

LINKS Tutorial #2: Inventory Tracking

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In LINKS, you are responsible for managing inventories of raw materials, sub-assembly components, and finished goods. And, as if that weren't complicated enough, many of you also have to worry about inventories at various distribution centers.

This tutorial is organized into two parts that each overview a LINKS report necessary for effective inventory management. A brief "hands-on" exercise follows each part:

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1. Tracking Finished Goods Inventories

After each simulation round, your firm receives a Finished Goods Inventory Report that tracks how each of your products flows through inventory at each distribution center. Let's look at Product 5-1 in the following example report to see how finished goods (FG) inventory is tracked:

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*****
FIRM 5: Ready SET go, Inc.
FINISHED GOODS INVENTORY REPORT, ROUND 14
*****

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	Product 5-0	Product 5-1
PLANT/DC1 FG INVENTORY		
Beginning Inventory	0	13,125
+ Regular Production	18,000	10,000
+ Emergency Production	0	0
+ Postponed Production	0	0
= Available Inventory	18,000	23,125
- Shipments To DCs:		
DC2, Surface	0	-6,000
DC2, Air	0	0
DC2, Emergency	0	0
DC3, Surface	-18,000	0
DC3, Air	0	0
DC3, Emergency	0	0
- Sales, Region #1		-9,872
- Sales, Other Regions		0
= Ending Inventory	0	7,253
DC2 FG INVENTORY		
Beginning Inventory	0	7,709
+ Plant Shipments, Surface	0	5,200
+ Plant Shipments, Air	5,000	0
+ Plant Shipments, Emergen	0	0
+ Postponed Production	-2,798	0
= Available Inventory	2,202	12,909
- Sales, Region #2		-9,269
+ Plant Shipments, Delayed	0	800
= Ending Inventory	2,202	4,440
DC3 FG INVENTORY		
Beginning Inventory	11,052	0
+ Plant Shipments, Surface	16,100	0
+ Plant Shipments, Air	0	0
+ Plant Shipments, Emergen	0	0
+ Postponed Production	-15,891	8,109
= Available Inventory	11,261	8,109
- Sales, Region #3		-8,109
+ Plant Shipments, Delayed	1,900	0
= Ending Inventory	13,161	0

At DC1, round #14 started with inventory that carried over from the round 13 (13,125 Product 5-1's).

10,000 **newly produced** units were added to inventory, bringing the total inventory of Product 5-1 available for sale to 23,125 units.

6,000 units were then shipped out to DC2 for sale in Region 2, and 9,872 units were sold in Region 1, leaving 7,253 in **ending inventory** at DC1. Assuming no reconfiguration, these 7,253 units will become the **beginning inventory** at DC1 in round #15.

Since the 6,000 units from DC1 were shipped surface, only 5,200 ($\approx 87\%$) of the order arrived at DC2 in time to fulfill round #14's demand. The remaining 800 units were **delayed**, arriving at the end of the round to become part of its ending inventory. The delivery reliability of surface transportation varies by shipper; air shipping is always delivered 100% on-time.

At DC3, Firm 5 had postponed production, finishing just enough Product 5-1's from 5-0's to meet regional demand. In the Product 5-0 column, 18,000 were ordered for shipment to DC3 to support postponed production this round, and 16,100 ($\approx 89\%$) arrived on time.

EXERCISE #1: *continued...*

3. Ending Inventory: Assume that they decided to use Shipper I ship 13,500 X-1 units via surface to DC2 for round #7. Assume actual sales were 13,500 units. What was DC2's round #7 ending inventory of product X-1?
4. Finished Goods Accounting: Assume Firm X used Shipper I to transport 13,500 Product X-1's to DC2 via surface mode, and actual sales were higher than forecast: 7,000 in channel 1 and 9,575 in channel 2 (a total of 16,575 units sold). Also assume that 94% of the X-1 shipment arrived on-time, and there was no postponed production. Complete the following inventory accounting as you'd expect to find it on their Finished Goods Inventory Report, Round #7:

<u>DC2 FG Inventory</u>	<u>Product X-1</u>
Beginning Inventory	_____
+ Plant Shipments, Surface	_____
+ Plant Shipments, Air	_____
+ Plant Shipments, Emergency	_____
Postponed Production	_____
= Available Inventory	_____
- Sales, Region #2:	_____
+ Plant Shipments, Delayed	_____
= Ending Inventory	_____

ANSWERS follow on the next page.

