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Decision Support System for resource allocation in Brazil public universities

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ABSTRACT

This study aims to present the design of a Decision Support System (DSS) for internal resource allocation in Brazil public universities, once, currently, there aren't any kind of general DSS for such a problem. To do so, the analysis is carried out by identifying the general model from the Ministry of Education and the models from every Federal University, finding similarities between each model, and, dividing the models into categories, according to their similarities. The perspectives are to contribute to the decision problem of how to allocate resources properly faced by Brazilians public universities, take safer and reliable decisions, seeking to reduce uncertainties and to maximize their results.

Keywords: Decision Support System, Design, Resource Allocation, Budgeting

INTRODUCTION

One of the ongoing challenges faced by universities in general and especially in Brazil, where public universities perform an important role, it is to improve the provision of beneficial results for the society interest, considering an increasingly complex and changing environment. Therefore, the design of a Decision Support System (DSS) for resource allocation it is an important tool to respond to this ongoing challenge.

A Decision Support System can be defined as a computer-based information system that supports decision makers use data and models to solve semi-structured and unstructured problems. It helps decision makers to make better decisions and to answer complex questions [1, 2].

Generally, considering different definitions for a DSS, they all share the idea that a DSS is essential to support the decision-making process [2] and that is the reason its applicability will be considered for this study.

Thus, this work aims to present the design of a Decision Support System (DSS) for internal resource allocation in Brazil public universities, once, currently, there aren't any general DSS for such a problem, and this can contribute to the decision question of how to allocate resources properly faced by Brazilians public universities, enabling them to take safer and reliable decisions. Also, it should be considered that public universities in Brazil use their taxpayers' money to provide education services. As a result, there is significant societal interest (or at least should exist) in the way such money is allocated, where the cost of a failure is seen as something unacceptable [3].

Within this context, it is important to clarify that the main decision of each model (not the problem situation of this study) it is how to allocate resources correctly, and the Decision Maker is considered as each Federal University.

It is known that the correct use of a DSS can improve the competences of the Decision Maker in understanding better the considered problem, how to select efficient alternatives, cost and time savings [2].

SURVEY

The design of the DSS will consist, at first, in analysing possible courses of action for the case [4]. It will involve the process of understanding the resource allocation models in public universities in Brazil, comparing them and finding similarities between the models, with the aim of generating solutions and testing feasible solutions in the future for the problem.

The general resource allocation model in Brazil is based on the "OCC Matrix" (Others, Costing and Capital Matrix). This matrix has the purpose of establishing criteria for resource allocation in Brazil's Federal Universities, and it has equitable, qualitative, inductors, measurable and auditable criteria. The model is common for all federal Universities and the structure of the budget is programmed the year before [5].

The parameters are legally defined by the Brazilian Ministry of Education (Department of Education - MEC), and the basis of the matrix is the number of students (equivalent students) from each Federal University (FU) [6]. The general model is described in Figures 3, 4 and 5.

There are 55 Federal Universities in Brazil that receive resources from the OCC Matrix, and each one of them has their own resource allocation model.

Therefore, the resource allocation process could be described by Figure 1.

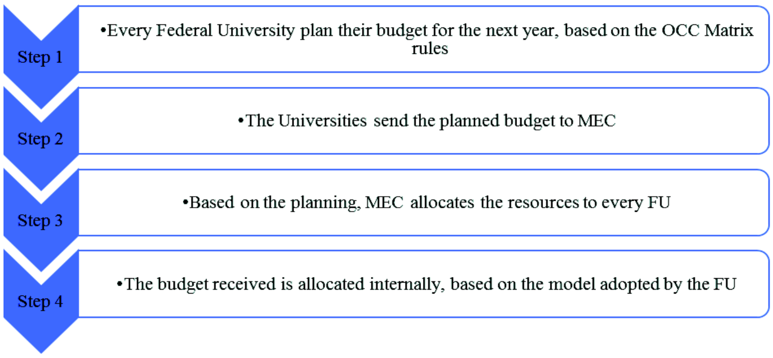

Figure 1: Resource allocation process in Brazil Federal Universities

It is important to point out that the DSS prototype proposed in this study is focused on the process described in STEP 4 (Figure 1), once the general model applicable for Steps 1 and 3 already exists (OCC Matrix). To do so, this survey was divided into three steps, that are shown in Figure 2.

