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# **LINKS Procurement Management Simulation**

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## Table of Contents

<b>Introduction .....</b>	<b>5</b>
<b>Why Use Simulations?.....</b>	<b>5</b>
<b>LINKS Overview.....</b>	<b>6</b>
<b>Product Development and Product Costs .....</b>	<b>8</b>
<b>Procurement Decisions.....</b>	<b>10</b>
<b>Raw Materials .....</b>	<b>10</b>
<b>Sub-Assembly Components and Supplier Decisions.....</b>	<b>10</b>
<b>Replacement Parts .....</b>	<b>13</b>
<b>Emergency Procurement .....</b>	<b>13</b>
<b>Relationship Management Costs.....</b>	<b>14</b>
<b>Manufacturing Decisions .....</b>	<b>16</b>
<b>Production.....</b>	<b>16</b>
<b>Unfilled Orders.....</b>	<b>17</b>
<b>Forecasting Decisions .....</b>	<b>20</b>
<b>Sales Forecasting Volume Decisions.....</b>	<b>20</b>
<b>Forecasting Accuracy .....</b>	<b>20</b>
<b>About Forecasting and Forecasting Accuracy.....</b>	<b>21</b>
<b>Forecasting Decisions Form .....</b>	<b>21</b>
<b>Financial and Operating Reports .....</b>	<b>23</b>
<b>Performance Evaluation Report.....</b>	<b>23</b>
<b>Corporate P&amp;L Statement .....</b>	<b>25</b>
<b>Historical Corporate P&amp;L Statement .....</b>	<b>26</b>
<b>Product P&amp;L Statement.....</b>	<b>26</b>
<b>Balance Sheet .....</b>	<b>26</b>
<b>Other Reports.....</b>	<b>26</b>
<b>Sample Reports.....</b>	<b>27</b>
<b>Appendix: Web-Based LINKS Access .....</b>	<b>37</b>



## Introduction

*"Learning is not a spectator sport."* - Unknown

Congratulations on your appointment to the LINKS set-top box procurement management team. For the four simulated calendar months in the LINKS Procurement Management Simulation exercise, you and your teammates will manage procurement, manufacturing, and forecasting for your firm. You'll be in direct competition with other firms in your LINKS high-tech manufacturing industry. Your goal is to improve your LINKS firm's financial and operating performance.

The learning objectives implicit in LINKS include the following:

- Balancing and managing procurement and manufacturing management trade-offs
- Appreciating information flows and integration of information with decision making
- Enhancing and encouraging fact-based analysis and decision making
- Gaining familiarity with financial statements used routinely in for-profit businesses.

In addition to the LINKS participant's manual, you have access to simulation support from the LINKS website which addresses frequently-asked questions (FAQs) and provides relevant links to interesting support materials and documents:

<http://www.LINKS-simulations.com>

## Why Use Simulations?

*"I hear and I forget; I see and I remember; I do and I understand."* – Confucius

Why use simulations in management education? Why not use traditional classroom lectures, perhaps combined with case studies? Adults learn best by doing. "Doing" involves taking responsibility for one's actions, receiving feedback, and having an opportunity to improve through time. In management education and training settings, management simulations support learning in a non-threatening but competitive environment of the kind that real managers face every day.

Like an airline pilot flight simulator, a management simulator allows rapid time compression, quick feedback to the learner, and is a low-risk process (except to one's ego). A well-designed management simulator can provide the student with a realistic education and training experience in the relative safety of the simulation's operating environment. And, perhaps more importantly, the lessons learned in the management simulator environment occur within hours or days, not the months, months, or years associated with real life.

Compared to traditional lecture/case/discussion educational events, simulations:

- Reflect active not passive participation, enhancing learning motivation.
- Apply key management concepts, especially coordination and planning.
- Demand analysis and decisions in the context of market-based feedback in the presence of thoughtful, vigilant competitors.
- Provide rapid feedback, encouraging participants to learn from their successes and failures within a relatively low-risk competitive environment.

- Provide learning variety through novel learning environments.

## LINKS Overview

LINKS teams manage their firm's procurement, manufacturing, and forecasting decisions. The LINKS financial statements and operating reports provide an information-rich environment.

Your firm manufactures, distributes, and sells set-top boxes in three regional markets in LINKS. Your firm's manufacturing plant is located in market region 1. Your distribution center in region 1 is located adjacent to your manufacturing plant and shares inventory of sub-assembly components with your manufacturing plant. Your distribution center fills orders from the retail and direct channels and stocks inventories of sub-assembly components for replacement parts for within-warranty failures.

**Each decision period in LINKS is one calendar month.** Within LINKS, each calendar month in the year is assumed to have an equal number of calendar days.

You assume control of your LINKS firm at the end of month 3. Thus, your first decisions will be for month 4. Although your firm has been operating for a number of years, detailed information is only available about the recent past.

All firms in your industry started month 1 identically. This is consistent with an industry that has evolved over time with all competitors now emulating each other exactly. Decisions in months 1-3 were constant throughout these three months. Due to the normal random forces in the various markets in which your firm operates, the financial and market positions of the firms in your industry will vary somewhat at the end of month 3

The "product" in LINKS is a set-top box. A set-top box is a high-tech electronics product purchased by individual consumers for home use and by a wide range of businesses for office and manufacturing/operations environment uses. LINKS set-top boxes are "fourth generation" versions. Fourth-generation set-top boxes include telephony applications (such as internet-based long-distance calling, interactive video conferencing, and interactive TV), local-area wireless networking, control/monitoring of a wide range of within-area electrical appliances and devices, digital media server, basic virtual reality, and teleportation enhancement capabilities.

Within LINKS, there are two set-top box categories: hyperware and metaware. These categories share many elements in common within your supply chain. But, these categories are quite different products for end users. **There is no direct competition across the hyperware and metaware set-top box categories.**

Each firm in your set-top box industry has two products referenced as "f-p" (for firm "f" and product "p"). For example, product 4-1 refers to product 1 of firm 4. For all firms, product 1 is a hyperware product and product 2 is a metaware product. Your firm has a manufacturing plant and distribution center in region 1. **Your manufacturing plant in region 1 produces set-top boxes that are shipped to customers in all market regions served by your firm.**

**Demand seasonality exists in LINKS markets.** Hyperware set-top boxes have a dramatic 3<sup>rd</sup>-month industry-wide demand peak compared to other calendar months due to end-of-

quarter purchasing by businesses and government organizations. Industry-wide demand for hyperware in months 3, 6, 9, etc. is 30%-35% higher than in other months. There is no known seasonality in the metaware set-top box sub-category.

