Linear Programming Model as a Decision Support System in Knowledge Management
Case Study: Hospitals in Jordan

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Abstract

This study aims to determine cost of knowledge assets between three hospitals in Jordan using quantitative methods. The results of the study explain that quantitative method (Linear Programming) can be used as decision support system(DSS) to help decision maker when he want to select between many kinds of knowledge assets with minimum cost.

Keywords: *Decision Support System, Linear Programming Model, Knowledge Assets*

1- Introduction

Under globalization and quality challenges, the strategic goal for each organization became building and improving decision support systems to improve the quality of a decisions [17], [11], [12], ,[9] . To achieve this goal; organizations must build and develop knowledge databases which are the source of knowledge assets (KA),[2],[18].The term "knowledge assets" refers to the accumulated intellectual resources for an organization. It is the knowledge possessed by the organization and its workforce in the form of information, ideas, learning, understanding, memory, insights, cognitive and technical skills, and capabilities, [1],[2],[6],[9]. Knowledge assets are strategic tools to increase the marketing value of an organization, when their knowledge assets used by other organizations,[7], [11],[18],[20].

The paper focuses on knowledge management-based DSSs (KMDSSs) defined as systems that facilitate decision making throughout and between organizations with the added component of knowledge management functions, [4]. Such functions include storage, manipulation, retrieval, transfer, and use of knowledge such that individuals and organizational memory benefit [5]. Knowledge management (KM) defined as a process through which organizations generate value from intellectual and knowledge based assets [1],[2], [11].

The objectives of this study are to explore the following:

- How organizations can apply a decision support system to help managers in knowledge management. ?
- What the rules are to measure and evaluate knowledge assets.
- What the criteria is which supports decision maker to choose between knowledge assets from different organizations?

2- Algorithm of applied model

This study will apply a linear programming model developed by (Kriniski & Badach, 1985)[12]. The model was justified by researcher to be suitable with environment of Jordan.

The constraints of model are as shown in the following formulas:

$$\sum_{m=1}^{M} Xlm = Xm$$

M

$$\sum_{m=1} Xlmn = bln$$

Where:

Xlm= the number of knowledge assets specialization in (l) and work in location (m).
Xm= the total number of knowledge assets which work in location (m).
Bln= the number of knowledge assets of kind (l) and wanted in location (n).
Xlmn= the number of knowledge assets of kind (l) that will be transfer from location (m) to location (n).

The objective function is computed by using the formula:
K= k1 + k2 + k3 → Min
Where:

$$k_1 = \sum_{l=1}^{L} \sum_{m=1}^{M} glm\ Xlm \qquad \text{(The holding cost of KA)}$$

$$k_2 = \sum_{l=1}^{L} \sum_{m=1}^{M} \sum_{n=1}^{N} Clmn\ Xlmn \qquad \text{(The cost of transferring KA)}$$

$$k_3 = \sum_{l=1}^{L} \sum_{m=1}^{M} Slm\ Xlm \qquad \text{(The cost of developing KA)}$$

The model can be displayed as transportation model as in Table (1) and Figure (1).

The above model will shed the light on the cost of knowledge assets in the following three hospitals located in Jordan:

1. University Hospital.
2. Al-Beshir Hospital.
3. Al-Hussein Hospital.

The study will address eight disciplines as kind of knowledge assets. The disciplines are:

1. Anesthesia.
2. Neurosurgery.
3. Heart Surgery.
4. Plastic Surgery.
5. Premature.
6. Renal Dialysis.
7. Gynecological.
8. Dermatological.

These disciplines are used by six units, which are:

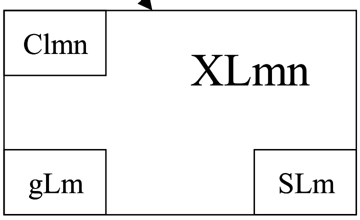
1- Intensive Care Unit.
2- Burn Unit.
3- Surgical Unit.

4- Catheterization Unit.
5- Gynecological Unit.
6- Operations Unit.

