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ECG 507
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II. Cost

A. Critical definitions

Cost in economics is defined as what you give up to pursue a particular objective. Text definition is "cost associated with opportunities that are foregone when a firm's resources are not put to their highest value use."

Let's start with some examples designed to flesh out this rather abstract concept:

- 1) What is cost of NC State's MBA program?
 - List of major cost items
 - Impact on cash flow
 - Cost to whom? (Student vs IBM)
- 2) What is cost of launching a new product, e.g., new drug at GSK?
- 3) What is cost of running your own business?
- 4) You run a construction company and have just purchased \$100k worth of lumber. Price of lumber then goes up 20%. What is cost of using that lumber to build structures?
- 5) You run an auto parts manufacturing company and purchase a die press for \$50k. The die press will last for 3 years. What is the cost of that die press in the first year? In the third year?

Now let's turn to some more formal definitions:

1. Cost = explicit cost + imputed cost = opportunity cost

Explicit cost = identifiable expenditures that are associated with current inputs, e.g., wages, equipment, rent, interest, materials, taxes. These are items that any accounting system will be able to flag. The main trick here is to understand which ones to include – see discussions of sunk costs and overhead below.

Imputed costs = lost chances to make \$ that are associated with current input allocation. Examples: salary not drawn by entrepreneur, rent not collected on land or structures, profits or interest that could have been earned on capital. These items can be measured by a good managerial accounting system but will not be captured in any financial accounting system (because of their backward-looking nature).

In practice, the best way to estimate cost is to compare cash flows, as suggested in HBS case. You need to structure the decision into two (or more) alternatives, and then cash out each option. This is what we were doing at the end of each of the examples that we talked about earlier.

2. Comparing cash flows

Companies make multiyear commitments when they decide to invest in new plant and equipment. To the extent they get locked into contracts with suppliers or workers, they would have to factor that into account as well. Merck is opening a new plant north of Durham. Suppose Merck execs know this will cost them \$5m in 2005, \$5m in 2006, and \$5m in 2007. Does the total cost equal \$15m?

Companies also must make decisions about the value of future revenue streams. Suppose Pfizer has a new drug coming to market that is likely to generate \$10m in revenue for each of the next 10 years. How much is that worth now? Is it \$100m?

The answer to both of these questions is clearly “NO.” A dollar today is not worth the same as the same dollar a year from now for at least two reasons:

- risk (we may not be here tomorrow, something might happen to the dollar)
- foregone earnings opportunities (\$1 could become \$1.02 by this time next year at an insured checking or savings account)

To estimate the value of future cash flows, we calculate their *present discounted value* or PDV. To make these calculations, one must use an interest rate R that best represents the opportunity cost of the agent making the decision. You will spend a good deal of time in your finance class learning about which value of R to use when. As you might guess, Bill Gates uses a different value of R for valuing possible new projects for Microsoft than a 75-year-old widow uses to value an annuity. (Hint: Bill would use a much higher value of R because he will expect a much greater rate of return than an elderly individual managing retirement assets.)

Once we have a value of R , we know that \$1 today is worth the same as $\$1(1+R)$ a year from now, $\$1(1+R)^2$ two years from now, $\$1(1+R)^3$ three years from now, and $\$1(1+R)^n$ in n years.

We also know that

- \$1 a year from now is worth the same as $\$1/(1+R)$ today
- \$1 two years from now is worth the same as $\$1/(1+R)^2$ today
- \$1 three years from now is worth the same as $\$1/(1+R)^3$ today
-
- \$1 n years from now is worth the same as $\$1/(1+R)^n$ today

Examples of PDV calculations:

a) Cost of Merck plant, assuming $R=.05$

$$PDV = 5/(1.05) + 5/(1.05)^2 + 5/(1.05)^3 = 4.76 + 4.54 + 4.32 = \$13.62m, \text{ well below } \$15m$$

b) Present value of future Pfizer profits, assuming $R=.08$

$$PDV = 10/(1.08) + 10/(1.08)^2 + 10/(1.08)^3 + 10/(1.08)^4 + 10/(1.08)^5 + 10/(1.08)^6 + 10/(1.08)^7 + 10/(1.08)^8 + 10/(1.08)^9 + 10/(1.08)^{10}$$

$$PDV = 9.26+8.57+7.94+7.35+6.80+6.30+5.83+5.40+5.00+4.63 = \$67.08, \text{ well below } \$100m$$

Whenever you are evaluating a decision that involves future revenue or costs, you must use PDV to evaluate the cash flow.

