Guidelines for Assessing Costs in a Logistics System

An Example of Transport Cost Analysis

Hany Abdallah

2004

DELIVER
No Product? No Program. Logistics for Health

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Abstract

Financial analysis is relevant for all major components of the logistics cycle. Any given organization can perform various functions of a supply chain, from procurement to warehousing and transport, each requiring unique or shared resources with associated costs. When an organization performs more than one function, to optimize the use of available resources, trade-offs can be made between these costs. Financial analysis can also be performed to rationalize the use of resources between several organizations performing various functions of the logistics cycle. While cost analysis is an area that has benefited from extensive attention and financial investment in the United States private industry (from manufacturing to retail), its application in country contexts where DELIVER works has largely been unexplored. There are a few contributing factors. Public sector organizations working with DELIVER have traditionally focused on effectiveness instead of efficiency. The nature of financing programs for pharmaceutical supply chains has also tended to be mainly donor-driven (dealing with donor-funded products). Frequently, complete or timely information to facilitate financial analysis is often unavailable, and tools and approaches to the specific environments must be adopted and customized.

DELIVER organized a technical task team to develop and strengthen its capacity in financial analysis in supply chain management. This guide was developed to help address one of the areas of unmet need in financial analysis: the definition of an approach for designing and conducting a cost analysis. This guide, using DELIVER's experience conducting analyses in field projects, was used in a short training course for logistics advisors to help them understand issues related to conducting a financial analysis.

Examples of how these guidelines can be applied are described in the *case study reports* that were developed with these guidelines, and by referring to technical reports developed as part of technical assistance assignments with various cost analyses. The reader is encouraged to review the following publications: (Vian 2003a) (Vian 2003b).

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Purpose of This Guide

The *primary aim* of these guidelines is to enumerate the major elements of a cost analysis, and briefly describe how to carry out these elements. The guide covers some basic concepts of conducting a cost analysis of a logistics system. By reading this guide, you will gain an understanding of the process and steps involved in assessing costs in a logistics system. You will learn some of the basic principles of cost analysis. You will not be an expert in conducting cost analysis studies, but you should feel comfortable enough with the issues to provide basic advice and to assess the kind of technical assistance that would be requested when faced with such situations. References to additional materials are provided for more advanced analysts.

The material in this guide focuses on developing both knowledge and skills in cost analysis. The analysis of transportation systems costs are an example of the general approaches, and it contains the most detail. The principles described for transportation systems generally apply to the assessment of the costs of other elements of the logistics cycle.

Examples of how these guidelines can be applied are described in more detail using case study reports that have been developed with these guidelines (see appendix C).

By the end of this guide, you should be able to—

1. Define fixed and variable (or running) costs related to transport systems.
2. Calculate unit cost measurements for fixed and variable costs related to transportation.
3. Describe factors that drive the cost of fixed and variable costs.
4. Identify information sources and approaches for measuring fixed and variable costs.
5. Define what constitutes transport-related costs relative to other distribution functions, and define transport costs in the context of this model.
6. Understand the different approaches for defining costs and choose the appropriate one.
7. Describe the general approach for conducting cost analyses.