Table 1. Transportation Table for Disciplines

	Intensive Care Unit	Burn Unit	Surgical Unit	Catheterization Unit	Gynecological Unit	Operations Unit
Anesthesia						
Neurosurgery						
Heart Surgery						
Plastic Surgery						
Premature						
Renal Dialysis						
Gynecological						
Dermatological						

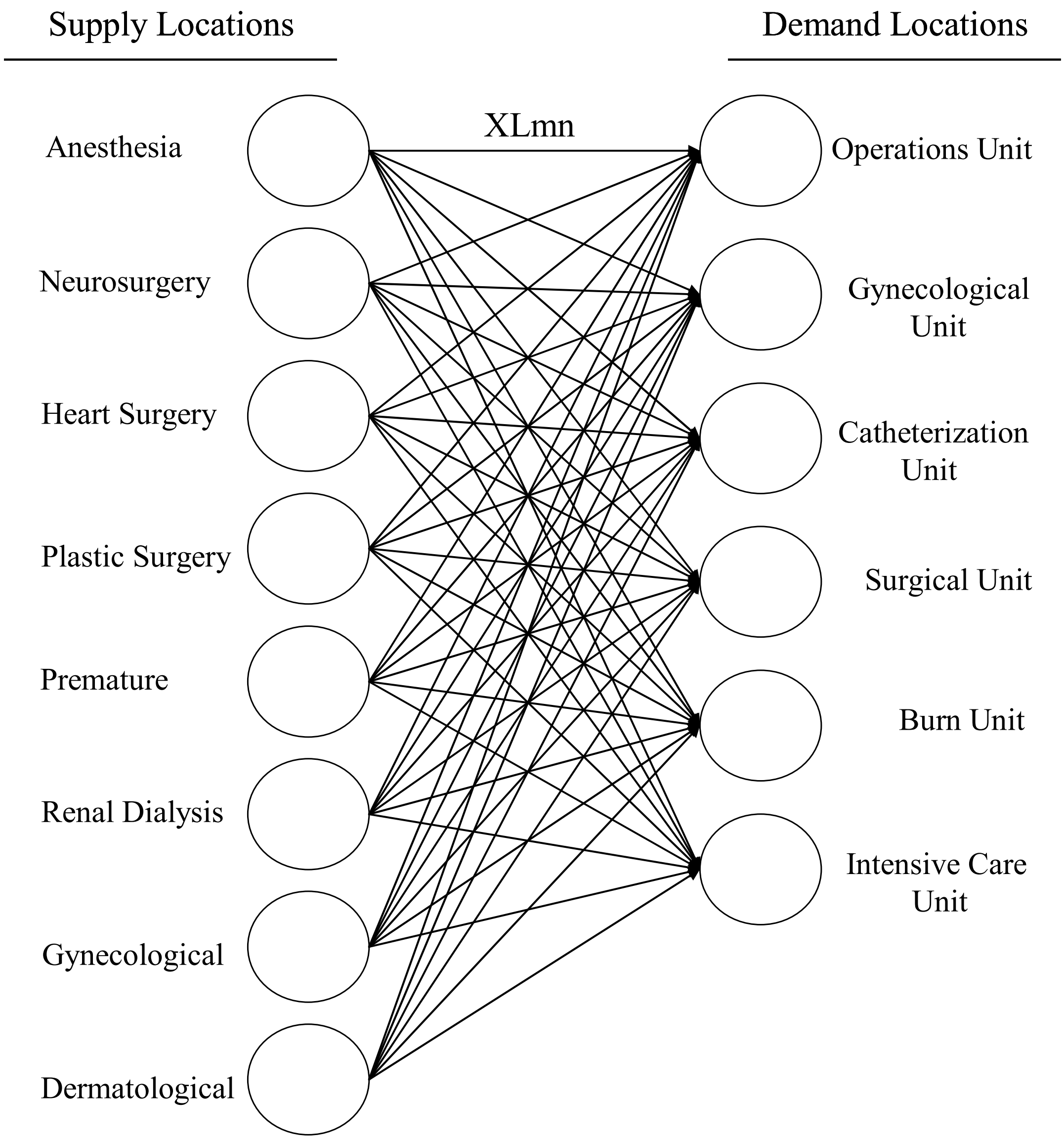
Transportation Cell



Which total transportation cost for disciplines equal to:

K= Clmn +glm + Slm

Figure 1. Transportation Network for Disciplines



3- Input data

Table (2), Table (3), Table (4), and Table (5) show the parameters of the problem.