3. Sunk cost = expenditures that have been made and cannot be recovered

Example. When the Eddie Murphy movie “The Adventures of Pluto Nash” got delivered to the studio, \$100m had been spent on the film. This is a sunk cost. The studio still has to decide whether it should distribute the film, which will cost an additional \$20m. As long as the studio thinks it can generate enough revenues from theatres and video to offset these additional costs, it should go ahead and distribute the film. However, if the studio thinks that the movie is such a big stinker that it will never see its \$20m back, it should not release the movie. As we now know, Pluto Nash was released and was one of the biggest bombs in movie history, netting \$4.4 million on opening weekend and a total of \$7.1 million over its entire viewing cycle.

Another movie that came out last weekend may also be in budget trouble: “The Constant Gardener” cost \$25.5 million to make, probably cost another \$20 million to distribute, and netted a mere \$3.9 million opening weekend. (Data source: [The Numbers](#) web site)

The key point on sunk costs is to not include them in explicit costs in making decisions about future activity. Before the film was made, the \$25.5m or \$100m figure plus distribution was relevant to decision making. But it is not relevant to decisions about the future marketing and distribution of the film.

The *Forbes* article shows that the theory that sunk costs should be ignored is not always followed up in practice. The key lesson: keep your ego in check when making decisions

Other examples of sunk costs? (class)

2. $TC = \text{Total cost} = \text{fixed cost} + \text{variable cost} = FC + VC$

Fixed cost = costs that do not vary with output; they are usually called overhead. They include buildings, equipment, and staff workers, plus any materials or labor that are under contract.

Variable cost = costs that vary with output, mainly materials and labor.

3. $\text{Average cost} = ATC = TC/Q$

4. $\text{Average variable cost} = AVC = VC/Q$

These are the cost concepts that are most often used by managers, because data on output and total cost are readily available. But the cost concept that is of greatest importance for decision making is

5. $\text{Marginal cost} = MC = dTC/dQ$

MC is the change in total cost resulting from the decision to produce an extra unit or batch of goods. In deciding production levels or doing cost-benefit analysis, this is the cost measure you want to be using.

B. Key economic issues

1. Difference between economic and accounting costs. Balance sheets and income statements are historical documents, designed to inform stockholders, potential investors, and top management about the firm's overall financial health. They are important sources of information for estimating economic costs but cannot be used without some adjustment to reflect such considerations as foregone opportunities to make money and sunk costs. Keep in mind that accountants must answer to regulatory bodies such as the FASB and IRS, which require them to follow standard procedures. Economists are not subject to such pressures and so can think more freely. Managerial accounting systems used to make decisions within organizations are much more flexible and, thus, more closely aligned with the economic definition of cost. Note that the accounting distinction between direct and indirect (overhead) costs is very similar to the economics distinction between variable and fixed costs.
2. Replacement cost. Must be careful about what you paid for items currently in stock and what you will pay to replace them. This concept comes into play in talking about
 - Depreciation: Value of equipment and structures declines over time to reflect wear and tear, plus possible obsolescence. If you purchase a server at the beginning of the year at \$10,000 that one year later is worth \$8,000, then the economic cost of that equipment is its decline in value of \$2,000 NOT the original \$10,000.
 - Inventory valuation: Suppose price of new servers goes down from \$10,000 to \$5,000 in first year. Then the economic cost must include not just wear and tear, but also loss of resale value. If used servers market for \$4k, then the economic cost is \$6k. This process can work the other way; if price of servers went up by enough, then this could offset the effect of depreciation on value. (OK, servers are not a great example of a capital good that could increase in value. But what about oil drilling equipment – if price of oil goes up?)
3. Fixed costs are not the same as sunk costs. Some fixed costs are sunk, especially inputs that are highly specialized to one particular organization, e.g., proprietary

software or specialized equipment. But some fixed costs are not sunk. For instance most types of equipment and all types of structures can be sold and used by another organization. (Example: suppose IBM spends \$10m on developing a particular piece of software that is not worth more than \$4m to any other organization. Then \$6m is sunk and \$4m is recoverable.)

4. Allocating overhead expenses to product lines or divisions is messy. This is well illustrated in the Harvard case "Relevant Costs and Revenues". All 3 product lines in that example have to cover overhead *together*, but many commonly used rules for overhead allocation make one or more of the product lines look like losers on paper. As more companies shift to performance-based pay, decisions about overhead allocation have become increasingly similar to discussions about the IRS.

Source: Lecture notes developed by Steve Margolis for earlier vintages of ECG 507 were used to develop much of the above discussion.

Exercises in class: see sample problems on the last two pages.

C. Cost curve mechanics: short run

NOTE: Please read this section before class. I would prefer to answer questions about this material rather than lecture.

This is covered in the text, pp. 220-223. This refers to the situation when some inputs are fixed. Consider a simple technology where all K is fixed and all L is variable. The key factors behind TC are as follows:

1. Productivity: same output from fewer inputs lowers TC, ATC, AVC, and MC
2. Price of inputs: higher wages mean higher TC, ATC, AVC and MC
3. Fixed cost: greater overhead translates into higher TC and ATC.

