Expanding Application of Cost-Volume-Profit Analysis under Uncertainty

Lu Yanrong, Zhu Xueyi

School of Business, Nantong Institute of Technology, Nantong, Jiangsu, 226002, China

Keywords: Fixed number cost-volume-profit analysis method; Cost-volume-profit analysis under uncertainty: Colleges and universities; Sensitivity analysis; Joint probability

Abstract: Cost-volume-profit analysis method is divided into fixed-number cost-volume-profit analysis method and uncertain conditional cost-volume-profit analysis method. This paper extends the cost-volume-benefit analysis method under uncertain conditions to decision-making in colleges and universities, including the application of sensitivity analysis method for multi-level running schools and the application of joint probability method for undergraduate running schools, which provides a basis for project decision-making in colleges and universities.

1. Introduction

Senior Management Accounting by Robert S. Robert S·Kaplan, a famous American accountant, classifies “cost-volume-profit analysis” into two categories: one is “fixed-number cost-volume-profit analysis”; the other is “cost-volume-profit analysis under uncertainty” [1]. The “fixed number” of the former means that the cost and income functions in the cost-volume-profit model are assumed to be fixed no matter how complicated. The latter “uncertainty condition” means that the sales volume, price or cost in the cost-volume-profit model are generally uncertain.

As for “fixed-number cost-volume-benefit analysis”, there are a lot of textbooks in our country, and the vast majority of cases are used for enterprise decision-making, and administrative institutions are almost unused, while “cost-volume-benefit analysis under uncertain conditions” is rarely introduced and applied. On June 22, 2016, China's Ministry of Finance issued the Basic Guidelines for Management Accounting, requiring enterprises and administrative institutions to take effect from the date of promulgation. Before the Ministry of Finance's “Basic Guidelines for Management Accounting” was issued, many articles in China discussed that the application of management accounting focused on enterprises and rarely involved the application of public institutions (such as universities and other institutions). There are four influential articles on CNKI's method of using management accounting tools in colleges and universities-cost-volume-profit analysis (specifically to model design): one is the application (research) articles [2][3] [4] published by Du Junping (2014), Yu Min and others (2015) and Zhang Xiaojun (2016) on management accounting “in the financial management of colleges and universities”. The article designs a formula for the number of students enrolled in colleges and universities in breakeven point and the number of students enrolled in colleges and universities under a certain profit target in connection with the number of students enrolled. Second, Lun Zongjian and Fu Qiuying (2016) published an article on “Application of Management Accounting in Financial Management of Colleges and Universities” [5]. Based on the number of students enrolled in previous years and the number of new students enrolled in the current year, they designed a model for recruiting breakeven point and achieving a certain “career balance” goal, which has great inspiration for readers. After the Ministry of Finance's “Basic Guidelines for Management Accounting” was issued, there have been many articles on the application of management accounting in colleges and universities, but the cost-volume-benefit analysis method has not been applied in the operation management of specific projects. Article 20 of the Basic Guidelines for Management Accounting stipulates: “Management accounting tools and methods applied in the field of operation management include but are not limited to cost-volume-profit analysis, sensitivity analysis, marginal analysis, benchmarking, etc.” In combination with this provision, this article refers to the simple classification and application of basic methods when universities apply the cost-volume-benefit analysis method, and has not carried

  DOI: 10.25236/ermbfe.2019.127

out the cost-volume-benefit analysis under uncertain conditions, such as sensitivity analysis and joint probability analysis, on the operation management items. This paper makes some discussions on this. First, it discusses the application of cost-volume-benefit technology under uncertainty. Second, it expands the application scope of cost-volume-benefit technology under uncertainty-universities.

2. Application of Sensitivity Analysis in Multi-level Running of Colleges and Universities

2.1 The Level of Running Colleges and Universities in China

At present, there are many levels of running schools in China's colleges and universities, especially in private schools, including secondary schools, junior colleges, undergraduate courses, secondary schools receiving junior colleges (or through classes in secondary and higher vocational colleges [7]), major-to-undergraduate courses, college-to-undergraduate courses, off-campus vocational training, etc. Funding and fees for running schools vary from level to level. How to run a school with limited educational resources to maximize the income [8] requires the application of sensitivity analysis in cost-volume-benefit analysis under uncertain conditions (see case 1).

