

## **Operations Management**

### **Midterm 1**

**26/3/2012**

**Duration 2h30m**

Remember the following tips:

- Budget your time. Skim through the exam before starting.
- Show all your work to allow us to give you partial credit if appropriate.
- Answer groups in separate pages and please write down your name in all pages.

**Good Luck!**

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#### **Group 1 (70 points)**

a) Classify the following statements as True (T), False (F), or Undetermined (U). Justify briefly your answer (max 3 lines). Most of the grade will be based on the justification.

a1) (5 pts) Using the terminology of statistical control, the variation outside the control limits on an X-bar or range chart, is assumed to have been caused by special or assignable causes.

a2) (5 pts) Using the terminology of statistical control, if we observed that the variation of the average is all within the control limits on an X-bar chart we know the process is under control.

a3) (5 pts) A company that uses control charts to continuously verify the evolution of some process quality metrics (e.g. averages, ranges, etc) is not taking into account its immediate customer needs.

a4) (5 pts) Exponential smoothing is a special type of weighted moving average.

a5) (5 pts) The EOQ (or optimal Q) refers to the order quantity for which the annual holding costs and the annual ordering costs are the same.

a6) (5 pts) In a product/process matrix, as we move from 'project' to 'continuous process', we typically will encounter lower volumes, less vertical integration, more resource flexibility, more customer involvement and less capital intensity.

a7) (5 pts) The hamburgers production system in fast-food chains like Mcdonalds and Burger King represents a good example of a 'assembly line' in the services context.

a8) (5 pts) In a optimal fixed-quantity system with backorders, if  $b=H$ , then  $2B^*=Q^*$

b) (10 pts) Show that in fixed-quantity system with backorders, the economic order quantity can be two times the amount of an equivalent model without backorders, if the holding cost is three times the backorder cost?

c) (10 pts) Let's use an example of queuing in healthcare. Suppose we know the average number of patients in the hospital is 102.5 and the average discharge rate is 67.5 patients per day. What is the average time a patient spends in the hospital?

d) (10 pts) At the drive-through counter of a fast-food outlet, an average of 10 cars waits in line. The manager knows that, on average, 2 cars per minute try to enter the drive-through area, but 25% of these cars are dismayed by the line and leave without entering the line and placing orders. Assume that no car entering the line leaves without service. On average, how long does a car spend in the drive-through line?

## Group 2 (35 points)

You are a senior consultant at a top consulting firm, Eccenture and have managed to sell a project to a major Crowdfunding Company, PPLFunder. If successfully implemented, your “boss” will seriously consider your promotion to manager and consequent compensation increase.

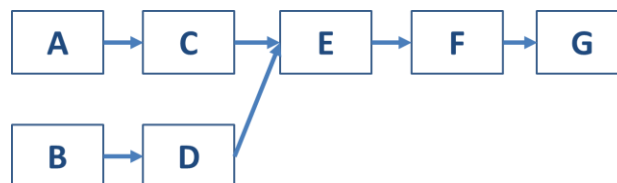
PPLFunder Crowdfunding – is an online collective finance platform, where entrepreneurs put up their projects for funding, offering rewards in exchange for investments from the crowd. The origination process for new projects (process of project application and approval until the project is live and soliciting funds from the crowd) goes through several steps. The CEO of PPLFunder has bought your project after you promised to significantly increase his capacity for processing new project applications per day whilst keeping overall costs to a minimum as the company is a start-up and they are bootstrapping (a self-sustaining process that proceeds without external help/finance).

Find below some relevant capacity information.

STEP	DESCRIPTION	TOTAL CAPACITY
A	Fill in application form	An application form takes on average 35 minutes to fill in by any applicant
B	Upload promotion video	PPLFunder has a bandwidth of 7.2 Mb per second for uploads
C	Application Risk Analysis	3 resources = 90 applications per day
D	Upload promotion images	PPLFunder has a separate channel for uploading images with a bandwidth of 0.2 Mb per second
E	Application final approval	1 resource = 30 applications per day
F	Publishing of application	100 applications per day
G	Message broadcast to launch investment	65 applications per day

Notes:

- Each application requires to have 1 video with, on average, 7200 Mb
- Each application requires to have 6 images, on average 6 Mb per image
- Application risk analysis is done by 3 resources of a certain skillset
- Application final approval is done by the CEO himself, with the same skillset as his 3 colleagues
- Capacity of publishing of an application consists of the system ability to process all components of an application
- Message broadcasting capacity is the willingness of the company to broadcast a maximum number of messages per period.



a) What is the capacity of PPLFunder in applications for new projects per day? Which resource(s) is(are) the bottleneck(s)?