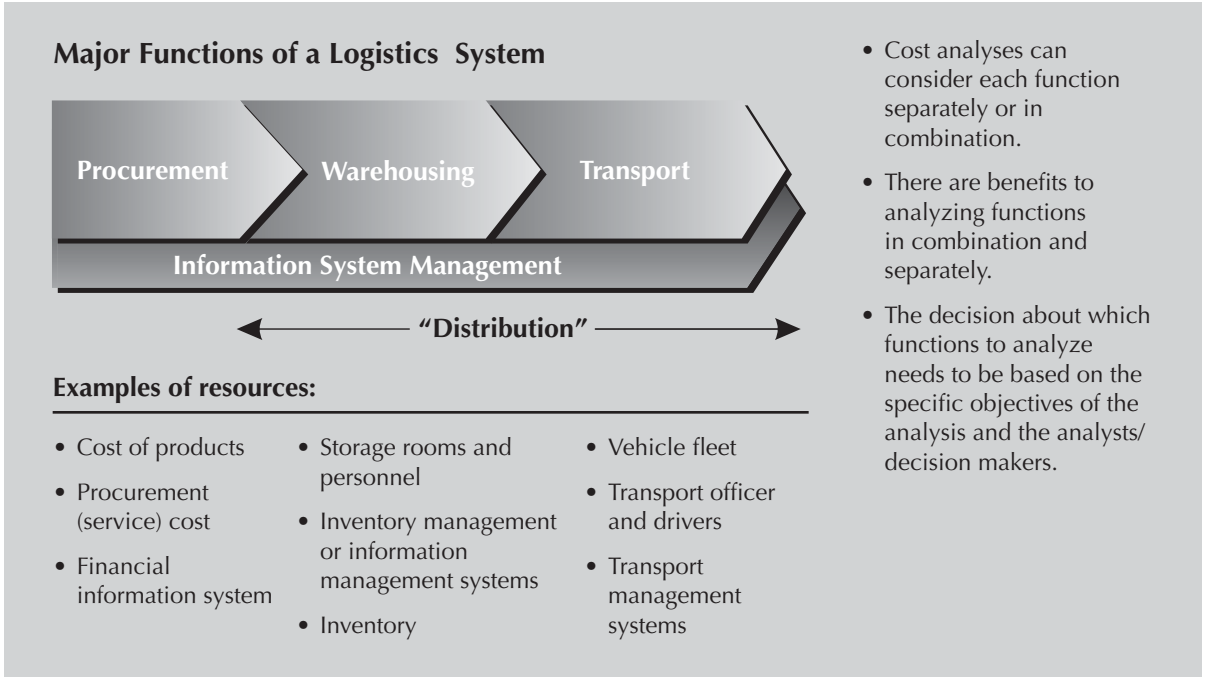
Cost Analysis in Logistics Management

Cost analysis is relevant to logistics management because resources are needed to operate all major components of a logistics system (see figure 1). The components range from procurement, to warehousing, to transport and information systems; and they involve human, capital, and material inputs.

Cost analysis can be used to understand the level of resources that are required to operate a logistics system, with the goal of maximizing the desired performance of the system while minimizing the cost of resources.

Cost analysis begins with knowing the costs needed to perform logistics functions. For instance, knowing the cost of holding and handling inventory can be used to find more cost-effective strategies for managing that inventory (e.g., by applying just-in-time strategies for inventory control to minimize the need for inventory handling). For the transport function, for example, a cost analysis for the central level in Egypt (Abdallah and Wilson 2002) showed that knowing the central warehouse level's cost of

Figure 1.
Costs Associated with Logistics Management



transport for family planning products concluded that the cost of outsourcing transport would be a cost prohibitive option.

One application of cost analysis in logistics management is to optimize the use of resources for any given function of the system. For instance, cost analysis can be performed for a central medical store responsible for warehousing and inventory management for a national drug supply chain. The analysis could evaluate whether the value and level of inventory held justifies the cost of holding that inventory (e.g., having and maintaining the storage space, and employing the staff and equipment to handle the inventory).

Cost analysis is also useful in evaluating the trade-offs between the costs of the logistics functions to optimize the use of available resources. More often than not, an organization performs various functions of the logistics system. For instance, the central medical store may be responsible for distribution. It would, therefore, be interested in the cost of holding and handling inventory in a warehouse versus the costs of transport to move product out of the warehouse as rapidly as possible to minimize inventory. In Ghana (Huff-Rousselle and Raja 2002), by analyzing the cost of the public sector logistics system, Huff-Rousselle and Raja found that by-passing regional-level storage and delivering products to the district level from the central warehouse was still a cost-effective option, despite increased transport costs to reach more locations.

Typical courses on cost analysis for the supply chain take a holistic or systemic approach to cost analysis. While examples typically come from manufacturing (where the essential functions are completed by various firms, from manufacturer to distributor to retailer), the courses emphasize the need for communication between organizations that perform the functions, with the aim of minimizing global costs. Ultimately, in these private sector examples, global supply chain costs are factored in the final product price that customers are charged, and, therefore, should be optimized in the interest of capturing market share and revenue. Typically, various organizations in a public sector system may be responsible for different functions (e.g., the district is responsible for transport and the central level is responsible for the major warehousing costs) or the same function but at different levels. This often makes an analysis of cost trade-offs less straightforward but still useful. An analysis of transport costs for the National Medical Stores (NMS) in Uganda for example (Abdallah, Healy, and O'Hearn 2002) compared the cost of the central level NMS delivering products down to the sub-district level versus the cost of the districts delivering to this level. The study found that the cost to the NMS was significantly higher and this strategy was not adopted.

