlo simulations

		Model recognising uncertainty and flexibility						
Initial Capacity Decision (no. of storeys)		2	3	4	5	6	7	8
NPV	Average	2959.06	2927.59	2962.08	2929.89	2959.99	2621.26	2209.64
	Std Dev	689.40	688.11	669.05	702.28	680.89	794.75	858.63
	Std Err	15.42	15.39	14.96	15.70	15.23	17.77	19.20
	Max	4666.59	4525.37	4661.23	4905.50	4800.88	4709.09	4490.20
	Min	856.70	946.27	697.67	359.69	582.81	-33.93	-182.84
Capex		109.50	158.30	207.10	255.90	304.70	353.50	402.30

Table AI.3: Effect of the initial capacity decision on the Trust's NPV with the total option fee of £7M using 2,000 Monte Carlo simulations

APPENDIX II: A RANGE OF POSSIBLE OPTION FEES

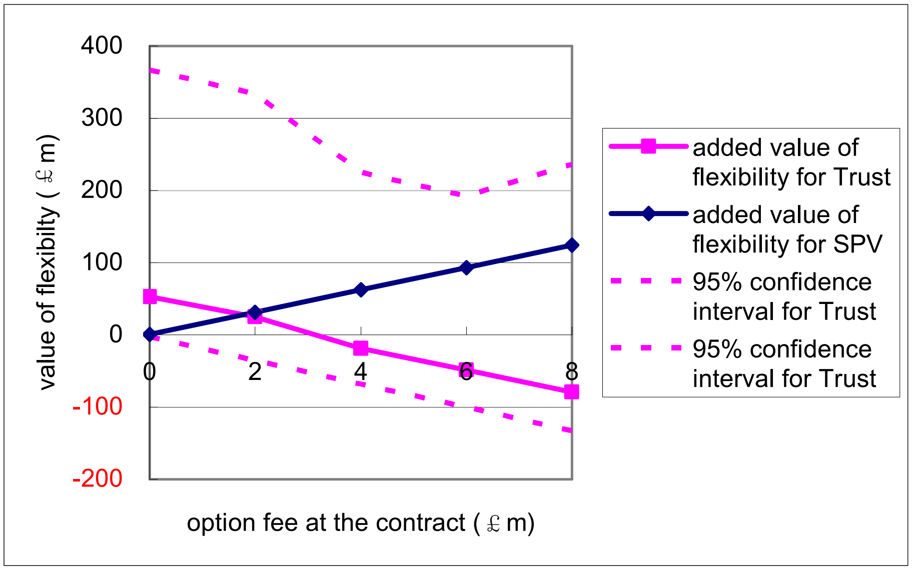

Figure AII.1: Obtaining a range of possible option fees at the contract for flexibility 2

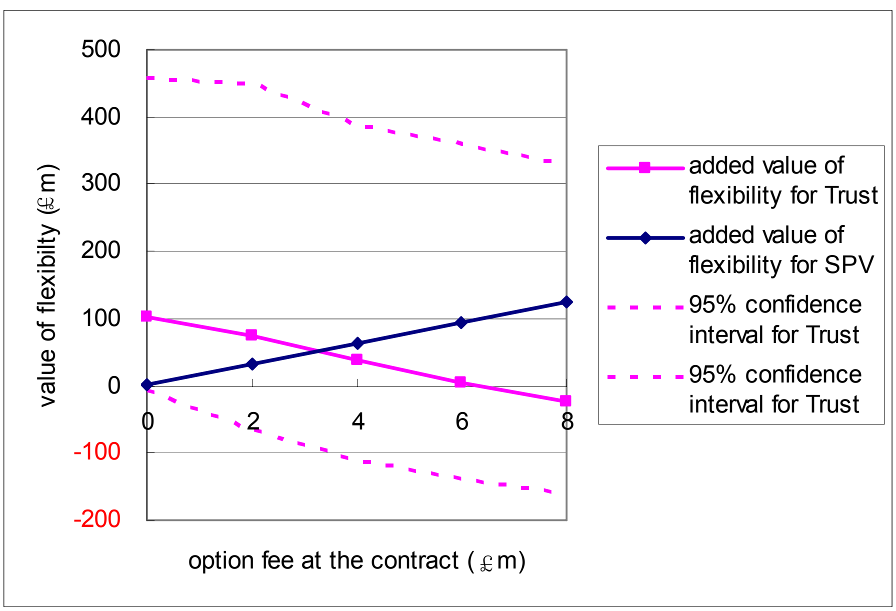

Figure AII.2: Obtaining a range of possible option fees at the contract for flexibility 3