
2.1 Introduction

Several academic and empirical studies have been devoted to studying the main benefits and pitfalls of PPP models. They have been identified in Chapter 1, and regardless of the extraordinary contributions made toward understanding the consequences of using this procurement model, it is of the utmost relevance to develop a “bird’s eye” perspective and look at the first moment when a PPP model was considered. Many problems with PPP utilization are related to the fact that some projects should not be developed under this model in the first place.

The literature provides several classifications for PPP (Allen 2001; Bennett and Iossa 2006; Meda 2007; Cheung et al. 2010; Marques and Berg 2011a), but as mentioned earlier, PPPs are essentially a procurement model for which there is always one alternative – traditional procurement. Governments should be focused on the final output (the public service) and the conditions under which it is provided (quality levels).

PPPs or traditional procurement arrangements are possible alternatives to provide that same output. Because decision makers have different models to ensure the provision of the infrastructure and/or service, it is necessary to compare both models and select the best one. This comparison can be made using qualitative or quantitative methodologies. To avoid the subjectivity of qualitative assessment, practitioners have developed a quantitative tool for their projects: the PSC. Although the PSC is not immune to criticism, it allows (at least partially) the subjectivity of the qualitative analysis to be addressed.

This chapter will analyze the concepts of PSC and VfM and will also provide an overview of the different alternatives for PSC calculation. The analysis will focus on its main strengths and weaknesses. The analysis also includes an international benchmark that looks at the calculation methods adopted by governmental agencies, particularly the discount rate.

Finally, this chapter will also present and discuss some real case studies to illustrate the different calculation methodologies and will perform a critical

assessment of each country's experience. Later on, it will illuminate the problem of uncertainty in a PSC calculation, shifting the process from a deterministic to a probabilistic source.

2.2 PSC Definition

The PSC is a theoretical calculation of the total costs for the public sector of developing and operating an infrastructure and/or service. It is basically the sum of cash-flows (including CAPEX and OPEX) for a pre-determined duration, incorporating the efficiency gains arising from the manager learning curve and the retained risk, assuming a public management model. However, there are some distinct approaches to the definition of the PSC. Quiggin (2004) defines the PSC as a single number, while Grimsey and Lewis (2005) prefer a more holistic definition of the PSC, which considers the entire process of decision making.

Considering the existing academic literature and technical reports, the authors summarize in Table 2.1 the main definitions of the PSC. The academic literature dealing with the PSC is still limited, with some exceptions (Heald 2003; Bain 2010; Hui et al. 2010; Cruz and Marques 2012a, 2013a) based on technical reports.

In this book, we adopted the first definition, under which the PSC can be interpreted as an extrapolation of the concept of life-cycle cost analysis (LCCA).¹ While LCCA only accounts for costs, the PSC also addresses revenues, either direct or indirect. Direct revenues are those arising from user charges (tariffs, tolls, etc.), while indirect revenues are related to third party revenues (sales of terrain, rentals, advertising, etc.).

There are several objectives behind PSC calculation. The main objective is to demonstrate VfM, i.e., allow an economically rational choice between PPP schemes and traditional procurement. While doing that, PSC calculation allows the project promoter to focus on the output specification and also on the risk allocation for the project (Partnerships Victoria 2001). The calculation of the PSC allows for simulating different risk allocations and selecting the one with the higher VfM.

The immediate purpose of the PSC is to provide a tool for the decision making process of the procurement model. However, before that, the type of knowledge and expertise that the public sector can acquire when assessing all costs and revenues, from a life-cycle perspective of the project, and exhaustively identifying the main sources of risk is extremely valuable in assessing the business model, the type of contract and the optimal risk sharing agreement.

¹ LCCA accounts for all costs, recurring and non-recurring, for the entire life-cycle of the infrastructure. These include all expenditures related to owning, financing, operating, maintaining and, if the case should arise, disposing the infrastructure and/or service (US Department of Commerce 1995; Sarma and Adeli 2002; Cruz and Marques 2012b).

Table 2.1 Literature review on PSC definition

Author	Proposed PSC definition
Netherlands Ministry of Finance (2002)	The Public Private Comparator (PPC) and the PSC are the first instruments which provide insight into the possible added value of a PPP procurement by comparing the PPP procurement option with the public approach. Furthermore, the PSC gives us an idea of the total projects costs over the project life-cycle
Industry Canada (2003)	PSC as a hypothetical, risk-adjusted costing by the public sector as a supplier, to an output specification produced as part of a procurement exercise
Quiggin (2004)	The idea of the PSC is to estimate the costs of delivering a given service through the public sector. Financing under the private finance initiative (PFI) is approved if and only if the cost of service is less than that of the PSC
Grimsey and Lewis (2005)	Rather, the possibility of achieving extra VfM by implementing a PPP can be estimated (under the approach in the UK and some other countries) with a twofold analysis conducted prior to the PPP implementation. It comprises, first, the calculation of the benchmark cost of providing the specified service under traditional procurement and, second, a comparison of this benchmark cost with the cost of providing the specified service under a PPP scheme. This benchmark is known as the PSC
Australian Constructors Association (2005)	A PSC is an estimate prepared for the Government on what it would cost to meet the performance specification for a PPP in the public sector, using traditional delivery methods and taking proper account of risk
Infrastructure Ontario (2007)	Estimated total costs (including adjustments for retained risks and ancillary costs) to the public sector of delivering an infrastructure project using traditional procurement processes
Morallos and Amekudzi (2008)	The PSC estimates the expected life-cycle costs to the public agency, if the project was pursued through a traditional procurement. It uses a discount cash-flow (DCF) analysis to provide a projection of the NPV of expected cash-flows
Ghavamifar (2009)	The PSC is a benchmark used to determine whether the private proposals offer better VfM to the public sector
Bain (2010)	A PSC represents the hypothetical, risk-adjusted cost of a project – such as a road scheme – when that project is financed, owned and implemented by the government. A PSC is commonly used in public procurement decision making as a yardstick against which private investment proposals are evaluated
Hui et al. (2010)	PSC is a benchmark cost that estimates the quality of services, price, time frame, risk apportionment and certainty of a publicly financed project to deliver equivalent benefits to the PPP option
Shugart (2010)	The basic idea is that it is important to demonstrate quantitatively that the PPP project is superior to an alternative public sector project that would deliver the same (or very similar) services. This hypothetical public sector project is often referred to as the PSC

Source: Adapted Cruz and Marques (2012a)

There is no other phase in a project development chain where the public sector develops such an insightful knowledge of the project/business main determinants, such as in the PSC calculation phase.

2.3 Problems with PSC Calculation

2.3.1 Decision Narrowed to a Single Number

The main problem with the PSC is that it narrows the decision making process to the comparison between two numbers: the PSC and the PPP.² The PSC is a theoretical calculation including long-term forecasts and is therefore highly vulnerable to errors. In fact, the difference between the PSC and the PPP values is often smaller than the error margin in the calculation of the PSC.

Many PSC critics have claimed that the decision between PPP and PSC is too important to be made on a simple comparison between two numbers. In fact, irrespective of the process complexity, particularly the calculation of the PSC, or of the political objectives that the government might have to develop PPP schemes, the final decision comes down to a simple comparison if one number is higher than the other.

2.3.2 Lack of Transparency

The PSC is often criticized because of its lack of transparency. As Bain (2010) claims, the PSC is often a “black box” without any scrutiny. This opaque process raises suspicion, particularly considering that it will support the decision making process of projects worth multi-millions of Euros.

CBA also suffers from this same problem. Some countries, e.g., the UK, have developed a short summary of the CBA to support a participatory environment and increase public scrutiny. This might be applied to the PSC because most technical reports are extremely complex.

2.3.3 Lack of Robustness

Heald (2003) affirms that “Even disinterested policy analysts, operating with different assumptive worlds about public versus private performance, are likely to generate different numerical answers.” When the decision is narrowed to a single number, the lack of robustness might jeopardize the final decision. This lack of robustness is difficult to overcome because the assumptions made in the beginning

² This number corresponds to the value proposed by the private sector to deliver the infrastructure or manage the service.

have an enormous impact on the final result. Just to give an example, it is not rare that a 1 % change in the discount rate will influence the final PSC by 7–10 %.

