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BIDIRECTIONAL APPROACH FOR UNIVERSITY MANAGEMENT: IMPROVED RELATIONSHIP WITH STUDENTS AND EDUCATIONAL COSTS MANAGEMENT

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Abstract. The research, through a bidirectional approach, aims to develop the university management of the degree programs in order to attract and maintain the potential students, as well as to estimate and manage the costs of the educational services offered during their life cycle. The authors bring into the centre of the study the importance of the simulation process in predicting a possible future and reduce the probable risks and costs from time. The results confirm that the simulation methods used help the universities to determine the future risks and to predict when and what relationship marketing programs to use in order to attract, maintain and grow the number of valuable students and also to ensure cost-effective management of university programs.

Keywords: university management, Monte Carlo simulation, Markov chains, Gauss distribution, stochastic simulation, life-cycle cost method (LCC).

JEL Classification: I20, I29, M41.

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Introduction

In the current period, many specific factors have occurred at the level of university education (demography, technical and technological discoveries, knowledge-based information society, artificial intelligence, data analytics, and block chain technology), which have completely

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transformed the structure and functionality of universities (Balzer, 2020; Chaminade & Lundvall, 2019; Kolomytseva & Pavlovska, 2020; Williams, 2019). The contemporary trend is for universities to be governed by the labour market, and their orientation is towards final consumers (economic entities, state institutions, who will benefit from skilled labour) (Altbach et al., 2009; Evans & Gill, 2017; Reichert, 2019). Knowing that relationships for human beings are essential, institutions, including universities, must understand that building a strategy on marketing relationships will lead to competitive advantage and satisfying students (Palmatier & Steinhoff, 2019; Toma, 2011). Universities, establishing their standards, creating new levels of excellent standards, are offering learning, education, and research (Kahn & Anderson, 2019). Now they are autonomous and ask from the pleasant student thinking, learning as understanding in a different way (Dall'Alba & Barnacle, 2007), due to their open-access mission (Schneider & Deane, 2015) and healthy attitudes, in order to face the economic, social, cultural, political, and technological challenges existing in the work market. Universities are increasingly taking inspiration from the business world in an attempt to achieve profitability in a competitive market. Universities are required to make realistic and valid estimates to ensure the essential sources of funding, and the costs involved must ensure both the supportability of the different categories of beneficiaries and the prosperity at the institution. That increasingly arises the need for evaluation, information, and communication on the cost of education in higher education (Ianos, 2010).

The study aims to develop the university management of undergraduate programs through an innovative two-way approach, on the one hand from the perspective of attracting and maintaining potential students and identifying optimal solutions for development, and on the other hand the estimation and management of the costs of educational services offered during their life cycle. Thus, the purpose of the research is to predict the future number of students enrolled, based on data from previous years and to estimate and manage the costs of educational services during their life cycle.

The objectives of the study are: Objective 1 – predict future problems in attracting and maintaining students and future solutions for developing the number of students; predict the right number of enrolled student in order to ensure effectiveness for the analyzed institution, observe the difference between the obtained calculation and the real data; improving the relationship with future students, getting in-value for students and the institution; Objective 2 – application of the life-cycle cost method (LCC) of an educational license program belonging to the economic profile, in order to identify whether the results of the LCC method add value to accounting information on the relevance of costs or the composition of the cost of production or provision of the service. Starting from the announced objectives, the research hypotheses are: Hypothesis 1: Statistical and econometric methods contribute to predicting future problems in attracting, enrolling and retaining students to improve the relationship students-university; Hypothesis 2: LCC and statistical methods applied for an educational license program belonging to the economic profile add value to accounting information on the relevance of costs or the composition of the cost of production or provision of the service. The novelty of the paper lies in the fact that it addresses a current problem with practical implications, which involves presenting a model in which statistical and econometric methods and the specific method of management accounting (LCC) are used as a bidirectional approach to improve university management. The structure of the research presents the main studies from the scientific literature, the applied materials and methods, followed by the results and conclusions of the research.

1. Literature review

Evans and Gill (2017) ask themselves if the university is a business, and they also answer, by providing the following information: that between the student and the institution is made a contract- students are obligated to attend the courses and the seminars, to pass the exams and to pay their fees, and the institution, through its professors, is obligated to offer excellent quality teaching, adequate facilities and well-designed courses, meaning education and academic excellence (Nejati, 2013; Sultan & Wong, 2019). The universities are using relationship marketing by increasing students' involvement in university activities, such as technology-based activities, programs based on the relationship students- librarians (Brock, 2019; Kaur, 2009; Pringle & Fritz, 2019). According to Baran et al. (2008), there are three levels of relational marketing. Level 1 is based on offering discounts in order to attract and maintain students, prices, money scholarships for good results, study scholarships for the same good results, reduction for student camps, travel, and transportation. Level 2 is based on user customization and social connections as special events for students: parties (just for students, for students and the professor, such as Christmas, seminars, conferences, workshops, focus groups, educational programs, PR events, sports activities, alumni relationships, counselling and assistance, counselling in career, social events (Christmas events, PR campaigns for children and families with lower income, international sessions for students, concerts, and programs for the beginning of the year, associations). Level 3 is based on connections sustained by structural solutions, as computers and IT programs in order to detect the students' payments, the preferences for some courses, the amount of money and the moment of paying the preference or for a program, or the frequency and the recency of presence, or the average calcification per semester or year, the evidence of results. These relationships allow the university to be known using recommendation and word-of-mouth (Oplatka & Hemsley-Brown, 2012), alumni relations (Ong, 2009), which represents acquisition and retention strategies for universities and a new approach for CRM, academic counselling and assistance, and new technology forming a new generation of students (Harland, 2012). Relationships are the way to gain new knowledge and experience and to confront different barriers (Sheldon & Turner-Vorbeck, 2019).

