Testing the Correlation Between Indoor Environmental Quality & Productive Time

Office		Office Location	No. of Concession, No. of Conces			
Operations Manage	ment G	Ground Floor	no. of Employees	Avg. Longevity	Ave. IFO Satisfaction	
Operations Departm	ient G	Fround Floor	2	7.6	E10/	Avg. Prod. Tim
Tender Managemen	t G	around Floor	3	1.8	01%	80%
Fiender Department	6	around Floor	1	65	48%	69%
Coordinations Mana	agement G	Ground Floor	3	22	50%	75%
Coordinator 1	6	Ground Floor	1	45	13%	5.69/
Projects Daval	0	around Floor	1	4.5	69%	50%
Projects Developme	nt Management	Ground Floor	1	3.5	33%	80%
Engineering Ma	nt Department	Sround Floor	1	1.3	20%	65%
Engineering Manag	ement 1	Lst Floor	2	8.0	34%	58%
Engineering Depart	ment 1 1	Lst Floor	1	2.2	6594	70%
Senior Engineering	ment 2 1	Ist Floor	10	12.0	73%	76%
Senior Engineering	1 1	1st Floor	10	3.3	72%	89%
Senior Engineering	2 1	1st Floor	2	1.9	5/%	6754
Senior Engineering	3 1	1st Floor	2	1.5	41%	0776
Senior Engineering	1	1st Floor	2	1.4	74%	67%
Accounting Departs	3 1	1st Floor	2	1.3	76%	79%
Human Resources	Dens	1st Floor		15	70%	80%
IN OVE	cpartment 1	1st Floor		5.8	70%	78%
of Unites			2	53	69%	78%
Contraction of the Contraction o		19		3.0	45%	82%
		3	Total Monthly M	1.0	66%	72%
			Wage Paya	bles		700/

Wissam Khoury, Issam Srour, Ali Yassine June 10, 2015





Premise of Study

- Improved IEQ in offices lead to enhanced productivity/profitability
 - Wages = 85% of office costs (Annika et al. 2013)
- IEQ: Physical and perceptual attributes of indoor spaces
 - E.g., thermal comfort, air quality, light, noise, sound, furniture, cleanliness

Hypothesis Tested



 H₀=No correlation between satisfaction with IEQ at workplace & productive time

Literature Review

- IEQ and Occupants' Well-Being
 Fever, asthma, stress, SBS
- IEQ and Satisfaction with Workplace
 - E.g., Kim and de Dear (2012) with Proportional vs Basic factors
- IEQ and Productivity
 - Qualitative and quantitative studies

Literature Review (cont'd)

- Methods used to measure productivity
 - Self-assessment: benchmark? Biased?
 - Simulations: complex, variability across workers?
- An easier approach may be measuring perceived *Productive Time*



Methodology

- Survey questionnaire
 - Section I: demographics
 - Section II: self-assessed time lost due to poor IEQ
 - Section III: self-assessed overall satisfaction with workplace
- 102 participants
 - Six organizations

Sample Questions

Section	Question	Measure/Scale
Section I	How long have you been working at your current workplace?	Years & Months
Section I	Your job description includes occupying your office for an average of:	Days a week & Hours a day
Section II	During the past week, how many days have you left work early due to being tired or depressed, and not feeling like dealing with the poor environmental conditions at your workplace as indicated in Questions I and 2?	Days
Section II	During the past 12 months, how many times have you felt that your workplace environment made you sick or too tired to work that you took a sick-leave (allergic, migraine, prolonged nausea, etc.)?	Times
Section III	How satisfied are you with the noise level in your workspace?	Scale I to 7
Section III	How satisfied are you with the temperature in your workspace?	Scale I to 7

Inferred Parameters

- Productive time=Working time Lost time
 - Lost time: QI-I5 covering various IEQ related impediments
- Percent IEQ satisfaction
 - Self-perceived, scale of I-7
 - Using weights proposed by Kim & de Dear (2012)*
- Longevity

* Kim, J. and de Dear, R. 2012. Nonlinear relationships between individual IEQ factors and overall workspace satisfaction. *Building and Environment* **49** :33-40.

