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Research Report

Supply Chain Management in the New Economy: Lessons from the Semiconductor Industry

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Supply Chain Management in the New Economy: Lessons from the Semiconductor Industry

Semiconductor products are a fundamental building block of the new information economy. In 1998, semiconductor sales were $ 126 billion on 257 billion units shipped, and the industry experienced double digit growth rates in 1999 and 2000. Semiconductors are now used a wide variety of industries, from computers to communications equipment to motor vehicles and industrial controls. As the importance of being "connected" continues to grow, semiconductors will be needed literally everywhere.

Semiconductors are also prototypical new economy products for supply chain managers. Chips are small, extremely valuable, quickly obsolete, and globally produced and distributed. Customers measure product lifecycles in months. Inventory is precious early in a product's lifecycle, but its contribution to profit can drop by 80% in a year. Faced with an absolute need for speed, chip manufacturers use air freight as the default transportation mode, except where surface is as fast or faster. Shipping across oceans, accommodating extraordinary growth, supplying key customers overnight are routine challenges in the high technology world of semiconductor logistics.

Until recently, these concerns were not on the executive radar screen. From its inception, the semiconductor business has been engineering and product driven. The essence of the business is Moore's Law – every 18 months performance capabilities double, putting continuous pressure on prices for older chips. Cutting edge technology and "design wins" were seen as the key to success. But now chip customers are also insisting on better service. Having the latest, fastest chip is not the only key to competitive advantage. Dell has built its business around expecting suppliers to deliver, and other users are following suit. Gateway recently penalized Intel for non-performance by shifting major amounts of business to AMD.[1] Some companies report that automotive customers like Ford expect JIT delivery schedules *and* refuse to share the risk of product obsolescence. Supply chain realities have descended on the semiconductor world with a vengeance.

Faced with these pressures, the International Sematech's Semiconductor Logistics Forum initiated a study of logistics practices throughout the manufacturing and delivery process. A research team from three universities and IBM's Thomas J. Watson Research Center analyzed detailed service, location,

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[1] Wall Street Journal, January 10, 2000.

and shipment data for seven global semiconductor companies.[2] The findings from this work can be condensed into six key "lessons" that are applicable to any firm serving the fast moving global marketplace. (See exhibit – Supply Chain Management in the New Economy: Lessons from the Semiconductor Industry)

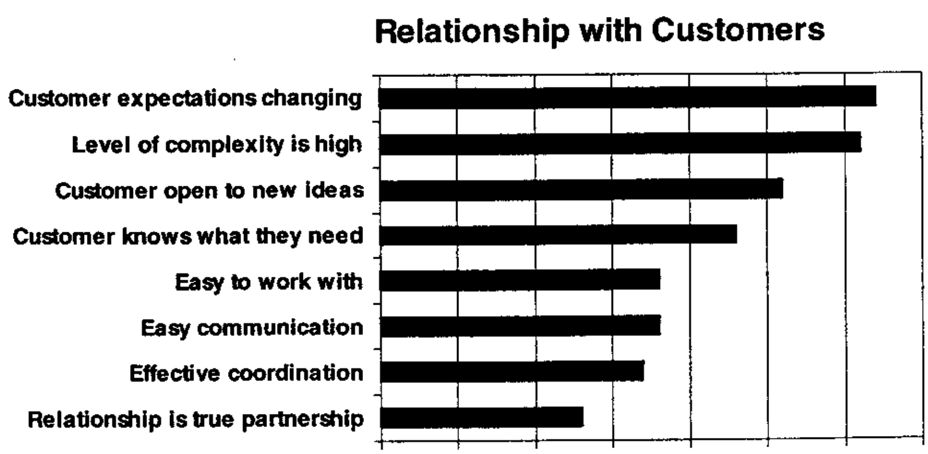
The operating environment for semiconductor logistics is conditioned by three elements – the increasing level of customer expectations, the dispersed nature of the manufacturing network, and the sky high cost of inventory. Understanding the interplay between these factors is fundamental to grasping the problems and potential of supply chain management for semiconductor manufacturers.

CUSTOMER EXPECTATIONS – HIGH AND RISING

One of the first tasks for the research team was to investigate customer expectations. We probed both manufacturers' perceptions of their customers and how those perceptions translated into planned service levels. Manufacturers were first asked about their customer relationships. The results are shown below.

Exhibit

Communication and coordination with customers was poor.
(1=Definitely Not, 7=Definitely Yes)

