THE LEONTIEF´S EQUATION TO IMPROVE THE LEARNING PROCESS OF MRP SYSTEM IN THE TOURISM STUDIES

Abraham Briones-Juárez, Ricardo Tejeida-Padilla, Isaías Badillo-Piña
Instituto Politécnico Nacional, México
Emails: abrahambriones2003@yahoo.com.mx, rtejeidap@ipn.mx, ibaillop@ipn.mx

ABSTRACT

This paper details the development of a simplified MRP through the equation of Leontief (linear algebra), and proposes its teaching in three parts a) data collection and recognition of the relationship between materials, b) a list of variables and mathematics explanation, c) obtaining results and verifying them by software. The academic exercise is about the flow of ingredients required to comply with a plan for food services and is intended to be a learning tool to facilitate the study of this method in the hospitality management courses.

Keywords — MRP, Leontief equation, Linear Algebra, hospitality

INTRODUCTION

Tourism study, a multidisciplinary field, is comprised by the areas of recreation, leisure and business management (Zhao and Ritchie, 2007). The Tourism plans studies are compound by a variety of knowledge that joins on curriculum design. This discipline applies different types of academic knowledge bases (Inui, Wheeler and Lankford, 2006). For example, the economic theory (Mochón, 2004), the social psychology (Castillo, 2005), the sociological theory (Bente, Graham and Mehmetoglu, 2006), the tourism anthropology (Siew, Lee and Geoffrey 2006) and the management resource planning (Puri and Chand 2006). These subjects are adapted for tourism application (Guevara Molina and Tesserras 2007) not only because they formulate their approach in tourism terms but also because they embody the means of their study. Programming tourism studies plans are difficult compared to conventional disciplines. The tourism changes in market diversification, technological development, production practices and marketing methods have been not incorporated into the academic activities as soon as their develop in the industry. Thereby, it has been generated pedagogical disagreements which come from a misunderstanding of empirical tourism development. Thereby they diminish the ability to generate implicit knowledge.

The hospitality education levels are compound by production food and lodging services. These skills are the relevant parts to teach and are divided (into) two parts which are the theoretical and practical knowledge both formed the academic bases to address the learning subjects. Indeed, they take the students development in two sides, through evaluation and analysis interpretation (knowledge) and through vocational training (skills and know-how) (Gurel, Altinay, and Daniele, 2010). Every one of this position does not exist in isolation but every they complement each other, ie, knowledge is embodied in academics and empirical aspects. The focus of student learning on real life problems ensures application of knowledge to the work field. (Zwaal and Otting, 2010). However, the theoretical knowledge maintains a lack of consistency with training skills. This occurs according with Mayak & Akama (2007) when the method exits of the application context.

There are several informatics models that provide a good possibility to be used in tourism industry explanation, such as MRP model to explain material services relations. Nevertheless, the model must be adapted to the special services relation. Academics have to develop a proper way to apply a bearing in mind that hospitality knowledge must permit the incorporation of explanatory theory into the practical context. Therefore, it is important to externalize the knowledge with academic exercises to abstract the core elements, in order to match them in a logical pedagogic relation. This adaptation must be according with curricula necessities, necessary industry skills and students preparation, to be useful and have an advantage in hospitality interpretation. For this, the used model has to match with environmental explanation, the methodological insertion and the identifying mathematical relation; furthermore it is important to have the proper system information. All of that, getting to increase knowledge application in hospitality services and trying to incorporate new technologies used as a means to advance the achievement of academic purposes.

In this context, hospitality education has two challenges 1) improving educational efficiency and 2) ensuring a consistent experience to teach (Brookes, 2010). The first depends on the teaching ability (Chang and Hsu, 2010) and the second depends on the researchers incorporate their experience in implementing programs to deal with tourism complexity (O'Connor and Baum, 2008). The academics must provide methods, concepts and models to cope with hospitality management and academic challenges. Thus, it is necessary to expose tourism students to different problems comparing the contrast differences and making them capable to use the prior knowledge (McGugan, and Peacock, 2005) which means to integrate new knowledge into their training experience. This may be more convenient for students because they have more effective mental conceptions (Slattery, 2002).

Teaching planning resources in hospitality services is a complex topic since it derived from the scheduling of simultaneous tasks, the synchronous service functions, the use of high speed information and the cyclical demand. The dynamic manifestation of these elements do not allow to link the input data programming with the services processes to have a better output data definition. Thus, it is hard to try to explain and understand the material flow hospitality services relation.