[Case 1] The accounting department of Xu Huai College has two levels of running a school: one is the level of running a college majoring in accounting; The second is the undergraduate level of accounting major.

2.2 Determine the Average Marginal Contribution of Students at All Levels

Looking up the data of the previous three years, the average annual income of the students in the accounting department of Xuhuai university after deducting the average annual variable cost of the students in the secondary school contributes 11000 yuan per year, and the average annual income of the students in the junior college calculated by the same method contributes 3000 yuan per year.

2.3 Establishing Equation to Seek Breakeven Point

(1) Determine fixed costs. Xuhuai College conducts education cost accounting in accordance with the “Accounting System for Higher Education” implemented on January 1, 2014. Through the calculation of the education cost accounting data for the three years from 2014 to 2016, the accounting department occupies the value of the school classroom (including the depreciation of fixed assets such as houses, projectors, computer desks, etc.), the shared value of public fixed assets such as school libraries and audio-visual halls. All fixed costs (depreciation, amortization) and other fixed costs are 720,000 yuan per year.

(2) Establish a business balance equation. The Xuhuai College of Accounting Department is an annual college student with an x1 degree, an undergraduate degree of x2 per year, and a career balance (profit) of π, then:

Business balance (profit) $\pi=0.1\times1+0.3\times2-72$

(3) Determine the capital preservation point. When the business balance is $\pi=0$, the equation is: $0.1x1+0.3x2=0$, then the equation has 9 guaranteed points.

① Calculate the maximum number of students in the two school levels (the school stipulates that the minimum number of students in each class for undergraduate or college classes is 30):

Let x1=0 (that is, only undergraduate classes), then: the number of students in the undergraduate insurance program = $72 \div (0.1 \times 0 + 0.3) = 240$ (person)

Let x2=0 (that is, only a college class), then: the number of students in the college insurance policy = $72 \div (0.1 + 0.3 \times 0) = 720$ (person)

The calculation results show that if only undergraduate classes are held, the maximum size of the students is 240/year, with a total of 8 classes (240÷30). If you only have a college class, the maximum size of the students is 720 people/year, a total of 24 classes (720÷30).

② For the calculation of other capital preservation points for college and undergraduate classes, see Table 1:

Table 1 Calculation table for holding college and undergraduate classes (the number of students in school)

Serial number	Run junior college classes (×1)		Run undergraduate classes (×2)		The total marginal contribution of the two levels (10,000 yuan)
	Number of people	Marginal contribution (10,000 yuan)	Class (Number of people)	Marginal contribution (10,000 yuan)	
	1	2	3	4	5=2+4
1	72÷0.1=720	720×0.1=72	0	0	72
2	(72-9)÷0.1=630③	630×0.1=63④	1(30)①	30×0.3=9②	72⑤
3	(72-18)÷0.1=540	540×0.1=54	2(60)	60×0.3=18	72
4	(72-27)÷0.1=450	450×0.1=45	3(90)	90×0.3=27	72
5	(72-36)÷0.1=360	360×0.1=36	4(120)	120×0.3=36	72
6	(72-45)÷0.1=270	270×0.1=27	5(150)	150×0.3=45	72
7	(72-54)÷0.1=180	180×0.1=18	6(180)	180×0.3=54	72
8	(72-63)÷0.1=90	90×0.1=9	7(210)	210×0.3=63	72
9	(72-72)÷0.1=0	0×0.1=0	8(240)	240×0.3=72	72

Note: ①=1 class, with a total of 30 people; ② = 30 undergraduates ×33,000 yuan per capita marginal contribution of undergraduate class = 90,000 yuan; ③ = (the total marginal contribution of the two classes is 720,000 yuan-the total marginal contribution of the undergraduate class is 90,000 yuan)-the average marginal contribution of the junior class is 0.1=630 people; ⑤ = Total Contribution Margin of Undergraduate Class 90,000 Yuan+Total Contribution Margin of Junior Class 630,000 Yuan = 720,000 Yuan

As can be seen from Table 1, there are nine breakeven point, each breakeven point's marginal contribution is 720,000 yuan, which is called “equal marginal contribution”.