Students are regarded as customers, to whom the universities are offering them education services, and because the clients have rights for what they are paying for, they may have complaints. However, also, the university has rights, because the contract is for the two parts (Evans & Gill, 2017). Relational marketing is perceived as a bond of equality between partners (Baran et al., 2008), and the partnership between the university and its students is characterized by trust, commitment, communication, collaboration, and knowledge sharing, resulted through the mutual satisfaction of objectives. The relationship with students is different according to the stage of student life-cycle: recruitment stage, enrolment, retention, and post-graduation (Ackerman & Schibrowsky, 2007; Lechtchinskaia et al., 2012; Perna &

Baraldi, 2014). Relations with students, perceived as the relations with customers, may conduct to collecting information for a database, which may become strategic knowledge and may be used in order to increase the ability of the institution to sell its educational services more efficient, to create at the highest level of satisfaction and loyalty with obtaining a high profit (Linger et al., 2004). Thus, the students-based orientation, become a 1-to-1 relation, based on creating and offering added-value; this type of relationship developed due to new technologies (Svend & Oliver, 2019) and is belonging to those organizations which are using data from the past about its customers and are used in order to predict what client wants. Thus, the organization will treat its customers differently and will grow the mutual value (Chen & Popovich, 2003; Foglieni et al., 2017; Fukuda, 2017; Lamb et al., 2012; Peppers & Rogers, 2004; Sauro, 2015; Valdani & Arbore, 2013; Winer, 2001).

2. Materials and methods

Objective 1 – The used tools are descriptive statistics, Monte Carlo simulation, Markov chains, Gauss distribution, and informatics programs (Excel and MATLAB). The institution which has been analysed is a university from Romania, denoted from strategic reasons, as UR. On the 17th days for the students' enrolment (the summer period), were extracted data for four years between 2016–2019. The total number of enrolled students is shown in the table below (Table 1).

Table 1. Number of enrolled students between 2016–2019

Day/Year	2019	2018	2017	2016
1	0	4	0	0
2	1	4	3	0
3	1	4	6	2
4	2	6	7	7
5	3	7	7	8
6	3	7	10	10
7	5	8	10	10
8	7	8	12	10
9	9	9	13	11
10	12	11	13	13
11	12	11	14	13
12	14	13	14	14
13	18	13	14	14
14	20	15	15	15
15	23	16	17	16
16	24	17	17	19
17	24	18	22	27
Total	178	171	194	189

Monte Carlo method is used in different economic activities, so using it in the education field is a novelty. Monte Carlo method is demonstrating its efficiency in analysing phenomenon characterized by a large number of variables and parameters (Duica & Florea, 2018; Zio, 2013). Markov chains are a mathematical method used in planning and forecasting (Beardwell & Claydon, 2007; Ching et al., 2013; Duica et al., 2019; Florea & Mihai, 2017; Nastase (Bidireanu) et al., 2019; Tracey, 2004), in this case, it is analysed the forecasting of the enrolled student evolution.

Objective 2 – The first variant of analysis of the results obtained by applying the model specific to the LCC method is the sensitivity analysis. The analysis can be repeated for each parameter of the model or only for parameters considered to have a significant impact on the results. Useful in one-way sensitivity analysis is the choice of the values of the smallest and highest of the parameters chosen to be analysed. The choice of these parameters was determined by their uncertainty or their dependence on factors that are not related to the incidence of decision-makers (population dynamics, the degree of promotion of students in the previous cycle, or market dynamics work). For the application of the LCC method and the sensitivity analysis was prepared Table 2, which shows the costs related to the introduction of a license program.

According to Brown and Yanuck (1980), the LCC method is used when it is necessary to draw up a decision related to the purchase of an asset that requires substantial maintenance and which induces considerable operational costs over its life (Brown & Yanuck, 1980). Dhillon (2009) considers that the primary usage of the LCC method lies in the possibility of comparing competitive projects, long-term planning, and providing support to budgeting and control processes, selecting the best bid or elaboration of decisions on replacement of equipment (Dhillon, 2009). More recent approaches regard the LCC method as a useful engineering tool that can be used in the design phase and when product or service development purchases are made, as well as as an instrument that can be applied in a pro-active manner in management and management accounting, as well as in the management of environmental issues (Asiedu & Gu, 1998; Ashworth, 1993; Emblemsvåg, 2003; Gluch & Baumann, 2004; Karim, 2006; Spickova & Myskova, 2015).