Teachers must build new learning techniques that integrate the fundamental relations of the phenomena to explain, without losing sight of the elements that put them in this particular context. They have to overcome the lack of education that according Garrigós Palacios, and Narangajavana, (2008) is one of the main reasons for the poor development of new methods and management science models in hospitality. Furthermore, it is necessary to establish new ways to promote student reflection in order to prepare highly skilled human resources.

MRP IN HOSPITALITY INDUSTRIES

The applied of MRP model in the Hospitality industry especially in restaurant services is difficult to achieve because each "unit" may be different from others "units" (Kotler, 1997). Restaurant management control works with cooking or culinary recipes programming which are known as standard recipes (SR). These standard recipes are used to uniform preparations, flavors and dishes portions. Nevertheless, they suffer constantly changes coming from customers requirements. This effect comes from inseparability, customers and suppliers interact together at the same time (Yu, and Lee, 2009), in which the processes of sale and consumption are simultaneous. Thereby, scheduling restaurant resources are based in customer decisions such as omitted, added or exchanged ingredients. This makes the scheduling restaurant resources more difficult.

The complex resource management decreases the possibility of establish accurate data of buying patterns. The mix of dishes, guarnitions and supplies ingredients create new combinations not scheduled to be integrated into the bases recipes development (sauces, dressings, funds, etc.). Thus, input buyers are faced with the challenge of providing sufficient variety of products to meet diverse customer needs (Zhang Song, and Huang, 2009). The costs of not existence usually increase the risk of adversely changing customer expectations, so that, customers must find satisfaction under different services or products. Because of that, the flow control inputs in restaurant services are used by empirical approach. Decision makers are aware of the market and could infer operational volume of purchases to carry out the production services. Wöber (2003) named it declarative knowledge from the experience industry. However, managers support their decisions by implement software programming development, which allow them to expand their empirical knowledge. These programs rely on the ingredients management as an automatic process which implies a production plan, stock inventory and material list. These data would be running in a MRP program to know what will be cooked prior to be consumed in a particular or group of services (Véronneau, 2009). Nevertheless, the relationship between production and purchase orders in amounts and frequencies has had a significant effect in food and beverage apartment not only because most of them are perishable (Madanoglu, and Olsen, 2005) but also because cooked ingredients have a short duration.

This paper details the development of a simplified MRP through the equation of Leontief (linear algebra), and proposes its application in three dimensions a) data collection and recognition of the relationship between materials b) a list of variables and explanation mathematics c) obtaining results and compering them in software. The academic exercise is about the flow of ingredients required to comply with a plan for food processing and is intended to be a learning tool to facilitate this method in courses of hospitality management.

FUNDAMENTS OF MRP

The first MRP system has developed and deployed by General Electric (G.E.) in 1965, when the memory of mainframes was measured in kilobytes rather than megabytes. The basic idea was to calculate the quantity and timing of production and purchase orders to support the Master Production Schedule (MPS), using a simple four step process: 1.-

Determinating the gross requirement from the master schedule (MPS) and bill of materials (BOM); 2.- Finding expected shortages by "netting" the gross requirement against inventory availability; 3.- Determinating lot sizes from order-policy rules; then 4.- Backschedulating to determine when starting the purchase or production order. The process continued level-by-level of the bill of materials, until all requirements were satisfied.

The net calculation assumed that there was enough available production capacity to complete all the activities within the specified lead times. To overcome this assumption, the capacity requirement planning (CRP) calculations were implemented and the MRP changed its name to Manufacturing Resources Planning (MRP II).

Material requirements planning (MRP) is arguably the most successful business management solution ever conceived, it is considerate in the broadest sense to the origin of its evolutionary offspring: Manufacturing Resource Planning (MRPII) and Enterprise Resource Planning (ERP). MRP is used in companies throughout the world, MRP/ERP is the backbone information system of these companies for tracking and controlling their operations from customer orders and procurement through to inventory, planning, production financial accounting and beyond (Turbide, 2004; Veith, 1970).

The structural and logical decisions of MRP systems, developed years ago, still influence many manufacturing and services information systems, therefore learning and understanding of ERP systems are easier by understanding the formal elements of MRP.