2.4 Carry out Sensitivity Analysis-Do Not Consider Enrollment Index

The so-called sensitivity analysis, accounting means: “used to discuss if there is a change with a certain factor of forecast or decision, then the expected result of the forecast or decision will be affected” [9], which includes sensitivity analysis in profit forecast, sensitivity analysis in long-term investment decision, etc. Sensitivity analysis is varied. High-level “decision makers are usually interested in establishing an enterprise financial model, which they can use to estimate the financial impact of different business decisions”, especially the impact on “profit results [10]. Experts and scholars in management and economics usually use the significance between dependent and independent variables to analyze sensitivity [11]. This paper uses the sensitivity analysis methods and techniques in Modern Cost Accounting [12] co-authored by Professor Deacon of the University of Texas and Professor Mel of the University of Michigan to make its decision.

(1) One to one simplified analysis. Let x1=x2, then: 0.1x1+0.3x2=72, ie 0.4x=72, x=180 (person). That is to say, 180 college graduates and 180 undergraduate classes. The total marginal contribution of the two classes is 180×0.1+180×0.3=72 (10,000 yuan)

(2) Three-to-one pairing analysis. The number of students in a college class is three times that of an undergraduate class, that is, the number of students in a college class is 75% [3÷(3+1)], and the number of undergraduate classes is 25% [1÷(3+1)] ,then:

Weighted average marginal contribution = 0.1 × 75% + 0.3 × 25% = 0.15 (10,000 yuan)

The number of students at the capital preservation point = 72 ÷ 0.15 = 480 (person), of which, the number of students in college classes = 480 × 75% = 360, the number of students in undergraduate classes = 480 × 25% = 120

(3) Pairing analysis of Sanqi. The number of colleges in the college is 30%, and the number of undergraduate students is 70%.

Weighted average marginal contribution = 0.1 × 30% + 0.3 × 70% = 0.24 (10,000 yuan)

The number of students at the capital preservation point = 72 ÷ 0.24 = 300 (person), of which, the number of students in the college class = 300 × 30% = 90, the number of students in the undergraduate class = 300 × 70% = 210.

2.5 Carry Out sensitivity analysis-consider enrollment indicators

[Case 2] According to Case 1, the number of students enrolled in the Accounting Department of Xuhuai College is set at 800 (according to a class of 30 people, 26-27 classes for college and undergraduate classes), and 800 students. Students are allocated funds and fees for school fees. Among them, the annual enrollment index of undergraduates should not exceed 120, and the number of students enrolled in the college year is not limited. Try sensitivity analysis and decision making.

(1) Under the one-to-one simplified scheme, 400 students are enrolled in the college class, and 400 students are enrolled in the undergraduate class. Business balance (profit) = income - variable cost - fixed cost = marginal contribution - fixed cost = 400 × 0.1 + 400 × 0.3 - 72 = 88 (10,000 yuan).

(2) Under the three-to-one matching scheme, there are 600 students (800×75%) in the college class and 200 students (800×25%) in the undergraduate class, then: career balance (profit) = income - Variable cost - Fixed cost = marginal contribution - Fixed cost = 600 x 0.1 + 200 x 0.3 - 72 = 48 (10,000 yuan).

(3) Under the matching scheme of 37, the number of students enrolled in the junior college is 240 (800×30%), and the number of undergraduate students is 560 (800×70%), then: career balance (profit) = income - Variable cost - Fixed cost = marginal contribution - Fixed cost = 240 x 0.1 + 560 x 0.3 - 72 = 144 (10,000 yuan).

Under the Sanqi Open Matching Program, the number of students enrolled in the Department of Accounting of Xuhuai College = 560 ÷ 4 = 140 (person) > 120 annual enrollment targets given by the state.

(4) Ensure that undergraduates meet the national maximum of 120 people per year (480 students in four years), and 107 students (800-120×4) ÷3 under the approved quota of 800 students.

Business balance (profit) = income - variable cost - fixed cost = marginal contribution - fixed cost = (800 - 120 × 4) × 0.1 + (120 × 4) × 0.3 - 72 = 104 (10,000 yuan).

2.6 Sensitivity Analysis Conclusion of Multi-level School Running

The number of students enrolled in the Department of Accounting of Xuhuai University is 800. Among them, the enrollment of undergraduates is no more than 120. Due to the large amount of education expenses per student in the undergraduate students, the student's schooling fee is also high. The income generated by each student in the school is deducted from the cost of training each undergraduate student. The marginal contribution is 0.3 million yuan. It is three times that of cultivating a junior college student (the marginal contribution of a college student is 0.1 million yuan/year), and the more undergraduate students are recruited, the better the economic benefits. For example, when the undergraduate students are 200 students (the college and the undergraduate students are paired with three to one), the profit is 480,000 yuan. When the undergraduate students are 400 students (the college and the undergraduate students are paired one by one), the profit is 880,000 yuan. Undergraduate students are limited to 480 people according to the national enrollment index (120 person/year) (the college and the undergraduate students are paired with 4-6), and the profit is 1.04 million yuan. This 1.04 million yuan profit is the optimal solution under limited conditions.