Basic Definitions

1. Cost

Cost can be defined in many ways. The definition varies based on the perspective taken when performing a cost analysis, i.e., defining who incurs the cost. Generally, *cost* denotes a loss or a sacrifice, which may or may not be quantifiable, but is usually incurred in the course of gaining something. Cost is the value of something that is expended to obtain a benefit, or it is the quantity of one thing that is exchanged for a service or a product. In more technical terms, cost can be defined in economic and financial terms:

- *Monetary or financial cost*. The expenses incurred for an input or to provide a product or service, at a given time (e.g., prices in a given currency paid for medical supplies, price charged for a clinical service).
- *Economic or opportunity cost*. Reflects the value of benefits forgone by using resources to provide alternate products or services (e.g., the value of employee's time engaged in work outside primary job duties); economic or opportunity costs may be a way of attributing a monetary cost to goods and services.
- *"Accounting" types of cost*. These costs are applied to reflect the real value of a product or service at a given time; the cost may actually not be incurred (e.g., depreciation allowance for medical equipment).
- *"Shadow" prices*. Applied to goods and services whose true value is not the same as listed (e.g., value of donated equipment, the time of volunteer staff).

Generally, you can expect to find *three major categories of costs*:

- costs related to people and their time (personnel)
- costs of equipment or capital (machine)
- cost of resources that are frequently replenished (materials and supplies).

These general categories can be analyzed in different ways depending on the specific need, e.g., looking at direct versus indirect cost, obvious versus hidden cost, fixed (or investment or capital) cost versus variable (or recurrent or running) cost, unit cost, average cost, and incremental cost (see appendix A for a glossary of key terms). When doing a cost analysis, you must look at the cost or value of all the human, material, and financial resources required to complete a given function.

2. Fixed and Variable Costs

In logistics cost analysis, we use two types of costs: *fixed* (or *standing*, *capital*) costs versus *variable* (or *running*, *operational*, *recurrent*) costs.

Fixed costs are costs that do not vary with quantity or volume of output provided in the short run (typically, one year). These costs usually vary with time.

Variable costs are costs that vary with changes in quantity or output volume.

Variable costs monetarily quantify those supply chain resources that vary or change with changes in volume of goods to be distributed and/or the distance to be covered for delivering those goods. For example, fuel costs required to operate the delivery vehicle would be considered a variable cost. Unlike variable costs, fixed costs describe resources—such as vehicles, drivers, and warehouse buildings—that are in place to prepare for the distribution of products. These resources typically do not vary in the short run (e.g., in a year) with variations in volume or distance. See the glossary at the end of this report for definitions and descriptive graphics.

To evaluate the cost of the logistics system, which is the objective of this guide, both fixed and variable costs are added to determine the total cost of logistics. While a distinction is being made between the types of resources, fixed and variable costs are interdependent in logistics management. For instance, the size of a vehicle (fixed cost) to be used for distribution will affect the operating cost of making a delivery (variable cost); the heavier or larger the vehicle, the higher the fuel costs to cover a given distance. Also, fixed and variable resources are affected by the same factors, although in different ways. For example, significantly increasing the number of delivery points will affect variable costs by increasing the distance to be covered (fuel cost will increase for example). Fixed costs may also be affected if the available vehicle fleet is not sufficient to cover the distance within a certain delivery time window (e.g., an additional vehicle may be required and added). Further on in the analysis of transport problems/scenarios, we describe how to more systematically assess the *trade-offs* between total fixed and variable costs.

3. Cost Analysis

The framework for conducting a cost analysis is fairly generic and typically involves a set of guidelines that define the approach to be taken and the expected purpose (outcome) of the analysis for decision making. A cost analysis generally—

1. begins with a concise definition of objectives (why)
2. includes a statement of who is interested in the analysis, its scope (who, where)
3. states what is needed/relevant to be measured (what)
4. and describes how the analysis will be conducted (how).

You can use several methods and approaches to conduct cost analyses (the *how*). The options may differ based on whether (1) you are trying to analyze the impact of a specific intervention or practice, or (2) you are looking to more systemically monitor, analyze, and manage costs. Examples of options to analyze intervention or dated costs include cost-effectiveness analysis, cost-benefit or return on investment analysis, and cost-utility analysis. Examples of more systemic cost analyses are activity-based analysis, target or should-costing, and cost of quality analysis. The latter are more often used in logistics management but are not covered in detail in this guide (refer to appendix C). This guide will first introduce a general cost measurement and analysis approach.