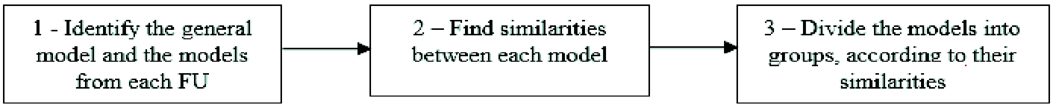

Figure 2: Steps of the survey

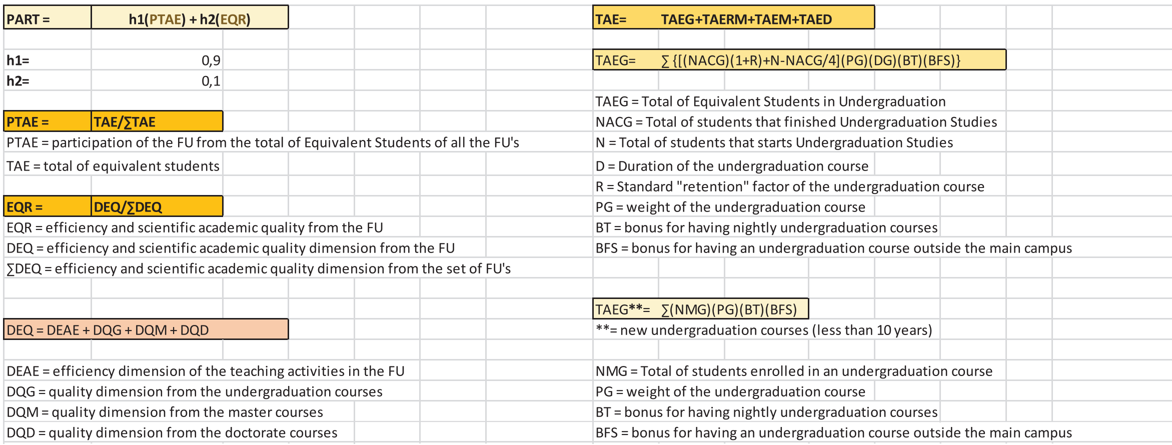

Figure 3: General model – part 1

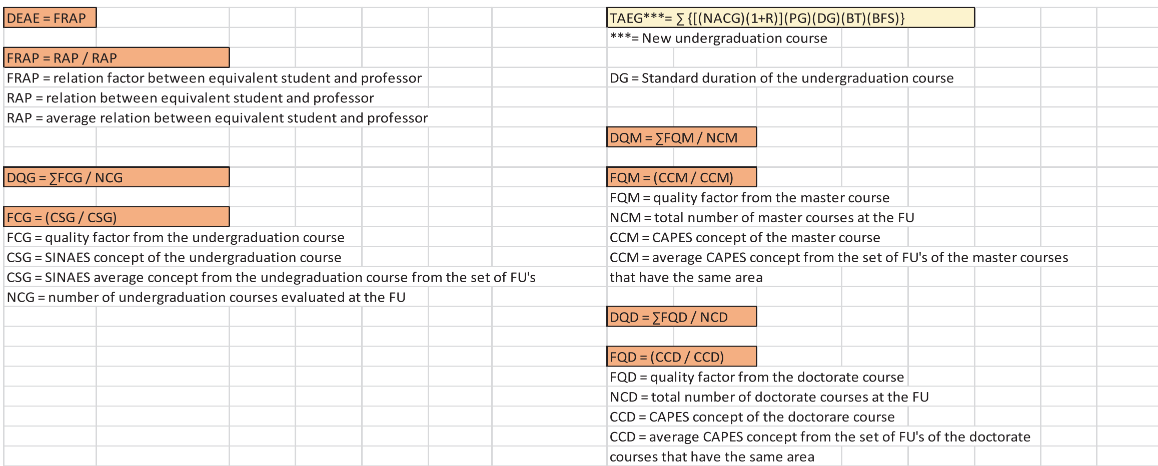

Figure 4: General model – part 2

TAERM = ∑(NAMRM)(PRM)

TAERM = total of equivalent students from medical residency
NAMRM = total of students enrolled in a medical residency course
PRM = weight of the group from the medical residency course

TAEM = ∑(NACM)(DM)(PM)

TAEM = total of equivalent students in a master course
NACM = total of students that concluded the master course
DM = standard duration of the master course
PM = weight of the group from the master course

TAED = ∑(NACD)(DD)(PD)

TAED = total of equivalent students in a doctorate course
NACD = total of students that concluded the doctorate course
DD = standard duration of the doctorate course
PD = weight of the group from the doctorate course

Figure 5: General model – part 3

When analysing the available models (only 30 models were available for consulting or the university doesn't have a defined model) and their similarities, it was possible to divide them into three main categories: Model 1, based on the general resource allocation model, Model 2, based on some indicators suggested by the Brazilian audit office (Tribunal de Contas da União - TCU) [7], and, Model 3, based on some indicators that will be shown next.

MODEL 1

Model 1 is based on the general resource allocation model presented in Figures 3, 4 and 5, but some universities vary or adapted a few parameters from it.