Heald also claims that the responsible parties for the PSC are not “neutral” but are “interested players”. In fact, consultants or public servants actively involved in the PPP programs often perform these calculations, and therefore, they are interested in the development of these projects. One might establish a parallelism with the optimism bias that takes place in most traffic forecasts in highways or consumption estimates in drinking water projects.

Pollock et al. (2002) mentions that the project samples used to estimate the costs and time are often small and/or unrepresentative. Therefore, the PSC number is often estimated using little credible data.

2.3.4 Lack of Data

PSC calculation is strongly based on using historical data to estimate future costs. This raises a number of problems:

- (i) If a project is entirely new, then there is no historical data (e.g., constructing a nuclear power plant in a country with no such infrastructure);
- (ii) The data may not be appropriate; this might happen when the projects are not entirely comparable for several reasons: the legal and fiscal framework changed significantly with strong impacts on the final cost accounting, special features among past projects, etc.;
- (iii) Historical data can also result in a lack of rigor because teams do not know how those values were calculated or if the owners accounted for cost escalations;
- (iv) There are no accounting standards to ensure data consistency and the comparability of projects; and
- (v) The pattern of quality of service changes considerably over time and it is difficult to measure.

2.3.5 Difficulty in Estimating Efficiency Gains

The calculation of the PSC should account for future efficiency gains. In a time period of 20 or 30 years, it is reasonable to expect an improvement in the public sector managerial capacity. This component of efficiency gains corresponds to the improvement in the project performance that one should expect over time because of the accumulated know-how of the public sector. For example, considering a hospital managed directly by the public sector, it is very likely that over the next 20 or 30 years, the efficiency levels will increase. This scenario of efficiency gains over time is very difficult to determine.

This difficulty arises at two different levels. One is related to the identification of the efficiency gains in the present based on the current levels of the efficiency of the benchmarking sample. Naturally, this requires comparability between the samples

(avoid comparing ‘apples’ with ‘oranges’), which is not always possible. The other is related to the forecast of future efficiency or productive gains, and here, the complexity is much higher. The situation is even more serious when the market structure is not well consolidated and when it is expected that strong reforms take place in that period (e.g., allowing for earnings of economies of scale and economies of scope).

2.4 VfM

The concept of VfM is directly related to the efficiency and effectiveness of PPP projects (Heald 2003). The same author argues that even though this instrument is clearly technical and developed within public auditing, it is not far from the political area and decision theory (see more in Schoemaker 1982; Anand 1993).

In fact, the VfM is about measuring the utility of the expenditure, or searching for the public procurement solution with the highest efficiency. The UK Audit Commission defines VfM as a way of “obtaining the maximum benefit with the resources available”. In this context, this is particularly relevant because resources, or expenditures, are taxpayers’ money and are therefore subjected to higher uncertainty and transparency.

Going back to Heald’s (2003) concepts of efficiency and effectiveness, one can argue that both alternatives provide the same output. Whether developed under public management or through a PPP arrangement, the project will deliver the same pre-determined outputs. These outputs are defined a priori by the government and incorporate not only the service characteristics (provided in an efficient way) but also the quality standards that should be met.

Therefore, if both alternatives are equally effective, the VfM is about efficiency. To produce the specified outputs, the alternatives consume different inputs. This process is illustrated in Fig. 2.1 which presents the production functions of two alternative procurement models: *Alt 1* and *Alt 2*.

As mentioned, the project specifications will define the service level O' . For that level of service, the purpose of the VfM test is to calculate the inputs used, I_{Alt1} and I_{Alt2} . In the example presented in the figure, $I_{Alt1} < I_{Alt2}$, and therefore, *Alt 1* should be adopted.

In practical terms, the difference can be measured by the amount of expenditure required by the concessionaire or the rents paid to the grantor. Note that this is different from simply choosing the cheapest solution.

Some projects work on a *stand-alone* basis, meaning that the revenues generated by the project (tariffs paid by users) are enough to cope with the CAPEX and the OPEX. Other projects require governmental subsidies to ensure the economic equilibrium of the project. It is common for transportation projects, hospitals and prisons to fall within this category.

Figure 2.2 illustrates these two types of projects. The grantor has a negative cash flow with Project A requiring subsidies and has a positive cash-flow with Project B working on a stand-alone basis and paying a rent.

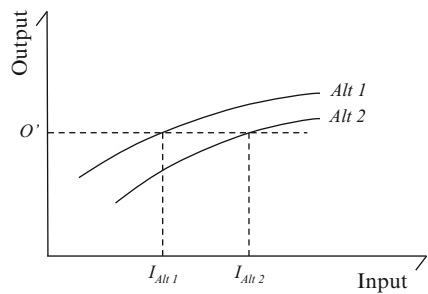


Fig. 2.1 Efficiency of the alternative procurement models

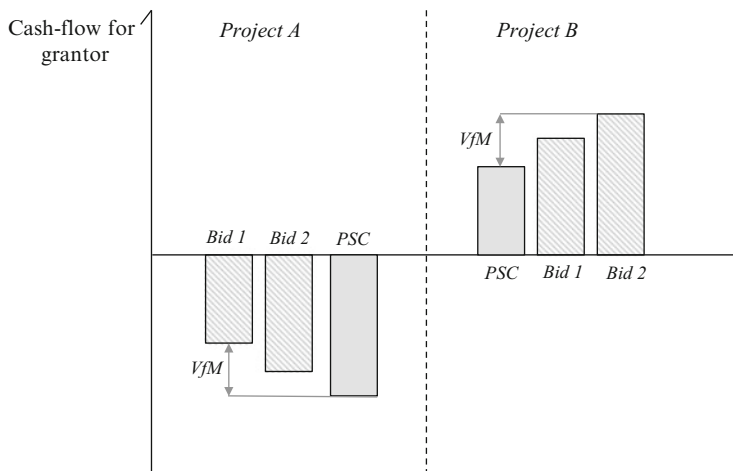


Fig. 2.2 Projects with alternative cash-flows

In both these theoretical cases, the PPP scheme is the option with the highest VfM. In Project A, the best solution is the cheapest (Bid 1), while in Project B, the best solution is the one maximizing the grantor’s revenue (Bid 2). Understanding the category (and the cash-flow value) in which the projects falls is crucial and will influence the criteria adopted for selecting the most advantageous proposal.

2.5 PSC Structure

The PSC is a valuation of the life-cycle costs of the project, but it also accounts for risks. Countries such as Australia and Canada follow a structure for the PSC divided into several components.

Figure 2.3 presents a typical PSC structure developed in the UK, Canada and Australia. The first component, raw PSC, corresponds to the baseline cost, accounting for all life-cycle costs of the infrastructure and/or service, deducted from the

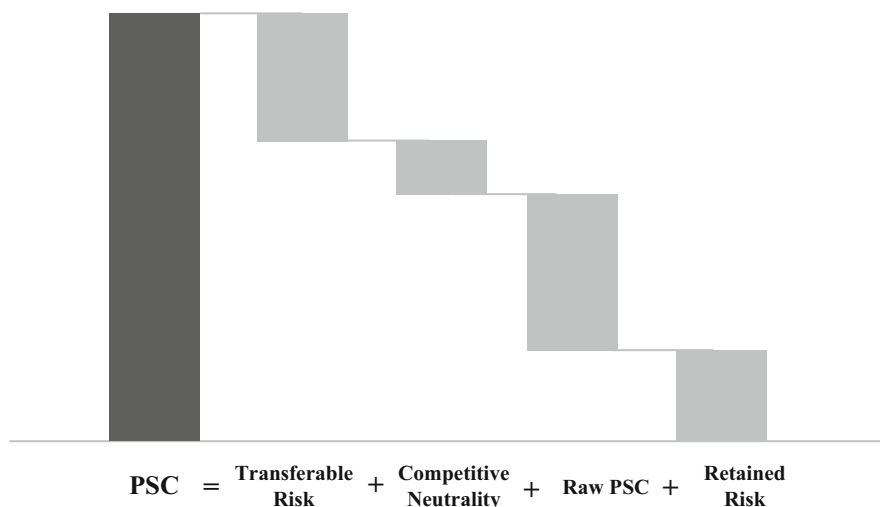


Fig. 2.3 PSC structure

expected revenues. The cash-flow is then discounted, and the sum of all cash-flow for the entire duration represents the raw PSC.

