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Original Research Article

Cost Benefit Analysis of Public Construction Projects under PPP Operation Mode

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Abstract: The public-private partnership (PPP) model that the state vigorously promotes is becoming a focus of stabilizing growth and adjusting structure. However, the application of the PPP model in public construction projects in China is still in its infancy. When the government makes project decisions, how to clarify the project risks, requirements and opportunities undertaken by all participants and weigh the external benefits brought by the PPP model has become an urgent problem to be solved to promote the reform of public service projects in China. Starting from practice, this paper reviews the relationship between school infrastructure investment and student performance involved in new school projects and the pros and cons of introducing the PPP model in the education field under the PPP framework. By comparing new PPP schools and non-PPP new schools in Victoria, Australia, the case is analyzed in multiple dimensions, it is concluded that there are indeed differences in operating expenditure and education performance between PPP schools and non –PPP schools. PPP schools have higher operating expenses than non-PPP schools and their educational achievements are also more prominent. The cumulative curve shows that the PoF of PPP school project operating expenditure is 48.37%, slightly higher than 48.05% of non-PPP school project. According to conclusion of this case data statistics, the introduction of the PPP model is explained to increase school infrastructure investment and promote better educational outcomes to a certain extent. School projects under the PPP framework can promote good educational achievements and provide theoretical support and countermeasures.

Keywords: PPP; School infrastructure investment; Education achievement; Hypothesis testing.

1. Introduction

Since the 1980s, China has gradually implemented the government social capital cooperation (PPP) model to alleviate government financial pressure, stimulate social capital vitality, and meet the growing demand for public services[1]. PPP will transfer the responsibility and risks of designing and implementing public services to private institutions through long-term contracts, and improve the efficiency and effectiveness of public services through innovative supply models[2]. As of November 2020, the number of projects entering the national PPP comprehensive information platform project management database has reached 9742, with an investment of 15.15 trillion yuan, involving multiple fields such as major transportation and water conservancy engineering construction, new infrastructure construction, and new urbanization construction[3]. Although PPP can provide assistance in promoting the efficiency of fiscal fund utilization and public service efficiency in China, in some cases, local governments have weak policies and incomplete contract terms in PPP practice, resulting in reduced service standards and quality, low public acceptance of projects, and even fierce opposition, leading to project stagnation and other problems[1]. The occurrence of these issues has raised doubts among various sectors of society about whether public infrastructure projects under the PPP framework can achieve expected benefits. Education is a significant and long-term investment highly valued by society. Education experts and economists

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theoretically hope that the application of PPP in public infrastructure projects in the field of education can not only drive the delivery efficiency of school infrastructure projects, but also ultimately benefit students from a high-quality educational environment[2]. However, further theoretical and empirical research is urgently needed to determine whether this idealized two-way promotion model can be achieved in concrete practice.

This article conducts a literature review on the relationship between school infrastructure investment and student performance in new school projects, as well as the advantages and disadvantages of introducing PPP models in the education sector under the PPP framework. It analyzes the benefits and benefits of introducing PPP into school infrastructure construction projects from two aspects: education investment and non monetary output of teaching outcomes. By comparing and analyzing the same period cases of PPP new schools and non PPP schools in Australia, Attempt to construct a PPP model to increase investment in school infrastructure and improve educational outcomes to a certain extent, thereby providing data support for the external benefits of promoting good educational outcomes in school projects under the PPP framework, and providing indirect and reference assistance in government decision-making.

2. Literature Review

2.1 Exploration of the Relationship between School Infrastructure Investment and Student Performance

At present, there is no consensus among domestic and foreign academic circles on the causal relationship between school infrastructure investment and student performance, but it cannot be denied that there is an inevitable connection between the two.

There is controversy that past investments in the education sector have not brought significant returns[4]. Hanushek and Lindseth confirmed through their overall study of the United States that from 1960 to 2005, the inflation adjusted expenditure per student significantly increased from $1606 to $9910. However, this significant increase in capital investment did not show any signs of growth in test scores, graduation rates, or overall performance rankings of American students in developed countries[5]. In addition, Hanushek has conducted nearly 20 years of targeted research, attempting to summarize the consistent relationship between increasing infrastructure investment in education and increasing student exam scores through a series of relevant literature and statistical studies, but unfortunately, he failed[6-8]. It is precisely because these studies have drawn a huge question mark on whether to continue increasing education investment. However, some scholars question the lack of rigor in the content of Hanushek's research literature and point out that the possibility of a reverse causal relationship between education investment and student exam scores has not been controlled[9]. For example, policymakers tend to prioritize investing more funds in underperforming schools and expect to see positive educational outcomes[4]. Obviously, this investment tendency will amplify the influencing factor of individual differences among students in the research sample, invisibly introducing interference variables, thereby limiting the feedback growth of educational achievements, ultimately leading to the inability to obtain a single linear positive correlation between school infrastructure investment and student performance.