EXERCISE #1: ANSWERS

1. Zero. It is a completely new product, and you have no inventory in your pipeline at the start of round #7. The 64 old X-1 units at DC2 at the end of round #6 were sold at a disposal sale for 80% of their value.
2. Since there was no starting inventory, you need to ship at least 13,500 units (6,500 + 7,000) to fill your total expected (forecasted) orders in Region 2. Some firms may have preferred to order greater than 13,500 units to have a buffer inventory ("Safety Stock") to fill orders if actual demand is higher than expected. Their quantity of safety stock would depend on their confidence in the accuracy of their forecasts and the importance of product availability to their particular target market (customers).
3. Ending inventory could range anywhere from 0 to about 6,750 units, with an expected ending inventory of 2,700 given Shipper I's average delivery reliability of 80%.

If you said "zero" ending inventory, you forgot about the fact that surface shipped units do not all arrive for use in the same simulation round. (Better to forget HERE than during your next decision round, right?)

Here's how we calculated the range of ending inventory:

	Best Case (100% arrive on time)	Expected Case (80% on time)	Worst Case (50% on time)
Beginning Inventory	0	0	0
+ Plant Shipments, Surface	13,500	10,800	6,750
+ Plant Shipments, Air	0	0	0
+ Plant Shipments, Emergency	0	2,700	6,750
Postponed Production	0	0	0
= Available Inventory	13,500	13,500	13,500
- Sales, Region #2:	13,500	13,500	13,500
+ Plant Shipments, Delayed	0	2,700	6,750
= Ending Inventory	0	2,700	6,750

4.	<u>DC2 FG Inventory</u>	<u>Product X-1</u>
	Beginning Inventory	0
	+ Plant Shipments, Surface	12,690 (94% of 13,500 ordered)
	+ Plant Shipments, Air	0
	+ Plant Shipments, Emergency	3,885
	Postponed Production	0
	= Available Inventory	16,575
	- Sales, Region #2:	16,575
	+ Plant Shipments, Delayed	810
	= Ending Inventory	810 (6% of 13,500 ordered)

2. Tracking Procurement Inventories

The Procurement Inventory Report has essentially the same format as the Finished Goods Inventory Report. It has more data, however, because you must track **five** components instead of just three finished goods. Like finished goods, procurement inventories are tracked by DC. Procurement orders are made using the Procurement Order Form.

Let's look at the following Procurement Inventory Report excerpt to see how it compares to the Finished Goods Inventory Report you learned about in the last part of this tutorial:

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FIRM 5: Ready SET Go, Inc.                                INDUSTRY ABZ
PROCUREMENT INVENTORY REPORT, ROUND 14                    PAGE 9
*****

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	Alpha	Beta	Gamma	Delta	Epsilon
PLANT & DC1					
Beginning Inventory	13,600	13,600	1,162	5,191	39,682
+ Purchases, Surface	330,000	330,000	7,900	16,600	20,000
+ Purchases, Air			0	0	0
+ Purchases, Emergency	0	0	1,600	7,100	0
= Available Inventory	343,600	343,600	10,662	28,891	59,682
- Production:					
Product 4-0	-162,000	-162,000			
Product 4-1	-10,000	-10,000	-10,000	0	-10,000
Product 4-2	-137,500	-137,500	0	-27,500	-27,500
- Emergency Production:					
Product 4-0	0	0			
Product 4-1	0	0	0	0	0
Product 4-2	0	0	0	0	0
- Postponed Production			0	0	0
- Replacement Parts			-631	-1,316	-1,233
+ Purchases, Delayed			2,100	10,400	0
= Ending Inventory	34,100	34,100	2,131	10,475	20,949

As you could see, the flow for procurement inventory is very similar to that for finished goods ...

... except *all* orders of alpha and beta *always* arrive 100% on time, so you'll never have "Purchases, Delayed" for raw materials.

Gamma and Delta tracking is very similar to finished goods. **Epsilon, however, is tricky because you must place orders one round in advance.** That means that the order for the 20,000 epsilon units above was placed with round 13 decisions for use in round 14.

EXERCISE #2: Procurement Inventory Tracking

Please refer to the example Procurement Inventory Report excerpt on the previous page to answer the following questions...