Table 2. Number of hospitals, units and disciplines

Hospitals (m)	*3*
Units (n)	6
Disciplines (l)	8

Table 3. Demand of disciplines as knowledge assets

Unit / Disciplines	Intensive Care Unit	Burn Unit	Surgical Unit	Catheterization Unit	Gynecological Unit	Operations Unit
Anesthesia	b11=2	b12=3	b13=1	b14=2	b15=1	b16=2
Neurosurgery	b21=1	b22=2	b23=2	b24=2	b25=4	b26=2
Heart Surgery	b31=2	b32=2	b33=2	b34=3	b35=1	b36=2
Plastic Surgery	b41=2	b42=3	b43=3	b44=2	b45=2	b46=4
Premature	b51=3	b52=1	b53=1	b54=1	b55=2	b56=1
Renal Dialysis	b61=3	b62=1	b63=2	b64=3	b65=1	b66=2
Gynecological	b71=2	b72=2	b73=2	b74=2	b75=3	b76=2
Dermatological	b81=1	b82=3	b83=2	b84=3	b85=2	b86=3
Total	bL1=16	bL2=17	bL3=15	bL4=18	bL5=16	bL6=18

Table 4. Supply of disciplines as knowledge assets

Hospital / Disciplines	University Hospital	Al-Beshir Hospital	Al- Hussein Hospital
Anesthesia	X11=5	X12=3	X13=5
Neurosurgery	X21=4	X22=3	X23=5
Heart Surgery	X31=3	X32=4	X33=4
Plastic Surgery	X41=2	X42=4	X43=3
Premature	X51=6	X52=5	X53=4
Renal Dialysis	X61=8	X62=3	X63=6
Gynecological	X71=7	X72=4	X73=5
Dermatological	X81=2	X82=2	X83=3
Total	**X1=37**	**X2=28**	**X3=35**

Table 5. Statement of disciplines cost which will enter in objective function

Unit / Disciplines	Intensive Care Unit	Burn Unit	Surgical Unit	Catheterization Unit	Gynecological Unit	Operations Unit	glm	Slm
Anesthesia	C111=40 C121=40 C131=80	C112=40 C122=20 C132=60	C113=40 C123=40 C133=100	C114=40 C124=20 C134=60	C115=90 C125=20 C135=60	C116=90 C126=40 C136=70	g11=50 g12=40 g13=50	s11=100 s12=120 s13=130
Neurosurgery	C211=80 C221=40 C231=90	C212=20 C222=80 C232=70	C213=30 C223=70 C233=90	C214=20 C224=40 C234=100	C215=80 C225=40 C235=80	C216=70 C226=40 C236=80	g21=60 g22=70 g23=80	s21=140 s22=100 s23=120
Heart Surgery	C311=40 C321=25 C331=60	C312=18 C322=40 C332=60	C313=20 C323=30 C333=60	C314=20 C324=80 C334=100	C315=20 C325=40 C335=90	C316=90 C326=20 C336=70	g31=50 g32=40 g33=30	s31=150 s32=100 s33=140
Plastic Surgery	C411=30 C421=40 C431=90	C412=85 C422=80 C432=70	C413=40 C423=60 C433=60	C414=20 C424=80 C434=90	C415=20 C425=50 C435=90	C416=80 C426=20 C436=100	g41=60 g42=70 g43=50	s41=100 s42=180 s43=100
Premature	C511=80 C521=85 C531=100	C512=15 C522=40 C532=80	C513=25 C523=50 C533=75	C514=90 C524=30 C534=90	C515=90 C525=15 C535=85	C516=80 C526=50 C536=100	g51=40 g52=60 g53=80	s51=120 s52=130 s53= 90
Renal Dialysis	C611=90 C621=40 C631=80	C612=85 C622=20 C632=100	C613=50 C623=60 C633=60	C614=40 C624=40 C634=100	C615=10 C625=40 C635=90	C616=20 C626=50 C636=90	g61=70 g62=50 g62=60	s61=140 s62=120 s63=130
Gynecological	C711=15 C721=20 C731=80	C712=85 C722=40 C732=50	C713=20 C723=30 C733=40	C714=50 C724=20 C734=80	C715=10 C725=40 C735=85	C716=70 C726=30 C736=100	g71=70 g72=75 g73=85	s71=150 s72=100 s73=120
Dermatological	C811=40 C821=40 C831=80	C812=68 C822=77 C832=80	C813=55 C823=40 C833=60	C814=50 C824=20 C834=90	C815=30 C825=40 C835=100	C816=70 C826=20 C836=70	g81=50 g82=40 g83=40	s81=140 s82=100 s83=100
	bL1=16	bL2=17	bL3=15	bL4=18	bL5=16	bL6=18		