Competitive neutrality intends to correct the PSC for biases arising from public ownership and management. In many countries, public owned companies are exempt from some types of taxes, construction permits or environmental permits. This component corrects the PSC for the potential benefits of such a status.

Transferable risks are those risks that fall under the private sector responsibility in the PPP model. This might include construction, availability or demand, among others. Finally, retained risks are those risks that even in the PPP model are managed by the public sector.

2.6 International Benchmarking

2.6.1 Overview

Most of the countries that have been developing PPP projects have adopted some form of the PSC, for example, Australia, Canada, Portugal, Republic of Ireland, South Africa, the Netherlands, the UK and the United States. The UK, Canada and Australia have inspired and influenced other countries' methodologies. The level of maturity in PSC calculation is very different across countries. These three countries have a much more detailed approach, and the process is guided by several technical reports containing recommendations and decreasing the subjectivity of the teams responsible for PSC calculation. The next subsections will look into the different methodologies used by these countries not only in PSC calculation (cost estimations and discount rate) but also in how the process is managed and when the PSC is used.

2.6.2 Australia

In the Australian state of Victoria, the PSC is calculated (by Partnerships Victoria) before the bidding process through the so-called preliminary PSC. This early and detailed calculation improves as the process goes forward. As in the UK, the Australian PSC is composed of the four typical components: transferable risk, competitive neutrality, raw PSC and retained risk.

The discount rate in Victoria followed a path similar to the UK. Until 2003, there was a 6 % discount rate, which dropped to 3.5 % in that year. However, unlike the UK, in Partnerships Victoria, it was possible to find different discount rates for the PSC and for the PPP bids because of systematic risks (the difference between the rates does not take into account for unsystematic risks).³ Unsystematic risks were incorporated in the transferable and retained components.

To allow for project risk classification, the Treasury defined three groups according to the level of risk. The asset beta for the capital asset pricing model (CAPM) calculation varies from 0.3 (to the less risky) up to 0.9 (to the more risky). The risk free rate is assumed to be the yield of the Commonwealth Bonds (10-year maturity period).

Partnerships Victoria addresses an important issue: the discounting of negative cash-flow. If, for a certain year, the costs exceed the revenues, generating a negative cash-flow (not rare in PPP projects) means depreciating a cost. In real cases, negative cash-flow tend to happen in the first years, when the discounting is not so significant, and because of construction costs. In the late years of the contract, when discounting is substantial, cash-flow are generally positive, mitigating this problem.

2.6.3 Canada

The Canadian guidelines for PSC calculation were established in 2003 (as in the UK and Australia). The technical guidelines establish six stages (Industry Canada 2003):

1. Construction of the risk matrix;
2. Identification of the specific risks;
3. Quantification/calculation of the consequences of the risks;
4. Estimation of the probability of the risks;
5. Valuation of the cost of the risks;
6. Allocation of the risks.

³ Systematic risks are those not controlled by the agents (e.g., market risk), while unsystematic risks can be mitigated (e.g., production risk).

The PSC should be calculated before the bids are presented and upgraded after the bids are delivered. In addition to providing a VfM test, the PSC in Canada is also used to fine-tune the risk-sharing agreement before the contract is formally signed. This is an interesting use of the PSC – simulating alternative contractual arrangements – and a sign of the usefulness of this calculation.

There are several government levels at which PPP projects are developed (federal, provincial and local), and each level is autonomous in deciding when and how to develop these projects. There are no binding methodologies or rules regarding PSC calculation because the typology of projects is so diverse that a “one size fits all” approach is not recommended. Nevertheless, the general guidelines are wide enough to be applied, with adaptations, to each individual project.

The guidelines also address the issue of in-house bidding.⁴ No restrictions are made, except that no member of the bidding team should be involved in PSC calculation because he would have access to privileged information, biasing the rules of the game. The guidelines also address the issue of unsolicited proposals, highlighting the importance of calculating the PSC in these cases.

The discount rate used should be the one arising from the weighted average cost of capital (WACC) of the private sector.

2.6.4 Portugal

In Portugal, there are no formal guidelines for PSC calculation. The teams responsible for assembling the PSC for each project can adopt whatever structure and methodology they intend. Naturally, this brings an undesired ambiguity to the process.

Nevertheless, PSC calculation has been mandatory by law since 2003, and to be exempt from the calculation, the projects need to have an investment requirement below 25 million Euros and a total financial burden below 10 million Euros.

The discount rate used in Portugal is fixed by legislation and results from two separate components, the inflation rate and the real nominal discount, which are combined using the Fisher equation:

$$\text{Nominal Discount Rate} = [(1 + \text{real discount rate}) \times (1 + \text{inflation rate})] - 1$$

The real nominal discount rate was determined in 2003 by the Ministry of Finance at 4.0 %. It is mandatory according to Portuguese legislation that the bids cannot exceed the PSC value. If this happens, the bidder of the tender should be excluded.

In Portugal’s experience with the PSC, it is possible to find cases that follow the typical UK structure for the PSC (light rail of Porto), while others simply calculate the total PSC without accounting for risks (Health PPPs).

⁴ In-house biddings are bids presented by public agencies.

2.6.5 Republic of Ireland

In 2003, Ireland approved specific legislation and a policy framework for PPP development, creating a special public body under the designation of “Central PPP unit” and dependent on the Ministry of Finance. The rationale for PSC calculation is no different from other countries, namely it is calculated under the premise of affordability with the intent of delivering VfM through optimal risk allocation.

Four tests are foreseen: before the bid delivery, (i) a qualitative VfM assessment and (ii) a quantitative assessment, and after the bid is delivered, (iii) VfM tests and (iv) a VfM test before the final closure to allow contract changes. Although the essence is the same, Ireland calls it the “public sector benchmark” (PSB), which is compared against the NPV of the life-cycle PPP costs. One important difference from Ireland case-study is that third-party incomes, for example, taxes, are also included.

Ireland divides the risk into three categories: transferable, retained, or shared risks. Risk adjustment is based on changes to the risk transfer structure that affect VfM calculations. Nevertheless, no specific information is set regarding PSC or VfM tests. According to the Irish Department of Finance, all methodologies and technical issues should follow the UK approach and the HM Treasury technical notes, respectively.

The Central PPP Unit guidelines for selecting the appropriate discount rate states that this should be based on the yield of the Government Bond (choosing the most adequate maturity period according to the project’s lifespan). Government bonds typically have the following maturity periods: 3 and 6 months and 1, 3 and 10 years.

Although large infrastructure such as roads, dams or hospitals might have lifespans over 30 years, the longest bond is 10 years. This means that the bond is based on the risk-free cost of debt. Risk factors are taken into account in the cash flow estimation and not in the discount rate itself. However, the effect is ultimately the same. Conceptually, it is an entirely different approach from the UK.

The same discount rate should be applied to the PSB and PPP. Qualitative assessments are also allowed, and for the final decision, the VfM test is not enough. Affordability is also a necessary condition when considering the PPP model.

2.6.6 South Africa

In South Africa, the unit responsible for PPP development, management and monitoring is the “South Africa National Treasury PPP Unit”. The development of VfM tests is mandatory before bids are presented. As in Ireland, two models should be built. A PSC reference model should include all capital and operating costs (base PSC) and adjust all associated and identified risks. Another model should be used by the private sector and should include the hypothetical costs of private sector delivery and also recommend affordability tests to be made.

The PPP Manual (National Treasury 2004) recommends the discount rate be the same as the risk-adjusted cost of capital to the government. This is different from the risk-free rate, which usually adopts a bond yield with an adequate mature period according to the project's duration. The difference is that the PPP Manual incorporates opportunity costs in the risk-adjusted cost and also the economic implications of capital deviation from private consumption to public consumption. This methodology does not take into account for the internal risks of the project itself. These should be corrected in the cash-flow over the duration of the project. If it is not possible to quantify the costs associated with the risks, then a risk premium can be added to the discount rate. Acknowledging the difficulties in dealing with risks as cash-flow, the alternative of adjusting the discount rate could be used. Both the PSC and PPP must use the same discount rate.

2.6.7 The Netherlands

In the Netherlands, VfM tests are thorough because in addition to the PSC, they also include the so-called public private comparator (PPC). The concept of the PPC is the same as the PSC but is used for private bids at an early stage of the process to evaluate whether the PPP model is a good alternative. At this point, without any bids presented, the PPC is used as a benchmark against the PSC. In fact, both numbers are theoretical, and the accuracy of such a comparison is not substantial.