A report by Conlin and Thompson points out that school infrastructure and post operation maintenance are key investments in the education sector[10]. There is a wealth of literature indicating that outdated school facilities, such as poor lighting and air quality, are often accompanied by poor test results, higher absenteeism and dropout rates, and other negative student performance[11-14]. The results of the Tennessee STAR experiment using a causal research design do confirm the inverse relationship between class size and student performance, and this experiment result has always been seen as a strong example by advocates who suggest increasing investment in educational resources[15,16].

Although the STAR experiment in Tennessee does provide some causal evidence for a single input, there is no broader literature to support the conclusion of the causal relationship between student outcomes and school infrastructure investment. To this end, Hong and Zimmer used the knowledge mastery proficiency rate of students in the Michigan School District as raw data to further explore the impact of school capital investment in infrastructure on student performance. Their research using Regression Discontinuity Design (RDD) showed that capital investment has a positive impact on educational outcomes, specifically reflected in a 2-6 percentage point improvement in reading ability among 7th grade students[4]. Conlin and Thompson analyzed the impact of Ohio State School Facilities Council (OSFC) teacher facility assistance programs on student performance from 1997 to 2011 using instrumental variables method and identification strategy. The plan allocates over $10 billion to improve local school facilities in 231 school districts. Research has found that in the first few years after capital expenditures, students in the districts show a slight decline in their math and reading test scores. However, when the new and renovated projects are completed, their scores show an upward trend. Conlin and Thompson believe that the short-term fluctuation and decline in student performance is due to the disruption of student learning caused by construction work[10]. Hong and Zimmer speculate that the delayed effect of no early growth in student performance is due to the time required for education investment to be in place[4]. Recent research by Abott et al. has shown that increasing operating expenses by $1000 per student can increase the standard deviation of test scores by about 0.15 and the graduation rate by 9 percentage points. Abott et al. concluded based on their research on the correlation between academic achievements and income that increasing school operating expenses has a significant impact on student performance and personal qualities, and these increases may have cost-effectiveness.

2.2 Exploration of the Relationship between School Infrastructure Investment and Student Performance

Education scholars have pointed out that PPP frameworks innovate and provide better education to achieve value for money. Other economic scholars have proposed that the application of PPP models will promote environmental competitiveness in the education sector, leading to higher project efficiency and higher quality education[2,18,19]. Wöβmann uses internationally comparable data from the PISA database, namely math, reading, and science exam scores, to map the distribution of countries in public funding and operations, and uses empirical methods to analyze PPP projects and student performance. Wöβmann 's research found a negative correlation between public school operations and student performance, while public funding in PPP school projects is positively correlated with their educational outcomes[19]. In the book “The Role and Impact of PPP in Education” by Patrinos et al., successful international cases, studies, and guidelines on how to establish the PPP framework in the field of education are outlined[20]. Public private cooperation can promote the provision of teaching services, and the private sector drives additional resources for education, raising more funds for the education sector, allowing government authorities to focus on their core functions, such as formulating policies and plans, thereby creating a more effective investment environment and expanding fair access opportunities to improve learning outcomes[21]. Obviously, the external benefits such as educational outcomes brought about by the PPP model in the field of education have no monetary value, but undoubtedly have a significant impact on the value-added of school projects.

In terms of education provision, the unique advantages that market mechanisms can play are the prerequisites for the introduction of PPP models in the education field to be valued. The central idea of the PPP model is widely accepted by many international organizations, development institutions, and scholars, with the premise that competition between public and private schools is an effective means to improve the quality and efficiency of education. It is expected that the PPP policy framework will establish true market dynamics, allowing the private sector to innovate and improve the quality of their education services to attract consumers depicted as maximizing benefits and being well informed-every household where students reside[20]. However, in the real world, the application of these market ideas in education has suffered a series of modifications and failures.