There are three regional markets in your set-top box industry. Two sales channels, retail and direct, exist to reach end users in these three regional markets. When you receive your initial financial reports for months 1-3, you will see the market region descriptors for the three market regions in your particular set-top box industry.

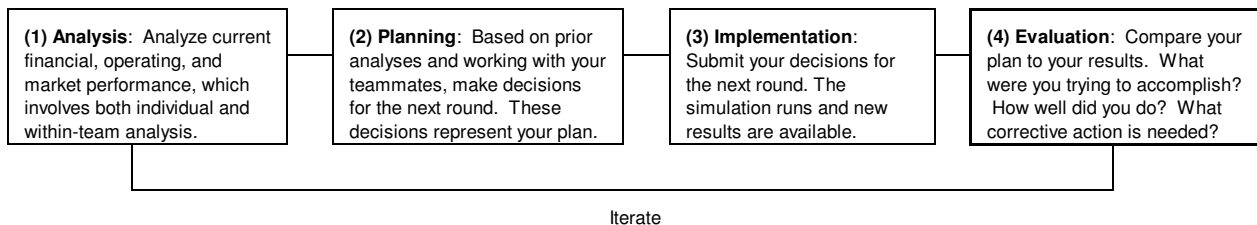
The LINKS currency unit is the LCU, the "LINKS Currency Unit." The LCU is abbreviated "\$" and pronounced Ldollar ("el-dollar"). The "LINKS Currency Unit" (LCU) is a Euro-like multi-country currency. In your travels, you might have



encountered the "\$" currency symbol associated with currencies in Australia, the Bahamas, Barbados, Belize, Bermuda, Brunei Darussalam, Canada, Cayman Islands, Fiji, Guyana, Hong Kong, Jamaica, Liberia, Namibia, New Zealand, Singapore, Solomon Islands, Suriname, Taiwan, Trinidad/Tobago, the United States, and Zimbabwe. That's merely a coincidence. The "\$" currency symbol is widely known to have originated with the Ldollar.

The LINKS analysis-planning-implementation-evaluation cycle is shown in Exhibit 1. This cycle repeats throughout your LINKS exercise permitting you to learn from experience.

### Exhibit 1: LINKS Analysis-Planning-Implementation-Evaluation Cycle



## Product Development and Product Costs

Your firm has two products. Product 1 is a hyperware product and product 2 is a metaware product.

Each set-top box product is defined by a configuration that is expressed as a six-character code with the following elements and interpretations:

- (1) Product category: "H" for hyperware, "M" for metaware
- (2) Raw material Alpha: 0-9 (number of kilograms)
- (3) Raw materialBeta: 0-9 (number of kilograms)
- (4) Bandwidth: 1-7 (terahertz)
- (5) Warranty: 0, 1, 2, 3, or 4 (length of warranty in months)
- (6) Packaging: "1" (standard), "2" (premium), or "3" (environmentally sensitive premium).

For example, the product H55321 is a hyperware set-top box with 5 kilograms of raw material Alpha, 5 kilograms of raw materialBeta, bandwidth of 3 terahertz, warranty of 2 months, and standard packaging.

Product configuration influences manufacturing, handling, and post-sale costs in known fashion. In addition to these six configuration elements, two sub-assembly components must be included within set-top boxes. Exhibit 2 contains a schematic representation of the hyperware and metaware set-top box product configurations.

In addition to one epsilon sub-assembly component, set-top boxes require a gamma (hyperware) or a delta (metaware) sub-assembly component. A variety of suppliers provide sub-assembly components and alternative suppliers' offerings are fully interchangeable. Thus, since their particular "value" (supplier) doesn't impact configuration, sub-assembly components are not a formal part of the set-top box configuration.

### Exhibit 2: Set-Top Box Configurations

	Product 1: <b>Hyperware</b>	Product 2: <b>Metaware</b>	Definitions
Configuration Elements	1. "H" 2. Alpha 3. Beta 4. Bandwidth 5. Warranty 6. Packaging	1. "M" 2. Alpha 3. Beta 4. Bandwidth 5. Warranty 6. Packaging	Category [hyperware ("H") or metaware ("M")] 0-9 Kg of Raw Material 0-9 Kg of Raw Material 1-7 Terahertz 0-4 Months Std ("1"), Prem ("2"), or ES Prem ("3")
Sub-Assembly Components	Epsilon Gamma	Epsilon Delta	Common Sub-Assembly Component Unique Sub-Assembly Component

Costs of raw materials and sub-assembly components are described in the following section. Costs other than those related to raw materials and sub-assembly components are detailed below:

- **Bandwidth:**  $\$10+0.5(T*T*T)$  where T is the terahertz rating of the product. A terahertz level of 1 costs \$10.50 while bandwidth of 6 terahertz costs \$118. You have the engineering capability to include any level of bandwidth in your set-top box products, within the technology range 1-7. Bandwidth is a "more-is-better" product attribute. Terahertz is just an industry-specific, generally-accepted metric describing the bandwidth performance of a set-top box. Customers will always prefer more bandwidth, but they might or might not prefer it enough to offset the additional bandwidth costs. You'd need to conduct appropriate research to assess customer preferences for higher bandwidth levels and then compare that preference to your input costs of providing higher bandwidth.
- **Warranty:** Set-top boxes may be configured with a warranty or with no warranty. With no warranty, there are no associated warranty costs. If you choose to offer a warranty, then the associated cost is  $\$8+3(W*W)$ , where W is the warranty length in months. For example, a one-month warranty costs \$11, a two-month warranty costs \$20, a three-month warranty costs \$35, and a four-month warranty costs \$56. Warranty coverage is outsourced to a reputable service provider in each market region. These warranty costs are paid directly to the outsourced warranty provider at the time the product is manufactured. Warranty costs do not depend on the failure rates of the sub-assembly components. Set-top box manufacturers are responsible for the costs associated with replacing sub-assembly components that fail in the field during the warranty period associated with a set-top box product. **Warranties are honored in the original calendar month of sale plus the additional number of months of the warranty associated with a product's configuration.**
- **Packaging:** "1" (standard) packaging costs \$10, "2" (premium) packaging costs \$14, and "3" (environmentally sensitive premium) packaging costs \$28. More expensive, premium packaging presumably has positive generate-demand implications and provides greater physical protection during shipping, resulting in somewhat reduced failure rates in the field (i.e., lower failure rates to customers). "3" packaging denotes premium packaging with environmentally sensitive design, construction, and materials.

## Procurement Decisions

*"Buy low, sell higher."* – Unknown

Your LINKS firm manages procurement by sourcing sub-assembly components from various suppliers for use in production and as replacement parts. Sub-assembly components must be sourced from specific suppliers and transportation method (surface or air) must be chosen.