Note the close resemblance between the production function in Figure 6.1 and the TC function in Figure 7.1. Suppose you did the following simple transformation:

- Start with the production function that relates Q (vertical) to L (horizontal)
 - Multiply the scale of the horizontal axis by the wage rate so that you get a function relating Q (vertical) to VC (horizontal)
 - Move the scale of the horizontal axis to the right by F units, where F=fixed costs.
- Now we have a relationship between Q (vertical) and TC (horizontal)
- Now flip the axes to make TC vertical and Q horizontal – you would now have the TC curve in Figure 7.1.

Key facts about cost curve shape:

1. MC is rising after some output level because of law of diminishing returns
2. ATC is U-shaped: downward sloping at low outputs as FC/Q declines but ultimately starts rising because of MC, reaches minimum where $ATC=MC$, then upward sloping because $MC>ATC$
3. AVC also U-shaped: downward sloping at first because MC is downward sloping at low levels of output (convex region of production function where there are large gains from specialization), stays downward sloping for awhile when MC starts rising because $MC<AVC$, reaches minimum where $AVC=MC$, then upward sloping because $MC>AVC$

D. Long run cost curves

Changes in fixed input result in new levels of fixed costs and potential changes in the shape of the TC curve at different ranges of output. In a simple world where K is fixed and L is variable, there is a unique set of short run cost curves defined by each level of K. Shape of this function depends on *returns to scale*. Long-run ATC (LAC) declines with Q when there are increasing returns, is constant when there are constant returns, and is increasing when there are decreasing returns to scale. This is shown in Figure 7.9 in text.

E. Real world cost curves

Great example on pp. 223-225 of text, dealing with aluminum smelting.

III. More on cost

A. Economies of scale

1. Theory. The firm may decide to change K/L at different output levels, so instead of talking about how Q changes with a given K/L ratio we will find it more useful to talk about how TC changes with Q, which we define as *economies of scale* (E_C), where

$$E_C = \% \Delta C / \% \Delta Q$$

When there are economies of scale, costs increase by less than 1 percent for each 1 percent increase in output, which means $E_C < 1$. When there are diseconomies of scale, costs increase by more than 1 percent for each 1 percent increase in output, which means $E_C > 1$.

Sources: Economies of scale arise from

- Spreading overhead over larger base. Examples: half a boxcar costs same to ship as full boxcar.
- Physical properties of production. Classic example is cube-square rule: volume increases with the cube of its linear dimension pipelines, while surface area increases with the square. (Don't believe me? Compare volume and surface area of 1x1x2 box to that of 2x2x4 box.) Production capacity increases with volume, but cost increases with surface area. Since volume increases at greater rate than surface area, we get economies of scale. Examples: pipelines, warehouses, brewing.
- Marketing economies. National advertising is cheaper on a per viewer basis than local, so McDonald's and Bud have an edge on Char-Grill and Carolina Brewing.
- Purchasing economies. Cheaper to sell HP computers to Wal-Mart and Radio Shack under national contract than to deal with local stores in each area, so Wal-Mart and Radio Shack can negotiate better terms.

Diseconomies arise from:

- Labor costs. Larger firms pay more, although this is partially offset by lower turnover of workers (and thus economizing on hiring/training costs)
- Bureaucracy. Harder to link individual or small group performance to firm performance in large firm, so incentives for good performance may not be as great. (But how can they afford high wages then?)
- Spread specialized resources too thin. Great chef can run one restaurant, but can get into trouble if he expands too much.

Estimation. Empirically, we must examine scatterplots or regression analysis of costs to determine if economies of scale are present. Key issue is whether ATC declines or increases with production level.

2. Economies of scope

Take two (or more) separate product lines that have complementarities in production or distribution. Examples: Kellogg can produce corn flakes or sugar frosted flakes using same production line. Wal-Mart can sell clothing, hardware, garden supplies, toys in the same store space. 3M took its knowledge of adhesives from selling Scotch Tape to develop Post-Its. American Airlines gets more passengers by flying RDU-DFW and DFW-LAX than by flying just one of the routes.

When is it economical for these goods to be produced by the same firm in the same facility? The answer depends on whether the costs of joint production are lower than the sum of the costs of producing each in separate facilities. *Economies of scope* result when costs to a single firm of producing two or more goods is less than the costs of having separate firms produce each good.

Economies of scale can be accompanied by economies of scope (e.g., Wal-Mart), but the two do not necessarily go together.

Economies of scope are believed to be very important in R&D. A firm with a large, well-diversified portfolio of research projects is in better position to leverage any breakthroughs than a firm with a smaller set of projects. Ideas from one project increase the odds of success on other projects. One study in pharmaceuticals found that for the average firm with 19 research programs, the addition of 2 more programs increased the productivity (patents per dollar spent on R&D) of the other 19 by almost 5 percent.

