Sales and inventory system essay sample

The objective of this chapter is to identify key operational measures that may be used to study process flows. They are linked together using Little's law. We then present a series of examples that show how process flow analysis may be used to study performance. The objective is to study current performance as well as identify target areas for improvement. We also link the operational measures of performance to financial measures.

In a class of 100 minutes we start by discussing the importance of building a time based capability in today's competitive environment. We then establish Little's law to set up other operational measures – namely inventory and throughput that impact flow time. Several examples from the chapter are discussed to make this relationship clear. We then link these operational measures to financial measures to identify what form improvements may take. We then discuss the Kellogg CRU Rental case to demonstrate how such an analysis may be used to identify key areas for improvement. 3. 2 Additional Suggested Readings

We assign a short case as supplemental reading for the analysis of process flows. The case is used to do a thorough analysis of flows and identify key drivers of cost and revenue in a process. This understanding is then used to identify actions that improve performance. * " CRU Computer Rentals". Kellogg Case. Author: Sunil Chopra. Available from: http://www. kellogg. northwestern. edu/cases/index. htm. Suggested assignment questions are contained in the case.

3. 3 Solutions to the Chapter Questions

Discussion Question 3. 1

The opposite of looking at average is looking at a specific flow unit's flow time, and the inventory status and instantaneous flow rate at a specific point in time. Because flow times change from flow unit to flow unit, it is better to look at the average over all flow units during a period of time. Similar for inventory and throughput.

Discussion Question 3. 2

In practice, one often tracks inventory status periodically (each day, week, or month). Flow rate is typically also tracked periodically (even more frequently than inventory status because it directly relates to sales). It then is easy to calculate the average of those numbers to obtain average inventory and throughput during a period.

In contrast, few companies track the flow time of each flow unit, which must be done to calculate the average flow time (over all flow units during a given period).

Discussion Question 3. 3

First, draw a process flow chart.

Second, calculate all operational flows: throughput, inventory, and flow time for each activity. Third, calculate the financial flow associated with each activity. If the activity incurs a cost (or earns a revenue), the cost or revenue rate is simply the throughput times the unit cost or revenue. If the inventory incurs a holding cost, the inventory cost rate is simply the average inventory times the unit holding cost. Fourth, summing all revenue rates and deducting all cost rates yields the profit rate, directly broken down in terms of the relevant throughputs and inventory numbers. The latter thus are the minimal set of operational measures to predict financial performance.

Discussion Question 3. 4

For the department of tax regulations we have

Average inventory I = 588 projects,

Throughput R = 300 projects/yr (we assume a stable system). Thus,

Average flow time T = I / R = 588 / 300 = 1. 96 yr.

This is larger than six months. So we should disagree with the department head's statement.

Discussion Question 3. 5

If GM and Toyota have same turns, and we know that

turns = 1/flow time = 1/T,

it follows that their average flow times are the same. We also know that Toyota's throughput is twice that of GM. Thus, from I= RT

it follows that Toyota has twice the inventory of GM. Thus, the statements are inconsistent, both companies have the same flowtime but Toyota has higher inventory than GM.

Discussion Question 3. 6

Yes, low inventories means few flow units are held in the buffer. In contrast, fast inventory turns means short flow times; i. e., flow units do not spend a long time in the process. As such, one can have high turns with high or low inventories (it all depends on what the throughput is).

Discussion Question 3. 7

A short cost-to-cash cycle means that it does not take long to convert an input into a sold output. Clearly, this is good because we do not need to finance the input for a long time before it earns revenue (i. e., lower working capital requirements). Short cost-to-cash cycle requires short flow times, which imply low inventories (for a given throughput), or high throughput (for a given inventory).

Exercise 3. 1 (Bank)

For the bank we have

Average inventory I = 10 people,

Throughput R = 2 people/min (we assume a stable system).

Thus,

Average flow time T = I / R = 10/2 min = 5 min.

Exercise 3. 2 (Fast-Food)

For the fast food outlet we have

Average inventory I = 10 cars.