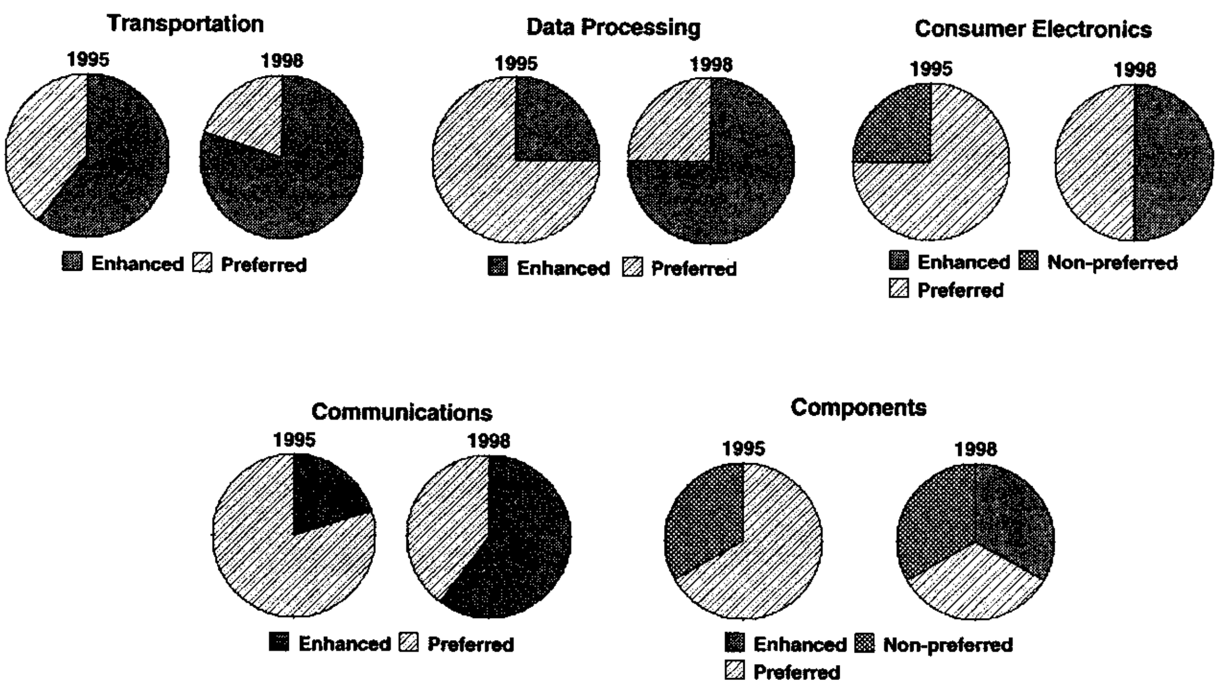


[2]The participating members of the Semiconductor Logistics Forum were Advanced Micro Devices, Intel, National Semiconductor, and the semiconductor divisions of Texas Instruments, IBM, Hewlett-Packard (now Agilent), and Motorola (including the since spun-off On Semiconductor group).

Manufacturers agree that customer expectations are changing. Accompanying comments made it clear that buyers are increasing the range and level of service expected. In fact, when we asked manufacturers to classify their service offerings into three levels – enhanced (including JIT, line-side stocking,[3] etc.), preferred, and non-preferred – it turned out that the proportion of enhanced service increased for all customer types between 1995 and 1998.

Exhibit - Changes in Service Levels, 1995-1998

Transportation customers moved early to enhanced service models.



[3] Line-side stocking is a practice whereby the supplier delivers components directly to the point of use, while maintaining ownership until drawn into the production process.

The preceding exhibit shows a clear hierarchy by industry in the levels of service offered. Transportation and data processing customers are most likely to get enhanced service, while component resellers are often classified as "non-preferred" customers. When questioned, manufacturers indicated that different factors drove the different markets. Cost was mentioned only in connection with component reseller customers (but see the sidebar – When Resellers are Crucial). Other customer groups emphasized the need for speed and flexibility, which entails higher service levels. The first lesson we drew from the research relates to customer segmentation.

LESSON 1 – Where customer service is involved, industry matters. Customers who use chips in their products insist on high service levels even at high cost; resellers accept lower service levels for lower cost.

But it turns out that the service model offered to customers is only part of the story. For example, one manufacturer has "preferred" communications customers with delivery times ranging from 1 day to 4 days, all within the U.S. Consumer electronics customers also see regional variations. Asian customers dominate this sector, and even "non-preferred" Asian customers mostly get next day service because they are close to manufacturers. Geography also plays a role in service to component customers. For two of the manufacturers, component demand is in the U.S. but is shipped directly from Asian plants. For these non-preferred customers, even air freight is a minimum of 3 days. Another manufacturer rates most component customers "preferred" but uses surface transport in Europe and the U.S., again resulting in 3 day and 5 day delivery cycles. These variations lead to our second lesson.

LESSON 2 -- Global companies may have uniform customer classifications, but these do not necessarily translate into global service standards.

As expected, we needed to look at the manufacturing networks to really understand semiconductor logistics.

SIDEBAR – WHEN RESELLERS BECOME CRUCIAL

One manufacturer recently took on the challenge of integrating forward toward the consumer (and got a taste of requirements in the consumer products marketplace). This company began to manufacture an OEM Internet terminal that went to market through distributors. The company found that delivery requirements were significantly different – these distributors demanded that product be in place to be drawn within 24 hours of the order. The manufacturer accomplished this by treating half of expected demand on a "make-to-stock" basis through improved forecast management and by moving finished goods to 3PL facilities in close proximity to key distributors.