Table 2. Costs related to the introduction of a licensing program

Activities	Duration	Costs involved	Year 1	Year 2	Year 3	Year 4	Year 5
Research and development costs (Eur)							
Program planning	1 Week	direct salaries (program manager, secretary)	202	–	–	–	–
		indirect overhead costs	21	–	–	–	–
Design and planning	2 Weeks	direct salaries	213	–	–	–	–
		costs related to the materials used	64	–	–	–	–
		costs of documentation and market study	170	–	–	–	–
		indirect overhead costs	43	–	–	–	–

Continued Table 2

Activities	Duration	Costs involved	Year 1	Year 2	Year 3	Year 4	Year 5
Design and engineering of the service	4 Weeks	direct salaries	426	–	–	–	–
		designing a web page	532	–	–	–	–
		marketing and promotion costs	1,064	–	–	–	–
		indirect overhead costs	85	–	–	–	–
Lifecycle management	5 Weeks	direct salaries	1,053	1,053	1,053	1,053	1,053
		indirect overhead costs	255	266	279	287	293
Testing and evaluating the service	One year	direct salaries	1,053	–	–	–	–
		costs related to performance monitoring	255	–	–	–	–
		indirect costs	11	–	–	–	–
Service market research	4 Weeks	direct salaries	223	–	–	–	–
		overhead costs	101	–	–	–	–
Total research and development costs			5,771	1,319	1,332	1,340	1,346
Service costs (Eur)							
Operational costs	Five years	personal salaries involved in the authorization of the program	426	213	213	213	213
		material costs	106	85	745	426	106
		costs of authorizing the program	213	–	–	213	–
Quality control	Five years	costs related to the program director	426	426	426	426	426
Initial logistic support	One year	logistical costs of providing the program	362	–	–	–	–
Operational analysis	Five years	operational analysis costs	277	255	234	213	106
Total service costs			1,809	979	1,617	1,489	851
Operational and support costs (Eur)							
Service costs	Five years	costs associated with teachers' salaries	49,660	49,660	49,660	49,660	49,660
Distribution costs	Five years	marketing costs	851	851	638	426	–
Costs related to logistic support	Five years	logistic costs	1,277	1,170	1,064	851	426
Total operating and support costs			51,787	51,681	51,362	50,936	50,085
Withdrawal costs (Eur)							
Final withdrawal costs	One year		–	–	–	–	426

End of Table 2

Activities	Duration	Costs involved	Year 1	Year 2	Year 3	Year 4	Year 5
Removal cost	One year		–	–	–	–	309
Final value	One year		–	–	–	–	4,787
Total withdrawal costs			–	–	–	–	5,521
LCC – annual (Eur)			59,367	53,978	54,311	53,766	57,803
LCC Total costs (5 years) (Eur)							279,225
Optimal total number of students to reach the break-even point							425
The average annual number of students							85

3. Results

3.1. Results for Objective 1

Making a summary of the descriptive statistics, using the data in Table 1, the following results are obtained and presented in Table 3.

Table 3. The summary of the descriptive statistics of analysed data on years

	2019	2018	2017	2016
Mean	10.47058824	10.05882	11.41176	11.11765
Standard Error	2.104123485	1.126129	1.336861	1.646928
Median	9	9	13	11
Mode	1	4	14	10
Standard Deviation	8.675523378	4.643148	5.512019	6.790456
Sample Variance	75.26470588	21.55882	30.38235	46.11029
Kurtosis	–1.34507682	–1.14557	0.13355	0.896127
Skewness	0.408550837	0.288797	–0.32767	0.253731
Range	24	14	22	27
Minimum	0	4	0	0
Maximum	24	18	22	27
Sum	178	171	194	189
Count	17	17	17	17
Confidence Level (99.0%)	6.146	3.289	3.905	4.81

The smallest mean from the four series of data is for 2018, and the biggest is 11.41 for 2017, and the median is between 9 and 13. The mode is between 1 (2019) and 13 (for 2017). The minimum for this series of data is 0 (for three series), and 4 (for 2018), and the maximum is 27 (for 2016), 24 (for 2019), 22 (for 2017), and 18 (for (2018). The range for the difference between the maximum value and the minimum value is the biggest for 2016 (27), and the smallest is for 2018 (14). The sample variance is between 21.56 (for 2018) and 75.26 (for 2019), and the standard deviation is between 4.643 (for 2018) and 8.676 (for 2019), having small values for all the variables. Therefore, it can be considered that the series is relatively homogeneous. The standard error is between 1.126 and 2.104. Skewness has negative value only for 2017 (–0.33), the series being negatively asymmetric, but weakly, the curve is in the left. For the other three series of data, the skewness is positive between 0.254 and 0.409, meaning that for 2017 the series of data is skewed to the left, and for other three are skewed to the right. The kurtosis is negative for 2019, and 2018, but for 2017 and 2016 is positive (0.134 and 0.896), being much below the benchmark for a normal distribution of 3, which is positioned near normality, meaning that the curve is not so sharpened, having a platykurtic curve.

3.1.1. Monte Carlo simulation

In order to simulate the future number of enrolled students, it will be determined the daily probability using relative frequency (Table 4).