Throughput evaluation is as follows: Cars attempt to enter the drive through area at a rate of 2 cars/min. However 25% of cars leave when they see a long queue. Thus, cars enter the drive through at a flow rate R = 75% * 2 cars/min = 1. 5 cars/min. Thus Average flow time T = I / R = 10/1. 5 min = 6. 67 min.

Exercise 3. 3 (Checking Accounts)

For a checking account we have

Average inventory I = average balance = $3, 000

Turns = 6 per year.

Average flow time T = 1 / turns = 1/6 year = 2 months.

Thus

Throughput R = I / T = 3, 000/2 = $1, 500 / month.

Exercise 3. 4 (ER)

First draw the flowchart with all the data given:

We assume a stable system. This implies that average inflow equals average outflow at every stage. In this case you are given inventory numbers I and flow rate R = 55 patients/hr. There are two flow units:

(1) Those that are potential admits: flow rate = 55*10% = 5. 5/hr. (2) Those that get a simple prescription: flow rate = 55*90% = 49. 5/hr.

To find the average flow times, we use Little's law at each activity for which the flow time is unknown:

(1) Buffer 1: R = 55/hr (both flow units go through there), I = 7, so that waiting time in buffer 1 = T = I/R = 7/55 hr = 0. 127 hours = 7. 6 minutes.

(2) Registration: flow time T = 2 min = 2/60 hr. All flow units flow through this stage. Thus flow rate through this stage is R = 55 / hr. Average inventory at registration is given by I = RT = 55*2/60 = 1. 83 patients.

(3) Buffer 2: R = 55/hr (both flow units go through there), I = 34, so that waiting time in buffer 2 = T = I/R = 34/55 hr = 0. 62 hours = 37. 1 minutes.

(4) Doctor time: depends on the flow unit:

4a: potential admits: T = 30 minutes

4b: prescription folks: T = 5 minutes

OK, now we have everything to find the total average flow times: find the critical path for each flow unit. In this case, each flow unit only has one path, so that is the critical path. We find its flow time by adding the activity times on the path:

(a) For a potential admit, average flow time (buffer 1 + registration + buffer 2 + doctor) = 7. 6 + 2 + 37. 1 + 30 = 76. 7 minutes (b) For a person ending up with a prescription, average flow time (buffer 1 + registration + buffer 2 + doctor) = 7. 6 + 2 + 37. 1 + 5 = 51. 7 minutes.

The answer to the other questions is found as follows:

1. On average, how long does a patient spend in the emergency room? We know the flow time of each flow unit. The average flow time over all flow units is the weighted average: 10% of total flow units spend 76. 7 minutes while 90% spend 51. 7 minutes. Thus, the grand average is:

T = 10% * 76. 7 + 90%*51. 7 = 54. 2 minutes.

2. On average, how many patients are being examined by a doctor? This question asks for the average inventory at the doctor’s activity. Again, first calculate inventory of each type of flow unit:

(a) Potential admits: R = 5. 5 patients/hr, T = 30 min = 0. 5 hr, thus, I = RT = 5. 5/hr*0. 5 hr = 2. 75 patients

(b) Simple prescription: R = 49. 5 patients/hr, T = 5 min = (5/60) hr, thus I = RT = 49. 5*(5/60) = 4. 125 patients Thus, total inventory at the doctor is 2. 75 + 4. 125 = 6. 865 patients.

3. On average, how many patients are in the ER?

This question asks for total inventory in ER = inventory in buffer 1 + inventory in registration + inventory in buffer 2 + inventory with doctors = 7 + 1. 83 + 34 + 6. 865 = 49. 695 patients.

Exercise 3. 5 (ER, triage)

The process flow map with the triage system is as follows:

The inventory, and time spent in various locations are as follows. In each case the calculated quantity is italicized.

Throughput through ER, R = 55 patients / hour = . 9167/min.

Average inventory in emergency room, I = sum of inventory in all stages = 50. 63 patients

Average time spent in the emergency room = I/R = 50. 63/. 9167 = 55. 23 minutes.