Your LINKS procurement strategies and tactics will need to balance input costs, supplier delivery performance, sub-assembly component quality, and associated relationship management costs (the explicit dollar costs associated with maintaining relationships with alternative suppliers and the implicit time costs associated with managing a supplier portfolio). The input costs of raw materials and sub-assembly components represent a sizeable portion of total product costs. Thus, thoughtful management of the procurement sub-process will be an important aspect of managing your firm in the set-top box industry.

### Raw Materials

Raw materials Alpha and Beta are widely available single-grade commodities purchased at spot-market worldwide prices. In-bound transportation costs are covered by the raw material suppliers. Due to their ubiquitous nature, surface transportation is the accepted mode of transportation. Raw materials are always delivered for use within the current month's production activities.

The current prices of raw materials are \$3/kg for Alpha and \$4/kg for Beta.

Vendors of raw materials in the set-top box industry provide inbound transportation as part of their bundled prices. Thus, there are no transportation decisions for set-top box manufacturers to make with regard to raw materials.

No explicit raw materials procurement decisions are required in the LINKS Procurement Management Simulation. The LINKS software automatically manages your raw materials procurement decisions, based on your manufacturing decisions. Your firm's raw material requirements are completely determined by your firm's production decisions. Thus, the exact amount of raw materials purchases is always known with certainty and you'll never have any raw materials inventory on-hand at the end of a month.

### Sub-Assembly Components and Supplier Decisions

Each set-top box product is composed of either one Gamma or one Delta sub-assembly component, depending on whether it is hyperware (Gamma) or metaware (Delta). Sub-assembly component Gamma may be sourced from suppliers "A", "B", "C", or "D" while sub-assembly component Delta may be sourced from suppliers "B", "C", "D", "E", or "F". Each set-top box (i.e., hyperware and metaware set-top boxes) is manufactured with an Epsilon sub-assembly component that may be sourced from suppliers "D", "E", "F", or "G".

Gamma and Delta sub-assembly components are available on the spot-market for immediate delivery. **Epsilon sub-assembly components are delivered one month after ordering, not within the current month.** You'll need to take this delivery lag into account in managing your Epsilon sub-assembly component inventories.

#### FAQ

*"We didn't order Epsilon last month but our financial reports include an in-bound Epsilon shipment. What's going on?"* Epsilon sub-assembly components are delivered one month after ordering, not within the current month. This in-bound Epsilon shipment was from your procurement order two months ago.

**Sub-assembly components from alternative suppliers are freely substituted without influencing manufacturing costs.** While all suppliers' versions of each sub-assembly component perform approximately the same, there are differences in price, delivery performance, and in-field failure rates of the sub-assembly component suppliers. Product failure in the field can result if the Gamma, Delta, or Epsilon components fail. By common practice, the customer (i.e., your firm) arranges and pays for the transportation associated with in-bound sub-assembly components.

Suppliers and manufacturers are jointly responsible for transportation decisions regarding inbound shipments of sub-assembly components. Suppliers quote unbundled sub-assembly component and transportation mode costs (surface and air). Manufacturers choose modes but suppliers arrange specific carriers for each transaction. Suppliers choose specific carriers for sub-assembly components to deal with less-than-truckload orders economically. In addition, suppliers' sub-assembly components are used in many other industries than just set-top boxes, so they must deal effectively and efficiently with cross-industry transportation requirements.

Your LINKS firm must make sourcing decisions for sub-assembly components used in manufacturing involving both supplier selection and transportation modes. Surface and air transportation modes are possible. Costs of air transportation exceed those of surface. However, air transportation ensures timely receipt of sub-assembly components so that they may always be used within the current month's production activities.

Gamma and Delta sub-assembly components cost \$3/unit [\$4/unit] for surface [air] transportation with the corresponding surface [air] transportation per-unit cost for Epsilon units being \$4 [\$6]. Emergency (expedited) orders of sub-assembly components incur a cost 50% higher than air transportation. Transportation costs are payable by the customer (i.e., your firm), although carrier-specific decisions are made by the sub-assembly component suppliers. And, of course, these transportation costs are in addition to supplier purchase costs.

Exhibit 3 contains cost, delivery, and failure data for sub-assembly components. "Delivery" refers to the average rate of receipt of sub-assembly components within the current month via surface transportation. With air transportation, sub-assembly components are always received within the current month and may be used within the current month's manufacturing activities. Recall that Epsilon sub-assembly components are ordered in this month and are delivered in the following month. Surface and air transportation options exist for Epsilon, but these deliveries are in the following month, not in the current month.

### Exhibit 3: Sub-Assembly Component Characteristics

	Sub-Assembly Components								
	Gamma			Delta			Epsilon		
	Cost	Delivery	Failure	Cost	Delivery	Failure	Cost	Delivery	Failure
Supplier A	\$12	80% ± 2%	2.0%						
Supplier B	\$14	85% ± 4%	1.9%	\$15	75% ± 4%	2.6%			
Supplier C	\$13	85% ± 6%	2.0%	\$16	78% ± 6%	2.5%			
Supplier D	\$22	90% ± 8%	1.2%	\$24	80% ± 8%	1.8%	\$29	80% ± 8%	1.1%
Supplier E				\$14	70% ± 10%	2.7%	\$20	75% ± 10%	1.7%
Supplier F				\$13	70% ± 12%	2.8%	\$19	77% ± 12%	1.8%
Supplier G							\$21	78% ± 14%	1.7%

- The delivery rates in Exhibit 3 are average delivery rates. The typical range of delivery rates is shown in "±" form (for example, "80% ± 2%" reflects an average surface delivery rate of 80% with a typical range for that average being 78% to 82%. Surface transportation of in-bound sub-assembly components is subject to various possible delays. While the typical ranges are plus or minus 2% to 14% from the published statistics in Exhibit 3, more extreme performance levels are possible. If you want to be certain of current-month delivery, you can always use air rather than surface transportation. But, as you might expect, there are higher costs associated with air compared to surface transportation of sub-assembly components. Variability in surface transportation performance is one of the many elements of supply chain variability that must be managed, in real supply chains and in the LINKS set-top box supply chain.
- "Failure" refers to the per-month failure rate for each sub-assembly component from each supplier. These failure rates refer to in-field failure faced by customers. A 1% failure rate is interpreted as a probability of 0.01 that a specific sub-assembly component fails in any month. These failure rates are especially relevant during your products' warranty periods, when your firm must bear any costs associated with sub-assembly component failure.
- The costs in Exhibit 3 are the spot-market prices for sub-assembly components as of month 1. You will be advised of any changes in these sub-assembly component spot-market prices.

Obviously, a range of trade-offs exist in sourcing sub-assembly components. Cost, delivery performance, and failure rates must all be balanced in sourcing sub-assembly components.