Verger et al. selected Chile, which has a market-oriented education system, as a typical case study, focusing on analyzing the impact of the nature of the supply structure, the expectations and behaviors of agents, and how much of the benefits that market-oriented education should bring can or will be realized. The conclusion of this study confirms that the competition triggered by the implemented PPP framework has led to vertical segmentation among competitors and social isolation among diverse stakeholders, with minimal improvement in educational efficiency[18],[22]. In fact, when exploring PPP value conflicts and coordination from the perspective of public values, Ning Liang and others also hold similar views. In PPP franchising, certain public utility projects are excessively intervened by the government, allowing only a single or a few competitors to enter the market while setting obstacles to exclude some enterprises, resulting in long-term monopolies of a few enterprises, reducing the efficiency of social resource allocation, and bringing problems to reasonable pricing of public services and PPP contract supervision. Over time, this is more likely to make the public question the legitimacy and authority of PPP operation procedures[1]. Risk is an important component of infrastructure projects, and the transfer of risk can affect the overall evaluation of the feasibility of PPP projects[23]. LaRocque emphasized the importance of policy formulation and contract design, as in PPP projects, if the design of risk allocation principles lacks fairness and rationality, and the rights and obligations of both parties are ambiguous, it may lead to repetitive negotiations during project implementation, increase project management costs, and even result in uneven risk allocation and intense conflicts between public and private parties, leading to project failure[21].

Through the analysis of numerous scholars who have increased investment in educational infrastructure, there is no consensus on the improvement of student performance. The conclusion that there is a causal positive correlation between school infrastructure investment and student performance cannot be ruled out due to the different market environments involved in the above literature, as well as various complex and diverse external factors such as poor visibility and strong lag of educational achievements. In addition, the operating expenses of projects in PPP mode are generally higher than those in BOT or other operating modes in terms of capital investment. Therefore, switching the operation mode of school infrastructure projects in the education field is equivalent to indirectly increasing investment in educational capital. However, there is no relevant literature exploring the relationship between educational capital investment and teaching outcomes between PPP education infrastructure new school projects and traditional operating model school projects. In addition, the inability to monetize and quantify teaching outcomes intuitively has become a bottleneck in the cost-benefit analysis of the PPP operation model applied in new school projects in the education field.

In summary, foreign scholars have provided multidimensional explanations on the relationship between educational investment in school infrastructure and student performance, as well as the impact of PPP models on the development of education and teaching. However, there is little research in the domestic academic community. Moreover, there is currently a lack of exploration on the progressive relationship between introducing PPP models to increase investment in school infrastructure and promote better educational outcomes. In addition, the construction of new schools under the PPP model in China is limited. Currently, empirical research in China is insufficient, and normative data analysis cannot explain or improve the conflict issues after the introduction of the PPP model in the education field. Therefore, it is necessary to use empirical research methods to go beyond normative debates in future research.

3. Case Studies

3.1 Case Selection Criteria

The primary factor in selecting Australia for case studies is that Australia is one of the countries with the most extensive experience in PPP project implementation. The early development of its PPP model is mainly attributed to the leadership and promotion of the Victoria Government. Based on the PFI model in the UK, Victoria (hereinafter referred to as “Victoria”) began using the PPP model in public infrastructure construction in 1998 and issued the “The Partnership Victoria Policy” in 2001. Subsequently, PPP was officially adopted as a professional term to refer to the government and private contractors in the construction The long-term contractual relationship formed by maintaining and operating infrastructure projects and purchasing related public services[1]. In the following decade of exploration and practice, PPP has focused on low-cost public infrastructure and efficient service supply in Australia's specific economic, political, and social context. Through government legalization and standardized management, it has gradually formed the characteristic of clear framework responsibilities. In PPP government decision-making, Australia has not only included considerations of public interest and public responsibility, but also formed a relatively complete economic benefit analysis system.

Secondly, this article takes the New Schools project, a PPP education infrastructure project in Victoria, as a typical case to compare and analyze the operating expenses of local PPP schools and non PPP schools in Victoria, as well as the scores of students in the National Assessment Program Literacy and Numeracy (NAPLAN), And attempt to explore whether increasing investment in school infrastructure will lead to an increase in student performance, whether adopting the PPP model in the education sector is more cost-effective, and whether it is more conducive to exploring the direct intrinsic causal relationship between education investment and educational outcomes.