For patients that are eventually admitted, average time spent in the emergency room = time in buffer 1 + registration + buffer 2 + triage nurse + buffer 3 + doctor (potential admit) = 71. 18 minutes.

Exercise 3. 6 (ER, triage with misclassification)

In this case the process flow map is altered somewhat since there are some patients sent from simple prescriptions to buffer 3.

(We will assume that the doctor " instantaneously" recognizes misclassification so that a misclassified patient does not spend 5 minutes with the doctor. However, if you assume such person also spends 5 minutes, the entire methodology below follows, only increase the relevant flow time by 5 minutes.) The inventories, throughputs and flow times are as follows:

Throughput through ER, R = 55 patients / hour

Average inventory in emergency room, I = sum of inventories in all stages = 37. 46

Average time spent in the emergency room T = I/R = 37. 46/. 9167 = 40. 86 minutes.

To calculate flow times, we should distinguish three types of flow units: (1) those that are correctly identified as potential admits the first time: flow rate = 55*9% = 4. 95/hr. Average flow time = time in buffer 1 + registration + buffer 2 + triage nurse + buffer 3 + doctor (potential admit) = 56. 82 minutes (2) those that are first mis-identified as simple prescription and later corrected and redirected to potential admits: flow rate = 55*1% = 0. 55/hr. Average flow time = time in buffer 1 + registration + buffer 2 + triage nurse + buffer 4 + buffer 3 + doctor (potential admit) = 74. 80 minutes (3) those that are correctly identified to get a simple prescription the first time: flow rate = 55*90% = 49. 5/hr. Average flow time = time in buffer 1 + registration + buffer 2 + triage nurse + buffer 4 + buffer 3 + doctor (simple prescription) = 38. 89 minutes

For patients that are eventually admitted, that is types (1) and (2), average time spent in the emergency room is the weighted average of their flow times. Type (1) is fraction 4. 95/(4. 95+0. 55) = 90% of those admitted and type (2) is 0. 55/(4. 95+0. 55) = 10% of those admitted. Thus, average flow time for patients that are eventually admitted is 90%*56. 82min + 10%*74. 80. 8min = 58. 62 min.

Note that the overall average flow time over all patients is: 9%*56. 82min + 1%*74. 80min + 90%*38. 89. 8min = 40. 86 min, in agreement with the number derived directly from Little's Law above.

Exercise 3. 7 (Orange Juice Inc)

First let us notice that there are two periods in the day:

1. From 7am-6pm, oranges come in at a rate of 10, 000kg/hr and are processed, and thus leave the plant, at 8000kg/hr. Because inflows exceed outflows, inventory will build up at a rate of R = 10, 000-8, 000kg/hr = +2, 000 kg/hr.

Thus, because we cannot have oranges stored overnight, we start with an empty plant so that inventory at 7am is zero: I (7 am) = 0. Because inventory builds up linearly at 2, 000kg/hr, the inventory at 6pm is I(6pm) = 2, 000 kg/hr * 11 hr = 22, 000kg.

2. After 6pm, no more oranges come in, yet processing continues at 8000 kg/hr until the plant is empty. Thus, inflows is less than outflows so that inventory is depleted at a rate of R = 0 – 8, 000 kg/hr = – 8, 000 kg/hr.

Thus, since we have that I(6pm) = 22, 000kg, we know that inventory depletes linearly from that level at a rate of -8, 000 kg/hr. Thus, to empty the plant, inventory must reach zero and this will take an amount of time t where: 22, 000 kg – 8, 000 kg/hr t = 0, or

t = 22, 000/8, 000 hr = 2. 75 hr = 2 hr 45min.

Thus, the plant must operate until 6pm + 2hr 45min = 8: 45pm.

This can all be graphically summarized in the inventory build up diagram shown above.