Sub-assembly component suppliers tend to change their prices (i.e., your costs) through time in response to market demand. (The costs reported in Exhibit 3 were the costs as of Month #1.) These cost changes are typically increases or decreases of \$1/month, although larger changes occasionally occur. See the "Set-Top Box Industry Bulletin" at the end of your

financial and operating reports for the current spot-market prices (i.e., your costs) for all sub-assembly components suppliers. A quoted price of "n/a" denotes temporary inability of a sub-assembly component supplier to service new customers, so that no spot-market orders will be accepted from non-current customers. However, orders continue to be accepted from current customers. Sub-assembly component supplier availability varies through time, so a currently-unavailable sub-assembly component supplier may become available again in the future.

Some suppliers may not be able to supply sub-assembly components for spot-market purchases in any given month due to capacity limitations and pre-existing contractual obligations with existing customers. Set-top box manufacturers that already have on-going relationships with suppliers (i.e., firms that purchased sub-assembly components last month from a supplier) receive preferential treatment as existing customers and, therefore, are normally unaffected by spot-market unavailability conditions with such suppliers.

## Replacement Parts

Sub-assembly components may fail in the field as customers use their set-top boxes. Within the warranty period associated with each product, replacement parts are provided without cost by set-top box firms. Obviously, your LINKS firm must maintain a suitable inventory of sub-assembly components to service replacement parts demand.

## Emergency Procurement

Your firm has a policy of never running out of inventories of sub-assembly components. If the available inventory of any sub-assembly component is insufficient to meet the requirements implicit in your production orders, an emergency procurement order is automatically executed by the simulation software.

Emergency procurement orders of sub-assembly components are made from supplier D. Emergency procurement orders of sub-assembly components involve extra charges of \$3/unit (\$6/unit for Epsilon sub-assembly components). Emergency procurement costs are recorded as "Emergency Procurement" costs on the "Corporate P&L Statement."

### FYI: JIT Versus JIC

*Companies have come to depend more and more on just-in-time (JIT) delivery. Perceptions of risk increases tilt the balance away from JIT and toward JIC, the just-in-case strategy of holding inventory against the risk of unexpected supply chain disturbances. This balance has been tilted further by sharp falls in interest rates, which cut the cost of holding inventory by more or less half, reducing the need for JIT systems.*

Source: "Taking Stock," *The Economist* (09/22/01)

Emergency orders are always shipped by air so that they arrive in time to be used within the current month's production activities. Emergency orders of sub-assembly components involve transportation costs that are 50% higher than the usual costs associated with sourcing via air transportation.

## Relationship Management Costs

Each relationship with a sub-assembly supplier incurs one-time start-up costs of \$20,000, plus on-going costs of \$10,000 in the initial month of procurement and \$5,000 in subsequent months as long as your firm continues to source sub-assembly components from a supplier. If you cease ordering sub-assembly components from a supplier and then start ordering again in a later month, these start-up costs are incurred again.

“Relationship” means one or more purchase orders processed with a sub-assembly component provider. Relationship management costs are recorded under “Procurement FC” on your financial statements.

Fixed order costs of \$1,250 accrue for every sub-assembly component procurement order (via surface or air) from every supplier used in a month. These costs are also recorded under “Procurement FC” on your financial statements.

On-going relationships with sub-assembly component suppliers have the positive benefit of reducing the risk associated with spot-market unavailability in any given month. As mentioned above, as an existing customer of a sub-assembly component supplier, your firm would receive preferential treatment with regard to any supply constraints. Thus, your firm would normally not face spot-market unavailability from your existing sub-assembly component suppliers.

## Procurement Decisions

Firm	
------	--

Month	
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Sub-Assembly Components, Plant&DC1	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F	Supplier G
Gamma, Surface							
Gamma, Air							
Delta, Surface							
Delta, Air							
Epsilon, Surface							
Epsilon, Air							

### Reminders

Only input changes. If you're happy with the current values of these decisions, leave the appropriate decision entries blank.

**Don't forget to zero-out prior procurement decisions if you don't wish them to continue on into the next month.**

All decision inputs change the existing values to the values that you specify. Do not enter "+" or "-" values. Rather, enter new values only (new values replace the existing value of the decision variable with your designated value).

## Manufacturing Decisions

*"Nobody wants to have inventory, but everybody wants a product there when they want it."* – Joe Chernay, Vice-President of Manufacturing and Technology, Bayer Corporation, <http://www.industry.net/discussions/supplychain.htm>

The LINKS production sub-process involves planning ahead to create your production volume orders in light of downstream demand forecasts that you craft. In a build-to-plan (build-to-stock) production system, the consequences of poor production planning are either too much inventory of unsold products or unfilled orders.

### Production

Manufacturing costs are described in Exhibit 4. There is a fixed cost per order associated with setting up each production run at the manufacturing plant. In addition to these production-related costs, the implied costs associated with the configurations of the products are also added into the costs of the products.

**Production volumes for each product can change by a maximum of 15,000 units from the previous month's value.** You may, however, change a product's production volume to 0 units at any time, but you'd then be limited to a maximum production volume of 15,000 units in the following month. This constraint on successive month's production volumes is necessitated by load balancing requirements associated with available plant capacity and labor force overtime scheduling requirements.

In addition to the order-related fixed costs and the unit-related variable costs described in Exhibit 4, your firm absorbs costs associated with depreciation and maintenance of your dedicated plant capacity to manufacture set-top boxes. These costs are \$100,000 per month for each production "shift," and they are recorded as "Plant Capacity FC" (plant capacity fixed costs) on your "Corporate Current P&L Statement." These costs are allocated equally among your products.

#### FYI: Why Hold Inventory?

While low inventory levels are attractive from a cost perspective, there are a variety of reasons for holding inventory:

- *To create buffers against the uncertainties of supply and demand.*
- *To take advantage of lower purchasing and transportation costs associated with high volumes.*
- *To take advantage of economies of scale associated with manufacturing products in batches.*
- *To build up reserves for seasonal demands or promotional sales.*
- *To accommodate products flowing from one location to another (work in progress or in transit).*
- *To exploit speculative opportunities for buying and selling commodities.*

Source: Jeremy F. Shapiro, *Modeling The Supply Chain* (Pacific Grove, CA: Duxbury, 2001), p. 477.

### Exhibit 4: Manufacturing Costs

<b>Hyperware</b>	
Fixed Costs (per order)	\$22,500
Labor Costs (per unit)	\$30
Production Costs (per unit)	\$20
<b>Metaware</b>	
Fixed Costs (per order)	\$24,500
Labor Costs (per unit)	\$36
Production Costs (per unit)	\$16

A production "shift" can accommodate up to 50,000 units of production per month. If your total production volume across all products is less than 50,000 units per month, then you only need one production shift, and the associated costs are \$100,000. If your total production volume across all products is 50,001 to 100,000 units per month, then you need two production "shifts" in that month, with associated costs of \$200,000. The LINKS software automatically schedules the appropriate number of production "shifts" based on your total production volume. You must always have at least one production "shift" capability at all times, even if your total production volume in a month is zero units.