END SIDEBAR

SEMICONDUCTOR MANUFACTURING – PRODUCING AND DISTRIBUTION FOR A GLOBAL MARKET

Semiconductor manufacturing and delivery is a three stage process, typically referred to in the industry as wafer fab, bond/assembly/test, and product distribution. Specifically:

1) Wafer fab (also called "front end"), short for wafer fabrication, is the process wherein multiple integrated circuits are fabricated on each raw silicon wafer. This is a highly repetitive process. A layer of material is deposited on the wafer, a specific pattern is created in the layer, another layer is added and patterned, and so on. The most modern wafer fab facilities are working with wafers of 300 mm (approximately 1 foot) diameter which contain thousands of integrated circuits, depending on the specific chips being made.

Wafer fab plants are extremely expensive. Etching pattern lines much finer than a human hair is done using precise beams of light produced by $1 million + photolithography machines. Keeping particles away from these patterns requires Class 1 "clean rooms" or elaborate mini-environments that allow no more than 1 particle larger than .1 micron per cubic foot of atmosphere. Given these extremely demanding requirements it is not surprising that the latest "fabs" cost $2 billion each. This level of capital investment mandates round the clock operation for these installations. Even so, the physics of the fabrication process sets a lower limit of thirty days for cycle time from raw wafer to finished wafer. More typical times are sixty days+ to make sure the fabs are always operating at optimum load.

2) Bond/assembly/test (BAT) facilities dissect finished wafers into separate chips, assemble the devices into various packages, make the appropriate electrical connections, and then test the packaged devices to make sure they are operating according to customer specification. The "assembly" stage of this process has a significant labor component, while final testing is performed using sophisticated and expensive automatic test equipment.

Bond/assembly/test is often referred to as "back end processing" because the output of this phase is a finished product ready for shipment to customers. The output unit of bond/assembly/test is typically a single packaged integrated circuit.

3) Product Distribution in the semiconductor industry refers to warehousing and shipping of finished goods. Since the product is light, small, and relatively high value (selling prices range from $500 per unit for microprocessors to $.05 per unit for discrete components, with an average of $0.49 per unit

overall in 1998) many semiconductor distribution centers have automated storage and retrieval systems. The short life cycles and high cost of inventory push most manufacturers to minimize final storage locations, and outsourcing of warehousing is common. On the other hand certain customers demand just-in-time delivery on four hours or less notice. These customers are serviced using small satellite locations close to the customer assembly plants.

Given this production process, the location decisions for these networks reflect the interplay between three factors - the need for technical expertise, the labor-intensive nature of assembly and test, and the importance of being close to customers. Local incentives and favorable tax treatment have also influenced assembly and test location choices.[4] Logistics and transport costs factor into these decisions, but typically are not large enough to overbalance the main drivers of the process. (Exhibit – Site Selection Criteria) The location decision turns out to be different, based on the facility type being considered – wafer fabrication, BAT, or product distribution.

Most **fabs** are located in relatively advanced economies - the United States, Europe, and Japan. Fabs are true high technology with extremely high capital costs and sophistication that make technically trained personnel a necessity. Historically, virtually all fabs have been sited in countries that have large supplies of engineers, technicians, and other technologically proficient workers as well as reliable physical infrastructure. In some cases the companies profiled here have fabs in less economically developed areas, but this remains the exception. All of our study companies maintain some wafer fabrication operations in the U.S.

Bond/Assembly/Test (BAT) is concentrated in Asian countries other than Japan. The bond, assembly, and test process requires significant amounts of labor, ranging as high as 20% of total cost. Chip companies early on went to low labor cost areas for these operations. Recently some companies have also located BAT in South America, North Africa, etc.

Product Distribution activities are evenly spread among the three geographies. The decision here is how much to pay in extra transportation and inventory cost to be close to the customer. The industry operates both Tier 1 and Tier 2 distribution centers. Tier 1 sites receive finished products from BAT and ship to customers for final use. Tier 2 sites receive inventory from Tier 1 centers and ship to

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[4] G. Peter Wilson, "The Role of Taxes in Location and Sourcing Decisions," in *Studies in International Taxation*, Alberto Giovanni, R. Glenn Hubbard, and Joel Slemrod, ed., National Bureau of Economic Research, 1993.

close customers as necessary. Tier 2 locations are frequently dedicated to important JIT customers. The number of tier 2 sites varies depending on inventory availability and the demands of customers. Where scarce new products are involved, both buyer and supplier prefer not to spread finished goods inventory too thin.