3. Truck dynamics: for this the inventory diagram is really useful. Notice that we have taken a total process view of the plant, including the truck waiting queue. Thus, inventory is total inventory in the bins + inventory in the trucks (if any are waiting). So, let's draw the thick line on the inventory build-up diagram, representing the bin storage capacity. First inventory builds up in the bins. When the bin is full, then the trucks must wait. This happens at: 2, 000 kg/hr t = 6, 000kg,

so that the first truck will wait after t = 6, 000/2, 000 hr = 3 hr, which is at 10am. Now, the last truck that arrives (at 6pm) joins the longest queue, and thus will wait the longest. That " unfortunate" truck will be able to start dumping its contents in the bins when the bins start depleting. This is at 22, 000 kg – 8, 000 kg/hr t = 6, 000,

or after t = (22, 000-6, 000)/8, 000 hr = 2 hr, after 6pm. Thus, the last truck departs at 8pm and the maximum truck waiting time is therefore 2 hours.

Now, among all the trucks that do wait (i. e., those arriving after 10am), the first truck waits practically zero minutes, and the last truck waits 2 hours, culminating in an average of (0 + 2)hrs/2 = 1 hour.

Notice that the trucks arriving before 10am do not wait. Thus, the overall average truck waiting time is (# trucks arriving before 10am * 0 + # trucks arriving after 10am * 1hr)/(total # of trucks). Because input rate is 10, 000kg/hr and each truck carries 1, 000 kg/truck, the truck input rate is 10 trucks/hr, so that the overall average truck waiting time is: (10 trucks/hr * 3hrs * 0 + 10 trucks/hr * 8hrs * 1hr)/(10 trucks/hr * 11 hrs) = 8/11 hr = 43. 63min. Average waiting time can also be calculated by noticing that the area of the upper triangle in the build-up diagram represents the total amount of hours waited by all trucks: Area = (22, 000 – 6, 000)kg * (8pm – 10 am) /2 = 16, 000 kg * 10 waiting hr /2 = 80, 000 kg waiting hrs = 80, 000 kg waiting hrs / (1, 000 kg/truck) = 80 truck waiting hrs. Now, we just calculated that there are 80 trucks that do wait, hence the average waiting time among those trucks that do wait is 80 truck waiting hrs/ 80 trucks = 1 hour.

Exercise 3. 8 (Jasper Valley Motors)

Part a.

TURNStotal = 1/Ttotal so Ttotal = 1/8 years = 1. 5 months

Itotal = RtotalTtotal = 160 vehicles/month * 1. 5 months = 240 vehicles, which is the answer.

Typical errors: wrong units and stating that “ I = 160*(1/8) = 20 vehicles.”

Part b.

Similar to part a, we have Tnew = 1/7. 2 years = 1. 667 months and Tused = 1/9. 6 years = 1. 25 months.

Inew = 0. 6 * 160 vehicles/month * 1. 667 months = 160 new vehicles

Iused = 0. 4 * 160 vehicles/month * 1. 25 months = 80 new vehicles

Total monthly financing costs then 160*$175 + 80*$145 = 28, 000 + 11, 600 = $39, 600/month.

Cost per vehicle are then $39, 600/month (160+80) = $165 per vehicle per month, which is the answer.

Typical errors:

1. Not realizing that the cost driver is inventory, not throughput. (Taking a throughput-weighted average would yield 60%* $175 + 40%*$145 = 163, instead of the correct inventory-weighted.) 2. Not taking a weighted average. Clearly, the answer must fall between $145 and $175. 3. Giving total monthly costs instead of per vehicle.

Part c.

From Little's Law, cutting time 20% while holding R unchanged will reduce inventory by 20%. From part b, average monthly financing costs for new vehicles is 160*$175 = $28, 000/month. A 20% drop gives $5, 600 per month, which is the answer.

Typical errors:

1. Assuming the service works also on used cars, leading to 20%$39, 600/month= $7920/mo. 2. Only stating the value per car per month: We reduce Tnew from Tnew = 1/7. 2 years = 1. 667 months by 20%*1. 667mo = 1/3 mo. This saves 1/3mo * $175/new car, mo = $58. 33/new car.

(Multiplying by 96new cars/mo would have yield the correct $5600/mo.) 3. Reducing the flow time by 20% does not mean that turnover is increased by 20%. (On the contrary, actually, turnover increases here from 7. 2 to 9, which is 25%.)