By means of using linear algebra concepts and considering MRP as an abstract system, the learning process of students and professionals of hospitality businesses not only could be faster but also they could become more competitive when they understand the fundamental principles. This method allows them to stimulate meaningful learning.

DEVELOPMENT

The learning process of MRP system operation becomes more efficiently by using Leontief ‘s (1951) equation and linear algebra. This process provides a didactic methodology that manages to increase the understanding of MRP system operation, which makes easier learning meaningful.

This study is focus on the tourism college program at the Mexican National Politecnical Institute. Given that graduated students of tourism have approved a course on Linear Algebra it is easy for them, to apply Leontief's input-output matrix to the basic processes of total ingredients calculations, required to satisfy a Master Food Processing Schedule, as follows:

$$\mathbf{R_G = (I-A)^{-1} \cdot P} \qquad (1)$$

Where:

$\mathbf{R_G}$= vector of gross requirements of ingredients, purchased ingredients, food processing and man hours, (without lot-sizing or time-phased lead times).

I= Identity matrix.

A= Unitary ingredients assembly matrix.

P= Vector of food process, master schedule production (MPS) (total planned quantities).

To obtain net requirements R_N (or netting process), the on hand inventory vector (E) is considered as follows:

$$\mathbf{R_N= (I-A)^{-1} \cdot (P-E)} \qquad (2)$$

Where:

E= On had available ingredients

To include lot sizing, the net requirement vector R_N is modulated by the lot size vector Q, as follows:

$$\mathbf{R_L=R_N \text{ module } Q} \qquad (3)$$

$\mathbf{R_L}$ provides an answer for the four food processing questions: what and how many meals will have been producing? And. What and how many ingredients will have been purchasing? In order to accomplish the total planned quantities of finished meals a Master Food Processing Schedule (MFPS).

A spreadsheet program or a didactic software known as WIN/QSB is used to check the total lot sized of quantities (Chang, 2003, 223). To obtain the needed quantities of ingredients and purchased ingredients, it is required to have a database official list of ingredients (LOI) authorized by Food and Beverage Manager and the Executive Chef as well as, the available on hand inventory of ingredients and purchased ingredients, updated and authorized by inventory Management.

The following didactic problem illustrates how to use the equations (1), (2) and (3). The classic form to determinate the number of ingredients used in food production is known as standard cost recipes (SCR), the recipe costs are calculated through the definition of real price (R_P) and real cost (R_C).

A DIDACTIC PROBLEM

This academic exercise is about a combination of ingredients to produce two appetizers and a sauce in common.

The construction of (SCR) is illustrated by the next chart (see table 1) it was made by assigning of an alphabetical letter to each component to permit easily visual location. The measurement units (MU) were changed to kilograms for easy handing since many ingredients are measured in recipes by using different systems like teaspoons, cups, ounces, pinches etc. The Calculation of the real price (R_P) is established by the relationship " R_P = P (1 +1 R) "where P = price of input and R = percentage yield. This value is determined to find out the price per kilogram of inputs, in general the stander cost are estimated by statistical methods which are applied as a margin of performance. The actual cost (R_C) is obtained by the relation " R_C = (R_P / UM) (P), and it represents the cost of acquiring a unit of real input. This result makes necessary to discount the waste part of not used ingredients according with the food processing. Thus, cleaning, stripping, chopping and cooking processes are considered along with the recipe instructions.

The standard costed recip of the exercise and the definition of variables for the MRP model are presented next.

Table 1 Standard cost recipe (SCR)