Exhibit - Site Selection Criteria

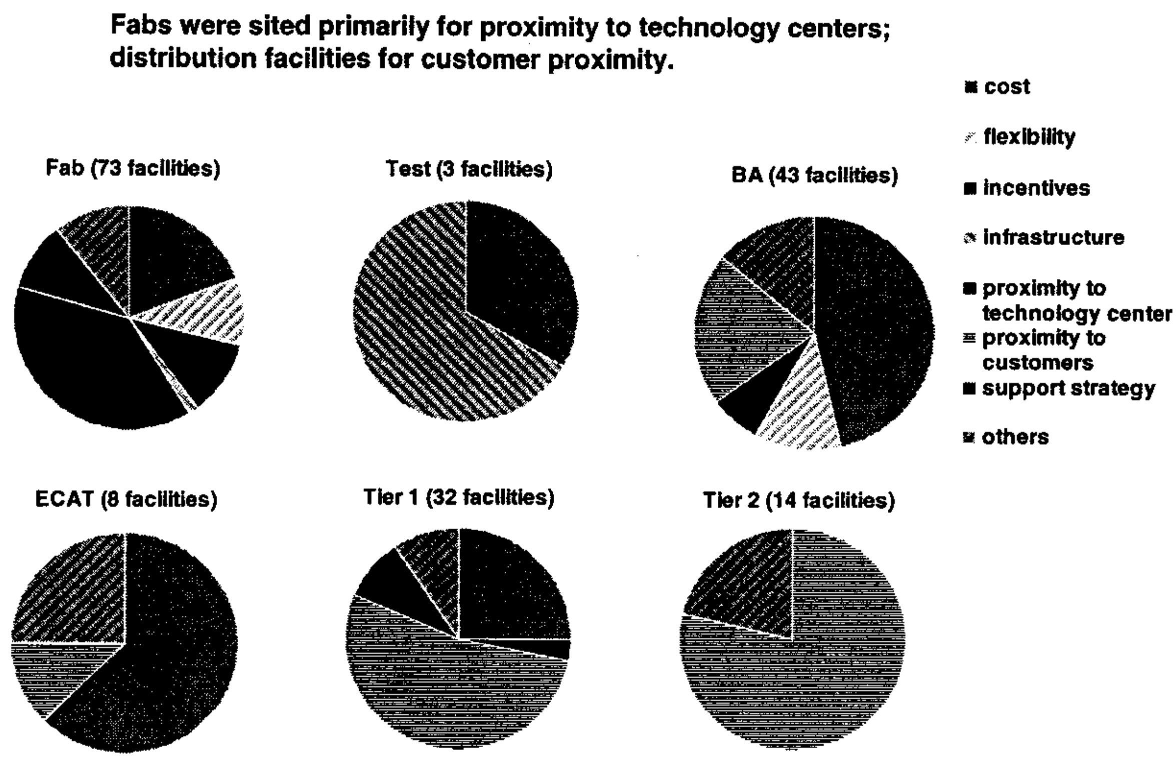
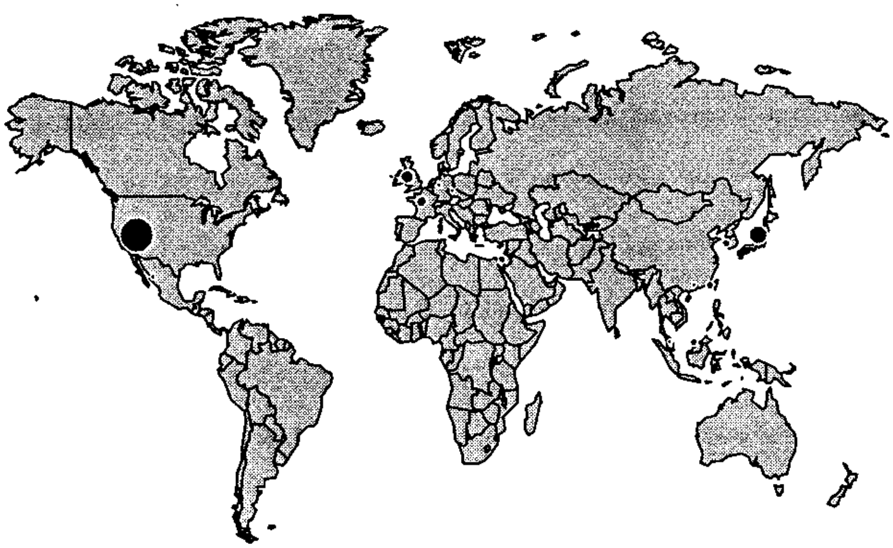


Exhibit – Semiconductor Installations by Function

Device fabrication activities were located predominately in the US, Japan, and Western Europe.



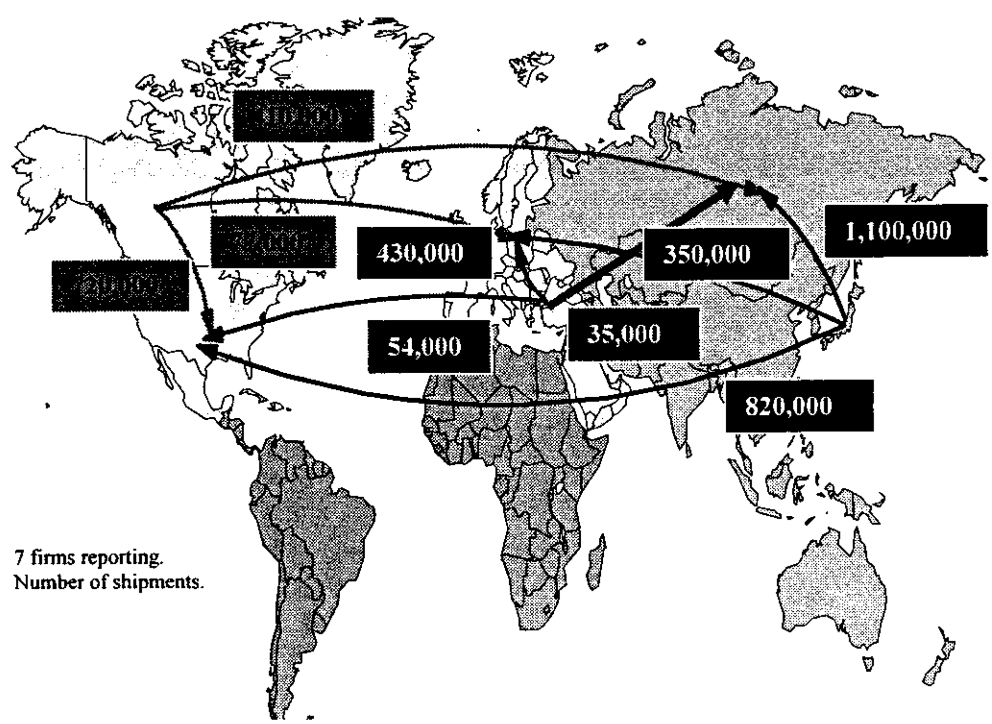
Back end manufacturing facilities (BA shown) were located predominately in the Far East.