The following guidelines are relevant when beginning a cost analysis (the how):

- decide on whether a retrospective or prospective data collection is appropriate
- decide on the timeline (e.g., recommend to analyze costs for the equivalent of a year)
- use reasonable estimates when precise numbers are not available or not easily obtained.

Major Steps for Cost Analysis

The following proposed steps can be performed to analyze logistics costs and assess the efficacy of logistics systems (appendix B is a more detailed breakdown of these steps):

1. Define the major factors that drive fixed and variable costs.
2. Assess variables that affect cost drivers.
3. Define relevant fixed and variable costs.
4. Calculate relevant fixed and variable costs.
5. Assess unit costs and total costs.
6. Analyze decisions.

In the following sections, we describe an example of analyzing transportation cost in a logistics system. Appendix C includes references for cost analysis methods that have been used for warehousing.

1. Define the Major Factors That Drive Fixed and Variable Costs

The first step in conducting a cost analysis is to determine what resources are involved in carrying out the logistics function you are assessing and to understand how those resources are being used. In other words, the aim of this step is to describe the factors that have an impact on the fixed and variable costs that you are concerned about and that you think/know will change when these factors change. We call these factors cost drivers (see box 1).

For example, the major resources required for transporting and distributing products are distribution vehicles (trucks or other transport mechanisms) and costs associated with operating these vehicles. Fixed and variables costs will be incurred depending on how these resources are used. Capacity refers to the size and number of accessible distribution vehicles, and it will affect the fixed costs incurred for distribution. The total distance to be covered affects how much distribution vehicles will be used, and it will influence the total variable costs to be incurred. Later, step 3 describes

Box 1: Cost Drivers of Transport Function

In the case of transportation cost analysis, essentially *two major cost drivers* influence transport system costs:

a. the total *capacity* for distribution in a system

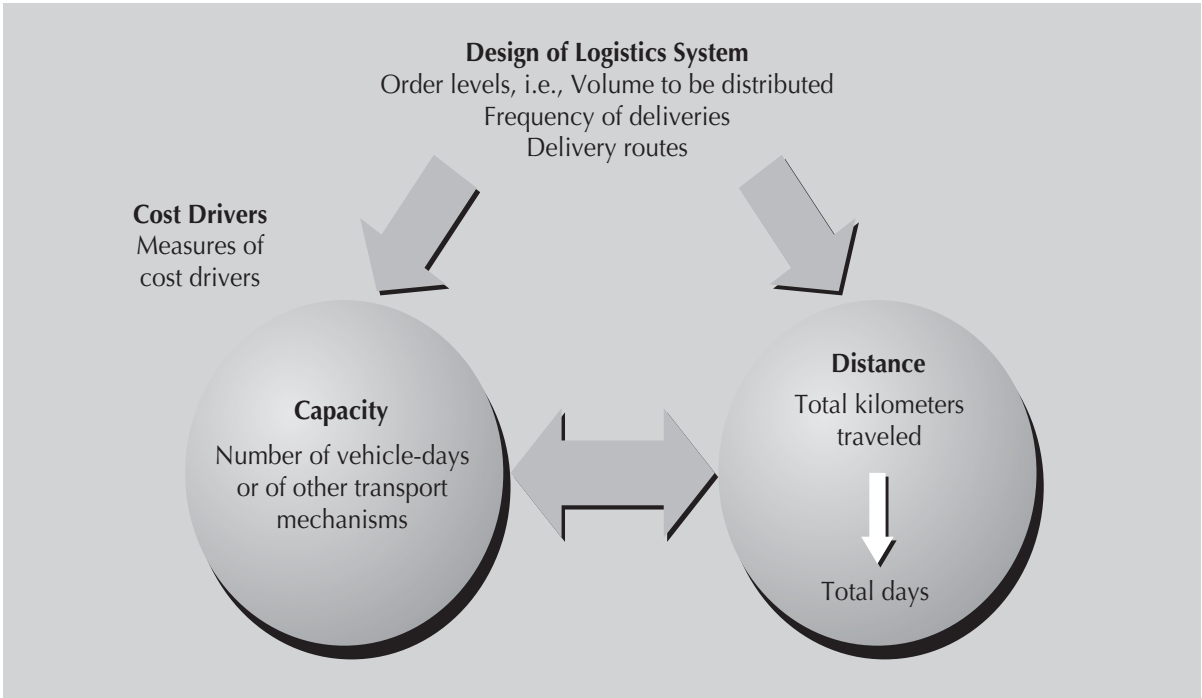
b. the total *distance* to be traveled in the system.

in more detail how these factors contribute to the fixed and variable costs of a transport system.