Table 4. Data regarding the enrolled students and the probability of enrolment

No. of enrolment (X_i)	No. of cases (f_i)	Prob. (P_{xi})	Cumulated prob. ($F(x_i)$)	Intervals ($F(x_i - 1), F(x_i)$)
0	1	0	0	
1	2	0.01	0.01	0–0.01
2	1	0.01	0.02	0.01–0.02
3	2	0.03	0.06	0.02–0.06
5	1	0.03	0.08	0.06–0.08
7	1	0.04	0.12	0.08–0.12
9	1	0.05	0.17	0.12–0.17
12	2	0.13	0.31	0.17–0.31
14	1	0.08	0.39	0.31–0.39
18	1	0.10	0.49	0.39–0.49
20	1	0.11	0.60	0.49–0.60
23	1	0.13	0.73	0.60–0.73
24	2	0.27	1.00	0.73–1.00
	N = ∑NE × NC = 178	1		

Using the Monte Carlo method involves applying the following procedure (Luban, 2005): in step 1, are determined the probabilities $P(X = x_i) = P(x_i)$ and the cumulative distribution function $F(x_i) = P(X \leq x_i) = \Sigma P(v)$, for $x_i \in \{x_1, x_2, ..., x_m\}$; in step 2, there are associated intervals of random numbers for each discrete variable (graphically, $F(x)$ has the form of a step, its height being equal to the probability $P(x_i)$, and the interval of random number associated with the value x_i as Figure 1). To each value xi is associated the interval $(F(x_i - 1), F(x_i))$ with $F(x_0) = 0$ (Table 5); in step 3, it is generated a random number u uniformly reported in the interval (0, 1) using a generator (Table 5); in step 4, the same procedure is made as in the step 3 until it is obtained the desired simulated selection.

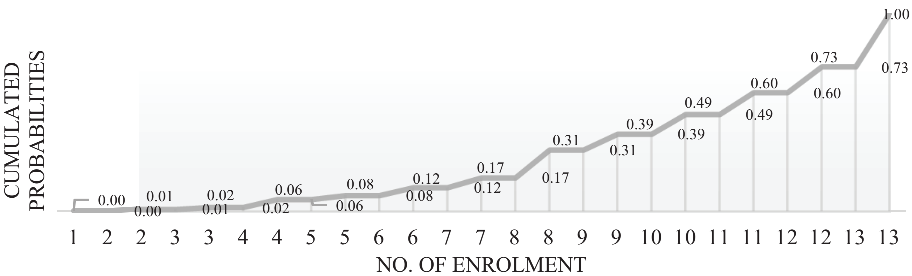

Figure 1. Generating a value xi of discrete probabilistic variable

Table 5. Generating random number *u*

No.	Random number u	Number of candidates registered according to the interval	$(x_i - x_{med})$	$(x_i - x_{med})^2$
1	0.3687	14	–4.95	24.5025
2	0.2405	12	–6.95	48.3025
3	0.6786	23	4.05	16.4025
4	0.6865	23	4.05	16.4025
5	0.6071	23	4.05	16.4025
6	0.4474	18	–0.95	0.9025
7	0.511	20	1.05	1.1025
8	0.413	18	–0.95	0.9025
9	0.9692	24	5.05	25.5025
10	0.4596	18	–0.95	0.9025
11	0.2568	12	–6.95	48.3025
12	0.7442	24	5.05	25.5025
13	0.527	20	1.05	1.1025
14	0.557	20	1.05	1.1025
15	0.905	24	5.05	25.5025
16	0.5298	20	1.05	1.1025
17	0.7359	24	5.05	25.5025
18	0.0061	1	–17.95	322.2025
19	0.9517	24	5.05	25.5025
20	0.5011	20	1.05	1.1025
	T/x_{med}	382	18.95	628.25
$\overline{X}$ = 382/20 =19.1; σ^2 = 628.25/20 = 31.41; σ = = 5.6; Cv = σ / $\overline{X}$ = 5.6/19.1 = 0.293; T = 2.09				
$\overline{X}I = \overline{X} \pm t\,\sigma / \sqrt{N}$; $\overline{X}_1$ = (19.1 + 2.09 × 5.6)/4.47 = 21.7125; $\overline{X}_2$ = (19.1 – 2.09 × 5.6)/4.47 = 16.4875				

According to the calculations, the number of registered candidates will vary between 16.48 and 21.71.

3.1.2. Gauss distribution

Calculating the distribution of the analysed series according to the pre-established coefficients of Gauss and the original series is obtained the values from Table 6. They are graphically represented in order to observe the difference between Gauss representation and the real situation for the four analysed years (Figure 2).