1	2	3	ID	Price	UM	Percentage Yield	Portion	R_P	R_C
A			Tacos						
	C		Corn Tortilla	$8,00	Kg	100	80	$8,00	$0,64
	D		Chicken	$32,00	Kg	90	120	$35,20	$4,22
	E		Sour cream	$25,00	Kg	100	30	$25,00	0,75
	F		Cheese	$60,00	kg	100	20	$60,00	1,2
	G		Tomatoes	$13,00	Kg	86	50	$14,82	0,0741
	H		Lettuces	$8,00	Kg	85	70	$9,20	0,644
Costo del componente A = 7,53									
standard cost recipe (SCR) by component A +L = 8,84									
B			Quesadillas						
	E		Sour cream	$25,00	Kg	100	30	$25,00	$0,75
	F		Cheese	$60,00	Kg	100	20	$60,00	$1,20
	G		Tomatoes	$13,00	Kg	86	10	$14,82	0,148
	H		Lettuces	$8,00	kg	85	70	$9,20	0,644
	I		Pumpkin flower	$12,00	Kg	90	40	$13,20	0,528
	J		Mushrooms	$39,00	Kg	83	40	$45,63	1,8252
	K		Huitlacoche	$28,00	Kg	88	40	$31,36	1,2544
Costo del componente B= 6,35									
standard cost recipe (CSR) by component B+L = 7,66									
	L		Sauce						
		G	Tomatoes	$13,00	Kg	86	30	$14,82	$0,44
		M	Tomatoes extract	$25,00	Kg	100	20	$25,00	$0,50
		N	Onions	$14,00	Kg	82	10	$16,52	0,165
		O	Chili	$9,00	kg	94	10	$9,54	0,095
		P	Coriander	$5,00	Kg	91	10	$5,45	0,0545
		Q	Salt	$12,00	Kg	100	2	$12,00	0,024
		R	Paper	$14,00	kg	100	2	$14,00	0,028
Component cost of L=1,31									

The results of the table show the cost ingredients of "A" Tacos, "B" Quesadillas and "L" Sauce. The cost of standard recipes conjunction is depicted by the sum of “A” plus “L” for the first case and the sum of “B” plus “L” for the second.
The estimation of total ingredients to produce a number of planned food services order is presented in the Master Food Processing Schedule (MFPS) In this case, it is for eight weeks (see table 2).

Table 2. Master Food Processing Schedule (MFPS)

IDENTIFICATION NUMBER OR NAME	PERIODS*								TOTAL PLANNED QUANTITIES **P**
	1	2	3	4	5	6	7	8	
A	30	35	34	33	46	42	36	44	300
B	15	24	32	35	31	18	21	24	200
L	65	65	65	65	65	65	65	65	520

The academic exercise shows a total planned quantity of 300 appetizer "A" and 200 appetizers "B" with different levels production for each period, meanwhile the processing of "L" is equal to 520 sauces with the same values for each period. Something similar happens in real a system food processing because “A” and “B” are estimated by food forecast while L is calculated by blocks or portions needed to satisfied part of the production, even if demand or production requirements are deferent. In such a case, it is necessary to conduct a new production of "L" when the previous is not enough or whether the product is used for other preparations or to face new customer requirements. These cases are not resolved in this academic exercise. However, it is important to mention them as disrupters of actual results.

The graphic ingredients construction for this didactic example is shown in Figure 1

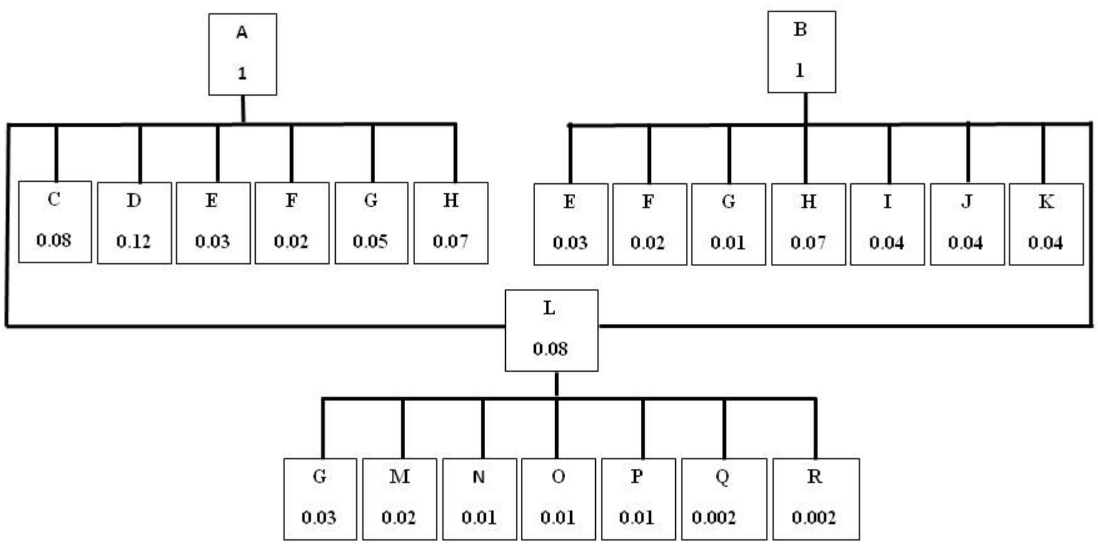

Figure 1. Meals structure of food services A and B

This structure with the same base can be used for a wider network services like the control of recipes for many consumer areas like restaurant, cafeteria, bar and room services. The combination of ingredients, sauces, dressings etc in a menu or a group of them are composed by layers which make up the upper and lower levels.