The purpose of such an early stage assessment is to avoid engaging in complex bid procedures that may not provide VfM, thus avoiding the transaction costs.

Other countries also perform this assessment but in a qualitative way. These qualitative methodologies intend to identify whether the project features are suitable to the PPP model. The assessment is made through a quantitative methodology – the PPC.

There is a commissioning authority that has to ensure that the final bids provide VfM when compared with the PSC. If this condition is not met, the process has to be terminated.

PSC calculation is also segmented in components, which are different from the UK categorization. The components are categorized into crude PSC, risks and supplementary financial considerations. The crude PSC is the equivalent of the designated “raw PSC”, but the risks are bundled together and not divided into retained, transferred or shared risks.

In 2002, a revised technical report on PSC calculation was published, replacing the initial technical note released in 1999. A second manual was released along with the PSC manual, specifically for calculating the PPC. The guidelines also present a structure for risk evaluation. Three steps define such a structure:

1. Determine the risks;
2. Value the pure risks (risks occurring in one of the project phases);
3. Value the spread risks.

Spread risks are divided into technical (related directly to the project) and market (related to the macroeconomic scenario) risks.

2.6.8 United Kingdom

The UK has vast experience in VfM tests. Nevertheless, before any VfM tests are performed, affordability⁵ has to be demonstrated. If and only if the affordability criterion is met, then it is possible to proceed with the selection of the best infrastructure provision model.

The UK guidelines comprise a three-stage approach for assessing the VfM of the PFI (HM Treasury 2006). These stages are sequential over time, and the focus progressively shifts from a strategic perspective to more in depth studies.

Figure 2.4 summarizes the UK approach, which is based on a three level assessment.

The first level (Program Level Assessment) corresponds to a high level approach, with the purpose of identifying whether the project is adequate according to the PFI model. In the second level (Project Level Assessment), the outline business case (OBC) is drawn. This is the first draft of the economic and financial model containing the project cash-flow estimation. Finally, the third stage is developed during the procurement phase to ensure that the assumptions initially made are still valid. These levels are sequential over time.

This three-stage process essentially uses quantitative techniques, particularly the PSC. However, a qualitative assessment can also be considered: viability – analyzing how a PFI can capture the service requirements and the efficiency, accountability or equity issues that may require a direct provision from the government; desirability – analyzing the advantages and disadvantages of developing a PFI, particularly regarding incentives and risk transfer; and achievability – verification of the market interest in such a project but also whether the public sector has enough capacity to develop and manage the PFI (Morillos and Amekudzi 2008).

The UK Treasury, in 2003, established more formal rules to overcome some of the gaps of PSC calculation (as identified earlier). One such rule is the mandatory requirement that both the PFI and PSC should be discounted at the same rate. The incorporation of risk is made through a separate cash-flow over the project duration (retained, transferred and shared risks).

The discount rate was 6 %, which is greater than the risk-free rate (interest rate paid on British Bonds, also called gilts). The rate was closer to the real discount rate used by the private sector for low risk projects. This rate was lowered in 2003 to 3.5 %. The 6 % was too high because risks were already calculated in the PSC and favored the PFI option.

⁵ Affordability is understood as the government's ability to keep its responsibilities without jeopardizing the economic sustainability of the system.

Program Level Assessment	High-level approach to select whether the project features fit the PFI model
Project Level Assessment	Procurement appraisal using the OBC
Procurement Level Assessment	Developed during the entire procurement phase and ensuring that the assumptions made on competitive interest and market capacity are valid

Fig. 2.4 The UK approach

2.6.9 United States of America

The use of the PSC in the USA has been scarce. Florida, Oregon and Virginia have used some form of the PSC (NCSL 2010). For example, in the evaluation of PPPs for toll highways in Texas, the government has used a form of “shadow bids” to estimate the costs of a public sector delivery model. In other states, such as Florida, Maryland, and Washington, CBA and qualitative assessments have been proposed and used.

In 2010, the National Conference of State Legislatures released a toolkit titled “Public-Private Partnerships for Transportation: A Toolkit for Legislators”. Although benchmarking experiences and best practices are presented, it does not provide an analytical guideline for PSC calculation or PPP development at the national government level. Nevertheless, regarding discount rates, there is an annual guideline (“Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs”) issued by the Office of Management and Budget that should be used to update any future costs or revenues. The guidelines published through Circular A-94 note the need to consider alternative provision methods and to evaluate the cost-effectiveness of these alternatives.

2.7 Case Studies

2.7.1 Reshaping Health Services Project (UK)

The aim of the Reshaping Health Services Project (RHS) in the UK is to deliver a new hospital and redesign the primary and social care services integrated in the NHS (National Health System) Plan, for a total of 1.287 beds and 158.669 m².

The project was developed under a PFI scheme for a 40-year period, and the funding was based on bonds. The overall advantage of the PFI model over the PSC was 1.81 %.

The methodology used to calculate the NPV was the DCF analysis. A 6 % discount rate was used, in accordance with the Treasury Green Book. The value added tax (VAT) was excluded from the costs, and the irrecoverable VAT was only considered within an affordability analysis (NHS Trust 2003).

Table 2.2 VfM assessment for the RHS

	PSC NPV	PFI NPV	PSC NPV	PFI NPV
	40 years	40 years	66 years	66 years
	(£ million)	(£ million)	(£ million)	(£ million)
Total estimated costs	3,406.6	3,422.3	3,679.1	3,694.7
Retained risk NPV	106.1	28.3	116.3	38.5
Risk adjusted NPV	3,512.7	3,450.6	3,795.4	3,733.2

Source: NHS Trust (2003)

Table 2.3 Risk matrix for the RHS

Risk category	Public sector	Private sector
Ensure plans are in place and fully consulted upon to provide alternative services before current services close	X	X
Develop protocols to ensure integration makes the most efficient use of hospital beds	X	X
Costs of the scheme are contained within the overall affordability envelope		X
Formulate strategies to manage shared risks		X
Manage relationship with the PFI provider		X
Make capital available to provide alternative facilities for services not being re-provided on the Derby City General Hospital site		X
Make funds available to meet transitional costs incurred during development, via strategic assistance fund	X	X

Source: Adapted NHS Trust (2003)

The risks were calculated as cash-flow over the life-cycle of the infrastructure, and the results are presented in Tables 2.2 and 2.3.

As expected, the NPV of the retained risk in the PSC option is higher than in the PFI because the public sector has to address all project risks, while in the PPP option, some risks are transferred to the private sector.

Risk calculation in the UK is performed under specific guidelines. In this case, it was performed in accordance with the Department of Health's generic economic model, which basically corresponds to identifying and assessing all possible risks. The model also included a sensitivity analysis for some key variables, such as capital cost or life-cycle cost, to determine the robustness of the calculation.

The PSC and PFI were compared for two periods: 40 and 66 years. Table 2.4 summarizes the main results.

Thus, the PSC solution provides a higher VfM, even though the difference is quite small. In fact, one may argue that the implicit error in the forecasts is higher than the final observed difference between the PSC and PFI.

Table 2.4 Example of a PSC for a hospital

	Over 40 years (£ million)	Over 66 years (£ million)
PSC	3,512.7	3,795.4
PFI	3,450.6	3,733.2

Source: NHS Trust (2003)

Table 2.5 NPV of the PSC and PPP scheme for the Sea-to-Sky highway project

	PSC (\$ million)	PPP (\$ million)
Description		
Capital costs	516.0	208.1
Operations and maintenance costs	107.5	3.2
Rehabilitation costs	36.3	
Risk adjustment	42.9	
Competitive neutrality adjustment	41.3	
Payment to Sea-to-Sky		578.5
Total costs – risk adjusted	744.0	789.8

Source: Partnerships British Columbia (2005)

2.7.2 Sea-to-Sky Highway (Canada)

The British Columbia Ministry of Transportation decided to improve a 95 km stretch of highway between West Vancouver and Whistler with a maximum budget of 600 million dollars, which was approved in 2003. The main objectives of the project were to improve the safety, reliability and capacity of the existing road while ensuring that the project was completed on time and on budget and minimizing the disruption in traffic flow during construction (Partnerships British Columbia 2005).