Summary of Results

	Ν	Range	Minimum	Maximum	Mean	Std. Deviation
Percent Productive Time	99	68.6	30.8	99.4	72.6	14.9
Percent IEQ Satisfaction	99	97.8	2.2	100	54.3	23.9
Longevity	99	11.9	0.1	12	3.1	2.9



		Percent Productive Time	Percent IEQ Satisfaction
Percent Productive Time	Pearson Sig. N	l 99	.56** 0 99
Percent IEQ Satisfaction	Pearson Sig. N	.56** 0 99	l 99

Regression Analysis



Explaining U-Shape

- Relatively high *longevity* on left-hand side
- Hence, longevity is another factor which affects the way IEQ affects productivity
 - E.g., % Productive Time = 0.39×IEQ Sat. +
 0.01×Longevity + 0.49

Putting This Work in Use

Capital budgeting optimization tool



Capital Budgeting Tool Formulation



User manual task (business owner; employer; human resource officer, etc.)

User fed data into optimization

program

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Automated action/decision performed by optimization program

Output result/decision by optimization program to end-user

Capital Budgeting Tool Formulation Phase I: Output

	A	В	С	D	E	F	G	Н				
1	Office Ref. #		Office	Office Location	No. of Employees	Avg. Longevity	Avg. IEQ Satisfaction	Avg. Prod. Time				
2	1	6	Operations Management	Ground Floor	2	7.6	61%	80%				
3	2	4	Operations Department	Ground Floor	3	1.8	48%	69%				
4	3	4	Tender Management	Ground Floor	1	6.5	50%	75%				
5	4	9	Tender Department	Ground Floor	3	2.2	13%	56%				
6	5	6	Coordinations Management	Ground Floor	1	4.5	69%	80%				
7	6	4	Coordinator 1	Ground Floor	1	3.5	33%	65%				
8	7	4	Coordinator 2	Ground Floor	1	1.3	20%	58%				
9	8	4	Projects Development Management	Ground Floor	1	8.0	34%	70%				
10	9	6	Projects Development Department	Ground Floor	2	2.2	65%	76%				
11	10	6	Engineering Management	1st Floor	1	12.0	72%	89%				
12	11	4	Engineering Department 1	1st Floor	10	3.3	37%	67%				
13	12	9	Engineering Department 2	1st Floor	10	1.9	41%	67%				
14	13	6	Senior Engineering 1	1st Floor	2	1.5	74%	79%				
15	14	6	Senior Engineering 2	1st Floor	2	1.4	76%	80%				
16	15	6	Senior Engineering 3	1st Floor	2	1.3	70%	78%				
17	16	6	Senior Engineering 4	1st Floor	2	1.5	70%	78%				
18	17	6	Senior Engineering 5	1st Floor	2	5.8	69%	82%				
19	18	4	Accounting Department	1st Floor	4	5.3	46%	72%				
20	19	6	Human Resources Department	1st Floor	2	3.0	66%	78%				
21												
22	Total Number o	f Of	fices	19	Total Monthly Wage Paya		\$155,850					
23	Total Number o	f En	nployees	52	Total Budget Allocated for	or Renovation	ation					

Capital Budgeting Tool Formulation



User manual task (business owner; employer; human resource officer, etc.)