### Unfilled Orders

Unfilled orders can exist in your set-top box industry. If demand for any product exceeds finished goods inventory, customer sales must be reduced (proportionately) by the amount that orders exceed finished goods inventory. The difference between potential customer sales (orders) and actual customer sales due to inadequate on-hand finished goods inventory is "unfilled orders" in LINKS.

**Unfilled orders are not backlogged orders. Unfilled orders are not guaranteed (i.e., contracted, pre-paid) future sales.** Unfilled orders occur at a particular time due to inventory shortages relative to potential customer demand (orders), given competitive conditions at that particular time.

**Unfilled orders incur processing and handling costs of \$25/unit.**

Past experience suggests that current unfilled orders reflect three types of set-top box customers. Some customers immediately defect to another competitor's (available) product. Other customers decide not to buy any set-top product now or in the near-term future. A third segment of customers are inclined to wait and attempt to repurchase the preferred product having these unfilled orders again in the future when supply (i.e., inventory availability) is more favorable. The size of these three types of unfilled-orders customers is unknown. In all cases, however, it should be expected that unfilled orders negatively impacting downstream demand to some extent.

Unfilled orders represent additional potential demand that might have been realized beyond

"filled orders" (i.e., sales) if sufficient product supply had been available to meet customer purchase requests. Note that unfilled orders also reflect industry-wide double-counting if multiple firms' products simultaneously have unfilled orders. If two products simultaneously have unfilled orders, then some customers might have wished to purchase first one of the products and then the other product when the stockout situation for the first product was encountered. In such a situation, a single customer would have been counted as an unfilled order by both stocked-out products.

The definition of unfilled orders varies by channel. For a direct channel (like channel #2), an unfilled order to an end-user customer is the same as an unfilled order to the manufacturer. However, for an indirect channel (like channel #1), inventory buffer stock routinely maintained by retailers complicates the interpretation of unfilled orders. If retailers order 1,000 units from a manufacturer but that manufacturer is only able to fill 600 units of that order, this represents 400 units of unfilled orders to the manufacturer. However, this doesn't necessarily mean that retailers have unfilled orders from end-user customers. If the 600 units of the retailers' manufacturer-order yield sufficient on-hand retailer inventory to permit all end-user customer orders to be filled, then there are no unfilled orders as far as retailers are concerned. (In this case, retailers' ending inventory level would be below the desired level, which presumably would lead to increased orders in the following month to meet expected end-user customer demand plus inventory restocking targets.) With the buffering nature of retailer inventory, there could be no industry-wide unfilled orders but individual manufacturers could still have unfilled orders in channel #1.

If dealers stockout, they'll reorder in anticipation of future rising demand above current sales levels, as well as having to account for their (i.e., dealers') desired inventory levels in the future. These are the total unfilled orders that manufacturers see arising from channel #1. Industry-wide unfilled orders, as reported in Research Study #12, reference actual final end-user customer stockouts now (not in the future). Note, too, that since industry-wide unfilled orders are customer-based, industry-wide unfilled order estimates presumably are based on customer surveys. Such survey-based estimates contain some statistical noise as well as reflecting the potential for biases in customer surveys, especially if there are lots of customers who encountered stockout situations. Thus, even a thoughtful/rational survey respondent might claim to have wanted to buy and encountered a stockout situation, to encourage manufacturers to have more plentiful inventory, especially when no contractual purchase commitment is required within the survey.

## Manufacturing Decisions

Firm	
------	--

Month	
-------	--

Manufacturing Decisions	Product 1	Product 2
Production		

**Notes:** Each production volume may change by a maximum of 15,000 units from the preceding month's value. You may, however, change production to 0 at any time. However, note that with a production value of 0 units, the following month's production volume would be limited to a maximum of 15,000 units.

### Reminders

Only input changes. If you're happy with the current values of these decisions, leave the appropriate decision entries blank.

**Don't forget to zero-out prior production decisions if you don't wish them to continue on into the next month.**

All decision inputs change the existing values to the values that you specify. Do not enter "+" or "-" values. Rather, enter new values only (new values replace the existing value of the decision variable with your designated value).

## Forecasting Decisions

*"Forecasting is difficult, especially about the future." – Unknown*

Your firm is responsible for short-term sales volume forecasts for all products/channels/regions for the next month and long-term sales volume forecasts for all products for each of the two months after the next month.

### Sales Forecasting Volume Decisions

*"Forecasting is like looking into a Kaleidoscope. The patterns are beautiful, but with a wrist flick, they change dramatically. The patterns all look clear today, but just a flick of fate, a competitor's action, or a shift in customer preferences and everything changes." – Claire Verweij, University of Michigan MBA (1995)*

Good forecasts are the cornerstone of any supply chain management process. Forecasting prowess reflects understanding of the demand drivers of any business. In LINKS, monthly sales volume forecasts are required for retail and direct channel sales of each of your products. While explicit recorded replacement parts forecasts are not required, you will need to forecast replacement parts demand to manage your inventories of sub-assemblies.

Administrative overhead costs increase by 1% for every 1% inaccuracy in your sales volume forecasts. For example, a forecast error of 10% (whether positive or negative) for a product in a region increases the administrative overhead costs for that product in that region by 10%.

- The maximum administrative overhead penalty associated with sales forecasting inaccuracy for each product in each region is a doubling of administrative overhead.
- Forecast error costs are recorded as "Forecast Inaccuracy" costs on your firm's profit-and-loss statements, so the reported base administrative overhead costs are always \$80,000/month and \$120,000/month per product in channels 1 and 2, respectively, in all market regions.

Sales volume forecasting decisions are independent of your procurement and production decisions. Sales volume forecasting decisions are your best estimates of customer demand. Of course, your actual procurement and production decisions will be based on additional factors, such as fixed order costs and target inventory levels.

**Demand seasonality exists in LINKS markets.** Hyperware set-top boxes have a dramatic 3<sup>rd</sup>-month industry-wide demand peak compared to other calendar months due to end-of-quarter purchasing by businesses and government organizations. Industry-wide demand for hyperware in months 3, 6, 9, etc. is 30%-35% higher than in other months. There is no known seasonality in the metaware set-top box sub-category.