A: no limit on capacity (note: 35 mins per application is irrelevant data)

B: 1 video = 7200 Mb but capacity = 7.2Mb / sec for upload

So this means 1 video takes  $7200/7.2 = 1000$  sec to upload

1 hr has 3600 seconds so 3.6 videos can be uploaded per hour

Assume 24 hours in a day, so 86.4 videos (round to 86) can be uploaded per day

1 video per application means B: 86 applications per day

C: 90 applications per day

D: 6 images per application. On average 6 Mb per image which means on average 36Mb per application. At a rate of 0.2 Mb per second this means an average of  $36/0.2 = 180$  seconds per application. In 1 hour (3600 seconds) this means 20 applications (3600/180). In 1 day, assuming 24 hrs in a day, this means 480 applications.

E: 30 applications per day

F: 100 applications per day

G: 65 applications per day

Current capacity of PPLFunder is 30 applications per day

System bottleneck is the CEO with 30 applications per day

- b) How much slack (unused capacity) is available in the other resources (in applications for new projects per day)?

Slack:

A: no limit on capacity which means the slack is infinite

B: capacity 86 applications per day but production of 30. Slack =  $86 - 30 = 56$  applications per day

C: capacity 90 applications per day but production of 30. Slack =  $90 - 30 = 60$  applications per day

D: capacity 480 applications per day but production of 30. Slack =  $480 - 30 = 450$  applications per day

E: system bottleneck: slack = 0

F: capacity 100 applications per day but production of 30. Slack =  $100 - 30 = 70$  apps per day

G: capacity 65 applications per day but production of 30. Slack =  $65 - 30 = 35$  apps per day

- c) You recommend that PPLFunder's CEO increase the capacity of Application Final Approvals to 60 applications per day. How would you increase this capacity? What is the new bottleneck?

Increase this capacity by delegating approvals on 1 resource that you remove from Application Risk Analysis. This way capacity of App Risk Analysis = capacity of App Final Approval = 60. New bottleneck = App Risk Analysis = App Final Approval = 60 apps per day.

- d) Based on your recommendation, do you get the promotion at Eccenture? If yes why? If not, what would it take? List 1 critical assumption you were required to make.

I would get the promotion as I was able to recommend an increase in capacity at no extra cost to PPLFunder. Had I recommended hiring a resource for Final Approval instead of delegating from the CEO and just moving 1 resource, I would be adding an unnecessary cost and this would result in an unhappy CEO and no promotion at Eccenture for myself.

Critical assumption taken:

All applications submitted for approval are approved and sent for Publishing and Message Broadcast. Otherwise the CEO's initial capacity of reviewing 30 applications per day for approval could result in even less than 30 applications published and broadcasted per day.

### Group 3 (30 points)

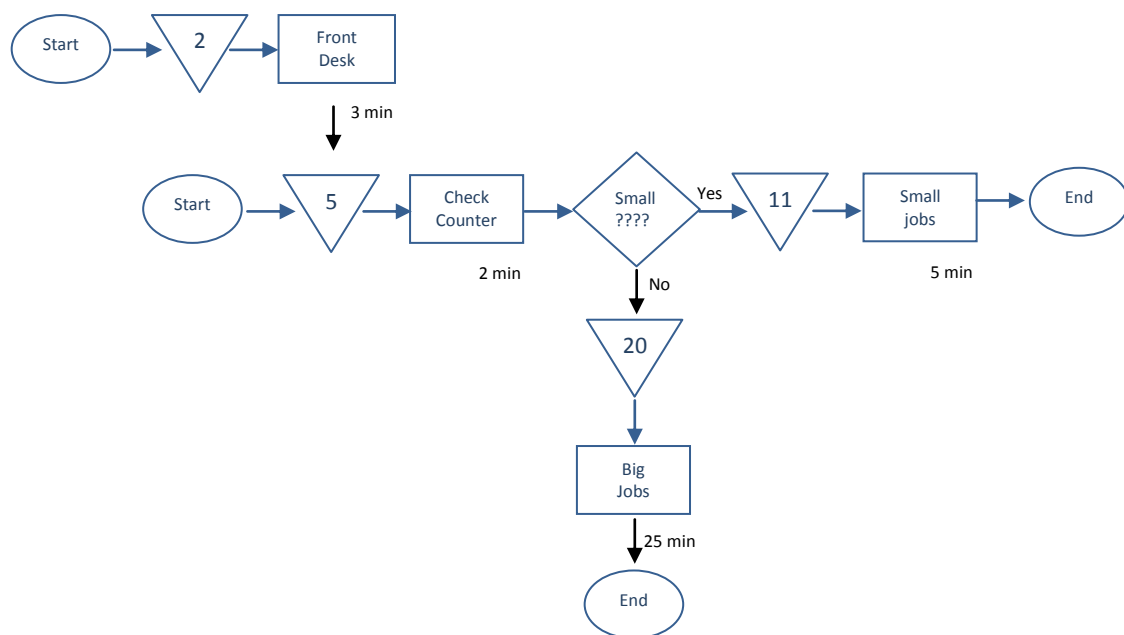
Printix is a copy service organized as a franchise system very well implemented with branches in several universities in Portugal. At their headquarters in Palm Top Street they have a 24 hours service, which receive orders from several franchisees and from the customers that go directly to the store.