User fed data into optimization program



Automated action/decision performed by optimization program



Output result/decision by optimization program to end-user

Capital Budgeting Tool Formulation Phase 2: Retrofit Options Definition

	A	В	C					D	E	E F	: C	βŀ	1	I J	K	(L	. 1	M	NC	P	Q	R S	3		
1	1 PRESS 'CTRL-R' BEFORE RUNNING SOLVER																								
2	Possible Retrofit Options												Affe	ote	d IE	Q F	ac	tors							
3	Retrofit	:	Description				C	ost		12	23	3 4	1 5	56	7	' 8	1	91	0 11	12	13	14 1	5		
8	5	×	Relocating all archives in a newly built archive areas near the company building				\$1	7,50		-	1	1	1		1						1	1			
9	6		Lighting replacement with LED equivalents for all the offices				\$2	2,00	0		1	1 1	1												
10	7	2	Lighting replacement with LED equivalents for Second Floor offices (Engineerin	ig ol	ffice))	\$10	0,00	5		1	1	1												
11	8		Lighting replacement with LED equivalents for ground floor office				\$14	4,00	2		1	1 1	1												
12	9		Replacing burnt lights with previously existing				\$	500				1	1												
13	10	4	Enlarging windows of Accounting Department				\$1	1,500		-	1 1	1 1	1												
14	11		Renewing all personal computers in Operations Department				\$6	6,000)										1				1		
15	12		Replace old furnishing in Operations and Engineering Management offices	T										ALC A		1 41	1			4 441	40	A D	1	40	40
16	13		Repainting whole building (internal and external)		U	V	W 2	S Y	4	HH H			HE	AF P		1 HI	- AJ	AK			AO	AP	АQ	AR	AS
17	14		Repainting ground floor only	d floor only								ed Of	fice	5						A	l-or-l	Non	One-of-Many		
18	15	4	Repainting first and second floor	1	2	3	4 5	56	7	8	9 10) 11	12	13 1	4 15	5 16	17	18	19 20) C1	C2	C3	C1	C2	C3
19	16		Expanding tender department	1				1 1	1	1	1 1		1	1	1	1	1	1							
20	17		Expanding operations department	1	1	1	1 .	1 1	1	1	1	_			_	_							\mid		
21	18		Expanding coordinations department	+ '	1	1	1	1 1	1	1	1	1	1	1	1 1	1	1	1				\vdash	\vdash		
22	19	L	Creating cubical-offices for more privacy and sound control	1	1	1					1	1	· ·		1 1	1	1	1							
23	20	Ľ	Fixing water leaks	1	1	1	1	1 1	1	1	1 1	1	1	1	1 1	1	1	1	1	1			\square		
24	21			1	-	-				-	1	1	1	1	1 1	1	1	1	1	1		\square	\mid		
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Capital Budgeting Tool Formulation Phase 2: Summary of Optimized Result

4	A	С	D	E	F	G	Н				
1	Office Ref. #	Office	Office Location	No. of Employees	Expected Avg. IEQ Sat.	Exp. Avg. Prod. Time	Exp. Prod. Time Increase				
2	1	Operations Management	Ground Floor	2	69%	84%	3%				
3	2	Operations Department	Ground Floor	3	81%	82%	13%				
4	3	Tender Management	Ground Floor	1	69%	82%	7%				
5	4	Tender Department	Ground Floor	3	53%	72%	15%				
6	5	Coordinations Management	Ground Floor	1	74%	82%	0%				
7	6	Coordinator 1	Ground Floor	1	68%	79%	14%				
8	7	Coordinator 2	Ground Floor	1	34%	64%	5%				
9	8	Projects Development Management	Ground Floor	1	38%	72%	2%				
10	9	Projects Development Department	Ground Floor	2	87%	85%	9%				
11	10	Engineering Management	1st Floor	1	85%	94%	5%				
12	11	Engineering Department 1	1st Floor	10	89%	87%	20%				
13	12	Engineering Department 2	1st Floor	10	75%	80%	13%				
14	13	Senior Engineering 1	1st Floor	2	79%	81%	0%				
15	14	Senior Engineering 2	1st Floor	2	93%	87%	0%				
16	15	Senior Engineering 3	1st Floor	2	84%	83%	0%				
17	16	Senior Engineering 4	1st Floor	2	85%	84%	6%				
18	17	Senior Engineering 5	1st Floor	2	88%	89%	7%				
19	18	Accounting Department	1st Floor	4	76%	84%	0%				
20	19	Human Resources Department	1st Floor	2	86%	86%	0%				
21											
22	2 Overall Expected Increase in Corporate Productive Time										
23	3 Total Cost of Optimal Solution for Renovation										
24	nonconte	The offices that will		Total Budget Available for	or Renovation		\$97,000				
25	25 Total Cost of Possible Retrofit Options										

Thank you! Issam Srour Associate Professor American University of Beirut issam.srour@aub.edu.lb

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