Table 6. Comparing the values obtained with the Gauss distribution

%	Gauss				Calc			
	2019	2018	2017	2016	2019	2018	2017	2016
0.1% the weakest	0	0	0	0	0	0	0	0
2.2% very weak	4	4	4	4	10	12	9	9
13.6% weak	24	23	27	26	21	20	24	38
68.2% medium	122	117	132	129	24	47	90	65
13.6% good	24	23	27	26	32	26	15	31
2.2% very good	4	4	4	4	91	66	56	46
0.1% the best	0	0	0	0	0	0	0	0
Total	178	171	194	189	178	171	194	189

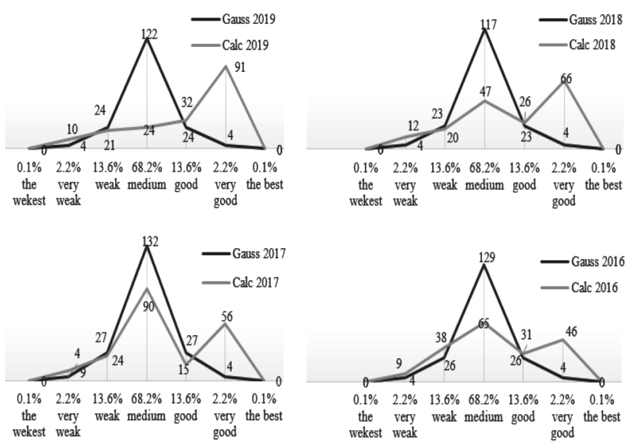

Figure 2. Graphical representation for Gauss and calculated values on years

Analysing the graphics above (according to both sets of data) are observed (Figure 3): In the first graphic, for 2019, compared with the Gauss representation, there are two kurtoses, the smallest is on the left and is very reduced compared to the other four graphics, the highest being on the right, so the skewness is positive and the series is leptokurtic; In the second graphic, for 2018, there are also two kurtoses, in the centre and the right, almost equal, so the series is platykurtic; In the third and the fourth graphic, for 2017 and respectively, 2016, they are also two kurtoses, the highest in the centre and the smallest in the right, but high enough, the series being leptokurtic. All the four series are not following a perfect Gauss distribution, but one made in the right and the centre, showing that the highest number of candidates is concentrated in the right, and respectively in the centre (for very good and medium values).

3.1.3. Markov chains

All the values per year are presented in Table 7, and then, using stochastic calculations, are transformed into probabilities.

Table 7. Data about enrolled students on years and days

Day/year	2016	2017	2018	2019	Totals
1	7	15	4	1	27
2	10	14	4	1	29
3	0	22	17	3	42
4	15	0	11	3	29
5	11	13	11	5	40
6	10	14	15	0	39
7	14	17	7	7	45
8	13	10	8	23	54
9	13	14	6	18	51
10	8	7	8	24	47
11	2	3	4	14	23
12	0	10	13	2	25
13	10	13	16	12	51
14	16	17	7	12	52
15	19	12	9	20	60
16	14	7	18	24	63
17	27	6	13	9	55
Totals	189	194	171	178	732

2016	2017	2018	2019	Percent
0.26	0.56	0.15	0.03	1
0.34	0.48	0.14	0.04	1
0.00	0.52	0.40	0.08	1
0.52	0.00	0.38	0.10	1
0.28	0.33	0.28	0.11	1
0.26	0.36	0.38	0.00	1
0.31	0.38	0.16	0.15	1
0.24	0.19	0.15	0.42	1
0.25	0.27	0.12	0.36	1
0.17	0.15	0.17	0.51	1
0.09	0.13	0.17	0.61	1
0.00	0.40	0.52	0.08	1
0.20	0.25	0.31	0.24	1
0.31	0.33	0.13	0.23	1
0.32	0.20	0.15	0.33	1
0.22	0.11	0.29	0.38	1
0.49	0.11	0.24	0.16	1

From the table above, data are put on four categories, in order to form an equal number of columns and rows to make probability calculations (Table 8). Making the calculations specific to probability, are obtained the numbers from Table 9.

Table 8. Data on years and days

Cumulated day/year	2016	2017	2018	2019	Total
day 1–4	32	51	36	8	127
day 5–8	48	54	41	35	178
day 9–13	33	47	47	70	197
day 14–17	76	42	47	65	230
Total	189	194	171	178	732

Table 9. Probability on days/years

Interval/year	2016	2017	2018	2019
day 1–4	0.17	0.26	0.21	0.04
day 5–8	0.25	0.28	0.23	0.20
day 9–13	0.18	0.24	0.28	0.39
day 14–17	0.40	0.22	0.28	0.37
Total	1	1	1	1

By calculating the probability P_i of each year in total candidates on analysed years ($P_i = T_i/T$), it is obtained the line vector: (0.26 0.27 0.23 0.24). Thus, $P_1 = 189/732 = 0.26$; $P_2 = 194/732 = 0.27$; $P_3 = 171/732 = 0.23$; $P_4 = 178/732 = 0.24$. Then, it is made the calculations, according to the Markov chains method (Table 10).