### Forecasting Accuracy

Forecasting accuracy is one component of the multi-factor LINKS performance evaluation scorecard. Forecasting accuracy influences operating performance both directly (via

adjustments in base administrative overhead for forecasting inaccuracies) and indirectly (via inventory pipeline inefficiencies [too much or too little inventory]).

Forecasting accuracy is equal to  $100 \times (1 - (\text{abs}(\text{Forecast} - \text{Actual}) / \text{Actual}))$  expressed in percentage terms, where "abs" is the absolute value function. Thus, a forecast value of 11,000 and an actual value of 8,000 results in a forecast accuracy of  $100 \times (1 - (\text{abs}(11,000 - 8,000) / 8,000)) = 100 \times (1 - (3,000 / 8,000)) = 100 \times (1 - 0.375) = 62.5\%$ . The minimum possible value of forecasting accuracy is 0.0%. For example, with an Actual sales volume of 8,000, a Forecast above 16,000 results in a forecasting accuracy score of 0.0%.

### About Forecasting and Forecasting Accuracy

Given the importance of forecasting in running your LINKS business, you might find that reading the following article has a positive return on your reading-time investment:

- J. Scott Armstrong, "The Forecasting Canon: Generalizations To Improve Forecast Accuracy," **FORESIGHT: The International Journal of Applied Forecasting**, Volume 1, Issue 1 (June 2005), pp. 29-35.  
[http://www.forecastingprinciples.com/paperpdf/The\\_Forecasting\\_Canon.pdf](http://www.forecastingprinciples.com/paperpdf/The_Forecasting_Canon.pdf)

### Forecasting Decisions Form

*"Predicting rain doesn't count; building arks does."* – Warren Buffett

A blank "Forecasting Decisions" form may be found on the page following the next page. Complete this decision form during your team deliberations.

## Forecasting Decisions

Firm	
------	--

Month	
-------	--

<b>Short-Term (i.e., Next Month) Sales Volume Forecast, Product 1</b>	Region 1	Region 2	Region 3
Product 1, Channel 1			
Product 1, Channel 2			

<b>Short-Term (i.e., Next Month) Sales Volume Forecasts, Product 2</b>	Region 1	Region 2	Region 3
Product 2, Channel 1			
Product 2, Channel 2			

### Reminders

Only input changes. If you're happy with the current values of these decisions, leave the appropriate decision entries blank.

All decision inputs change the existing values to the values that you specify. Do not enter "+" or "-" values. Rather, enter new values only (new values replace the existing value of the decision variable with your designated value).

## Financial and Operating Reports

The LINKS financial and operating reports are described in this section of the manual. These are the standard reports that you receive after each month of the LINKS exercise

### Performance Evaluation Report

The performance measures within the LINKS multi-factor quantitative performance evaluation scorecard monitor key elements of performance assessment: efficiency (input usage); effectiveness (output quality); productivity (conversion of inputs into output); firm-wide profitability; and, external performance (e.g., market share change and customer satisfaction).

Trade-offs arise in potentially conflicting performance measures that move in opposite directions. For example, inventory reductions save costs on the inventory and manufacturing fronts but may lead to shortages to meet customer demand. Balancing these conflicting trade-offs is the challenge for management.

The LINKS scorecard is perhaps better described as a boardroom-level scorecard. It focuses on top-line boardroom kinds of financial, operational, and customer performance measures and sub-measures. The LINKS scorecard includes the measures and weights described in Exhibits 5-7. Each firm in your set-top box industry submits their raw data to the Set-Top Box Trade Association, which provides your firm's personal scorecard every month.

The LINKS scorecard is based on a ranking of performance on each sub-measure. These rank-order comparisons across all competing firms within your industry avoid the undue influence of particularly extreme values of individual sub-measures. This LINKS scorecard is a within-industry performance evaluation system. Comparisons across industries are problematic due to variations in environmental and competitive milieu. Your firm receives weighted points for each competitor for whom your performance on a sub-measure is better. For some of the sub-measures, "better" means a lower sub-measure value (e.g., the "Ratio of Controllable Procurement and Manufacturing Costs To Revenues" is a lower-is-better sub-measure). For example, if your firm's ratio of "Net Profits" to "Revenues" is better than three other firms' ratios, your firm receives 9 points. (Of course, the top-performing firm on "Net Income" to "Revenues" ratio in a 6-firm industry would receive 15 points.) In general, the maximum available points on any sub-measure are  $W \cdot (N-1)$  where "W" is the sub-measure's weight and "N" is the number of firms in the industry. Points accumulate each month throughout the LINKS exercise.

To avoid overemphasizing minor variations in calculating firms' rankings on these performance sub-measures, minor differences in sub-measures are treated as ties in the calculation of ranking points. The thresholds for differences to be treated as meaningful are listed in Exhibits 5-7. For example, differences of 0.2% or less for "Ratio of Net Income to Revenues" are considered to be statistically insignificant, and firms within 0.2% of each other would be treated as being tied. Thus, two firms with ratios of Net Income to Revenues of 4.5% and 4.6% would be treated as being tied in the calculation of ranking position and points received.

### Exhibit 5: Scorecard Financial Measures

Sub-Measures	Weight	Sub-Measure Details
Ratio of Net Income to Revenues	3	Current profitability is the best overall signal of business performance, hence its high weight. Firms are "tied" if their scores are within 0.2% of each other.
Change in Ratio of Net Income to Revenues	1	Improvement in profitability is important but less important than current profitability. Firms are "tied" if their scores are within 0.2% of each other.
Return on Assets	2	Return means "Net Income" (from the "Corporate P&L Statement") and investment equals "Total Assets" (from the "Balance Sheet"). This ratio is expressed in annualized terms. Firms are "tied" if their scores are within 0.5% of each other.
Net Asset Turns	1	Ratio of revenues to net assets. Net assets are assets minus loans. This measure reflects the desirability of higher revenues relative to the assets deployed to yield these revenues. This ratio is expressed in annualized terms. Firms are "tied" if their scores are within 0.2 of each other.

### Exhibit 6: Scorecard Operational Measures

Sub-Measures	Weight	Sub-Measure Details
Inventory Turnover	2	Ratio of cost of goods sold to average inventory value. Firms are "tied" if their scores are within 0.2 of each other.
Fill Rate	1	The percentage of orders that are filled. "Unfilled orders" occur when available inventory is less than orders in a month. Firms are "tied" if their scores are within 0.5% of each other.
Failure Rate	-1	Ratio of replacement parts demand to sales volume (orders). Firms are "tied" if their scores are within 0.5% of each other.
Ratio of Controllable Procurement and Manufacturing Costs to Revenues	-1	Controllable procurement and manufacturing costs include "Disposal Sales," "Emergency Procurement," "Inventory Charges," "Procurement FC," and "Production FC." Firms are "tied" if their scores are within 0.2% of each other.
Transportation Costs Per Unit Sold	-1	Equal to total transportation costs divided by total units sold (orders). Firms are "tied" if their scores are within 0.5 of each other.
Forecasting Accuracy	2	Forecasting accuracy is a relatively pure signal of management skill and expertise (in this case, in the area of understanding customers and customer demand generating forces). Firms are "tied" if their scores are within 0.5% of each other.
Ratio of (Marketing + Service Spending) to Revenues	-1	Service spending is service outsourcing costs. Marketing spending is an easy way to boost short-run sales volume without necessarily contributing to long-run profitability. Relative to revenues, spending less in marketing and service is desirable. Firms are "tied" if their scores are within 0.2% of each other.