The project was developed under a PPP scheme with a 25-year duration, including the design, financing, construction, maintenance and operation of the highway.

The methodology used was the DCF analysis to calculate the NPV. A 7.5 % discount rate was used, which is a significantly higher rate than the one used in the UK. Like in the UK example, the risk was calculated as a cash-flow over the life-cycle of the infrastructure. Table 2.5 presents the PSC calculation, and Table 2.6 shows the project's risk matrix.

In this example, the PSC alternative has a lower NPV than the PPP option. This means that the project should be developed directly by the government. Nevertheless, the government decided that the qualitative benefits of developing a PPP arrangement justified the choice over this option.

The reason given was that there were additional highway improvements provided by the PPP option that were not considered in the PSC, such as 20 km of additional passing lanes, improved lighting, safer intersections, etc. (Partnerships

Table 2.6 Risk matrix for the Sea-to-Sky highway project

Risk category	Public sector	Private sector
Design		X
Construction		X
Environment		X
Operation and maintenance		X
Protests or trespass actions		X
Geotechnical		X
Land acquisition	X	
<i>Force majeure</i>	X	
Legal	X	X
Archaeological		X
Insurance costs		X

Source: Adapted Partnerships British Columbia (2005)

British Columbia 2005). The government argued that the user benefits of such improvements, although difficult to quantify, would justify the PPP schemes.

This is an interesting example for several reasons. First, it highlights that the PSC is an instrument to be taken into account by decision makers, but it does not provide a single answer. Second, it illustrates how difficult the analysis becomes when the objects under consideration are not exactly the same. When the project specifications are alike, a direct comparison of NPVs is sufficient. Otherwise, the comparison is qualitative, subjective and has a high level of uncertainty.

2.7.3 Barwon Water Biosolids Management Project (Australia)

Barwon Water is a regional water corporation providing water and sewerage management to a population of approximately 270,000 over more than 8,000 km² (Partnerships Victoria 2007). To cope with this responsibility, Barwon Water operates, among other infrastructure, several sewerage systems and water reclamation plants.

To improve the beneficial use of biosolids while reducing land area requirements, greenhouse gas emissions and truck movements, Barwon Water defined a project including the following (Partnerships Victoria 2007):

- *Sludge receival facilities to receive biosolids from the Black Rock water reclamation plant and from regional water reclamation plants;*
- *Fully enclosed sludge storage;*
- *Dual train Keppel Seghers HARD Pelletizers (Indirect gas fired dryers);*
- *Fully enclosed intermediate storage at the Black Rock site; and*
- *A program to use biosolids in agriculture and/or fuel.*

To develop the project, the government decided to consider the possibility of a PPP arrangement. After considering several alternatives, the authorities decided on a DBFO model with a 20-year duration. The rationale behind this duration is that

Table 2.7 PSC calculation

Description	PSC (\$ million)
Capital costs	39.0
Operation and maintenance costs	30.8
Other costs	0.7
Raw PSC	70.5
Competitive neutrality adjustment	0.2
Risks	11.5
Total PSC	82.2

Source: Partnerships Victoria (2007)

although significant investments are required, it was not reasonable to commit to longer contracts because the technology in this sector can change significantly.

The methodology used to calculate the NPV was the DCF analysis, with a discount rate of 6.50 % and an inflation rate of 2.50 %. The results are presented in Table 2.7.

The risk component in the previous table only concerns the transferred risks. The retained risks are not incorporated in this parcel, but the risk matrix in this case is described in Table 2.8.

Only those risks allocated to the private sector are accounted for in the risk adjustment component. The comparison with the PPP option is illustrated in Table 2.9.

In this case, the cost of the PSC option was 5.6 % higher than the equivalent in the PPP. This means that the PPP offers VfM and therefore should be adopted.

2.7.4 High-Speed Rail Line (Portugal)

The project of the high-speed rail line between Lisbon and Madrid is a ground-breaking project in Portugal because no other high-speed line exists. The project costs have to be estimated without historical data regarding these specific lines. The business model developed for the entire high-speed system in Portugal included several PPP arrangements: five PPP contracts for the infrastructure construction and maintenance, one for energy systems, and one for operating the train services. The five infrastructure PPP projects include two for the Lisbon-Madrid line (two sections of the line) and three for the Lisbon-Porto line.

The PSC presented in this section was calculated for the two infrastructure PPPs of the Lisbon-Madrid line (Tables 2.10).

The capital costs were not included in the PSC because in both the PPP scheme and traditional procurement options, the public sector will ensure most of the

Table 2.8 Risk matrix for the biosolids management project

Risk category		Public sector	Private sector
Planning risks			X
Site risks	Development of site		X
	Site unsuitable for technical solution		X
	Cultural or heritage value	X	
	Native title	X	
	Pre-existing contamination of site	X	
	Restoration of site		X
Design, construction and commissioning	Design and construction		X
	Commissioning		X
Operational	Asset performance		X
	Compliance with legal requirements		X
	Volume	X	
	Quality	X	
	Odor		X
	Maintenance		X
	Operational		X
	Price energy	X	
	Energy volume		X
Asset	Ownership and maintenance		X
	Decommissioning		X
Market risk	Availability of beneficial use markets		X
Environmental	Environment Protection Agency works approval	X	X
	Contamination of land		X
Legal and political	Changes in law and legislation	X	X
	Tax		X
<i>Force majeure</i>		X	X
Finance	Interest rate		X
	Residual value		X

Source: Adapted Partnerships Victoria (2007)

Table 2.9 PSC and PPP comparison

Description	PSC (\$ million)	PPP (\$ million)
NPV	82.2	77.6
Savings	5.6 %	

Source: Partnerships Victoria (2007)

financing of the system through EU funds and government bonds. The PSC took into account several types of risks: construction (cost overruns and delays), maintenance (cost overruns), and financial, and it also made adjustments regarding fiscal

Table 2.10 PSC versus PPP for the HSR

	Value (million Euros)	Difference for the PSC
PSC	1.514	–
PPP	1.217	24.4 %

taxes. The costs had to be estimated using data from conventional lines and from similar international projects.

The PPP arrangement was 24.4 % lower than the expected PSC. This difference is mostly due to the construction risk considered, which may have been over estimated. One of the main reasons for cost overruns in these types of projects is the change in the system's design due to political interference. It does not seem credible that this would happen in this case because environmental permits ensure that there are few stations to allow for changes in the location. At least, this is a risk that is easily mitigated. The PSC developed a sensitivity analysis to determine the level of cost overruns under which the best model would be a traditional procurement. The result was 8.2 %.

2.7.5 Case Study Analysis

The short examples presented illustrate the wide range of possibilities in PSC calculation. The level of risk disaggregation can vary significantly. It can be more or less detailed, and it has to account for the trade-off rigor versus the costs. The more detailed it is, the more accurate is the calculation of the PSC. However, the transaction costs involved also increase, though the lack of data frequently prevents this.

Regarding the discount rates, because different countries have different approaches, one would expect to find different values. However, the differences are not meaningful (between 6 % and 7 %). Nevertheless, as mentioned before, a 1 % difference in the discount rate can significantly affect the results, particularly in cases where the difference between the PSC and the PPP alternative is not high. This is the case of the “Reshaping Health Services” project, where the PFI model presented an advantage of just 1.81 %. The error in the cost estimation and forecasts is much higher than this difference.

This is why in the case of the Sea-to-Sky Highway project, the government decided to go ahead with the PPP alternative, even though it was worse than the PSC by 6.2 %. The argument was that there were benefits not captured by the calculation that would be higher than the difference. Although the PSC is just a number to help with the decision making process, this calculation might be helpful in start discussion about the project.

2.8 Critical Issues in PSC Calculations

2.8.1 Discount Rate

The discount rate is used in financial valuation techniques (e.g., DCF) to calculate the present value of future cash-flow. It accounts for the time value of money because for investors, 1 Euro today is more valuable than 1 Euro in 1 year.

Different agents value this concept of time value of money differently. Typically, private investors attribute less “importance” to future cash-flow and therefore discount these values at a higher rate. In contrast, governments tend to give a higher value to future cash-flow and therefore use lower rates. Evidence of this behavior can be observed in financial markets. Under normal conditions, the countries’ debts pay lower interest rates than private debts. Governments tend to have a long term perspective on growth and development and represent the entire society. Therefore, they take less risks. Private investors are more concerned with short to medium term returns.