If the accounting department of Xuhuai College can further expand the enrollment scale to 140 people/year (560 students), the profit will be 1.44 million yuan. This scenario is an optimization solution.

It must be pointed out that to expand the enrollment of undergraduates, we must also consider the strength of the teachers, the conditions for running schools (including hardware and software), the level of running schools, and the degree of social recognition. The above assumptions are all in place, so the conclusions of the study are also hypothetical.

3. Application of Joint Probability in Undergraduate School-running Decision

The optimization plan of the above research is: the future enrollment scale of the accounting department of Xu Huai college can be expanded to 140 students/year (560 students) with a profit of 1.44 million yuan. This is the plan determined according to the school running situation (data) in the previous three years. In fact, there are many uncertain factors in running schools in the future. For example, if Xu Huai College is a private college, how much is the appropriate level of private undergraduate fees when the number of undergraduate students in the accounting department can be increased to 180 in the future? How much is appropriate for private undergraduate schools to spend on students? Should we improve the conditions for running schools and increase investment in fixed assets such as teaching instruments and equipment? Wait, this needs to be predicted. Using "telpei method", that is, according to the conclusion (joint probability [14]) drawn by expert investigation (scoring) [13], to make prediction is a commonly used method.

[Case 3] The accounting department of Xu Huai College will enroll 180 students in the coming year. However, there are different opinions on the decision of charging price, personnel training cost and fixed cost. The following probabilities are obtained after consulting external experts and senior school leaders (see table 2:)

Table 2 Xuhuai College Accounting undergraduate undergraduate school may determine the level of non-determined factors and related probability table

Possible factors	Average price per student (Yuan/Year)		Average Training Cost per Student (Yuan/Year)		Fixed cost (Yuan/Year)	
	Level	Probability	Unit variable cost	Probability	Level	Probability
1	16800	0.6	12500	0.4	600000	0.55
2	18000	0.4	13500	0.6	720000	0.45

(1) Calculate the joint probability to determine the number of students enrolled in the capital (see Table 3)

Table 3 Xuhuai College Accounting undergraduate undergraduate school in accordance with the joint probability calculation of the number of students enrolled

Annual charge price	Probability	Average annual training cost per student (unit variable cost)	Probability	Fixed cost	Probability	Number of guaranteed enrollment	Joint probability	Joint guaranteed enrollment
1	2	3	4	5	6	7=5÷(1-3)	8=2×4×6	9=7×8
16800	0.6	12500	0.4	600000	0.55	140	0.1320	18.4186
16800	0.6	12500	0.4	720000	0.45	167	0.1080	18.0837
16800	0.6	13500	0.6	600000	0.55	182	0.1980	36.0000
16800	0.6	13500	0.6	720000	0.45	218	0.1620	35.3455
18000	0.4	12500	0.4	600000	0.55	109	0.0880	9.6000
18000	0.4	12500	0.4	720000	0.45	131	0.0720	9.4255
18000	0.4	13500	0.6	600000	0.55	133	0.1320	17.6000
18000	0.4	13500	0.6	720000	0.45	160	0.1080	17.2800
Total							1	162

(2) The calculation results in Table 3 show that the annual guaranteed enrollment calculated by joint probability in the running of accounting undergraduate courses in Xu Huai University is 162.