Table 10. Future number of enrolled students using Markov chains

Interval/Forecasted year	2020	2021	2022	2023	2024	2025
day 1–4	0.26	0.25	0.26	0.24	0.25	0.25
day 5–8	0.25	0.26	0.26	0,26	0.25	0.25
day 9–13	0.25	0.24	0.24	0.26	0.25	0.25
day 14–17	0.24	0.25	0.24	0.24	0.25	0.25

Putting this data in a graphical representation (Figure 3) could be perceived as a forecasted trend for the future years. Can be observed that: i) for the first period between 1–4 days the forecasted number of enrolled students will follow a decreasing trend for 2021 (0.25) and 2023 (0.24), and after 2024 it will stabilize to 0.25 for a long time; ii) for the second period of enrolment between 5–8 days the trend will be rising for 2021, 2022 and 2023 (0.26), after this from 2024 also tend to stabilize to 0.25, as the first period; iii) For the third period between 9–13 days the trend is decreasing, having lower values as 0.24 for 2021 and 2022, is increasing for 2023 at 0.26, then stabilizing at the same values as the first periods at 0.25 for an extended period; iv) for the last analysed period, the trend is entirely stagnated at 0.24, being the lowest, with a pick of 0.25 in 2021, then stabilizing after 2024 at 0.25, like all other analysed periods. The value where all four periods may be probably stabilized is 0.25. Thus the ideal number of enrolled students may run between 180 and 186 (by approximation in minus or plus).

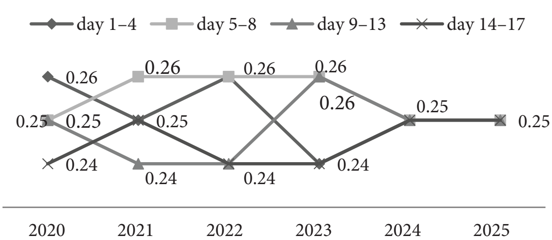

Figure 3. Forecasted number of enrolled students between 2020–2025

According to the forecasted values per year, measures could be taken from time for the last two periods when the values of enrolled students were the lowest, even if they will be stabilized at the same values as the others, meaning for the periods between 9–13 days and 14–17 days. That means that for the first two periods, in the first eight days, students are coming more to enrol. Thus, a plan for a better enrolment could be implemented in order to diminish this issue. It means that the website information, the mouth-to-mouth methods from professors and students, the new technologies (Facebook, WhatsApp, and telephones), the campaigns taken from the time of the analysed university had results, and the interested persons will come in the first days to enrol.

Based on the results obtained for objective 1, Hypothesis 1 is validated as follows: i) The Monte Carlo method allows the simulation of the future number of enrolled students and the determination of the daily probability, by using the relative frequency obtaining an average interval of the daily enrollments. This can significantly contribute to ensuring the efficiency of the analyzed institution; ii) The Gaussian distribution highlights the difference between Gauss's predetermined coefficients and the real situation for the analyzed period, so the method can be applied to manage student enrolment; iii) Since the prediction of enrollment of future students can be done by the Markov chains method, it is considered that this method can be useful for implementing future university management strategies, which will contribute to improving the relationship with students, from the enrollment stage.

3.2. Results for Objective 2

For the product lifecycle cost assessment, it was performed the first two forms of sensitivity analysis. In both one-way sensitivity analysis and multi-directional sensitivity analysis, the parameters whose values were tested were the number of students and the amount of the annual fee (Table 11–13).

Table 11. One-way analysis by the number of students

	Year 1	Year 2	Year 3	Year 4	Year 5	Total per life cycle
Variant 1						
Number of students	50	100	200	100	50	500
Annual student/study fee (Eur)	638	638	745	745	638	–
Total receipts from tuition fees (Eur)	31,915	63,830	148,936	74,468	31,915	351,064
Annual income (Eur)	–27,452	9,851	94,626	20,702	–25,889	71,839
Variant 2						
Number of students	45	75	175	75	30	400
Annual student/study fee (Eur)	638	638	745	745	638	–
Total receipts from tuition fees (Eur)	28,723	47,872	130,319	55,851	19,149	281,915
Annual income (Eur)	–30,644	–6,106	76,009	2,085	–38,654	2,690

End of Table 11

	Year 1	Year 2	Year 3	Year 4	Year 5	Total per life cycle
Variant 3						
Number of students	40	85	180	50	20	375
Annual student/study fee (Eur)	638	638	745	745	638	–
Total receipts from tuition fees (Eur)	25,532	54,255	134,043	37,234	12,766	263,830
Annual income (Eur)	–33,835	277	79,732	–16,532	–45,037	–15,395

Table 12. Sensitivity analysis according to the value of the annual fee – one-way analysis

	Year 1	Year 2	Year 3	Year 4	Year 5	Total per life cycle
Variant 1						
Number of students	50	50	50	50	50	250
Annual student/study fee (Eur)	745	745	745	745	745	–
Total receipts from tuition fees (Eur)	37,234	37,234	37,234	37,234	37,234	186,170
Annual income (Eur)	–22,133	–16,744	–17,077	–16,532	–20,569	–93,055
Variant 2						
Number of students	50	50	50	50	50	250
Annual student/study fee (Eur)	851	851	851	851	851	–
Total receipts from tuition fees (Eur)	42,553	42,553	42,553	42,553	42,553	170,213
Annual income (Eur)	–16,814	–11,425	–11,757	–11,213	–15,250	–66,459
Variant 3						
Number of students	50	50	50	50	50	250
Annual student/study fee (Eur)	1,064	1,064	1,064	1,064	1,064	–
Total receipts from tuition fees (Eur)	53,191	53,191	53,191	53,191	53,191	265,957
Annual income (Eur)	–6,176	–787	–1,119	–574	–4,612	–13,268

From the sensitivity analysis of the LCC method model we can draw the following conclusions: for a constant number of 50 students annually it is impossible to reach the break-even point, the licensed program being ineffective for fee values between €638 and €1,064; in the variant of attracting a maximum number of students for each year of study, profitability can be obtained from year 2 of the program to year 4; in the case of average values of the number of students generated from the analysis of other master programs, the master program is profitable in years 2 and 3, and its overall profitability is achieved. However, the same result cannot be achieved in the variant of a total number of students over the life cycle below the minimum allowable values of the average break-even threshold (438 students).