PSC calculation is needed to discount future cash-flow. The literature on investment analysis has provided large discussions on this subject (e.g., Marglin 1963; Miles and Ezzell 1980; Esty 1999). From a public sector perspective, the discount rate used is generally the “risk-free rate”, which is the interest rate on long term public debt (bonds).

From a private sector perspective, the interest rate should be the discount rate obtained by the WACC.⁶ However, for the purpose of PSC calculation, one of the main questions is whether to use, or not, the same discount rate for the PSC and for PPP bids.

The discount rate is used to accommodate the risk profile of the project. There are two alternatives to incorporate risk in the PSC calculation. One is to add a risk component to the discount rate – the riskier the project, the higher the value. The other alternative is to calculate risk separately as an annual cash-flow. It is then added to cash-flow and discounted with the selected discount rate. Each one of these alternative risks is considered for in a different way.

What model should be preferred? The incorporation of risks as cash flows needs a more elaborate knowledge of these risks. It is necessary to identify all risks and evaluate, quantify and allocate each risk to the respective partner. This exercise increases the level of knowledge about the project and allows the government to be aware of the main sources or risks. This might lead to a more pro-active risk management attitude by decision makers. Conversely, if risk considerations are taken in the discount rate, then the degree of uncertainty is much higher. The risk premium will take into account the project profile, but it will not address (at least accurately) the project specificities.

⁶ For more on the WACC, see Miles and Ezzell (1980).

The choice of the discount rate has an enormous influence on the final result. Higher discount rates will favor the PPP option. This has to do with the cash-flow profile (Fig. 2.5).

Under the PPP arrangement, most payments from the public sector to the concessionaire are made in the medium to long term. When using a high discount rate, those future payments will be devaluated, thus making the option look “cheaper”. Under traditional procurement methods, a large majority of the expenditure is made in the first years (during construction). Under DCF, those payments made initially are less devaluated than those occurring in the distant future.

2.8.2 Cost Estimation

One of the critical tasks in PSC calculation is cost estimation. Because many, if not most, PPP projects have a large investment component, and considering that construction risk is one of the main risks in PPP development, the correct estimation of the costs is extremely important.

It is possible to estimate costs using different models with distinct levels of complexity. Table 2.11 presents, in a very succinct way, some of the main cost estimation models, with distinct levels of complexity, accuracy and robustness.

Models have been evolving since the 1970s, when the first parametric models were developed (Kouskoulas and Koehn 1974; Bowen and Edwards 1985), until neural network models were proposed by the latest literature.

The underlying principle of regression analysis is the selection of variables, for which historical data are collected. The values for the dependent variable are calculated based on the statistical relation with the explanatory variables.

Several types of relationships can be assumed a priori between the dependent variable and the explanatory variables. The simplest relationship is the linear regression, and the complexity can increase toward probit and logit models or other estimation models (Skitmore and Thomas 2003; Trost and Oberlender 2003).

In PSC, the dependent variable is usually a cost (construction, operation, maintenance, etc.), while the explanatory variables are related to the characteristics of the infrastructure and/or service. In the case of a road, the explanatory variables can be the length, the percentage of the length in a tunnel or bridge, or the number of lanes. In the case of a hospital, one can consider variables such as the number of beds, the area per bed, the expected case mix index, the type of medical specialties, etc.

A case-based reasoning method solves new problems based on past experience (Kim et al. 2004). These models are organized according to four steps: (i) building a database with past experiences; (ii) inserting a new case into the system and verifying the similarity between the new case and the existing cases in the database; (iii) solving the new case based on the past solution adopted in the most similar old case; and (iv) updating the database with the new case and the respective solution (Perera and Watson 1998; Kim et al. 2004).

Neural networks (NN) are a computer-based system simulating the knowledge-building model of the human brain. Some researchers have used NN to improve

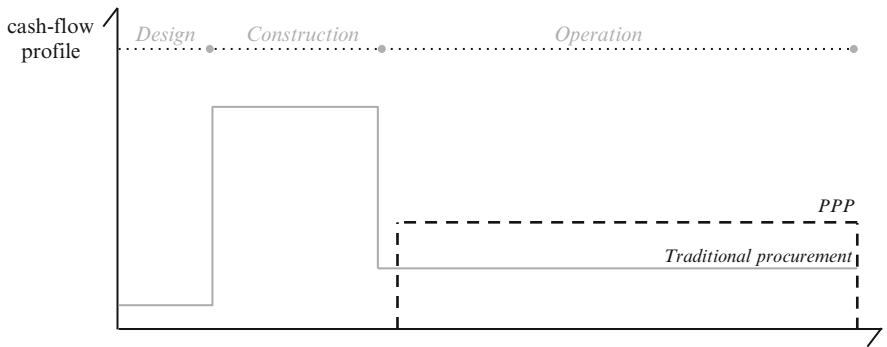


Fig. 2.5 VfM analysis using the PSC

Table 2.11 Comparison of cost prediction models

	Regression	Case-based reasoning	Neural networks
Weight of historical data	Heavily dependent	Heavily dependent	Heavily dependent
Complexity	Simple to use	Complex	Highly complex, even though there is commercial software to compute the model
Accuracy	Poor	Relevant	High
Robustness	Poor	Relevant	Relevant

costs estimations (McKim 1993; Yeh 1998; Boussabaine 1996; Adeli and Karim 1997; Hegazy and Ayed 1998; Tam and Fang 1999; Reuter and Moeller 2010).

The concept behind NN is trying to relate inputs and outputs (in this particular case, costs) through hidden layers and neurons. Determining the number of layers and neurons is basically performed through trial and error. The complexity behind these calculations is a severe drawback for these models, though some commercial software has been developed; for those not familiar with the concept, NN become a “black-box”.

Irrespective of the model adopted, cost estimates are heavily dependent on historical data. As mentioned before, this raises several problems related to the absence of data and the lack of consistency across data panels.

The infrastructure sector also faces another problem concerning the accuracy of forecasts in maintenance plans. This sector is known for relatively low quality standards, at least when compared to other industrial areas (automotive, technologies, etc.). Thus, it is more difficult to forecast the exact maintenance needs for the long term based on the greater patterns of the quality.

2.9 Probabilistic Calculation of the PSC

2.9.1 Uncertainty in PSC

It is now clear that a PSC calculation incorporates many sources of uncertainty. Instead of having that uncertainty in the background, it should be made explicit right from the start. This means that instead of a single number, the PSC might be a distribution to accommodate the uncertainty of the calculation, the result of several uncertainties in the cost components.

Currently, the process of determining the VfM of the PPP option is based on the direct comparison of the two numbers (PSC and PPP).

Figures 2.6 and 2.7 represent two theoretical projects with different PSC values and distinct “errors” in each calculation. The direct comparison between the PPP score and the PSC ignores the error inherent to the PSC calculation. Assuming these two examples, it is clear that the degree of confidence when comparing PSC 1 with the best bid is significantly lower than the one in project 2 (PSC 2).

Nevertheless, the decision makers are not always aware of these differences because the uncertainty behind the calculation is rarely made explicit in the decision making process.

Therefore, for each cost component, one should assess the uncertainty, or risk, and the input variable should also be a distribution function instead of a single number, which has an almost null probability of being the real number.

2.9.2 Risk Management for PSC Calculation

The calculation of a probabilistic distribution for the PSC depends on the quantifying risks. As mentioned earlier, these risks are related to construction, operation, financing, etc.

The literature provides several guidelines for risk assessment, but in this book, the authors use the methodology of ISO 31000: Risk management – Principles and guidelines. This international standard defines a three-stage process for risk assessment (Table 2.12): (1) Risk identification; (2) Risk analysis; and (3) Risk evaluation.

Risk assessment is one of the two components of risk management, the second being risk treatment. In the context of PPP, risk treatment is the identification of measures that decrease the impact of risk, either by its probability of occurrence and/or its impact. Regarding this particular issue, Chap. 4 will address flexible mechanisms to cope with risk mitigation.

At this stage, the focus should be on assessing risks to incorporate in the PSC calculation.