As the world map in Exhibit __ shows, semiconductor manufacturing is truly a worldwide enterprise. The need for expertise and reliable infrastructure means that fabs historically were located in advanced countries, and these fabs would be ruinously expensive to move. Bond/assembly/test, historically difficult to automate and relatively labor intensive, is now entrenched in southern Asia. Finished goods inventory is located consistent with service requirement. Powerful customers like Dell can dictate so-called Tier 2 facilities near their plants, although some companies store inventory for the world in one or two sites.

Although logistics costs may be too small to influence location decisions, the reverse is clearly not true. The next exhibit shows shipment flows reported by study participants on an annualized basis. Material routinely crosses oceans two or three times before finished goods arrive at customer plants. Over 40% of all shipments cross oceans, typically between the U.S. and Asia, while even the so-called "intraregional" shipments are often international. Two-thirds of industry shipments are by air, consistent with the value of the product and the long distances involved. This reality leads to the third lesson learned.

Figure 6 - For Semiconductor Manufacturers, Long Distance Shipping is the Norm

For the industry, the largest flows of shipments were within Asia, within North America, and from Asia to North America.



LESSON 3 – For high tech industries in the new global economy, logistics may have relatively little influence on location decisions, but these decisions can drive high cost transportation alternatives.

The semiconductor industry is not the only one with demanding customers and a globally dispersed production process. But semiconductors are almost as perishable as fresh food or designer fashions, a fact that makes inventory expensive. To understand semiconductor logistics, it is important to realize how costly holding inventory can be.

<u>SEMICONDUCTOR INVENTORY – THE COST OF CONTINUOUS INNOVATION</u>

Semiconductors are good examples of the "innovative products" Marshall Fisher talked about in his 1997 article, "What is the Right Supply Chain for Your Product.[5] Fisher's examples were drawn from consumer goods such as ski fashions. He pointed out that the cardinal sin for innovative products is to be out of the marketplace in the early stages of product introduction, when prices are high and demand is strong. He recommended a flexible supply chain with an emphasis on improved forecasting and quick replenishment of stocks when consumer fashion choice reveals itself.

That prescription holds when retailers are handling fashion goods and customers are disappointed one at a time. But what happens when your customers are manufacturers practicing mass customization, offering thousands of configurations on demand? Now the consequences of a stockout are not a few lost sales, but whole factories brought to a halt. Worse, industrial purchase decisions are made infrequently and involve large commitments. Just ask Intel about Gateway's decision to second source with AMD. Being out of stock is not a viable option; in these markets business is lost in chunks, not one sale at a time.

Still, being "in stock" is not cheap. Semiconductor prices depend on many factors, in particular the balance between capacity and demand and the position of the specific product in its lifecycle. The example below assumes chip prices decrease at the same rate as higher performance chips become available – i.e. Moore's Law. Although this is clearly a gross simplification, it allows Exhibit ___ to illustrate the double impact of holding products with short cycle times. Not only are there costs to finance the inventory, the potential return from the inventory investment decreases on a daily basis.

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[5] Fisher, Marshall, "What is the Right Supply Chain for your Product?," <u>Harvard Business Review</u>, May-June, 1997.

Exhibit

Semiconductor Inventory Costs and Supply Chain Realities

a. The Realities of Price Erosion

Before we get into the specifics of the semiconductor industry, let's look at a simplified example. Suppose you have a product that initially sells for $2.00, has a 50% gross margin, and experiences 25% annual "price erosion." What is the effect on profits? On the return on inventory?