Aside: economies of scope concept is used widely in business/strategy. Often called "leveraging core competencies," which can be in production, research, or marketing.

3. Learning curves

Concept originated in analysis of aircraft production by T.P. Wright in 1925. Wright noticed that average cost per plane assembled declined with cumulative number of planes produced. Rate of decline was about 20 percent every time output doubled. In other words cost per plane would fall 20 percent as output went from 1 to 2, another 20 percent as output went from 2 to 4, etc. (Aside: this is exactly the pattern in Table 7.3 as you go from 10 to 20, 40, 80). In technologies where the learning curve is known, this allows managers to make sensible cost projections, which in turn can be fed into business and marketing plans.

Learning curve phenomenon helps explain why new technologies start off very expensive in the market place, but price gradually falls over time. Examples: VCRs, PCs, cell phones, high-def TVs (we hope!) Also seems to apply to some service industries, e.g., surgery.

Sources of learning: improved training and worker efficiency from learning-by-doing, better organization and coordination; product redesign and standardization; new processes. There also can be organizational “forgetting” resulting from poor labor relations, turnover.

Strategic implications: firms should recognize growth potential in technologies subject to learning curve. Firm should endeavor to grab dominant market share quickly so it will be in position to exploit learning curve.

Can be used for planning. Lockheed should have used a learning curve in 1971. At that time it wanted to launch a widebody jet the L-1011 Tristar, but could not get further support from commercial lenders after spending \$1b. Ultimately it got a quarter-billion loan from Congress. The first plane would cost \$100 million to produce. It was expected to follow a 77 percent learning curve (i.e., AC after second plane \$77m, AC after fourth plane \$59m, AC after eighth plane \$45m, etc.). Market price of these jets was expected to be about \$15m. How many jets would Lockheed have to sell before it starts making money? (A: over 128, an unrealistically large share of world market at that time.)

Sample problems

1. Leith Honda has six Civics on the lot for which it paid \$14,500. New models are coming in, and with special promotions will cost Leith \$13,900. A customer offers Leith \$14,250 for a Civic in stock. Should Leith accept or reject?
2. Shania Twain has a contract that calls for her to make one album per year, for which she gets paid \$5 million. She decides to change musical directions and sing famous arias from well-known operas. It has cost \$500,000 to produce and market each of her earlier albums. What judgments do you have to make before deciding whether to release Shania’s new material?
3. Pete Zah is thinking about opening a submarine sandwich in Morrisville. He knows that over the year he can sell 50,000 subs at \$4 each. His accountant tells him that the costs of producing so many sandwiches include

Materials (bread, cheese, meat, etc.)	\$60,000
Labor	120,000
Rent	20,000

Zah wonders whether to open the shop. Assuming that Zah continues in his current job and does not work in the shop, what is your advice?
4. Here is what it would cost you to fulfill your life-long ambition to operate a small ski resort:

Land acquisition	\$200,000
Build ski lift	100,000
Build an open shelter	20,000
Operation	50/hour

You plan to be open 50 hours per week for 20 weeks per year, so operating costs should be \$50,000 per year. You will be able to borrow \$320,000 under a 20-year loan with annual payments (principal and interest) of \$43,000 per year.

- a) What is the minimum amount of annual revenue from the sale of lift tickets that you will expect in order to take the plunge and invest \$320,000?
 - b) Suppose your actual revenue in the first year of operation turns out to be \$60,000. Keeping in mind that your resort is already built, would you have been better off in retrospect by not opening that year?
 - c) Once in a while you can earn \$600 by opening your resort for 8 hours on weekdays (when it would otherwise be closed) for the benefit of special charter groups. The revenue will cover your operating costs of \$400 per day, but since your operating costs are 54 percent of your total costs, you would need about \$750 in revenue to make it worth your while to be open. Or would you?
 - d) If you spend \$10,000 on advertising in your second year, and as a result total revenue increases to \$75,000, was the decision to advertise a good one?
5. (From Steve Margolis) A tent making company is considering an offer from a restaurant chain. The restaurant chain would contract to purchase 115 awnings in the coming year, and none after that. The tentmaker currently turns out 1500 tents per year, which it wholesales for \$140 each. The costs of tent production are:

Fixed overhead (rent, equipment, insurance, utilities, etc.)	\$12,000
Other overhead (manager)	30,000
Direct materials	40,000
Direct labor	60,000

The tentmaker cannot accommodate any additional workers, but it estimates that it could produce the awnings with the current staff and manager as long as it cuts tent production in half. They also would have to have some special forms made at a cost of \$10,000. These forms are proprietary to the restaurant chain, so they could not be used for any other purpose. Direct materials per awning are \$135. The contract would pay \$800 per awning. Should they contract to produce the awnings? How much better or worse off are they if they accept the offer?