Risks should be ranked according to the product of the impact and the likelihood of occurrence. The impact can be estimated using the OBC or by directly quantifying the occurrence of an event.

Fig. 2.6 Distribution function of PSC 1

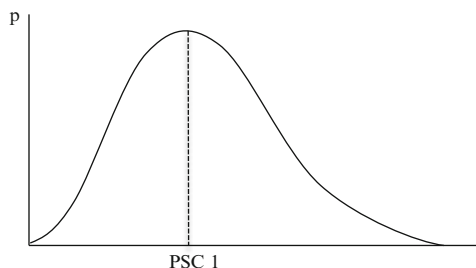
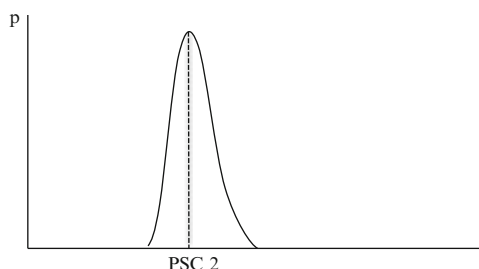


Fig. 2.7 Distribution function of PSC 2



The probability of occurrence is more difficult to estimate, and its calculation is restricted to the use of historical data, predictive techniques (basically, modeling and, in most cases, the use of historical data to calibrate the models) and expert opinion. Over the next sections, these methods will be exploited using a case study. The rationale is to make explicit in the PSC the uncertainty perceived by the agents at risk. Two models will be used: a simpler model – Monte Carlo simulation – and a more complex model – BN.

2.9.3 Probabilistic PSC Calculation: A Case Study

2.9.3.1 Summary of the Case Study

The case study used to illustrate the probabilistic calculation of the PSC is an extension of the example developed by Cruz and Marques (2012a). The PSC is calculated for a Hospital PPP developed under the UK model, i.e., just regarding the infrastructure and ancillary services.

Some hospital PPP projects include clinical management (e.g., Spain and Portugal), but the most used model regards only the construction and maintenance of the infrastructure and ancillary services (e.g., laundry, cleaning and security). The example presented next is a real case developed in Portugal where the model

Table 2.12 The three-stage process for risk assessment

Stage	Description	Methodologies
Risk identification	For each project, all risks should be identified. These risks might be under the control of the stakeholders (e.g., production risk) or it may not be manageable by any of the partners (e.g., demand risk of a highway, which depends mostly on GDP growth and car ownership)	Check-lists, interviews, brainstorming, benchmark, etc.
Risk analysis	Risk analysis encompasses the understanding of risks, particularly their fundamentals (e.g., the causes, consequences, and potential impacts on the final outcome, probability, etc.). The impact and probability of the risk is usually determined by modeling, which can be complex. Simple techniques might include extrapolation, and more advanced techniques can also be used (e.g., artificial intelligence)	Modeling techniques
Risk evaluation	After the risk analysis, it is necessary to evaluate several risks and determine which of them are more critical and require particular attention. This may imply a more sophisticated model to understand the risk, but it also implies the identification of measures to mitigate the risk	Modeling techniques, valuation techniques

began as infrastructure plus clinical services,⁷ but because of political reasons, it changed toward the typical UK model.

2.9.3.2 Risk Identification

There are many risks associated with construction and operation that might correspond to each cost component. The exhaustive identification of all cost components is a complex task that frequently involves several officers with different responsibilities for the project. Table 2.13 presents an example of risk identification for a hospital PPP.

2.9.3.3 Risk Analysis and Risk Evaluation

For each risk, it is necessary to identify, whenever possible, the variability of historical data. The modeling of this risk can be conducted by fitting the most likely distribution. These distributions can be different. For example, there is a trend to underestimate construction costs, which is why they often follow a log normal distribution, $C \sim \ln(\mu, \sigma^2)$ (Fig. 2.8).

⁷The Portuguese model was quite unique because the PPP arrangement for the hospital is composed by two different contracts: one for the infrastructure and one for the clinical management, the first with a longer duration than the second, 30 and 10 years, respectively (Cruz and Marques 2013d).

Table 2.13 Example of risk identification for a hospital

Class	Sub-class
Construction	Building construction
	Underground parking
	Exterior works (gardens, access)
	General equipment
	Project design
	Supervision works
Infrastructure maintenance	Maintenance works
Operation	Energy
	Water and wastewater
	Solid waste
	Security
	Cleaning
	Laundry
	Catering
	Sterilization
	Other

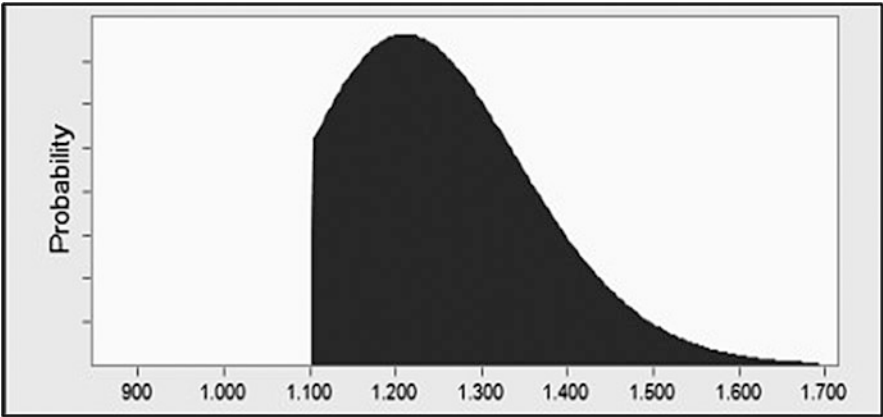


Fig. 2.8 Distribution of the hospital building construction cost per square meter (Source: Cruz and Marques 2012a)

2.9.4 Modeling Risk

2.9.4.1 Alternative 1: Monte Carlo Simulation

The use of a Monte Carlo simulation to quantify uncertainty is one of the most straightforward approaches and has already provided good results.

A set of iterations, usually around thousands, generates random numbers for each one of the inputs following the pre-defined distributions. In the case of the

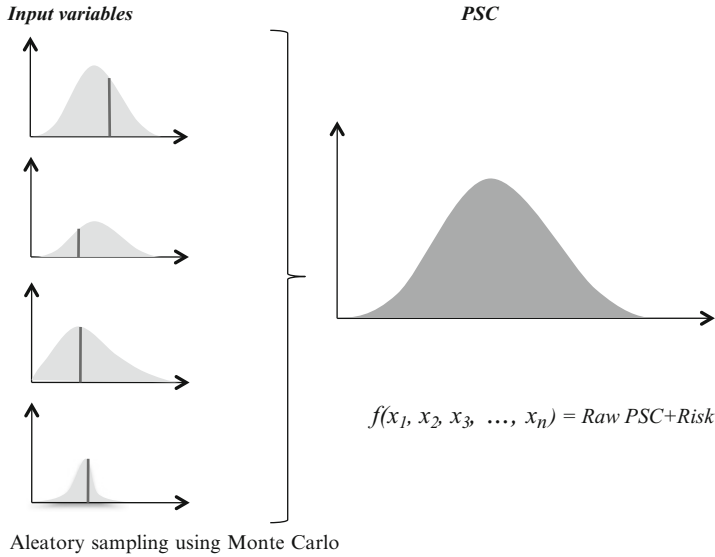


Fig. 2.9 Scheme of the Monte Carlo simulation for the PSC calculation

PSC, they are the cost components and the associated risks. Figure 2.9 presents a scheme for uncertainty modeling of the PSC using a Monte Carlo simulation.

The left side of Fig. 2.9 illustrates the random sampling for the inputs. As mentioned, associated with each input is a distribution function. The Monte Carlo simulation will generate a single number based on the distribution – a more skewed distribution will generate numbers less dispersed. The sampling is made for each one of the distributions. For each sampling, a PSC number is generated. It is through several iterations that several PSC numbers are generated and that a PSC distribution function (right side of Fig. 2.9) is found. Naturally, the skew of the PSC distribution function is highly correlated with the skew of the original distribution functions for each input. In some way, this can be interpreted as a measure of risk.

A higher risk (more uncertainty in the cost estimations or revenue forecasts) will generate distributions with longer “tails”, thus providing a wide range of PSC values. Those projects that are highly standardized with low degrees of uncertainty will have a small variance. Figure 2.10 illustrates a PSC distribution function of a real case.