3.2 Data Collection

The registration database provided by the Victorian government includes annual reports of all schools in Victoria, and the annual reports of each school in the database can be used to learn about the PPP primary schools and public primary schools opened in Victoria during the same period. In each annual report, the overall performance and expenses of the school are outlined. The NAPLAN scores, attendance rates, and health status of students, as well as data on school income, operating expenses, equity, and financial commitments, can all be obtained in the school's annual report. Through preliminary data analysis, it was found that the high investment in school infrastructure in PPP projects is mainly concentrated in annual operating expenses. The additional benefits expected by various stakeholders for PPP new schools are reflected in the increase in NAPLAN scores for teaching outcomes. Therefore, in 2018, the operating expenses of eight PPP and nine non PPP schools, as well as student NAPLAN scores, were used as two variables to explore the intrinsic relationship between educational investment and educational outcomes.

3.3 Exploratory Data Analysis

Exploratory data analysis was conducted on operating expenses and student NAPLAN scores in the collected school data in the early stage. From the line graph converted from the raw data below, it can be intuitively seen that the overall operating expenses of PPP schools are higher than those of non PPP schools, but the overall NALPAN level of third and fifth grade students in non PPP schools is lower than that of their peers in PPP schools. However, this simple comparative analysis conclusion only holds true in the existing sample data, and complex systematic analysis is required to ensure the consistency and reliability of the results. (Figure 1)

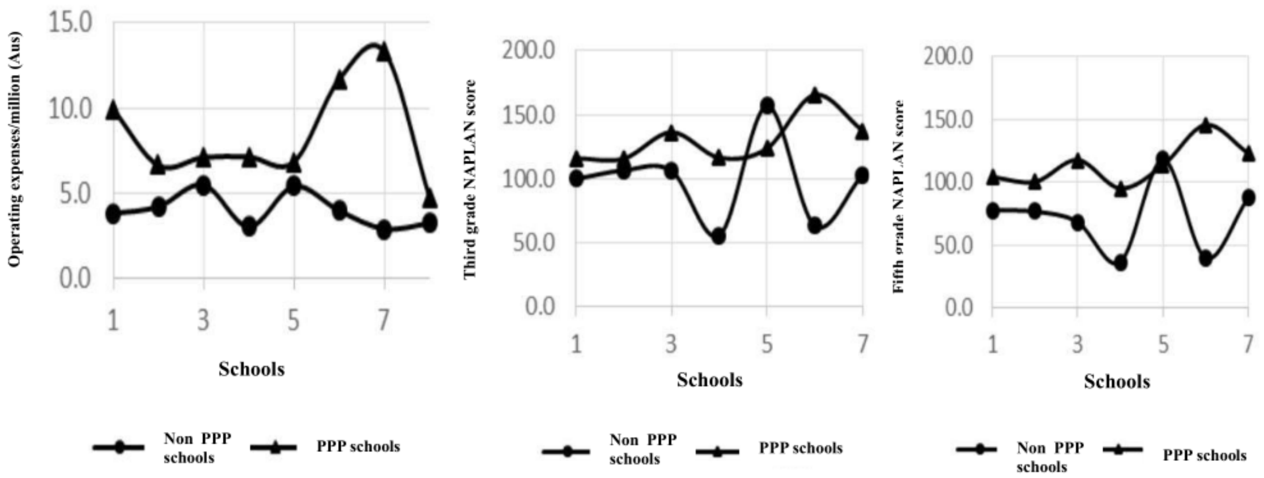


Figure 1 Performance of PPP and Non PPP schools in victoria.

4. Research Methods and Data Analysis

4.1 Methodology

Figure 2 shows the entire implementation process of systematic data analysis in this article.

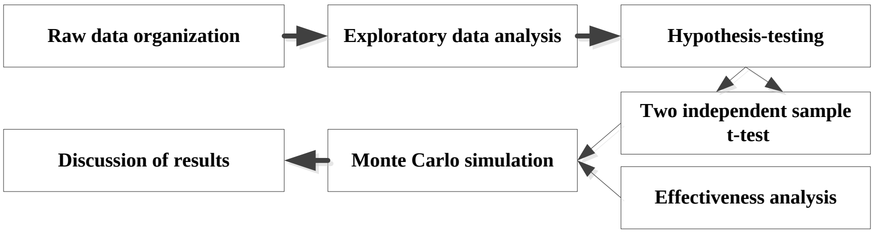


Figure 2 Technical roadmap.