According to input data we can explain linear programming model as follow:

$$k_1 = \sum_{l=1}^{L} \sum_{m=1}^{M} glm\ Xlm$$

k_1= g11X11 + g12X12 + g13X13 + g21X21 + g22X22 + g23X23 + g31X31 + ... + g83X83

$$k_2 = \sum_{l=1}^{L} \sum_{m=1}^{M} \sum_{n=1}^{N} Clmn\ Xlmn$$

k_2=C111X111 + C121X121 + C131X131 + C211X211 + C221X221 + C231X231 + ... + C836X836

$$k_3 = \sum_{l=1}^{L} \sum_{m=1}^{M} Slm\ Xlm$$

k_3=S11X11 + S12X12 + S13X13 + S21X21 + S22X22 + S23X23 + S31X31 + S32X32 + ... + S83X83

Then:

$$k = k_1 + k_2 + k_3$$

Subject To:

X111+X121+X131= 2
X211+X221+X231= 1
X311+X321+X331= 2
X411+X421+X431= 2
X511+X521+X531= 3
X611+X621+X631= 3
X711+X721+X731= 2
X811+X821+X831= 1

X112+X122+X132= 3
X212+X222+X232= 2
X312+X322+X332= 2
X412+X422+X432= 3
X512+X522+X532= 1
X612+X622+X632= 1
X712+X722+X732= 2
X812+X822+X832= 3

X113+X123+X133= 1
X213+X223+X233= 2
X313+X323+X333= 2
X413+X423+X433= 3
X513+X523+X533= 1
X613+X623+X633= 2
X713+X723+X733= 2
X813+X823+X833= 2

X114+X124+X134= 2

X214+X224+X234= 2
X314+X324+X334= 3
X414+X424+X434= 2
X514+X524+X534= 1
X614+X624+X634= 3
X714+X724+X734= 2
X814+X824+X834= 3

X115+X125+X135= 1
X215+X225+X235= 4
X315+X325+X335= 1
X415+X425+X435= 2
X515+X525+X535= 2
X615+X625+X635= 1
X715+X725+X735= 3
X815+X825+X835= 2

X116+X126+X136= 2
X216+X226+X236= 2
X316+X326+X336= 2
X416+X426+X436= 4
X516+X526+X536= 1
X616+X626+X636= 2
X716+X726+X736= 2
X816+X826+X836= 3

4- Output data

The resulting data explain the cost of knowledge assets which transport between the three hospitals under study. A software package called (Win QSB) was used to solve the linear programming model. From Table (6) the following can be concluded:

1. The final result from (WinQSB) determine the number of knowledge assets for each kind of disciplines, for example:
   - X111=2, this value means that hospital number (1) (University Hospital) will need two disciplines in Anesthesia for Intensive care Unit.
   - X221=1, this value means that hospital number (2) (Al-Beshir Hospital) will need one specialization in Neurosurgery for Burn Unit.
   - X321=2, this value means that hospital number (2) (Al-Beshir Hospital) will need two disciplines in Heart Surgery for Intensive Care Unit
   - X812=3, this value means that hospital number (1) (University Hospital) will need three disciplines in Dermatological for Burn Unit.
   - X432=3, this value means that hospital number (3) (Al-Hussein Hospital) will need four disciplines in Neurosurgery for Burn Unit.
2. Using input data in Table (4) and Table (5) we determine the cost of k1 and k3 k1= 5895, k3 = 12420
3. From Table (6) we can explain that the cost of k2 = 3120
4. Now we can determine the total cost of k by adding k1, k2 and k3 then the total transportation cost equal to: **K= 21435**

Table 6. The final result of decision variables (Xlmn)