MODELS 2 and 3

$$PART_{u,cust} = 0{,}2 \cdot \left(\frac{ADIS_u}{\sum_{i=1}^{N_{UU}} ADIS_i} + \frac{CHDD_u}{\sum_{i=1}^{N_{UU}} CHDD_i} \right) + \sum_{j=RO_{u,ant}, N_{Lab,u}, IQCD_u, IDCD_u, Ex_u, Prod_u} \beta_j \cdot C_j$$

$$PART_{u,cap} = 0{,}1 \cdot \frac{CHDD_u}{\sum_{i=1}^{N_{UU}} CHDD_i} + 0{,}3 \cdot \frac{N_{Lab,u}}{\sum_{i=1}^{N_{UU}} N_{Lab,i}} + 0{,}2 \cdot \left(\frac{RO_{u,ant}}{\sum_{i=1}^{N_{UU}} RO_{i,ant}} + \frac{IQCD_u}{\sum_{i=1}^{N_{UU}} IQCD_i} + \frac{IDCD_u}{\sum_{i=1}^{N_{UU}} IDCD_i} \right)$$

$$\boxed{IQCD = \frac{5D + 3M + 2E + 1G}{D + M + E + G}}$$

$$RO_{i,G} = \frac{Ne_{i,G}}{\sum_{k=1}^{NC_G} Ne_{k,G}} \cdot RO_G$$

$$RO_{i,PG} = \frac{Ne_{i,PG}}{\sum_{k=1}^{NC_{PG}} Ne_{k,PG}} \cdot RO_{PG}$$

$$IQCTA = \frac{0{,}75 \cdot T_{ADM,EM} + 0{,}5 \cdot T_{ADM,EF} + 1 \cdot T_{ADM,G} + 2 \cdot T_{ADM,E} + 3 \cdot T_{ADM,M} + 5 \cdot T_{ADM,D}}{T_{ADM}}$$

Figure 6: Indicators from model 2

$$PART_u = \frac{\left(0{,}7 \cdot Ne_u + 0{,}1 \cdot Prod_u + 0{,}1 \cdot Ext_u + 0{,}1 \cdot AP_{Con,u}\right) \cdot (1+FE)}{\sum_{i=1}^{N_{UU}} \left(0{,}7 \cdot Ne_i + 0{,}1 \cdot Prod_i + 0{,}1 \cdot Ext_i + 0{,}1 \cdot AP_{Con,i}\right) \cdot (1+FE)}$$

$$FA_{u,i} = \sum_{k=1}^{N_V=7} V_{u,k} \cdot Peso_k$$

$$PART_{u,i} = PART_{u,i,ant} \cdot FA_{u,i}$$

$$Prod_u = \frac{\sum_{i=1}^{N_{TPC}} wp_i \cdot ALCP_{u,i}}{ND_u}$$

$$AP_{Con,u} = 100 \cdot \frac{A_{Con,u}}{\sum_{i=1}^{N_{UU}} A_{Con,i}}$$

$$RO_u = PART_u \cdot \left(RO_j - \sum_{i=1}^{N_{UA}} RO_i \right)$$

$$PART_u = \frac{\sum_{i=1}^{N_{ed}=5} \overline{RO}_{u,i}}{\sum_{k=1}^{N_{UU}} \sum_{i=1}^{N_{ed}=5} \overline{RO}_{k,i}}$$

$$\overline{RO}_{u,i} = PART_{u,i} \cdot \left(RO_{j,ant} - D_{ANC,ant} - D_{COL,ant} - \sum_{i=1}^{N_{UA}} RO_{i,ant} \right)$$

$$Ext_u = \frac{\sum_{i=1}^{N_{TPE}} we_i \cdot PEC_{u,i}}{ND_u}$$

$$RO_u = PART_u \cdot \left(RO_j - D_{ANC} - D_{COL} - \sum_{i=1}^{N_{UA}} RO_i \right)$$

Figure 7: Indicators from model 3

Model 2 is based mainly on indicators like costing; the amount of hour of each course; the number of students in every course; the number of professors and their workloads in teaching, research and extension activities; publications from every academic department; the number of laboratories and qualification of the academic staff.

Model 3 is based basically on the following indicators: number of professors; the number of technical employees; the number of students from each department; the total area from the laboratories; the total area from the departments; scientific production from the departments; extension activities and others.

DSS PROTOTYPE

The DSS Prototype from the main three models found by this study is presented next. The models were divided into categories, according to their similarities. This initial prototype was designed in a Microsoft Excel file and it was the first step of a bigger research, that aims to improve the design of this DSS, by transforming the prototype into a web-based system, with a programming language, developing the data basis for the model and for the users, implementing the program, and, finally, tested by the users. The research also will include a project portfolio selection approach as an appropriate model to analyze the resource allocation process of the universities.