(3) When the enrollment number reaches 180, the achievable profit is determined according to the joint probability (see table 4)

Table 4 The achievable income statement calculated by the joint probability in the undergraduate accounting of Xuhuai University (calculated by the number of new recruits per year)

Annual enrollment	Average annual price	Probability	Average annual training cost (unit variable cost)	Probability	Fixed cost	Probability	Profit	Joint probability	Expected achievable profit
1	2	3	4	5	6	7	8=1×(2-4)-6	9=3×5×7	10=8×9
180	16800	0.6	12500	0.4	600000	0.55	174000	0.132	22968
180	16800	0.6	12500	0.4	720000	0.45	54000	0.108	5832
180	16800	0.6	13500	0.6	600000	0.55	-6000	0.198	-1188
180	16800	0.6	13500	0.6	720000	0.45	-126000	0.162	-20412
180	18000	0.4	12500	0.4	600000	0.55	390000	0.088	34320
180	18000	0.4	12500	0.4	720000	0.45	270000	0.072	19440
180	18000	0.4	13500	0.6	600000	0.55	210000	0.132	27720
180	18000	0.4	13500	0.6	720000	0.45	90000	0.108	9720
Total								1	98400

The calculations in Table 4 show that the achievable profits calculated by the joint probability in the undergraduate accounting of Xuhuai University. According to the annual number of new recruits, 180 people are calculated as 98,400 yuan, four years of students in school (180 × 4 = 720 people), and the annual profit is 393,600 yuan [15] (98,400 × 4).

Acknowledgement

Fund Project: 2018 Jiangsu University Philosophy and Social Science Research Fund Project “Research on Management Accounting Information Construction of Private Colleges and Universities” (Project No.: 2018SJA1281); Jiangsu Provincial “13th Five-Year” Business Management First-level Key Construction Project (Project No.: SJY201609)); Research Center for Humanities and Social Sciences outside the University of Jiangsu Province - Tonghu Industry Coordinated Development Research Base Project (Project No.: SJSZ201716); Nantong Institute of Technology “Professor, Doctoral Fund Project”, “Enterprise Resource Allocation Efficiency Research” (Project No.: Scientific research 201823) Phased research results.

References

[1] Robert S. Kaplan, author, Zhong Bojiang, Liu Zhishan, Wen Guangwei, Trans. Senior Management Accounting [M]. Beijing: China Business Publishing House, 1989

[2] Du Junping. Application of Management Accounting Theory and Practice in University Financial Management [J]. Friends of Accounting, 2013(26):113-117.

[3] Yu Min, Zhang Huan. Research on the Application of Management Accounting in University Financial Management [J]. Accounting Learning, 2015(17):20-21.

[4] Zhang Xiaojun. Application of Management Accounting Theory and Practice in University Financial Management [J]. research of finance and accounting, 2016(10):37-38.

[5] Lun Zongjian, Fu Qiuying. Application of Management Accounting in Financial Management of Colleges and Universities [J]. Friends of Accounting, 2016(13):70-72.

[6] Scott B, Eugene F.B. Author, Liu Aijuan, Zhang Yan, Translation, Chen Guoxin, Reviser. Essentials of Financial Management (12th Edition of the Original Book) [M]. Beijing: Machinery Industry Press, 2005.

[7] Xu Weiwei. Research on Consolidated Accounting Statements of Multi-level Running Institutions-Taking Higher Vocational College of G University as an Example [D]. Shanghai: East China University of Technology, 2015-11.

[8] Zhang Haibi, Liu Chunzhi. Cost-benefit analysis of the introduction of foreign high-quality educational resources [J]. Modern Women (late), 2014(5):23.

[9] Tianmin Li. Management Accounting [M]. Beijing: Central Radio and Television University Press, 1984.

[10] Robert S.K,Anthony A.A a, author, Lu Changjiang, main translation. senior management accounting [M]. Dalian: northeast university of finance and economics press, 1999

[11] Xu Mingdong, Chen Xuebin. Sensitivity Analysis on Capital Cost of Investment by Chinese Industrial Enterprises [J]. Economic Research, 2012,(3):40-52+101.

[12] Deakin E.B., Mager M.W., Sun Qingyuan, Tang Fangrui, Xu Qingzhu, Cao Dehao, Trans. Modern Cost Accounting [M]. Shanghai: Lixin Accounting Book Supplies Co., 1992

[13] Zhu Xueyi. Research and Design of Financial Analysis Innovation System for Coal Enterprises [M], Xuzhou: China University of Mining and Technology Press, 2012.

[14] Zheng Aihua, Zhang Yajie, Li Wenmei. Management Accounting [M]. Beijing: Mechanical Industry Press, 2017 (reprint).

[15] Zhu Xueyi, Zhu Liangfeng. Practice of Value Added Goal of Management Accounting-Taking Private Enterprises of Huaihai Holding Group as an Example [J]. Management Review, 2017 (9): 262-272.