Table 13. Sensitivity analysis by the number of students and the amount of annual fee – multi-directional analysis

	Year 1	Year 2	Year 3	Year 4	Year 5	Total per life cycle
Variant 1						
Number of students	50	50	200	100	50	450
Annual student/study fee (Eur)	638	745	745	745	745	
Total receipts from tuition fees (Eur)	31,915	37,234	148,936	74,468	37,234	329,787
Annual income (Eur)	–27,452	–16,744	94,626	20,702	–20,569	50,562
Variant 2						
Number of students	45	45	175	75	30	370
Annual student/study fee (Eur)	851	851	957	851	851	
Total receipts from tuition fees (Eur)	38,298	38,298	167,553	63,830	25,532	333,511
Annual income (Eur)	–21,069	–15,680	113,243	10,064	–32,271	54,286
Variant 3						
Number of students	40	45	150	40	20	295
Annual student/study fee (Eur)	638	745	851	745	638	
Total receipts from tuition fees (Eur)	25,532	33,511	127,660	29,787	12,766	229,255
Annual income (Eur)	–33,835	–20,468	73,349	–23,979	–45,037	–49,970

Based on the results provided by the multi-directional analysis it can be concluded that a positive return on the overall life cycle study program can be achieved in the context of the annual increase in both the number of students and the tuition fee. Another tool offered by econometric modelling is the analysis of correlations between variables (Table 14). There is a strong inverse correlation between R&D and operational cost variables, as well as between R&D and closing costs.

Table 14. Analysis of correlations between variables

		Total service costs	Operational costs	Withdrawal costs
Total service costs	Pearson Correlation	1	0.570	–0.671
	Sig. (2-tailed)		0.315	0.215
	N	5	5	5
Operational costs	Pearson Correlation	0.570	1	–0.878
	Sig. (2-tailed)	0.315		0.050
	N	5	5	5
Withdrawal costs	Pearson Correlation	–0.671	–0.878	1
	Sig. (2-tailed)	0.215	0.050	
	N	5	5	5

The linear regression method studies the link between the LCC cost dependent variable and several independent variables associated with the various stages of the study program's life cycle – R&D costs, operational costs, and support costs and withdrawal costs. Independent variables have been chosen as the main cost elements, components of the LCC method, which define its structure. The cost values associated with the LCC method were previously calculated and are presented in Table 15, and used cost values at the level of 2019.

Table 15. Variables of linear regression equations

V1 R&D costs	V2 Total Service Costs	V3 Operational costs	V4 Withdrawal costs	V5 LCC Associated Cost
5,771	1,809	51,787	0	59,367
1,319	979	51,681	0	53,978
1,332	1,617	51,362	0	54,311
1,340	1,489	50,936	0	53,766
1,346	851	50,085	5,521	57,803

The general form of the simple regression equation is $Y = c(1) + c(2) \times X$, X defining the independent variable and Y defining the dependent variable. The probability associated with parameters c(1) and c(2), (which can take values between 0 and 1) gives the measure of the significance of the parameters generated (obtained from the generation of the regression equation), i.e., the closer the value obtained is closer to 0, the higher the significance of the parameter. If the probability value is close to 1, by studying the results of the t-test or student test, the insignificance of the parameter can be concluded.

In order to interpret the results presented above, related to simple regression equations, it is necessary to define the main elements generated by the modelling program theoretically. Based on the estimates of the regression parameters for the proposed equations obtained using the SPSS program (Supplementary Material, Annexes 1–4), the information in Table 16 was obtained.

By observing the data in Table 16, it can be concluded that there is a high significance of the parameters for Model 1 and Model 4, while Model 2 and 3 have low meanings of the parameters. In the case of the first model, R-square = 0.591 means that 59.10% of the variance of variable y can be explained using the regression equation, the difference up to 100% not explained. In the case of the second econometric model, R-square = 0.022 means that 2.20% of the variance of the dependent variable is explained by the econometric model, which allows us to conclude that this model is less relevant than the first. For the third and fourth equations, the values of R-squared are 0.01 and 0.1815, so 1.01% in the case of model three and 18.15% in the case of the model appeared from the variance of the dependent variable is explained by the chosen model. The decreasing order of relevance of the chosen models is, therefore, Model 1, Model 3, Model 4, and Model 2. Thus, we can conclude that the value of the cost of the LCC is strongly dependent on the value of the R&D costs as well as the operational ones, with the total and closing costs having a lower impact. The t-test is utilized to test the statistical significance of the linear relationship between the two variables