This information is used to create the input array of ingredients which are composed by units required of lower level components (children) to combine the units above (parents). It shows the mix ingredients for each element and in it appears the total ingredients. This exercise is composed by the ingredients from “A” to “R”. The array presentation must be square to permit mathematical operations. Thus, the list of ingredients are arranged the same for rows and columns arranged.

The requirements production by ingredients of “A”, “B” and “L” together with the array composition of them, are shown in the next table.

Table 3. Matrix unit quantities.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0.02	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0.05	0.01	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
H	0.07	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	0.08	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
O	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
Q	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0
R	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0

The graphical arrangement of data in the presentation of the production matrix and its combination with the production plan along with the inventory stocks and lot size constitute the inputs for MRP model. Those are parts of black-box system which integrates a combination process of phase for searching output results. The critical decisions to preparing meals are composed by two questions: How many ingredients are needed for the production process? And In which volume are they request to keep the production flow? This information is important to elaborate dishes and control inputs. They concern to the kitchen and purchase department respectively (See annex 1).

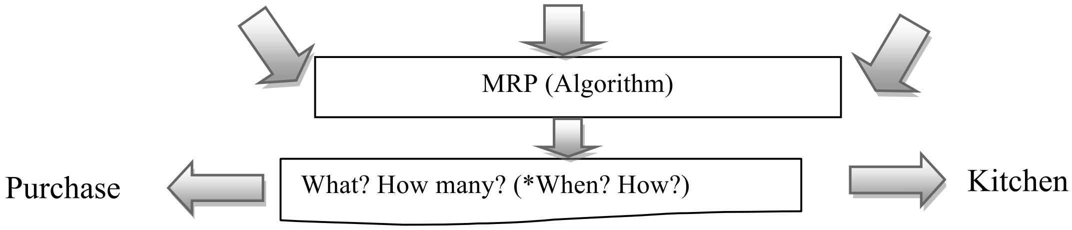

Figure 1 MRP and Food and Beverage Production Process

Delivery times, the lot size and the different ways to form the stock inventory for this academic example are shown in Table 4.

Table 4. Inventory Control (simplified for didactic problem)

IDENTIFICATION NUMBER	LEAD TIME * PERIODS L	LOT SIZE (PIECES) Q	ON HAND INVENTORY (PIECES) E
A	0	1	0
B	0	1	0
C	1	1	2.4
D	3	1	3.45
E	5	2.5	2.25
F	5	1	2.49
G	3	1	8.36
H	3	1	9.24
I	3	0.500	1.75
J	3	0.500	1.25
K	2	0.500	2.14
L	1	1	0
M	2	1	3.4
N	2	1	0.8
O	3	0.500	1.78
P	3	1	2.98
Q	7	1	0.1
R	7	1	0.1

The lead time is presented as a week fraction (*). It is not considered in this academic exercise.

In annex 1 it is shown the linear algebra calculations performed with Mathlab.

RESULTS

The gross and net requirements calculated by equations 1 and 2 are shown in annex 2 the for equations (1) and (2). The results were calculated using the Mathlab ® program in which we obtained the Gross requirements $\mathbf{R_G}$ from equation (1), the Net requirements $\mathbf{R_N}$ from equation (2) and modulate data of lot size vector from the equation (3). (See table 5)

Table 5. Results of equations (1), (2) and (3)

Gross requirements R_G (1)		***Net requirements R_N (2)***	***lot size R_L (3)***
ID	**Results**	**Results**	**Results**
A	**300**	**300**	**0**
B	**200**	**200**	**0**
C	**24**	**21.6**	**22**
D	**36**	**32.5**	**33**
E	**15**	**12.7**	**13**
F	**10**	**7.51**	**8**
G	**33.8**	**25.4**	**26**
H	**35**	**25.7**	**26**
I	**8**	**6.25**	**6.5**
J	**8**	**6.75**	**7**
K	**8**	**5.86**	**6**
L	**560**	**560**	**0**
M	**11.2**	**7.80**	**8**
N	**5.6**	**4.8**	**5**
O	**5.6**	**3.8**	**4**
P	**5.6**	**2.6**	**3**
Q	**1.12**	**1.02**	**2**
R	**1.12**	**1.02**	**2**

The vector $\mathbf{R_L}$ is the same that obtained through Orlicky's (1975) programmed algorithm, in commercial software packages, which also processes the time phased lead times of each component, as shown in table 4. They are not considered for this academically exercise. Running the Win QSB program permits us to check the chart data. That is important since it is possible to correcting correct components disposition if it is necessary.