It is worth noting that cost drivers can also be linked. For example, the number of vehicles and the carrying capacity of each vehicle will affect the number of trips required to complete a distribution cycle and the total distance covered to complete the cycle. Evaluated in financial terms, this trade-off is often at the heart of defining the most cost-effective solutions for transport problems, and it forms the basis for most transport cost issues.

The management of cost drivers is central to the analysis and management of costs. In addition to managing the variables that affect cost drivers (step 2), one of the important levers that can be affected is the logistics system *design* (see figure 2). The factor of *design* is defined at a high level and includes the inventory level (or order level/volume) in the system and the system to control that inventory (or the frequency of order). A feature, such as the *order level*, defined in the logistics system will influence the volume to be distributed in a given delivery cycle or the required *capacity*. The *frequency* of orders (or deliveries) will be reflected in the total *distance* that will need to be covered over a period of time (e.g., a year for cost analysis purposes). In the case of transport cost analysis, the *delivery routes* in a logistics system—the location of delivery points, the network of connections (roads, etc.) between the points, and the distance between them—can also be considered a feature of *design* that affects the major

Figure 2.
Major Cost Drivers of Transport System



cost drivers. Typically, the delivery routes are also designed based on an assessment of distribution costs and, therefore, can be considered a *variable* that will influence the cost drivers (step 2). This is because delivery routes can be optimized based on the size and number of vehicles to be deployed to cover routes (in turn, depending on the volume to be delivered to delivery points) balanced against the frequency of trips or total distance needed to cover the route. Said another way, delivery routes are both an element of the *design* factor and a variable for assessing the major cost drivers (step 2), and you will find both in this guide.

Box 2: Measures of Major Cost Drivers for Transport Function

For *capacity*:
- number of vehicle-days[1]

For *distance*:
- total kilometers (i.e., total distance to be traveled)
- total days to cover distance.

2. Assess Variables That Affect Cost Drivers

This next step assesses the variables that will influence the major cost drivers. This step uses these variables to link the resources used in a logistic system with the design of the distribution system. Before defining the variables, appropriate measures of the cost drivers need to be defined. After the cost associated with these measures is determined (step 3 of these guidelines), these measures will form the basis for a cost analysis. To do this in the case of transport, we refer back to the description of the cost drivers (*capacity* and *distance*), and the following measures can be defined (see box 2).

Vehicle-days are a practical and useful measure of distribution *capacity* because they quantify the capacity of a vehicle in terms of the number of days that a vehicle is available for operation (for example, in a year) or the number of days a vehicle has been in operation. With this approach, the ability of a vehicle to deliver a given volume of goods in a period of time is estimated based on the number of vehicle-days required to complete the delivery (depending on the carrying capacity of the vehicle and, therefore, the number of trips required to deliver that volume). The result is typically compared to the number of vehicle-days the vehicle is actually available to operate within a delivery period to determine the total number of vehicles required. For example, more than one vehicle would be needed if the number of vehicle-days required is greater than the number of vehicle-days available.

1. Other indicators or variables can be used to measure vehicle capacity, as is measured here by vehicle-days. See, for example, the approach of using a distance-based indicator (Abt Associates et al. 2001).

Table 1 outlines the variables that can be analyzed for transport cost drivers. (See box 3 for a practical example of measuring cost drivers.) Note that, given the nature of variables influencing both cost drivers, one factor can be a limiting factor for the other factor. For instance, variables that influence the "total days" required to cover a given distance (such as the speed of the vehicle and the loading and unloading time required at each delivery point) will limit the "total kilometers" to be covered in a day. A variable such as the legally allowable time that a truck driver can operate a truck in a day will determine the number of "vehicle-days" (measure of *capacity*) but will also have an effect on the "total days" required to cover a given *distance*.

As shown earlier in figure 2, the *design of the logistics system* has an impact on both capacity and distance; it can also be disaggregated and analyzed into its own influencing variables, as shown in table 2. Though these are not costed, they contribute to a better understanding of the cost drivers. The main factors for consideration related to *design* are the volume level of products that need to be distributed in the system and the frequency of distribution. The delivery route can also be part of the design, and it is divided into more detail in table 1 as variables affecting the *distance* cost driver.