Hypothesis testing, also known as statistical hypothesis testing, is a statistical inference method used to determine whether the differences between samples or between samples and populations are caused by sampling errors or essential differences. Significance testing is the most commonly used method in hypothesis testing, and it is also the most basic form of statistical inference. Its basic principle is to first make a certain hypothesis about the characteristics of the population, and then use statistical inference through sampling research to make inferences about whether this hypothesis should be rejected or accepted[25]. The t-test, also known as the Student's t-test, is mainly used for normal distributions with small sample sizes (such as $n<30$) and unknown population standard deviation σ. T-test is the use of t-distribution theory to infer the probability of differences occurring, in order to compare whether the difference between two means is significant[26]. Due to the fact that student performance and school operating expenses are two independent data samples with the same sample size, a two sample t-test was selected for hypothesis testing, with the aim of testing whether PPP schools and non PPP schools have significant differences in the mean values of student NAPLAN scores and school operating expenses, respectively.

The subsequent efficacy analysis is used to discuss whether the existing sample size makes the t-test conclusion meaningful[27]. In addition, the Monte Carlo method, also known as random sampling or statistical trial method, is applied to obtain the probability of failure (PoF) of educational outcomes and operating expenses from the cumulative curve of Monte Carlo Simulation (MCS). Cost estimation and quantitative risk analysis are conducted on PPP schools and non PPP schools.

4.2 Hypothesis Testing

When conducting hypothesis testing, a predetermined testing level of 0.05 is set, and an acceptable probability level (p-value) of <0.05 is specified. After collecting data, use the corresponding test formula to calculate the test statistic. Then compare the test statistics with the thresholds in the table to observe whether the results are within an acceptable probability level[26]. The entire hypothesis testing process is presented in the form of a table in Table 1.

Based on the previous table, it can be observed that both invalid hypotheses have been rejected, namely, there is a fundamental difference between the operating expenses of PPP schools and non PPP schools and the mean NAPLAN score.

Due to the fact that the collected data is based on PPP and non PPP schools with the same operating years, the sample size is relatively small (7 pairs of student performance observations and 8 pairs of operating expenditure observations). Despite limited data, the sample size is still larger than the number of samples required to fully perform t-tests. The result of t-test does not depend on the sample size, but on the accuracy of the sample. Therefore, the t-test results in this study are highly reliable. In this case, when t-tests were applied between those affected groups, both H0 scenarios were rejected, indicating significant differences in student performance and costs between PPP and non PPP schools. Based on the results of previous exploratory data analysis, it can be concluded that the operating expenses of PPP schools are higher than those of non PPP schools, but the educational outcomes are also better.

Table 1 Hypothesis testing process.

	NAPAN/Annual Operating Expenses: Comparison between PPP and Non PPP Schools
Ask a question	Unilateral testing to determine if the NAPLAN and operating expenses of PPP schools are higher than those of non PPP schools
Invalid assumption (H_0)	NAPLAN/overall average operating expenses of PPP schools = NAPLAN/overall average operating expenses of non PPP schools
Alternative hypothesis (H_1)	The overall average NAPLAN/operating expenses of PPP schools > The overall average NAPLAN/operating expenses of non PPP schools
Inspection Level (α)	α =0.05
Select inspection method	Two independent sample t-test with equal population variance
Calculate the test statistic (t)	Freedom $\nu = N_1 + N_2 - 2$ $t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{(N_1-1)\times s_1^2 + (N_2-1)\times s_2^2}{N_1+N_2-2}} \times \sqrt{\frac{1}{N_1}+\frac{1}{N_2}}}$ The mean of NAPLAN/operating expenditure sample data for PPP schools and non PPP schools, respectively; s_1, s_2 represents the variance of the NAPLAN/operating expenditure sample data for PPP schools and non PPP schools, respectively; N_1, N_2 represents the corresponding number of NAPLAN/operating expense sample data for PPP schools and non PPP schools, respectively.
Critical t-value	Application t-distribution table
Calculate p-value	Conversion by t-test
Conclusion	If $t > t_{critical}$, or p<0.05, reject H_0
	If $t < t_{critical}$, or p>0.05, accept H_0

Tables 2 and 3 show the results of the t-test.