From the franchisees they receive an average of 90 jobs per hour. All the jobs from the franchisees are received by a check counter which distributes the orders by type – this process takes on average 2 minutes per work. 60% of the jobs, the small ones (under 100 pages), go to the small copy machines which take, in average 5 minutes / each. The bigger jobs take, on average 25 minutes to process.

From the clients that go directly to the store they receive more 20 jobs/hour which are received in the front desk and then enter in the regular process (check counter and copy machines). In the front desk, on average there are 2 clients waiting to deliver their order and the registering process takes 3 minutes. Assume the same type of work distribution as the franchisees.

On average, there are 5 jobs waiting to be processed in the check counter, 11 waiting to be processed in the small machines and 20 in the big ones.

a) Draw a flow diagram for the Printix copying process.



b) If you go to the store to copy a document with 30 pages how long will you wait until the job is done?

Little Law  $I = R \times T$

Waiting Front Desk =>  $2 = 20 \times T \Rightarrow T = 0,1 \text{ hours} = 6 \text{ minutes}$

Waiting Check Counter =>  $5 = 110 \times T \Rightarrow T = 0,0(45) \text{ hours} = 2,73 \text{ minutes}$

Waiting Small Jobs =>  $11 = (0,6 \times 110) \times T \Rightarrow T = 0,1(6) \text{ hours} = 10 \text{ minutes}$

Waiting Big Jobs =>  $20 = (0,4 \times 110) \times T \Rightarrow T = 0,455 \text{ hours} = 27 \text{ minutes}$

Time Small machines =  $6 + 3 + 2,73 + 2 + 10 + 5 = 28,73 \text{ min}$

c) On average, how many jobs are in the process?

Little Law  $I = R \times T$

Front Desk =>  $I = 20 \times 3/60 \Rightarrow I = 1 \text{ job}$   
 Check Counter =>  $I = 110 \times 2/60 \Rightarrow I = 3,6 \text{ jobs}$   
 Small Jobs =>  $I = (0,6 \times 110) \times 5/60 \Rightarrow I = 5,5 \text{ jobs}$   
 Big Jobs =>  $I = (0,4 \times 110) \times 25/60 \Rightarrow I = 18,3 \text{ jobs}$

Number of jobs in the process =  $2 + 1 + 5 + 3,6 + 11 + 5,5 + 20 + 18,3 = 66,5 \text{ jobs}$

#### Group 4 (35 points)

Shoex is a Portuguese shoe manufacturer, known for its extravagant designs. Their flagship product, Shoex SX2k, is currently hand-made in its factory, in the North of Portugal. This differentiated product sells for 80€ and costs 35€ to produce. There is a constant demand of 200 pairs per week. The factory operates 5 days a week, all 50 weeks per year, and can currently produce 50 pairs of Shoex SX2k per day. Finished goods are stored in a rented warehouse, which charges 5€ per pair, annually. Just before every new production run, the technicians need to perform a light maintenance which costs 450 €.

Sell price	80,00 €
Production cost	35,00 €
Holding cost	5,00 €
Demand (D)	200 / week
Production rate	50 / day
Labor weeks	50 / year
Labor days	5 / week
Setup cost	450,00 €
Production (P)	250 / week

a) Under these conditions, what is the optimal batch size and how many productions runs must the factory perform each year, on average?

$$Q^* = 3000,00$$

$$\text{Nr. of yearly runs} = 3,33$$

b) Shoex management is considering outsourcing its production to Asia, to reduce manufacturing costs. In fact, a supplier already proposed Shoex to manufacture each pair at 29€, assuring the same build quality. However, the shipping costs and lead time are high. The estimate is a 10.000€ cost per order, including taxes. In addition, the shipping company also constrains the batch size to multiples of 500 units. The management team is unsure about this decision and has asked you, a senior top consultant from BGC, which is the best option.