Table 1: Measures of Transport Cost Drivers and Variables That Influence Them

	Variables That Influence Cost Drivers…
Related to Capacity Number of vehicle-days	• Types of vehicles or transport mechanisms and the real carrying capacity of a vehicle type (e.g., cubic meters that can be loaded in each type, adjusting for percentage of vehicle volume that can be used, allowing for loading and unloading space) • Number of vehicles • Number of days vehicle is available for operation (e.g., in a year), allowing time for vehicle maintenance and major holidays • Number of hours drivers can operate a vehicle in a given day (typically 8 hours for each 24-hour period) • Number of available drivers • Percentage of time the vehicle is used for making deliveries or for distribution functions (on average); this percentage can be used to *attribute* the total number of available vehicle-days to distribution-related functions Note: This factor is typically pre-determined, i.e., based on available type and number of vehicles.
Related to Distance Total kilometers	• Location of delivery points • Distance to and between the points on the route network (see Design factor also) • Frequency of trips that need to be made based on the design of the logistics systems (e.g., reorder frequency) and the carrying capacity of the vehicles making the delivery • Other considerations for district/regional boundaries
Total days	• Total kilometers to be covered (above) • Vehicle speed to cover a given distance • Time required for essential logistics or delivery functions to performed while vehicle is on the road (e.g., loading, unloading, inspection of goods delivered) • Other: Number of hours drivers can operate a vehicle in a given day (typically 8 hours for each 24-hour period)

Table 2: Variables Related to Design of Logistics System

	Variable
Order level or volume	• Type of product ordered/delivered • Number of units of a product ordered/delivered • Dimensions of packaging form of a unit of product
Frequency	• Type of inventory control system (e.g., general pull versus push, forced ordering, min-max levels set by product or in general) • Number of deliveries (e.g., in a year)
Delivery route	• Relative location of delivery points • Type of link between delivery points (e.g., tarmac or murram roads) • Type of delivery mechanism used (e.g., car, rail, boat, bicycle, etc.)

The major effort required in this step is to assess the variables defined in table 1 and, hence, the condition of the logistics system as it relates to the variables. This involves developing an understanding of how the distribution system works and how the products move through the system, and the people who are involved. In other words, this is conducting an assessment/survey/information collection activity. DELIVER has done a lot of work with logistics system assessments, culminating in assessment tools—the Logistics Indicator Assessment Tool (LIAT) and the Logistics System Assessment Tool (LSAT) (see appendix C). These can be used to obtain a general or specific understanding of functions of the logistics system.

In the case of transport cost analysis, if computerized geographical and/or logistics management information systems are not available, it is often too costly or time-consuming to evaluate all delivery positions in a logistics system to assess the variables related to distance or capacity. While this would be the ideal, analyses can default to sampling representative regional or national sites of the logistics system until data is experientially compiled on the whole system. Appendix C lists references to DELIVER documents, and provides examples of transport assessments completed in various countries, including Ghana, Uganda, Nigeria, Zimbabwe, including descriptions of the methodology used. Some general guidelines may be useful to make the sampling relevant and as representative as possible:

- *If possible, stratify survey sites and survey all major site types.* Criteria for stratification depend to a large extent on the specific objective of the cost analysis, and should relate to major factors that are expected to influence total costs. In the case of transport, for example, criteria related to the major cost drivers should be considered, such as remote versus nearby sites, and high volume/demand versus low volume/demand sites. Selection of criteria should increase confidence that the types of sites that will be most costly to distribute to are well understood.
- *Sample in a way that facilitates a reasonable mechanism for projecting results of the survey.* For example, in a transport cost analysis for the National Medical Stores in Uganda (Abdallah, Healy, and O'Hearn 2002), in addition to factors related to cost drivers, sampling criteria

Box 3: Example of How to Measure Transport Cost Drivers

Imagine a hypothetical scenario where a district health department is responsible for quarterly distribution of contraceptives to its 20 health units. The total volume of contraceptives to be distributed to all units in a given cycle totals 30 cubic meters per quarter. The total distance to be covered to reach all sites (assume all health units are reached in one route) is 450 kilometers, on an all tarmac road. The district owns a truck that can carry 2.4 cubic meters when packed to its full capacity, and is operated by only one driver (full-time, working eight hours per day, five days a week). The average vehicle travel speed is 40 kilometer per hour. Finally, the following facts apply to this context. There are—

- 52 weeks per year
- eight official holidays per year
- about two days for maintenance per calendar month, which is done on working days only.