Table 2 T-test results of NAPLAN scores.

Inspection object	**t**	**p**	$t_{critical}$	α	**Reject H_0?**
Third grade: Reading	2.391	0.020	1.833	0.05	yes
Third grade: Arithmetic	1.939	0.038	1.782	0.05	yes
Fifth grade: Reading	3.968	0.001	1.782	0.05	yes
Fifth grade: Arithmetic	2.653	0.011	1.782	0.05	yes

Table 3 T-test results of operating expenses.

Inspection object	**t**	**p**	$t_{critical}$	α	**Reject H_0?**
Operation costs	4.059	0.001	1.761	0.05	yes

4.3 Effectiveness Analysis

The basic idea of hypothesis testing is to use the principle of "small probability events" to make statistical judgments, and whether "small probability events" occur is related to the sample obtained from a single sampling and the selected significance level α. Due to the randomness of the sample and the difference in the selected significance level α, the test results may not match the true situation, so hypothesis testing may make errors. Generally, there are two types of errors in statistical hypothesis testing, one is type I error and the other is type II error. Type I errors represent rejection of true and invalid hypotheses, while type II errors mean failure to reject erroneous and false hypotheses[28]. In theory, completely eliminating these two errors is considered statistically impossible, but there are still many statistical theories that delve into minimizing one or two errors.

In practical applications, the probability of making the first type of error is controlled, that is, given α, and then B is reduced by increasing the sample size n. The sample size of this article is fixed, and α and β cannot both be small at the same time. The evaluation of Type I errors is implemented in t-tests, where the p-value threshold is set to 0.05 (α). In addition to Type I errors, GPower also needs to further explain Type II errors. GPower is an open-source software designed for effective sample size calculation and efficacy analysis. Usually, the effectiveness threshold (1-β) is set to 0.8, so if the calculated power probability exceeds 0.8, the original assumption is considered true[27].

GPower effective sample size and efficacy value analysis:

By using the GPower plugin, Table 4 presents the results of the GPower effect size and efficacy threshold (1-β).

Table 4 GPower analysis results of t-test.

GPower test object	Effective sample size	Effectiveness value (1-β)
Third grade: Reading	1.278	0.728
	1.036	0.573
Third grade: Arithmetic	2.121	0.982
Fifth grade: Reading	1.418	0.804
Fifth grade: Arithmetic	2.030	0.986

From Table 4, it can be observed that except for third grade students whose NAPLAN arithmetic scores did not exceed the originally set efficacy threshold (1-β) of 0.8, the efficacy values of the other t-test sample subjects all exceeded 0.8.

In summary, the p-values listed in Tables 2 and 3 are both below the significance level of 0.05, and the corresponding calculated efficacy values usually exceed the set threshold of 0.8 (as shown in Table 4). This result can to some extent ensure the credibility of the hypothesis testing conclusions in this article.

4.4 Monte Carlo Simulation of PoF

Monte Carlo simulation (MCS), also known as statistical experimental method, is a computational method based on probability theory and statistical theory. It considers the variability of data and is a more advanced technique for evaluating data. It uses the probability function of the input variable to generate a distribution function for its output[30]. The results indicate the likelihood of expected values and the comprehensive impact range of multiple risks[31]. Although the sample size is small, MCS still samples random variables based on the random probability characteristics of interest through multiple iterations[32]. Lai et al.'s study also concluded that complex probability problems often utilize MCS because it can easily generate a series of output values corresponding to different scenarios, and its results are relatively intuitive and can be further analyzed[33]. However, since sampling occurs in a random pattern, it is difficult to ensure the accuracy of the results. In the case where it is known that random patterns may lead to incorrect results, this paper conducted multiple experiments by increasing the number of iterations until a convergence range was observed to ensure the accuracy of the probability results.