1. Beginning Inventory: Where did the 13,600 beginning inventory of alpha and 13,600 beginning inventory of beta come from in round #14?

2. a. Surface Purchase Delivery: What percentage of surface-shipped deltas arrived on-time for use in roundh #14 production?

b. What implication(s) is(are) apparent on this report?

3. Epsilon Purchase Delivery: Assume that Firm 5 ordered 20,000 epsilons for surface shipment on their Procurement Order Form for round #14. These will show as "+Purchases, Surface" on their Procurement Inventory Report in round _#____.

ANSWERS follow on the next page.

EXERCISE #2: ANSWERS

1. Both were ending inventories at DC1 in round #13 that was carried over as beginning inventories in round #14.
2. a. $16,600/27,000 \approx 61.5\%$ on-time. 16,600 units arrived on-time via surface transportation and 10,400 were delayed until the end of the simulation round. In total, that makes an order of 27,000 units, of which 61.5% were delivered on-time for round #14 production.

b. Two are most apparent: (1) 10,400 units (38.5%) were delayed; (2) emergency procurement of 7,100 units was required. This emergency procurement probably cost Firm 5 a premium, including air transportation at a cost 50% higher than normal air transport.
3. #15 (the *next* simulation round)

Now let's explore how inventory tracking links to the Performance Evaluation Report.

3. Links to the Performance Evaluation Report

Inventory management is directly linked to the **inventory turnover** performance metric found on the Performance Evaluation Report each simulation round. Here's how it's calculated:

$$\text{Inventory Turnover} = \text{Cost of Goods Sold}/\text{Average Inventory}$$

In LINKS, calculations include data from various reports:

$$\text{Inventory Turnover} = \frac{\text{Product Cost for "All Products" from the Corporate P\&L}}{1/2(\text{Beginning Inventories} + \text{End Inventories for FG \& Procurement})}$$

Inventory turnover is a measure of operational efficiency. The higher the ratio, the less cash is tied up in inventories. If cash is not in inventory, it *could* be put to other more profitable uses. But if inventories are too limited, you run the risk of running out of stock, and resorting to costly emergency production or unfilled orders. Inventory requires careful planning and a keen understanding of demand.

Our fictitious Firm 5 earned an inventory turnover of 1.2 in round #14. In a month with 31 days, an inventory turnover ratio of 1.2 means that inventory was typically on hand about 30 days before it was used (that's 31 days/1.2 times per month). Firm 5's Product Costs for "All Products" were \$8,903,959 in round #14; given this, we could figure out their average inventory for the month using the inventory turnover formula, above:

$$\begin{aligned} 1.2 &= \$8,903,959/\text{Average Inventory} \\ (\text{Average Inventory}) \times 1.2 &= \$8,903,959 \\ \text{Average Inventory} &= \$8,903,959/1.2 \\ \text{Average Inventory} &\approx \$7,419,966 \end{aligned}$$

At \$7,419,966, Firm 5's average inventory was worth 83% of the cost of products actually sold.

EXERCISE #3: Inventory Turnover

1. Calculation: Industry Z's average inventory turnover was 4.1. If Firm 5 had achieved this inventory turnover ratio with their Product Costs of \$8,903,959, what would their average inventory have been?

2. Relationship to Operations: Given your answer to question #1, what appears to be the relationship between average inventory levels and the inventory turnover ratio?
 - a. Inventory levels have no effect on the inventory turnover ratio.
 - b. Higher inventories lead to higher inventory turnover ratios.
 - c. Higher inventories lead to lower inventory turnover ratios.

3. Relationship to Decision Making: Given Firm 5's low inventory turnover ratio for round #14, what advice would you give to them to improve their inventory management in the future?

ANSWERS follow on the next page.

EXERCISE #3: ANSWERS

1. $\$8,903,959 = 4.1(\text{Average Inventory})$
Average Inventory = $\$8,903,959/4.1 \approx \$2,171,698$
2. c
3. While it's impossible to know Firm 5's reasons for their high inventories, there is some general advice they may find helpful:
 - Reduce inventories, but don't reduce them so much that you risk stock-outs.
 - Revisit your forecasting methods and try to improve your forecasting accuracy since those forecasts may be the drivers of your inventory levels.

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