	If sold immediately	If sold 1 year later	Difference	%
Price	$2.00	$1.50	($ .50)	-25%
Cost of Goods (=inventory investment)	$1.00	$1.00	-	-
Gross Profit	$1.00	$ .50	($.50)	-50%

In this example a price decline of 25% results in a 50% decrease in the profit the inventory can generate. The ability of the inventory to generate profit has eroded *50%*. Now let's look at the situation in semiconductors.

b. Semiconductor Specifics

Semiconductor capabilities are always changing, but Moore's Law – 50% increase every 18 months - has turned out to be a good approximation of long-term trends. For planning purposes, we assume that this translates into a 37% price decrease for product in inventory for a year. Applying the logic from part (a) to each dollar of finished goods inventory[6]

	If sold immediately	If sold 1 year later	Difference	%
Price	$2.17	$1.37	($ .80)	-37%
Cost of Goods (=inventory investment)	$1.00	$1.00	-	-

[6] To estimate Cost of Goods, we used published gross margins for all firms, recognizing that some companies have considerable business besides semiconductor manufacturing. Gross margins for our sample group averaged 54% in 1998. Note that over time production costs will also decrease, which may change the gross margin differential.

Gross Profit	$1.17	$ .37	($ .80)	-68%

Assuming Moore's Law is a good surrogate for pricing behavior, semiconductor inventories lose over 1% of their value (gross margin) per week, on average. What's more the usual components of inventory cost – financing, storage, shrinkage, etc. – are not included in the above calculation. Adding 15% for annual capital costs pushes the weekly loss over 1.5%. Of course, the exact risk will vary depending on the company's product mix and profit margins.

In more mature markets, inventory is routinely accumulated to insure product availability. For semiconductors, this has to be a strategy of last resort for three reasons:

1) Inventory carrying costs, including price erosion, can easily exceed 75% on an annual basis.
2) When product is in the wrong place (maldistribution) in a global market, chips may have to move between continents to handle unexpected demand.
3) In a cyclical growth industry with short lifecycles, demand periodically outruns capacity. In that case, safety stock is not a realistic option. To paraphrase one executive, "Right now, I don't *have* any inventory. So detailed location planning is not an issue."

How much can the industry afford to spend on freight? A typical semiconductor company spends up to 2% of sales on freight and warehousing. In the example above, reducing cycle time by 1 week would pay for a 35% increase in freight and warehousing expense.[7]

So a careful look at inventory costs leads to the following lesson:

LESSON 4 - In fast paced global industries, using inventory to improve service is prohibitively expensive and for new products, simply impossible. Fast transportation, improved information and better processes are the only realistic alternatives.

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[7] In exhibit 10b. gross profits decrease weekly by ($.80/52) = $.015. Weekly finance costs amount to ($.15/52) = $.003. At 2% of sales freight and distribution comes to $.0434. Reducing inventory by 1 week saves $.0153. Since ($.0153/$.0434) = 35%, 1 week of inventory savings offsets a 35% increase in logistics costs.

SEMICONDUCTOR SUPPLY CHAINS – PERFORMANCE

Semiconductor logistics is not for the faint of heart. Short product lifecycles, rapid price declines, demanding customers, and highly dispersed facilities – any one of these would cause logistics problems. All four together make for an extremely challenging environment. How well are the semiconductor manufacturers managing their supply chains in the face of these challenges? As usual, it depends on your perspective. We collected data on three aspects of supply chain performance – on-time delivery, cycle times, and inventory levels. The results reflect the global nature of company supply chains, the mobility (i.e. high value/light weight) of semiconductor materials, and customers' demands for speed of delivery.

On-time Delivery

Exhibit __ shows the industry's delivery performance against two accepted standards – customer request date and manufacturer commit date. In most cases late deliveries happened because the company did not have the product in time to fulfill the customer's request. As one executive noted, the tough part of semiconductor logistics is not moving the product, it's planning enough capacity to make the product.

Figure 7

On Time Delivery (%) by Company

Company	1	2	3	4	5	6	7	Composite
To Customer Request	45%	65%	60%	65%	65%	77%	65%	64%
To Customer Commit	91%	92%	87%	80%	83%	95%	90%	86%

By consumer product standards, the industry is not doing well. Customer requirements are met, on average, two times out of three. Conversations with the manufacturers surfaced a classic dilemma. Semiconductor manufacturing times range from 40 to 80 days in fabrication alone. But customers can (and do) change orders up to the day of requested delivery. So semiconductor manufacturers are operating in a volatile, make-to-forecast environment. The companies do much better at fulfilling internal commitments but that does not translate into satisfied customers.

Where customers have choices, larger customers – Compaq, Dell, and Gateway in PC's, Qualcomm, Cisco, Nokia, and Ericsson in communications, etc. – may apply real penalties for non-performance. These customers are also in "technology/fashion" businesses with short lifecycle products and high growth curves. They increasingly demand just-in-time deliveries or even line-side stocking. In some cases customers have contracted manufacturing to outside specialists operating on very thin margins. If several chipmakers appear to offer equivalent technology, either the customers or their manufacturing partners will press to switch business to suppliers who can perform on service. In fact, one semiconductor maker stated that "good/bad service...may be the primary reason for customer turnover."

The mismatch between manufacturing cycle times and customer planning horizons is a familiar problem for logistics professionals. There are two general approaches to "fixing" the resulting customer service problems – higher inventories or shorter cycle times. As we noted above, more inventory/safety stock is prohibitively expensive for the semiconductor industry. So the industry is working hard to emulate customers, shorten cycle time, and improve process flexibility.[8] High profile success stories include Dell's assemble to order operations and Hewlett-Packard's postponement program for printers. Based on our data, shorter cycle times will have to come from design or manufacturing, the parts of the supply chain which precede the final shipment to customer. Transportation times to customers are already near the physical limits for speed.

