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**ICDSST 2017 on
Data, Information and Knowledge Visualization in Decision
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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.

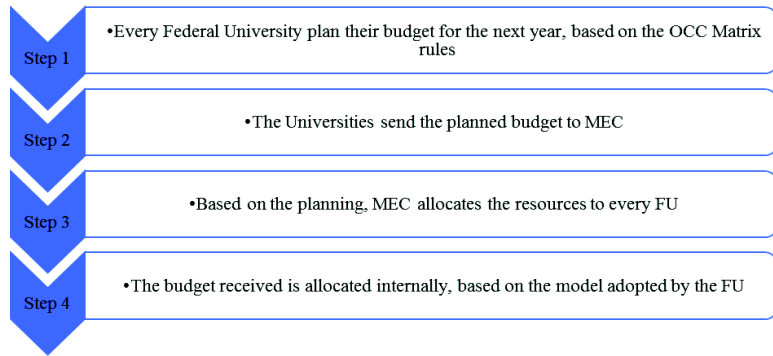


Figure 1: Resource allocation process in Brazil Federal Universities

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.

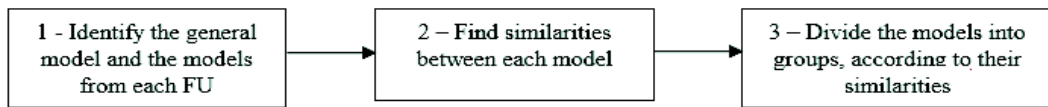


Figure 2: Steps of the survey

PART =	$h1(PTAE) + h2(EQR)$	TAE =	$TAEG + TAERM + TAEM + TAED$
h1 =	0,9	TAEG =	$\sum \{[(NACG)(1+R) + N - NACG/4](PG)(DG)(BT)(BFS)\}$
h2 =	0,1		TAEG = Total of Equivalent Students in Undergraduation
PTAE =	$TAE / \sum TAE$		NACG = Total of students that finished Undergraduation Studies
PTAE = participation of the FU from the total of Equivalent Students of all the FU's			N = Total of students that starts Undergraduation Studies
TAE = total of equivalent students			D = Duration of the undergraduation course
EQR =	$DEQ / \sum DEQ$		R = Standard "retention" factor of the undergraduation course
EQR = efficiency and scientific academic quality from the FU			PG = weight of the undergraduation course
DEQ = efficiency and scientific academic quality dimension from the FU			BT = bonus for having nightily undergraduation courses
$\sum DEQ$ = efficiency and scientific academic quality dimension from the set of FU's			BFS = bonus for having an undergraduation course outside the main campus
DEQ =	$DEAE + DQG + DQM + DQD$	TAEG** =	$\sum (NMG)(PG)(BT)(BFS)$
DEAE = efficiency dimension of the teaching activities in the FU		** = new undergraduation courses (less than 10 years)	
DQG = quality dimension from the undergraduation courses		NMG = Total of students enrolled in an undergraduation course	
DQM = quality dimension from the master courses		PG = weight of the undergraduation course	
DQD = quality dimension from the doctorate courses		BT = bonus for having nightily undergraduation courses	
		BFS = bonus for having an undergraduation course outside the main campus	

Figure 3: General model – part 1

DEAE =	FRAP	TAEG*** =	$\sum \{[(NACG)(1+R)](PG)(DG)(BT)(BFS)\}$
FRAP = RAP / RAP		*** = New undergraduation course	
FRAP = relation factor between equivalent student and professor		DG = Standard duration of the undergraduation course	
RAP = relation between equivalent student and professor		DQM =	$\sum FQM / NCM$
RAP = average relation between equivalent student and professor		FQM =	(CCM / CCM)
DQG =	$\sum FCG / NCG$	FQM = quality factor from the master course	
FCG =	(CSG / CSG)	NCM = total number of master courses at the FU	
FCG = quality factor from the undergraduation course		CCM = CAPES concept of the master course	
CSG = SINAES concept of the undergraduation course		CCM = average CAPES concept from the set of FU's of the master courses that have the same area	
CSG = SINAES average concept from the undegraduation course from the set of FU's		DQD =	$\sum FQD / NCD$
NCG = number of undergraduation courses evaluated at the FU		FQD =	(CCD / CCD)
		FQD = quality factor from the doctorate course	
		NCD = total number of doctorate courses at the FU	
		CCD = CAPES concept of the doctorate course	
		CCD = average CAPES concept from the set of FU's of the doctorate courses that have the same area	

Figure 4: General model – part 2

$TAERM = \sum(NAMRM)(PRM)$	$TAED = \sum(NACD)(DD)(PD)$
TAERM = total of equivalent students from medical residency	TAED = total of equivalent students in a doctorate course
NAMRM = total of students enrolled in a medical residency course	NACD = total of students that concluded the doctorate course
PRM = weight of the group from the medical residency course	DD = standard duration of the doctorate course
	PD = weight of the group from the doctorate course
$TAEM = \sum(NACM)(DM)(PM)$	
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	