### Exhibit 7: Scorecard Customer Measures

Sub-Measures	Weight	Sub-Measure Details
Change in Market Share	1	Change in market share is an overall measure of customer reaction to the firm's offerings. ("Market share" equals customer purchases in all channels and regions.) Firms are "tied" if their scores are within 0.1% of each other.
Customer Satisfaction	2	Customer satisfaction measures the performance of a product from the perspective of purchasers. Thus, it's a clear measure of customer performance and a long-run leading indicator of repeat purchasing behavior and customer retention. Average customer satisfaction across all products, channels, and regions is used here. Firms are "tied" if their scores are within 0.5% of each other.

**Notes To Exhibits 5-7:** Positive "weights" are associated with sub-measures where "more is better" and negative "weights" are associated with sub-measures where "less is better." "Change" measures are based on month-to-month changes.

## Corporate P&L Statement

The "Corporate P&L Statement" aggregates all of the product-specific profit-and-loss statements into an overall corporate profit-and-loss statement. A variety of line items appear on the "Corporate P&L Statement" only, because it is not possible to unambiguously allocate those costs to specific products in specific regions for specific channels.

Definitions of non-obvious line items on the "Corporate Current P&L Statement" follow:

- Administrative overhead ("Administrative O/H") is \$80,000/month and \$120,000/month per product in channels 1 and 2, respectively, in all market regions.
- "Consulting Fees" may be positive or negative. "Consulting Fees" are adjustments to income or expenses. Conversations with your coach/instructor are normally without charge, so don't worry about "Consulting Fees" associated with these consultations. In LINKS, the "Consulting Fees" line item represents a convenient mechanism for making adjustments to income or expenses.
- Corporate overhead ("Corporate O/H") is \$250,000 per product per month. This per-product charge is incurred if a product is actively distributed in one or more market regions.
- "Distribution FC" reflects the fixed costs associated with operating distribution centers.
- "Emergency Procurement" reflects all emergency procurement costs.
- "Forecast Inaccuracy" records the costs associated with forecasting errors.
- Inventory charges arise for sub-assembly components and finished goods. These costs are recorded under the heading "Inventory Charges" on the "Corporate P&L Statement." This inventory charge is equal to 3% per month based on the value of inventory as recorded on your firm's balance sheet. Inventory charges are levied on the average of beginning-of-month and end-of-month inventory values, and include all costs related to storage, handling, waste, and insurance.
- "Marketing" equals total marketing spending.
- "Non-Operating Income" derives either from interest earned on "Marketable Securities" (from the previous month's "Balance Sheet") or from interest paid on "Loans" (from the previous month's "Balance Sheet").
- "Operating Income" equals "Gross Margin" minus "Total Fixed Costs."
- "Plant Capacity FC" represents the costs associated with production "shifts" in your manufacturing plant. These costs cover all depreciation and maintenance associated with your plant capacity. These costs are allocated equally among your products.
- "Procurement FC" includes the fixed costs associated with procurement.
- "Production FC" includes the fixed costs associated with production orders.
- "Service Outsourcing" costs include the costs of service outsourcing provided by reputable call-center service providers in each region. Your firm uses "Standard" outsourcing, with the following per-call costs: \$10, \$12, and \$13 per call in regions 1, 2, and 3, respectively.
- "Taxes" represents the corporate taxes payable in the market region in which your firm has its manufacturing plant. Your manufacturing plant is located in market region 1, which has a corporate tax rate of 50%.
- "Total Fixed & Other" is the sum of all fixed costs. Note that "Total Fixed & Other" does not sum correctly down and across since some fixed costs are not allocated to specific products.
- "Unfilled Handling" records unfilled orders processing and handling costs of \$25/unit.

## Historical Corporate P&L Statement

The "Historical Corporate P&L Statement" reports the previous and current month's corporate-level profit-and-loss data. In addition, all elements in the "Historical Corporate P&L Statement" are expressed in percentage-of-revenue terms.

## Product P&L Statement

Each product has a current profit-and-loss statement each month. The product "P&L Statement" includes the relevant data for all channels.

## Balance Sheet

Your balance sheet records the usual assets and liabilities associated with your firm at the end of each month. Among other things, current levels of procurement and finished goods inventories are reported on the balance sheet.

On the "Balance Sheet":

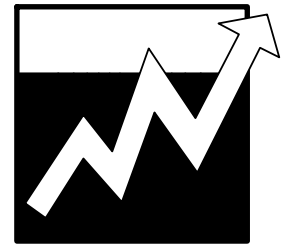
- "Cash" represents your cash balance. Cash in excess of 10% of revenues is automatically invested in short-term "Marketable Securities" which earn 0.5% per month in "Non-Operating Income" on the "Corporate P&L Statement" in the following month. If cash falls below 5% of revenues, a loan is automatically arranged to increase cash to 5% of revenues. You pay interest of 1% per month on "Loans" and this interest payment is recorded as "Non-Operating Income" (a negative value of "Non-Operating Income") in the following month's "Corporate P&L Statement."
- "Corporate Capitalization" is the dollar-value of the original capital invested by your shareholders to start your firm.
- "Dividends" are cash payments to shareholders. In any month in which "Net Income" is positive, 30% of the "Net Income" is allocated to "Dividends."
- "Plant Investment" represents the dollar-value of your firm's investment in a manufacturing plant to produce set-top box products. The normal per-unit production charges that you pay for producing set-top boxes includes a component to cover the maintenance and depreciation of your plant. Thus, your "Plant Investment" value will also be the same through time.

On-order epsilon sub-assembly components for delivery next month are reported at the bottom of your balance sheet. While you don't pay for epsilon sub-assembly components until delivery, this contract is notable since it represents a future procurement purchasing commitment. Each region's epsilon orders are noted. For example, a reported value of "12,000Fa" refers to a sub-assembly component order of 12,000 units from supplier F via air.