2.9.4.2 Alternative 2: Bayesian Network

Bayesian statistics is gaining momentum over the last two decades in several fields, including the infrastructure domain (e.g., Yin et al. 2010; Cheung and Beck 2010). The Bayesian approach is based on Bayes’ formulae (2.1), which allows the conditional probability $P(b|a)$ to be calculated given the conditional probability of $P(a|b)$ and the probabilities of $P(b)$ and $P(a)$:

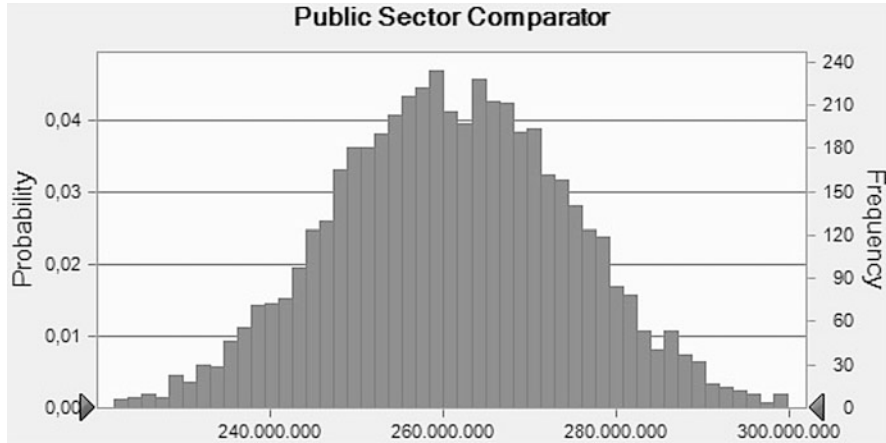


Fig. 2.10 Frequency distribution of a real PSC calculation (Units: euros)

$$P(b|a) = \frac{P(a|b)P(b)}{P(a)} \quad (2.1)$$

In this particular case study and for PSC calculation in general, BN, also called a Belief Network, is particularly useful. A BN is a representation of variables and qualitative (causal dependency of variables) and quantitative (the probability relationship between variables) relationships between those variables (Janz et al. 2006).

The nodes are the variables and the arcs are the dependencies between those variables. Each parent node has a distribution, or table of *prior* probabilities, $P(Y)$, and each subsequent node has a conditional probability $P(Y/X)$, where X is the parent node. Considering a BN where x_i is a set of n random variables ($X = x_i$), the conditional probability distribution becomes:

$$P(X) = \prod_{i=1}^n P[X_i | pa(A_i)] \quad (2.2)$$

where $pa(A_i)$ is the parent set of A_i .

The steps described earlier regarding risk assessment are also required to build a BN. However, it is also necessary to define the relation between the variables (nodes). Each node corresponds to a cost and has a certain risk associated with it. Figure 2.11 illustrates the BN built for the case study.

This project will require governmental subsidies, and the best bid is the bid requiring fewer subsidies. The final result of the BN is a distribution for the PSC.

Based on the best bid – Bid' – in this case, the lowest bid, it is possible to identify the probability p' of the PSC being lower (Fig. 2.12).

Taking into account this method, what is the reasonable p' ? This has to be fixed according to the decision maker's degree of confidence. What type of error do they

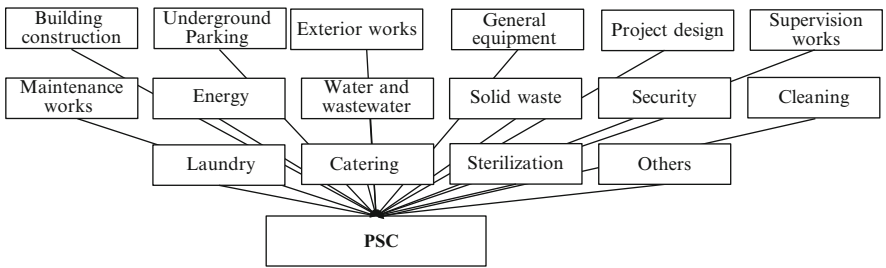


Fig. 2.11 BN for the PSC calculation of a hospital PPP (Source: Adapted Cruz and Marques 2012a)

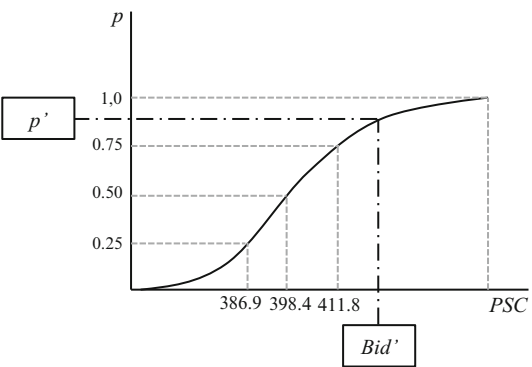


Fig. 2.12 Probabilistic comparison between the bid and the PSC (Source: Adapted Cruz and Marques 2012a)

accept? If they are only willing to accept a residual error, then the p' value has to be very low, and if the criteria are relaxed, p' can be higher.

2.10 Main Findings

PSC calculation remains a controversial issue. It is important to have more accurate and sophisticated models to support the decision making process for selecting the best procurement model.

Although each country has developed its own approaches to PSC calculation, it is possible to identify some trends and best practices. One of those best practices is the calculation of the PSC in different components (raw PSC, retained risk, transferred risk, shared risk and competitive neutrality). By doing so, the public sector has a more precise and insightful knowledge of the project and, above all, of the risks incurred. Even if in the UK, Canada and Australia, this segregate calculation is the norm, this is not so in other countries. For instance, in Portugal, some PSC calculations adopted this methodology, while others did not. Nevertheless, for

those countries without stable and exhaustive guidelines, the teams assembling the PSC often choose entirely different approaches. This is also evident regarding cost estimations, where entirely different approaches can be followed. Regarding cost estimation, one needs to take into account the different degrees of information available, which are dependent on each project, and therefore, the teams need to have the flexibility to select the most adequate model for each case. Not all projects have an extensive and comparable database of similar projects developed in the past.

In contrast, the choice of the discount rate needs to be administratively fixed. This does not necessarily mean that the value should be determined, but the calculation model and whether to use the same discount rate for the PSC and the PPP should at least be determined. The authors believe that the use of separate discount rates will create a comparability problem and that the use of higher discount rates in the PPP model will favor this option. Therefore, the greater valuation of risks by the private sector, e.g., higher financing costs, should be reflected as a cash-flow rather than being incorporated as an adjustment in the discount rate.

Another important issue is the fact that traditional procurement, in some cases, is not really an alternative. This means that the project either is developed through PPP or it is not developed at all. In these cases, is it worth calculating the PSC, even if we are comparing it with an alternative that does not exist? In the authors' opinion, the PSC should always be calculated for different reasons. First, it gives the public sector profound knowledge of the project: the costs, the main risks, the business determinants, the organization, etc. This is extremely helpful in designing the tender and the evaluation model. The insightful knowledge of the project helps the public sector to determine what is really relevant to evaluate in the proposals. Second, the PSC provides a useful tool to determine alternative risk sharing agreements. Even after the best bids are selected, it is often necessary to have a negotiation phase where the two best bids are tuned, which will give rise to the best and final offer (BAFO). In this phase, the PSC can provide a relevant instrument for the public sector because it allows for the assessment of the potential impact of changes in some terms. Finally, the PSC can be used as a "cap" even if traditional procurement is a real alternative. This means the PSC can be used to set a maximum base cost. This provides a benchmark and a tool to foster the private sector to deliver higher VfM solutions.

There is also the procedural issue of whether to disclose the PSC, for which there is no definitive answer. There are advantages and disadvantages to both alternatives. If the PSC is disclosed, it allows for bidders to validate the hypothesis of the calculation. If there is any mistake or misjudgment, it can be detected, thus improving the original PSC calculation. However, if the PSC is too conservative or, in other words, if the private sector expertise allows for significant savings compared with the PSC, the bidders might adopt a less aggressive approach, presenting bids closer to the PSC. If the process is really competitive, i.e., if there is a sufficient number of bidders ensuring real competition, this is not a problem, but the fact is that not all procedures are truly competitive.

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