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

$$PART_{u,med} = 0,2 \left(\frac{ADIS_u}{\sum_{i=1}^{N_{ADM}} ADIS_i} + \frac{CHDD_u}{\sum_{i=1}^{N_{ADM}} CHDD_i} \right) + \sum_{j=RO, N_{ADM}, IQCD, ECCT, Ext, Prod} \beta_j \cdot C_j$$

$$PART_{u,med} = 0,1 \frac{CHDD_u}{\sum_{i=1}^{N_{ADM}} CHDD_i} + 0,3 \frac{N_{Labs}_u}{\sum_{i=1}^{N_{ADM}} N_{Labs}_i} + 0,2 \left(\frac{RO_{u,med}}{\sum_{i=1}^{N_{ADM}} RO_{i,med}} + \frac{IQCD_u}{\sum_{i=1}^{N_{ADM}} IQCD_i} + \frac{IDCD_u}{\sum_{i=1}^{N_{ADM}} IDCD_i} \right)$$

$$IQCD = \frac{5D+3M+2E+1G}{D+M+E+G} \quad RO_{AG} = \frac{N_{PG}}{\sum_{i=1}^{N_{ADM}} N_{PG_i}} \cdot RO_G$$

$$RO_{LPO} = \frac{N_{PG}}{\sum_{i=1}^{N_{ADM}} N_{PG_i}} \cdot RO_{PG}$$

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

Figure 6: Indicators from model 2

$$PART_u = \frac{(0,7 \cdot N_e + 0,1 \cdot Prod + 0,1 \cdot Ext + 0,1 \cdot AP_{Coul}) \cdot (1+FE)}{\sum_{i=1}^{N_{ADM}} (0,7 \cdot N_{e_i} + 0,1 \cdot Prod_i + 0,1 \cdot Ext_i + 0,1 \cdot AP_{Coul_i}) \cdot (1+FE)}$$

$$FA_{u,i} = \sum_{k=1}^{N_{ADM}} V_{u,k} \cdot P_{eso_k}$$

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

$$Prod_u = \frac{\sum_{i=1}^{N_{ADM}} w_{P_i} \cdot A_{LCP_{u,i}}}{ND_u} \quad AP_{Coul} = 100 \cdot \frac{A_{Coul}}{\sum_{i=1}^{N_{ADM}} A_{Coul_i}}$$

$$RO_u = PART_u \cdot \left(RO_j - \sum_{i=1}^{N_{ADM}} RO_i \right) \quad PART_u = \frac{\sum_{i=1}^{N_{ADM}} RO_{u,i}}{\sum_{k=1}^{N_{ADM}} \sum_{i=1}^{N_{ADM}} RO_{k,i}}$$

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

$$Ext_u = \frac{\sum_{i=1}^{N_{ADM}} w_{E_i} \cdot PEC_{u,i}}{ND_u} \quad RO_u = PART_u \cdot \left(RO_j - D_{AVC} - D_{COL} - \sum_{i=1}^{N_{ADM}} RO_i \right)$$

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 course	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				Doctorate Program						
Course	NACM	DM	Weight	TAEM	Course	NACD	DD	Weight	TAED	
Civil Eng.	15	0,75	2	22,5	Civil Eng.	10	0,38	2	7,6	
Manag. Eng.	15	0,75	2	22,5	Manag. Eng.	10	0,38	2	7,6	
Electrical Eng.	10	0,75	2	15	Electrical Eng.	8	0,38	2	6,08	
Medicine	10	0,75	4,5	33,75	Medicine	10	0,38	4,5	17,1	
Natural Science	18	0,75	1	13,5	Natural Science	15	0,38	1	5,7	
	107,25	TOTAL							44,08	TOTAL

Figure 8: DSS Prototype – Model 1

Model 2

Department	ADIS	CHDC	B	C	RO	N	PART cos	PART e	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	ADM, EM	ADM, EF	ADM, G	ADM, E	ADM, M	ADM, D	IQCTA
150	120	50	10	1	3,69697	8	56	6	47	44	17	351
110	99	41	8	1	3,63178	76	28	67	37	27	48	533
160	150	46	4	1	3,73889	50	23	48	44	4	54	467
85	90	32	11	1	3,53211	40	54	80	36	56	21	482
155	110	62	3	1	3,73333	71	78	20	50	38	61	631

Figure 9: DSS Prototype – Model 2

Model 3

Depart.	Ne	Proc	Ext	AP	FE	PAR	Wp	ALCP	ND	Prod
Engineering	2518,88	5,17	0,76	0,23	0,4	1,25	0,6	80	220	5,17
Computer Sci.	1799,4	10,33	1,53	0,16	0,4	0,89	0,4	45	110	10,33
Human Sci.	1092,9	4,84	0,72	0,21	0,6	0,62	0,8	112	235	4,84
Mathematics	1461,1	13,37	1,98	0,14	0,3	0,67	0,5	22	85	13,37
Medical School	2715,25	4,66	0,69	0,26	0,7	1,64	0,6	133	244	4,66

We	PEC	ND	Ext	Aoonu	Aooni	Apcon	PART	Roj	Roi	RO
0,6	12	220	0,76	480	2130,0	23	1,25	183192,6	778375,61	744.077
0,4	8	110	1,53	350	2130,0	16	0,89	214741,6	778375,61	503.673
0,8	16	235	0,72	450	2130,0	21	0,62	98820,1	778375,61	421.438
0,5	4	85	1,98	300	2130,0	14	0,67	118901,1	778375,61	444.590
0,6	18	244	0,69	550	2130,0	26	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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