## Other Reports

Additional reports included in the standard LINKS financial and operating reports are as follows:

- **Finished Goods Inventory Report:** The details of your finished goods inventories are reported on the "Finished Goods Inventory Report."
- **Procurement Inventory Report:** The "Procurement Inventory Report" reports sub-assembly components inventories.
- **Other Decision Variables Report:** Procurement and manufacturing decisions are either sprinkled around in the financial and operating reports or not directly reported in the "Product P&L Statement." To provide an easy-to-access listing of the current values of these decision variables, an "Other Decision Variables Report" is provided as part of your financial and operating reports.
- **Replacement Parts Demand Report:** Details of replacement parts demand (by product, region, and channel) for each of your sub-assembly components are provided in the "Replacement Parts Demand Report."
- **Forecasting Accuracy Report:** The "Forecasting Accuracy Report" provides details of the forecasting accuracy associated with each of your sales volume forecasts. Forecasting accuracy is equal to  $100 \times (1 - (\text{abs}(\text{Forecast} - \text{Actual}) / \text{Actual}))$  expressed in percentage terms, where "abs" is the absolute value function. For example, a forecast value of 11,000 and an actual value of 8,000 result in a forecast accuracy of  $100 \times (1 - (\text{abs}(11,000 - 8,000) / 8,000)) = 100 \times (1 - (3,000 / 8,000)) = 100 \times (1 - 0.375) = 62.5\%$ . The minimum possible value of forecasting accuracy is 0.0%. With an Actual sales volume of 8,000, a Forecast above 16,000 results in a forecasting accuracy score of 0.0%. The "Forecasting Accuracy Report" also includes industry-wide sales volumes and unfilled orders in the "Sales History" portion of this report, based on industry trade association data pooling across all of the firms in your set-top box industry.



## Sample Reports

*"The meaning of life is to do the best you can with what you've got."* – Anonymous

The following pages provide samples of the standard LINKS financial and operating reports. These samples are provided to familiarize you with the style and format of the reports that are provided to your firm after each LINKS round. The data reported in these sample reports are only illustrative of reports formatting. These data aren't specific to your particular LINKS industry. Please do not interpret these samples as suggested guidelines or benchmarks for good decisions and performance within LINKS.



If you'd like some further background on interpreting LINKS financial statements, please access Tutorial #1 ("P&L Statements") on the LINKS website and spend 45 minutes or so working through it prior to (or close to) the beginning of your LINKS event.



















## Appendix: Web-Based LINKS Access

LINKS has no software to download/upload/install. Point your favorite web browser at the LINKS website to interact with LINKS

<http://www.LINKS-simulations.com>

and then access the LINKS Simulation Database using your firm's case-sensitive passcode. **You'll be e-mailed your LINKS firm's passcode just before your LINKS event begins.**

LINKS uses e-mail to communicate with all LINKS participants. Please ensure that your preferred e-mail software is configured to receive e-mail messages from domains ending with:

@ChapmanRG.com

@LINKS-simulations.com

@LINKS-simulations.info

You may wish to consult your personal information technology advisor to ensure that your e-mail software is configured appropriately to receive LINKS e-mail from these domains.

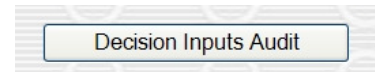
While the LINKS Simulation Database works with all web browsers, Microsoft's Internet Explorer is recommended. **LINKS website access requires a Java-enabled browser.**

**Output Retrieval After a LINKS Round:** You'll be advised via e-mail when LINKS game-run results are available. Clickable links within the LINKS Simulation Database permit you to access your Word doc and Excel results after a game run.

**Inputs For the Next LINKS Round:** When you're ready to input decisions for the next LINKS round, access the LINKS Simulation Database and make your input changes.

- **While any number of members of a LINKS firm may access the LINKS Simulation Database simultaneously to "browse," only one member at a time can input new decisions.** If multiple members of a LINKS firm attempt to make inputs simultaneously, problems can arise; all decision inputs might not be saved successfully on the LINKS server with simultaneous inputs from multiple LINKS firm members.
- You may make some inputs now and others later. Only your final LINKS inputs at the input submission deadline for your LINKS industry are included in the next LINKS round.
- Within the LINKS Simulation Database, current decision values are displayed on the input screens. You only need to make changes. All LINKS decision variables are "standing orders" and remain in effect until changed. However, you must input specific instructions each LINKS round for ordering research studies. Otherwise, research studies will be executed only once since "standing orders" don't exist for research studies.
- Inputs are checked for input integrity, including upper and lower bounds on permissible numeric inputs. Invalid entries result in an error message reporting valid minimums and maximums. And, informative messages are reported at the bottom of each web screen.
  - **Execute the "Submit" button after making changes on a LINKS input web screen.** Then, review new reminder, warning, and error messages reported at the bottom of the regenerated web screen after the inputs are processed by the LINKS web server.
  - **"Submit" each webpage's inputs before moving to another input screen in the LINKS Simulation Database.** After you "Submit" a webpage's input changes, check for new reminder, warning, or error messages at the bottom of the refreshed webpage (just above the "Submit" button) before moving on to other web screens.

- **Decision Inputs Audit:** To provide decision inputs auditing support, the LINKS Simulation Database includes a Decision Inputs Audit. Accessible on the initial login and Exit web screens in the LINKS Simulation Database, the Decision Inputs Audit checks a firm's current decision inputs for potential problems and inconsistencies. This LINKS Simulation Database audit function is not an audit of the individual quality of each decision input (e.g., there's no attempt to assess whether a price of \$345 is good or bad). But, possible problems are flagged for attention. For example, forecasts that haven't been changed since the last decision round are noted in the audit display because forecasts are normally updated every decision round.



**Accessing LINKS Results Files Via Internet Explorer on a Public Computer:** Internet Explorer leaves “tracks” to previously accessed web-pages in its browser history. If you access LINKS results files on a public computer (e.g., in a public PC lab), others could access your results too via the Internet Browser history. **If you access LINKS results files on a public computer, follow these steps to clear Internet Explorer's browser history:**

1. Exit/close Internet Explorer after accessing your LINKS results file.
2. Re-start Internet Explorer.
  - a. Click on “Tools” and then “Internet Options.”
  - b. On the “Internet Options” screen, look for the “Browsing History” sub-section. Check “Delete browsing history on exit” (it may already be checked).
  - c. Click the “Delete” button in the “Browsing History” sub-section.
  - d. Check the “History” box on the “Delete Browsing History” screen (it may already be checked).
  - e. Click the “Delete” button at the bottom of the “Delete Browsing History” screen.
  - f. Wait until the “Internet Options” screen re-appears.
  - g. Click the “OK” button.
3. Exit/close Internet Explorer.

These steps clear the browsing history from Internet Explorer on any computer and preserve the security and privacy of your LINKS results files.