Cycle Times and the Geography of Global Service

What logistics cycle times can a global industry deliver? What cycle times should it deliver? In semiconductors, this is determined by a combination of geography and customer requirements. We first looked at overall performance levels, then separated out the influence of geography, customer type, and service model variations on industry performance.

Semiconductors are delivered fast, **if they are in stock**. In our sample, 40% of all shipments were delivered *next day* for data processing, consumer electronics, and transportation customers. At least

[8] Fisher, op. cit.

two thirds of all customer shipments were delivered within two days, unless the customers were resellers. Only 5% of shipments (again excepting reseller customers) had delivery times as long as 5 days.

Manufacturers have set up distributed networks to support this service level. Overnight shipments originate in the customer's country 90% of the time. European firms buying within the EC can also get overnight service, as can U.S. customers buying in Canada (and vice-versa). These results hold whether air or surface transportation is used. Conversations with semiconductor manufacturers confirm that if a border has to be crossed, one day service is not a realistic option.

GEOGRAPHIC VARIATIONS

Locating bond/assembly/test facilities in Asia has had an interesting result in terms of service. Asian buyers of semiconductors enjoy on average 1 day shorter delivery times vs. U.S. and European customers, with some variation by type of customer. For example, Japanese data processing customers get their chips in 1.1 days, U.S. data processing customers wait 2.1 days, and European customers wait 2.9 days. Asian component and consumer electronics companies also enjoy 1-1.5 days faster delivery than the rest of the world. The only exceptions are 1) transportation customers, where cycle times are roughly equal across geographies and 2) European communications customers, who get almost the same service as their Asian competition.

One other point related to geography and service should be noted. Terms of sale for domestic North American shipments differ from those in Europe and Asia. In North America freight is paid by the customer who may be sensitive to the extra cost of overnight delivery. In Europe and Asia delivery is paid for by the manufacturer and overnight service is standard practice. Reseller customers are concentrated in the U.S. and the necessity for them to budget for and pay transportation costs is probably one of the reasons they accept longer transportation times.

LESSON 5 – Geography matters, even when high velocity transportation is used. In particular, next day service usually requires in country (or at least in customs union) inventory.

Both geography and customer expectations play a role in determining delivery times for semiconductors. Most customers get two day service or better, although component customers get significantly worse service. Asian semiconductor users have a 1 day advantage over the rest of the world, except for automotive customers.[9] In general one day service requires a shipping point within the customer's nation, suggesting that borders remain a hindrance to fast delivery. Customers working under the highest service model – enhanced service – get the fastest service, but actual service levels also depend on the extent of the manufacturer's network and the details of both shipper and receiver location.

SHORTENING THE SEMICONDUCTOR PIPELINE

Of course, fast service is costly. But in the semiconductor world inventory and obsolescence are dominant parts of the cost mix. Faster deliveries may actually be cheaper on a total cost basis. As noted above, reducing lead times by a week may save enough to finance 35% increase in logistics costs.

How much room do the manufacturers have for improving cycle times?. The manufacturers indicated that front end (wafer fab) cycle times are very dependent on the specific types of chips being made. Cycle times at back end operations – bond/assembly/test and product distribution – are not as affected by product mix. In other words, decreasing fab cycle times will probably require new product designs, while changes in logistics processes by themselves can lower post-fab inventory and throughput times. Accordingly, we estimated the average cycle time for each manufacturer based on reported finished goods inventory at each site and customer shipments from each site. We found that front end (fab) cycle times varied from 35 to 93 days depending on the product and the age of the fab technology. The industry composite was 76 days. Post fab, or back end cycle times varied by company from 20 days to 51 days, depending on network structure, market volatility, and the availability of capacity. The industry composite for backend time to customer was 41 days. The majority of cycle time is taken up in the complicated front end processes where the wafers are processed to create chips from raw materials. But there is clearly room for improvement in the 3-4 weeks of processing time used by the bond/assembly/test and product distribution activities.[10]

The participants in our study indicated at least three major approaches to shortening logistics cycle time. First, companies are working on *postponement* strategies. Borrowing from their customers such as Dell and HP, these companies are looking for ways to avoid committing finished inventory until

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[9] Although we did not ask for individual customer identification, it appears that manufacturers in our sample do not ship to Japanese auto companies in Japan.

firm orders are in hand. Second, companies are *reorganizing* to eliminate process delays which are adding to cycle time. Finally, semiconductor manufacturers are adopting information technology including ERP systems and other tools that are providing inventory visibility and better planning capabilities. Examples of each strategy follow.

[10] Firm 2 shows no "backend" activities because these are collocated with its other chip processing operations.

Postponement

One semiconductor manufacturer operates four regional product distribution centers for shipping final product to customers. Although manufacturing postponement in a classic sense is not practiced, these end shipping points have become more involved in customizing outbound shipments by furnishing and applying unique shipping labels and barcodes. Nearly every customer has different requirements, so this customization activity amounts to postponing the finishing process until firm orders are available.