Model 1

Undergraduation

Course	N. of students entering the course	N. of students that finished the cour	Group	Weight	Area	Standard "retention" factor	Duration of the course	Duration of the course at the FU	Bonus Nightly Course	Equivalent Student - TAEG
Civil Eng.	50	27	A2	2,0	ENG	0,0820	5	5,5	1	385
Manag. Eng.	50	35	A2	2,0	ENG	0,0820	5	5,1	1	425
Electrical Eng.	50	29	A2	2,0	ENG	0,0820	5	5,2	1	381
Medicine	60	54	A1	4,5	CH2	0,0650	6	6	1	1.593
Natural Science	40	33	A4	1,0	CS1	0,1000	4	4,5	1,15	197
	250	TOTAL								2.980 TOTAL

Master Course

Course	NACM	DM	Weight	TAEM
Civil Eng.	15	0,75	2	22,5
Manag. Eng.	15	0,75	2	22,5
Electrical Eng.	10	0,75	2	15
Medicine	10	0,75	4,5	33,75
Natural Science	18	0,75	1	13,5
				107,25 TOTAL

Doctorate Program

Course	NACD	DD	Weight	TAED
Civil Eng.	10	0,38	2	7,6
Manag. Eng.	10	0,38	2	7,6
Electrical Eng.	8	0,38	2	6,08
Medicine	10	0,38	4,5	17,1
Natural Science	15	0,38	1	5,7
				44,08 TOTAL

Figure 8: DSS Prototype – Model 1

Model 2

Department	ADIS	CHDD	β	C	RO	N	PART cos	PART c	W	Total Part
Engineering	8000	7500	0,2	1,0	220000	22	0,2	0,2	0,2	0,316
Computer Sci.	6000	5500	0,2	1,0	140000,0	14	0,2	0,2	0,2	0,281
Human Sci.	5500	4800	0,2	1,0	210000,0	8	0,1	0,1	0,2	0,275
Mathematics	4000	3600	0,2	1,0	130000,0	10	0,1	0,1	0,2	2,266
Medical School	4500	4100	0,2	1,0	250000,0	28	0,4	0,4	0,2	4,026

D	M	E	G	W	IQCD
150	120	50	10	1	3,69697
110	99	41	8	1	3,63178
160	150	46	4	1	3,73889
85	90	32	11	1	3,53211
155	110	62	3	1	3,73333

ADM, EM	ADM, EF	ADM, G	ADM, E	ADM,M	ADM, D	IQCTA
8	56	6	47	44	17	351
76	28	67	37	27	48	533
50	23	48	44	4	54	467
40	54	80	36	56	21	482
71	78	20	50	38	61	631

Figure 9: DSS Prototype – Model 2

Model 3

Depart.	Ne	Prod	Ext	AP	FE	PART
Engineering	2518,88	5,17	0,76	0,23	0,4	1,25
Computer Sci.	1799,4	10,33	1,53	0,16	0,4	0,89
Human Sci.	1092,9	4,84	0,72	0,21	0,6	0,62
Mathematics	1461,1	13,37	1,98	0,14	0,3	0,67
Medical School	2715,25	4,66	0,69	0,26	0,7	1,64

Wp	ALCP	ND	Prod
0,6	80	220	5,17
0,4	45	110	10,33
0,8	112	235	4,84
0,5	22	85	13,37
0,6	133	244	4,66

We	PEC	ND	Ext
0,6	12	220	0,76
0,4	8	110	1,53
0,8	16	235	0,72
0,5	4	85	1,98
0,6	18	244	0,69

Aconu	Aconi	Apcon
480	2130,0	23
350	2130,0	16
450	2130,0	21
300	2130,0	14
550	2130,0	26

PART	Roj	Roi	RO
1,25	183192,6	778375,61	744.077
0,89	214741,6	778375,61	503.673
0,62	98820,1	778375,61	421.438
0,67	118901,1	778375,61	444.590
1,64	162720,2	778375,61	1.007.408

Figure 10: DSS Prototype – Model 3

PERSPECTIVES AND CONCLUSIONS

The purpose of this study was to present the design of a Decision Support System (DSS) for internal resource allocation in Brazil public universities. To do so, the survey was divided into three steps: identify the general model and the models from each FU; find similarities between each model; and, divide the models into categories, according to their similarities. This initial prototype was the first step of a bigger experiment. The system still must be improved to be useful for the users.

The next step is to transform the DSS prototype into a web-based system, with a programming language, constructing its data basis for the model and for the users, implement the program, and, finally, tested by the users. Also, the DSS could have potential expansions in the future, expanding its general prototype to be used by the Ministry of Education in Brazil or others public institutions with the similar decision problem.

The perspectives are to contribute to the decision problem of how to allocate resources correctly faced by Brazilians public universities, take safer and reliable decisions, seeking to reduce uncertainties and to maximize their results. In addition, it could be used to provide background for the Federal Universities strategic resource allocation planning.

It is worthwhile to note that the DSS prototype has no production intention but to deal with as an experiment with only research purposes.

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