Table 6. Results by Win QSB2.0

MRP Report for Example					
Item: A	Tacos	@Cost = **8.84**	Item: J	Mushrooms	@Cost = 39
$\mathbf{R_G}$	300	300	$\mathbf{R_G}$	8	8
Item: B	Quesadillas	@Cost = **7.66**	Item: K	Huitlacoche	@Cost = 28
$\mathbf{R_G}$	200	200	$\mathbf{R_G}$	8	8
Item: C	Tortilla	@Cost = 8	Item: L	Sauce	@Cost = **1.31**
$\mathbf{R_G}$	24	24	$\mathbf{R_G}$	560	560
Item: D	Chicken	@Cost = 32	Item: M	Pure de T.	@Cost = 25
$\mathbf{R_G}$	36	36	$\mathbf{R_G}$	11.2	11.2
Item: E	Sour cream	@Cost = 25	Item: N	Onion	@Cost = 14
$\mathbf{R_G}$	15	15	$\mathbf{R_G}$	5.6	5.6
Item: F	Cheese	@Cost = 60	Item: O	Chili	@Cost = 9
$\mathbf{R_G}$	10	10	$\mathbf{R_G}$	5.6	5.6
Item: G	Tomatoes	@Cost = 13	Item: P	Coriander	@Cost = 5
$\mathbf{R_G}$	33.8	33.8	$\mathbf{R_G}$	5.6	5.6
Item: H	Lettuce	@Cost = 8	Item: Q	Salt	@Cost = 12
$\mathbf{R_G}$	35	35	$\mathbf{R_G}$	1.12	1.12
Item: I	Pumkin flower	@Cost = 12	Item: R	Paper	@Cost = 14
$\mathbf{R_G}$	8	8	$\mathbf{R_G}$	1.12	1.12

$\mathbf{R_G}$ = Gross Requirement

It is important to emphasize that the electronic results for cost of table 6 for the ingredients "A" "B" and "L" are the same as in table 1 (in bold letters). The student can recognize the useful of match results. The same values obtained by software that compound the $\mathbf{R_G}$ in table 6 are obtained, by linear algebra, requirement ingredients of table 5. This shows that the academic exercise is made successfully. In case of discrepancy it is necessary to verifying the Matrix of unit quantities to check the data disposition so as the student can make the necessary changes.

CONCLUSIONS

The previous exercise is an effort to understand the applied of MRP model in management of hospitality services. It is an attempt to explain the relation flow of restaurant ingredients through the presentation of an academic exercise in order to apply in hospitality courses. For that, the use of Leontief equation was proposed as proper method for explaining mathematical disposition relations. The previous knowledge of cost dishes and liner algebra skills are needed for its application. Therefore, this academic exercise is helpful to understand the food programming and supplies in restaurant management.

Getting the input information data its is easy when services areas like kitchen, audit and purchase have maintained to share relevant information. In this relation is important to know how the services and information are related, according with brand differences, segment market, type of companies, categories, etc. However, the handling materials can be clarified for academic purposes through mathematical solution and supported by the use of software. Nevertheless, the explanation of context must be according with the teacher knowledge and students experiences. For example, a high category restaurant may be has less ingredients control because of its compensation system. The menu prices is enough to support food lost. They are concentrated in customer satisfaction but they do not lose sight of ingredients flow.

This exercise shows the following advantages for learning in hospitality programs. 1) It calculates the volume of production required for the ingredients "A" "B" and "L" under Master Food Processing Schedule. This information is vital when it is combining several dishes with equal bases (sauces, creams, dressings, etc.). 2) The standard cost recipe calculation allows us to introduce the students to the new knowledge from previous background knowledge. Reinforcing them appears at the end of the academic exercise when students adjust net requirements by waste. 3) The model can handle many menus, food services, and consumer areas simultaneously. This is important since food analysis have a complicated explanation which is hard to understand especially with wider services. 4) The linear algebra allows to keep tracking of data and compare results. 5) The graphic ingredients construction allows visually check of dishes, appetizers, soups etc., their parts like sauces dressing etc., as well as their ingredients that comprise them. This example serves to address more complex exercises using the same principles outlined above. 6) The programming of dishes in this exercise allows the students to recognize critical information for management of materials that would be difficult to define otherwise.