Another manufacturer has changed bond/assembly/test procedures to postpone inventory commitment and thus reduce inventory and cycle times. This company has set up three "die banks" where integrated circuits are stored in the Far East close to assembly and test operations. Undifferentiated product is "pushed" from U.S. fabs into these storage facilities and is "pulled" by customer orders when required. This staging of the input to bond/assembly/test has resulted in reductions of up to five days in "back end" total processing time.

Reorganization

Pressure to reduce order cycle time is constant in today's semiconductor marketplace. One producer has addressed this by adding logistics managers to cross-functional customer teams. These teams, with the support of top management, are encouraged and empowered to negotiate and work out process improvements with customers. Recently this company received a strong request from an important OEM customer to reduce lead time from 100 days to 70 for a class of high-tech products. Reducing manufacturing time was difficult, so the team attacked distribution time first. They found several places to shorten the process, including making direct deliveries to a contract manufacturer used by the OEM. Although the 30-day target has not yet been achieved, significant progress has been made, and the team continues to seek ways to get faster.

Information Technology

Semiconductor manufacturers believe that better information technology will improve customer service and lower logistics costs. When asked to identify the most important future logistics trends, four firms emphasized the demand for more information, automation, and connectivity throughout the semiconductor supply chain.

Unfortunately, logistics and supply chain management is not always a priority for IT investment. But there have been successes that can point the way to improved global logistics capabilities.

For example, one company implemented several modules of an ERP package to cope with both growth and Y2K issues. Implementation of the modules for order processing, inventory management, and production planning took approximately 2 years. The implementation was phased in by product line and location. Systems supporting transportation and warehousing were initially left untouched except for interfaces to the corporate ERP package and necessary adjustments such as naming conventions and lot adjustment capabilities. Nevertheless, this company found that customer service increased from the low 70 percent range to the high 80's. Inventory visibility really does matter.

The initiatives from these three firms all share a common goal – better control of scheduling to shorten the semiconductor supply chain. This can be summarized in the final lesson we learned.

LESSON 6 – For short lifecycle products that are manufactured and sold globally, scheduling discipline is critical all the way to the customer.

LOGISTICS IN THE NEW ECONOMY

Logistics managers are learning to cope with demands that would have been unthinkable 10 or 15 years ago. Four hour response times, contractual requirements for upside flexibility, calls for vendor-managed inventory are becoming routine capabilities to do business with electronics manufacturers. But practice is still evolving. Geography matters, even when air freight is automatic. Global reach notwithstanding, overnight delivery across borders is still problematic. Companies segment customers by service model, but this does not translate into global service standards. Inventory costs and price erosion, already nearly 80% annually, will increase as product lifecycles get shorter. Recognizing the physical limits to manufacturing and transportation speeds, firms have to count on planning and scheduling innovations for further supply chain improvements.

In the final analysis, semiconductor logistics is a prototype for what may very well be the dominant industrial model in the coming century. Small, high value, short lifecycle items will be produced wherever the total costs are lowest and sold on demand to customers who are directly fronting the final user market, be that consumer or business. Our study suggests the gaps that remain before this vision can be realized. Better data, especially cost data will be critical. Models will encompass both traditional manufacturing and logistics costs and true inventory costs. This should lead to intelligent location decisions. Activities will be spread throughout the supply chain, based on cost and real needs for proximity and technology. Postponement strategies will be used to minimize the problems caused by long production times vs. short customer lead times. Border frictions have to be eliminated, and manufacturers must stand ready to manage their customer's component inventory, if necessary.

Underlying all of these efforts will be information, and that is perhaps the most important lesson we learned. For all their sophistication and positioning in the forefront of the technology revolution, the semiconductor manufacturers participating in this study did not have the information or the processes in place to continuously monitor network and allocation decisions. In a number of cases accurate shipment counts by site were unavailable. One company accepted a uniform number for worldwide operations since it had a single worldwide delivery process. Finding regional details proved to be difficult. Most companies were working to improve their logistics analyses through implementing decision support tools, and some are testing these tools, or even using them, as this is written. But supporting a global customer base through a worldwide supply chain remains a goal to be pursued even for those leading the race toward a high tech world.

Supply Chain Management in the New Economy: Lessons from the Semiconductor Industry

LESSON 1 – Where customer service is involved, industry matters. Customers who use chips in their products insist on high service levels even at high cost; resellers accept lower service levels for lower cost.

LESSON 2 – Global companies may have uniform customer classifications, but these do not necessarily translate into global service standards.

LESSON 3 – For high tech industries in the new global economy, logistics may have relatively little influence on location decisions, but these decisions can drive high cost transportation alternatives.

LESSON 4 - In fast paced global industries, using inventory to improve service is prohibitively expensive and for new products, simply impossible. Fast transportation, improved information and better processes are the only realistic alternatives.

LESSON 5 – Geography matters, even when high velocity transportation is used. In particular, next day service usually requires in country (or at least in customs union) inventory.

LESSON 6 – For short lifecycle products that are produced and sold globally, scheduling discipline is critical all the way to the customer.