By applying the MCS method, the PoF of educational outcomes can be calculated using Eq.1, where $N_{below,score}$ is the total number of scores below the failure threshold and N_{total} is the number of iterations.

$$PoF = \frac{N_{below,score}}{N_{total}} \qquad \text{(Eq.1)}$$

The PoF of the annual operating expenses of the school can be calculated using Eq.2, where $N_{below,cost}$ is the total number of costs below the failure threshold, and N_{total} is the number of iterations.

$$PoF = 1 - \frac{N_{below,cost}}{N_{total}} \quad \text{(Eq.2)}$$

The exploration perspective of this article focuses on the horizontal comparison between PPP schools and non PPP schools, but it was not ignored in the data analysis, that is, comparing the educational outcomes of PPP schools and non PPP schools between higher and lower grades. According to exploratory data analysis, NAPLAN scores in third grade are usually higher than those in fifth grade, both in PPP schools and non PPP schools. This may be due to the varying levels of knowledge difficulty among different grades, resulting in different grading standards for students in different grades. Considering the external factor involved in implementing the Monte Carlo method, the performance of third and fifth grade students was simulated separately.

Considering the need for horizontal comparison of NAPLAN results between PPP schools and non PPP schools datasets, failure was first defined as being lower than the average NAPLAN score in Victoria, as shown in Table 5. However, the results showed that the PoF of non PPP schools was extremely high (> 90%), indicating that the initial setting of the failure threshold was unreasonable. This article ultimately chooses the overall average between non PPP groups (excluding the maximum and minimum values in the sample data) as a more reasonable critical point.

Table 5 MCS preliminary education achievements (Iterations=400).

Test object	PPP school PoF (%)	Non-PPP school PoF (%)
Third grade: Reading + Arithmetic	72.79	94.89
Fifth grade: Reading + Arithmetic	19.25	99.27

In Table 6, the average PoF for the third and fifth grade education outcomes of PPP school projects are 0.25% and 0%, respectively. In contrast, the average PoF for non PPP third and fifth grade students was significantly higher than that for PPP school projects, at 38.36% and 45.21%, respectively.

Table 6 MCS education achievements.

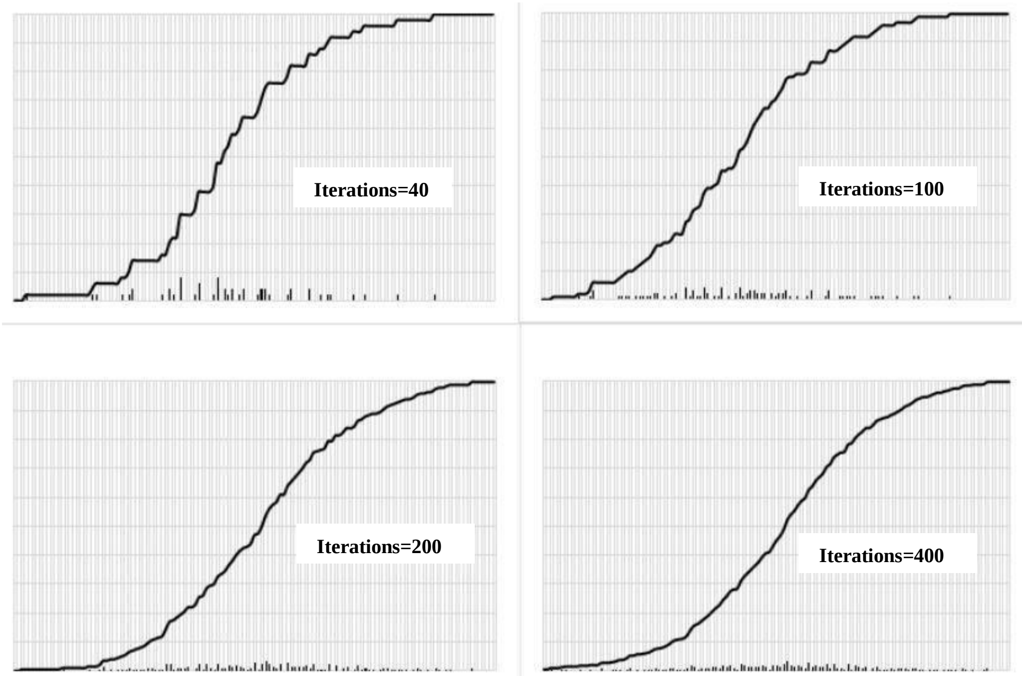
Grade	Iterations	PPP school PoF (%)	Non-PPP school PoF (%)
Third grade	50	0	34.90
	100	0	42.88
	200	0.50	38.89
	400	0.50	36.77
Average value	-	0.25	38.36
Fifth grade	50	0	54.18
	100	0	46.15
	200	0	40.88
	400	0	39.63
Average value	-	0	45.21

Considering the significant difference in operating costs between PPP schools and non PPP schools, the failure threshold was set as the average of their respective datasets. As shown in Table 7, the average result value shows that the operating expenditure PoF of PPP school projects is 48.37%, slightly higher than the 48.05% of non PPP school projects.