Decision Variables In Mathematical Model		Decision Variables From (Win QSB)	Solution Value
X111	→	X1	2
X121	→	X2	0
X131	→	X3	0
X211	→	X4	0
X221	→	X5	1
X231	→	X6	0
X311	→	X7	0
X321	→	X8	2
X331	→	X9	0
X411	→	X10	2
X421	→	X11	0
X431	→	X12	0
X511	→	X13	3
X521	→	X14	0
X531	→	X15	0
X611	→	X16	0
X621	→	X17	3
X631	→	X18	0
X711	→	X19	2
X721	→	X20	0
X731	→	X21	0
X811	→	X22	1
X821	→	X23	0
X831	→	X24	0
X112	→	X25	0
X122	→	X26	3
X132	→	X27	0
X212	→	X28	2
X222	→	X29	0
X232	→	X30	0
X312	→	X31	2
X322	→	X32	0
X332	→	X33	0
X412	→	X34	0
X422	→	X35	0
X432	→	X36	3
X512	→	X37	1
X522	→	X38	0
X532	→	X39	0
X612	→	X40	0
X622	→	X41	1
X632	→	X42	0
X712	→	X43	0
X722	→	X44	2
X732	→	X45	0
X812	→	X46	3
X822	→	X47	0
X832	→	X48	0
X113	→	X49	1
X123	→	X50	0
X133	→	X51	0
X213	→	X52	2
X223	→	X53	0
X233	→	X54	0
X313	→	X55	2
X323	→	X56	0
X333	→	X57	0
X413	→	X58	3

X423	➔	X59	0
X433	➔	X60	0
X513	➔	X61	1
X523	➔	X62	0
X533	➔	X63	0
X613	➔	X64	2
X623	➔	X65	0
X633	➔	X66	0
X713	➔	X67	2
X723	➔	X68	0
X733	➔	X69	0
X813	➔	X70	0
X823	➔	X71	2
X833	➔	X72	0
X114	➔	X73	0
X124	➔	X74	2
X134	➔	X75	0
X214	➔	X76	2
X224	➔	X77	0
X234	➔	X78	0
X314	➔	X79	3
X324	➔	X80	0
X334	➔	X81	0
X414	➔	X82	2
X424	➔	X83	0
X434	➔	X84	0
X514	➔	X85	0
X524	➔	X86	1
X534	➔	X87	0
X614	➔	X88	3
X624	➔	X89	0
X634	➔	X90	0
X714	➔	X91	0
X724	➔	X92	2
X734	➔	X93	0
X814	➔	X94	0
X824	➔	X95	3
X834	➔	X96	0
X115	➔	X97	0
X125	➔	X98	1
X135	➔	X99	0
X215	➔	X100	0
X225	➔	X101	4
X235	➔	X102	0
X315	➔	X103	1
X325	➔	X104	0
X335	➔	X105	0
X415	➔	X106	2
X425	➔	X107	0
X435	➔	X108	0
X515	➔	X109	0
X525	➔	X110	2
X535	➔	X111	0
X615	➔	X112	1
X625	➔	X113	0
X635	➔	X114	0
X715	➔	X115	3
X725	➔	X116	0
X735	➔	X117	0
X815	➔	X118	2
X825	➔	X119	0
X835	➔	X120	0

X116	→	X121	0
X126	→	X122	2
X136	→	X123	0
X216	→	X124	0
X226	→	X125	2
X236	→	X126	0
X316	→	X127	0
X326	→	X128	2
X336	→	X129	0
X416	→	X130	0
X426	→	X131	4
X436	→	X132	0
X516	→	X133	0
X526	→	X134	1
X536	→	X135	0
X616	→	X136	2
X626	→	X137	0
X636	→	X138	0
X716	→	X139	0
X726	→	X140	2
X736	→	X141	0
X816	→	X142	0
X826	→	X143	3
X836	→	X144	0
Total Cost of k2 = 3120			

5- Conclusion

From the results of this study the following can be concluded:

1. Linear Programming model can be used as a tool to determine the economic value of knowledge assets as we saw above.
2. It is very important for decision makers to support decision-making processes related to investing in knowledge assets by applying quantitative methods which help get the best result with minimum cost.
3. Knowledge assets are strategic resources in service organizations such as hospitals, these resources need more attention from managers and academic researchers to develop scientific tools to manage them more efficiently and effectively.

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