7) The software permits to enter data for waiting times, costs of storage and lot size, thus the more experienced student can simulate the advanced applying for materials use. 8) The teaching-learning process for hospitality management area is simplified by using proper methods to facilitate the understanding of ingredients flow relations. The same principles used in this academic exercise can be proposed to explain the flow of materials in other hospitality areas such as travel companies, travel agencies, cruise lines etc.

Future work.- Industrial engineering methods can be used within the teaching and learning processes in the hospitality courses, as long as they can make applications that do not leave their explanatory contexts. However, it is necessary to conduct investigations in this regard that can promote the best techniques to link the business and academic knowledge. The models develop must be easily to explain and to understand, where as the relationship between data and its calculate results must be clear. Thus, the researchers must broadening the knowledge of new methods while the hospitality college courses prepare human resources with useful tools in their work environment.

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Annex1. Data arrangements in Graphical shape

Production Structure “A”, “B” and “L”

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0.02	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0.05	0.01	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
H	0.07	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	0.08	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
O	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
Q	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0
R	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0

Production Plan

P=

A	300
B	200
C	0
D	0
E	0
F	0
G	0
H	0
I	0
J	0
K	0
L	520
M	0
N	0
O	0
P	0
Q	0
R	0

On hand inventory

E=

A	0
B	0
C	2.4
D	3.45
E	2.25
F	2.49
G	8.36
H	9.24
I	1.75
J	1.25
K	2.14
L	0
M	3.4
N	0.8
O	1.78
P	2.98
Q	0.1
R	0.1

Lote sizes

Q=

A	1
B	1
C	1
D	1
E	2.5
F	1
G	1
H	1
I	0.500
J	0.500
K	0.500
L	1
M	1
N	1
O	0.500
P	1
Q	1
R	1

Annex 2. Mathematical results formulas (1) y (2)

$$R_G = \left[\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix} - \begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.08 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.12 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.03 & 0.03 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.02 & 0.02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.05 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.03 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.07 & 0.07 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.08 & 0.08 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.02 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.002 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.002 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix} \right]^{-1} \cdot \begin{pmatrix} 0 \\ 300 \\ 200 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 520 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} \mathbf{0} \\ \mathbf{300} \\ \mathbf{200} \\ \mathbf{24} \\ \mathbf{36} \\ \mathbf{15} \\ \mathbf{10} \\ \mathbf{32.6} \\ \mathbf{35} \\ \mathbf{8} \\ \mathbf{8} \\ \mathbf{8} \\ \mathbf{520} \\ \mathbf{10.4} \\ \mathbf{5.2} \\ \mathbf{5.2} \\ \mathbf{5.2} \\ \mathbf{1.04} \\ \mathbf{1.04} \end{pmatrix}$$

RG= vector of gross requirements of ingredients

$$R_N = \left[\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix} - \begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.08 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.12 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.03 & 0.03 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.02 & 0.02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.05 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.03 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.07 & 0.07 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.08 & 0.08 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.02 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.002 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.002 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix} \right]^{-1} \cdot \left[\begin{pmatrix} 300 \\ 200 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 520 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} - \begin{pmatrix} 0 \\ 0 \\ 2.4 \\ 3.45 \\ 2.25 \\ 2.49 \\ 8.36 \\ 9.24 \\ 1.75 \\ 1.25 \\ 2.14 \\ 0 \\ 3.4 \\ 0.8 \\ 1.78 \\ 2.98 \\ 0.1 \\ 0.1 \end{pmatrix} \right] = \begin{pmatrix} 300 \\ 200 \\ 21.6 \\ 32.5 \\ 12.7 \\ 7.51 \\ 25.4 \\ 25.7 \\ 6.25 \\ 6.75 \\ 5.86 \\ 560 \\ 7.80 \\ 4.8 \\ 3.8 \\ 2.6 \\ 1.02 \\ 1.02 \end{pmatrix}$$

RN = vector of net requirements ingredients