Table 7 Results of MCS operating expenses.

Number of Iteration	PPP school PoF (%)	Non-PPP school PoF (%)
50	40.89	43.58
100	54.51	48.21
200	49.36	46.74
400	48.73	53.68
Average value	48.37	48.05

Figure 3 illustrates a set of MCS results related to NAPLAN scores, and each specific MCS result (including NAPLAN scores and operating expenses) can be found in Appendix D and E. Based on Figure 3, it is not difficult to observe that as the number of iterations increases, the distribution of occurrences gradually becomes sparse and uniform, and the histogram presented is closer to the shape of a normal distribution; The cumulative probability fluctuation decreases, and the curve becomes more delicate and smooth. Similar changes can also be observed when applying MCS to operating expenses.



Note: *The x-axis in the figure represents the NAPLAN score (reading+arithmetic);*

The y-axis represents the cumulative probability (PoF)

Figure 3 Shows the graphical results of MCS using NAPLAN scores for third grade students in a non PPP school as an example.

5. Summary and Discussion

Through literature review and case analysis of the PPP new school project in Australia, the author believes that applying the PPP operating model in government public building projects such as new schools may result in higher operating expenses than other traditional operating models, but it will also bring higher educational returns, specifically reflected in student performance. In addition, as this article has not yet addressed the conversion of social benefits such as school teaching outcomes and various risks associated with applying PPP operating models into equivalent monetary values that contribute to cost-benefit analysis, it can only provide indirect reference assistance in government decision-making.

In fact, China has gradually implemented the government social capital cooperation (PPP) model since the 1980s, and there are limited examples of new school projects applying this model. For Victoria, the PPP new school project is a benchmark project that has already been implemented. Therefore, the case analysis results of the PPP new school project in Australia serve as a benchmark, providing forward-looking guidance for promoting PPP in school projects and other public buildings in China. With the acquisition of more data from future PPP school projects in China and the inclusion of external factors in China's national conditions, it is possible to compare it with existing data from Victoria and draw conclusions that are more in line with China's national conditions.

The final conclusion of this hypothesis test is consistent with previous literature reviews. Although schools invest heavily in PPP mode, the overall performance level of primary school students is high. However, the entire hypothesis test is not flawless, especially when it comes to the power (1-β) value of the GPwoer test, where the problem focuses on the t-test results in third grade. The effectiveness results of the corresponding tests, whether it is reading scores or arithmetic scores, have not exceeded the threshold. According to the results of the existing MCS in PPP schools, the NAPLAN performance of fifth grade students is more stable than that of third grade students. However, this can only be noticed in PPP schools, and there is suspicion that the PPP model has a higher impact on older students. On the premise of ensuring that the t-test conclusion remains unchanged, it can be seen that manually increasing the reading and arithmetic scores of third grade students in PPP schools by 5% resulted in a effectiveness result higher than 0.8. This situation also proves that the higher education performance of lower grade students guided by the PPP model is not as significant as that of higher grade students.

Therefore, after comparing third and fifth grade, these two methods have a consistent guess, that is, the impact of the school's operating model on higher and lower grades is different, while the PPP model has a greater impact on higher grades. It is expected that this speculative conclusion will be further validated in the future, allowing for continuous tracking surveys of lower grade students and data sampling comparisons within a certain time frame. In this way, it can to some extent eliminate the interference of objective differences in schools and individual differences among students.

Compared with the results of the aforementioned benefits (student performance), the cost of school operating expenses is simpler and clearer after applying hypothesis testing and Monte Carlo simulation methods. The average PoF of PPP mode is 0.32% higher than that of non PPP mode, indicating that under the influence of comprehensive factors, the risk of PPP school projects is slightly higher than that of other types of school projects. However, this number needs to be further validated and confirmed by expanding the effective sample size. Furthermore, the failure threshold defined for obtaining PoF is subjective and has not yet been validated under the guidance of education professionals.

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