Table 16. Main elements generated by the modelling program

Regression equation	Constant c(1)	Regression coefficient c(2)	R- squared	Std. Error c(1)	Std. Error c(2)	T-stat c(1)	T-stat c(2)	Prob c(1)	Prob c(2)
Cost_LCC = c(1) + c(2) × R&D costs	53634.545	0.994984	0.591	1360.050689	0.478312	39.435695	2.080	0.000036 <0.001	0.129
Cost_LCC = c(1) + c(2) × Service Costs	54602.429	0.921105	0.022	4948.207	3.537	11.035	0.260	0.002	0.811
Cost_LCC = c(1) + c(2) × Operational costs	74951.859	–0.373	0.01	109267.545	2.13	0.686	–0.175	0.542	0.872
Cost_LCC = c(1) + c(2) × Closing Cost (Withdrawal Cost)	55355.500	0.443	0.1815	1341.862	0.543	41.253	0.815699	0.000031 <.001	0.474

of a model or equations. A value of probability p associated with the low t-test means that there is a significant link between the two variables. For the regression equations analysed we have the following values of east t: Equation 1: $t = 2.080$ with 3 degrees of freedom and associated probability $p = 0.129$; Equation 2: $t = 0.260$ with 3 degrees of freedom and associated probability $p = 0.811$; Equation 3: $t = 0.175$ with 3 degrees of freedom and associated probability $p = 0.872$; Equation 4: $t = 0.815$ with 3 degrees of freedom and associated probability $p = 0.474$. It can also be observed in this analysis the increased significance of models 1 and 4 compared to the other two models. Once again, the strong influence of R&D and operational costs in determining the cost associated with the life cycle compared to the closing costs or baskets of service is highlighted.

Based on the results obtained for objective 2, Hypothesis 2 is validated as follows: i) the sensitivity analysis of the LCC method highlights the positive profitability of the study program throughout the life cycle resulting in the context of the annual increase in both the number of students and the tuition fee or in the case of values averages of the number of students the study program is profitable in years 2 and 3; ii) The LCC allows the identification of those cost areas or areas that require higher growth or deeper control in order to maintain them at specific rates or to reduce them, where possible; iii) the statistical methods applied highlight the strong influence of research and development costs and operational costs in determining the cost associated with the life cycle compared to closure costs.

Conclusions

The education market is dynamic and continuously changing, and economic-social factors and internationalization require universities to rethink their missions and have greater flexibility concerning today's developments. Universities need to restructure their curricula so that they quickly meet labour market requirements. To attract more valuable students and maintain them, the institution could follow the steps developed above and use the Monte Carlo simulation in order to determine possible future problems and to determine the right number of necessary students, which may ensure the future performance of the university. As it is observed, the simulation method used above helps the institution to determine the future risks and to predict when and what relationship marketing programs to use in order to attract, maintain and grow the number of valuable students.

The introduction of a new study program should start from a thorough analysis of market requirements, customer characteristics, and competitors' offers, which often makes the price at which it can be offered on the Market. Furthermore, an analysis of the profitability of a new study program is not complete and relevant if it does not cover the entire life cycle of the program, thus it is essential to include the LCC method in the analysis. One of the main problems in reaching and maintaining a specific rate of profitability is estimating the majority of costs in the initial phase, and managing them in the growth phase and after the time of their appearance. The main problem with cost management is thus the failure to include all costs over the life cycle of the services at the time of the initial estimate. Thus, there is a high risk that there will be a cost of study programs that are not accurately estimated, and that is not properly managed in terms of strategic management. In this context, the financial target at a university should aim to maximize income while maintaining or even reducing expenditure. The solution of creating their funding resources and avoiding dependence on a single funder seem to be fundamental needs. The calculation of standard costs per student could also ensure the economic basis of the fees charged for university services. At the same time, creating an organizational culture based on saving could ensure financial performance. Also, as a research limitation, it is considered that the application of LCC requires considerable resources of time and the data necessary for its application may be challenging to obtain or that its accuracy may suffer due to uncertainties that may arise in the future.

Universities, both state and private, need to be aware of the inadequacy of the funding from study fees and must become much more cautious in calculating costs. Often, management structures, as well as students, need detailed justification of how funds are managed. As a result, the accounting tool is best suited to highlight the costs associated with the educational process, only thus succeeding in calibrating tuition fees, which meet both the expectations of potential students and the need for survival and/or institutional prosperity.

The paper contributes to the development of scientific literature in the field of university management and managerial accounting, by the fact that the study proposes a reorganization of the management of universities by making calculations on the viability of developing new undergraduate study programs throughout their life cycle. The research limitation results from the fact that the proposed model is implemented only on a single license program. It is obvious that each university program (bachelor, master, doctorate) has its own requirements (number of teachers, university infrastructure, methodological requirements, number of students, etc.) that must be analyzed separately. The model can be extended to other university study programs, so as to contribute sustainably to increasing university performance and cost management. As a future research direction, it can be considered, the application of the bidirectional model on other university specializations, which have different characteristics for the study programs and different student admissions.

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