From a cost perspective, what would your recommendation be? Should Shoex outsource its production or keep its local manufacturing?

Product cost = 29 €  
Order cost = 10.000 €

**POQ:**

TC = 1.500,00€ + 1.500,00€ + 350.000,00€ = **353.000,00 €**  
Setup          Holding          Production

**EOQ:**

$Q^* = 6324,56 \Rightarrow 6325$  pairs  
Nr. orders per year = 1,58

Q	Order	Holding	Product	Total
6000	16.666,67 €	15.000,00 €	290.000,00 €	321.666,67 €
6325	15.810,28 €	15.812,50 €	290.000,00 €	321.622,78 €
6500	15.384,62 €	16.250,00 €	290.000,00 €	<b>321.634,62 €</b>

**Ans.: 321k < 353k = better to outsource**

- c) Given the fact that its consumers are fashion-savy, Shoex decided to create the concept of seasons. Thus, every 20 weeks, a new variation of the SX2k is launched in the market. The average demand remained the same but some designs sell more than others. The estimated standard deviation is 200. The company is okay with some stock-outs. In fact, this scarcity effect creates a sense of exclusivity. But even less popular designs can be sold after the end of the season, at outlet retails, at 30% the normal price. In this case, they have to pay 3€ per pair for the storage.

Assuming the management decided to opt for the outsourcing solution, due to the lower unit cost, please explain how to calculate the optimal number of units the company should order (please quantify your answer as much as you can)?

Season length          20 weeks  
Demand                  4000  
Std dev                  200  
Outlet price            24,00 €  
Holding cost            3,00 €

$C_u = 51,00 €$   
 $C_o = 8,00 €$

CSL = 0,864  
 $Q = 4220,07$

**Ans.: They should order 4220 items per season.**

### Group 5 (30 points)

You are a manager at CrowdDreams, a company that takes advantage of the crowd's resources to help entrepreneurs make their dreams come true. Entrepreneurs submit their projects online, and your team job is to review their business plans, decide whether to approve or reject the project, and help the entrepreneur build a powerful and inspiring pitch to attract the interest from the crowd.

- a) **(5 points)** You would like to know how many projects are going to be submitted in the near future, given the data of the previous months. Because the industry is very recent, the number of submissions is quite unpredictable, and you decide to use the 3-period simple moving average method. Calculate the forecast for months 4 to 7, as well as the Mean Absolute Deviation (MAD) and Mean Square Error (MSE) for the same period, based on the data obtained from the initial 6 months of operation.

month	1	2	3	4	5	6
submitted projects	7	12	8	19	24	26

month	1	2	3	4	5	6	7
submitted projects	7	12	8	19	24	26	
Forecast				9	13	17	23
Error				10	11	9	
Abs Error				10	11	9	
SQ Error				100	121	81	

MAD	10
MSE	100,7

- b) **(10 points)** After one year, you decide to change your forecasting method. You are still using the 3-month moving average, but you think that the data from the last month is twice as meaningful as the other two months. Calculate the forecast for months 10-13 as well as the MAD and MSE for that period.

month	7	8	9	10	11	12
submitted projects	12	8	16	28	32	24

month	7	8	9	10	11	12	13
submitted projects	12	8	16	28	32	24	
Forecast				13	20	27	27
Error				15	12	-3	
Abs Error				15	12	3	
SQ Error				225	144	9	

MAD	10
MSE	126,0

w1 0,5  
w2 0,25  
w3 0,25

- c) **(15 points)** Three years have passed, and you finally realize that the number of submitted projects is cyclical. You have summarized the quarterly data as shown in the table below. You also have computed the least squares regression line function and the seasonality indexes for each month. Find the forecast for each quarter of 2014 using seasonal indexes.

	2011				2012				2013			
Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Submitted projects	27	69	36	84	43	92	50	112	62	134	70	154
Seasonal index	0,74	1,57	0,70	1,42	0,65	1,24	0,61	1,26	0,64	1,29	0,63	1,29

Linear regression:  $y = 28,95 + 7,51 x$

First use the linear regression formula to calculate the Forecast without seasonal index for each of the periods of 2014

$$y = 28,95 + 7,51 x$$

Then calculate the average seasonal index for each of the quarters:

St Q1	0,68
St Q2	1,37
St Q3	0,65
St Q4	1,33

Finally, calculate the forecast with the seasonal index for year 2014.

	2014			
	Q1	Q2	Q3	Q4
x	13	14	15	16
Tt	126,55	134,05	141,56	149,07
St	0,68	1,37	0,65	1,33
Forecast w/ seasonal	85,61	183,24	91,56	197,57