What is the total number of vehicle-days available for transport given the following conditions?
The answer is *228 vehicle-days* per vehicle, per year:

(52 weeks × 5 days per week that the driver can work in a week) – 8 holidays per year – (2 days × 12 months for maintenance)

What are the total kilometers covered to complete distribution of contraceptives per cycle?
The answer is *5,850 kilometers*:

a. Given its maximum carrying capacity, the truck needs to make 13 trips to deliver the quantity of contraceptives: 30 m^3 / 2.4 m^3 carrying capacity = 12.5 (a half trip may still require the truck to be out on the route; to be conservative, 12.5 is rounded up to 13)[2]

b. The truck covers 450 kilometers on each trip taken on the delivery route; therefore, 13 trips would require the truck to cover 5,850 kilometers (or 450 kms × 13 trips).

What are the total days required to complete distribution of contraceptives in a cycle? Is one truck sufficient?
The answer is 73.2 days and, yes, one truck is sufficient.

a. With a speed of 40 kph, it would take 5,850 / 40 = 146.25 hours to cover the required distance.

b. Given that the driver can only operate a vehicle for eight hours a day, 146.25 / 8 or 18.3 days per quarter would be required to cover the distance. The total days for the year would be four times that (four quarters) or 73.1 days (18.3 x 4 = 73.2).

c. Because the vehicle is available for 228 vehicle-days in a year (see above), one truck would be enough to cover the distribution of contraceptives (73.1 days < 228 available days).

2. The example is simplified. Creative delivery schedules could be investigated to minimize the number of trips by determining the sequence of health units that would receive deliveries based on their relative demand for contraceptives and relative distance from the district.

included population size/density and the relative complexity of district distribution network (i.e., large or small number of sub-districts to deliver to at the district level). Doing so allowed analysts to estimate national distribution costs for NMS based on per capita population-based projections, as well as per sub-district-based projections. Interestingly, findings from both approaches did not differ significantly, increasing confidence that estimates of national costs were relatively representative.

- *Use estimates where precise measures are not realistically collected in a short amount of time*. This is applicable for any of the factors or cost drivers. For example, in the transport cost study for NMS in Uganda (Vian 2003a), to facilitate the calculation of the total volume delivered, the team categorized essential drug products into three major groups, depending on their packaging size (large, medium, and small). The team estimated the average volume of a large, medium, and small package based on a sample of 10 packaging forms in each group.

Appendix D contains sample data collection forms for gathering information relevant to a transport cost analysis. For easy reference, the guide is sectioned into factors that affect variable versus fixed costs, as well as a section related to logistics design factors. The forms were culled from various studies of transport cost analysis performed by the DELIVER project. Reports of original analyses contain more complete forms (see appendix C).

3. Define Relevant Fixed and Variable Costs

This step describes fixed and variable resources associated with the factors that influence the cost of a logistics system. Later in this section, you will find brief descriptions about how to measure these fixed and variable costs. The approaches for measuring the costs can be used to define the resources that *would be* required if a transport system is being designed, as well as to evaluate the *existing* costs of a transport system.

Table 3 provides examples of the costs that are associated with the cost drivers defined for transport.

Table 3: Costs Associated with Transport Cost Drivers

	Costs associated with…		
Number of vehicles-days	• Vehicle depreciation costs	➔	Fixed
	• Cost of inputs required for placing and maintaining the vehicle on the road (e.g., licensing, insurance, taxes, etc.)	➔	Fixed
	• Salary costs for drivers and packers	➔	Fixed
	• Costs associated with pooling or parking the vehicle[3]	➔	Fixed
	• Vehicle leasing or contracting costs, where applicable	➔	Fixed
Total kilometers	• Fuel costs	➔	Variable
	• Maintenance costs for vehicles (e.g., tires, oil change)	➔	Variable
Total days	• Travel allowance (day per diem) costs for drivers and packers	➔	Variable
	• Night allowance (night per diem) costs for drivers and packers	➔	Variable

Depending on the type of analysis required, other related *indirect* transport costs may also be analyzed, but they are not indicated above. For example, if the entire Transport and Distribution Unit was being evaluated, to evaluate the total performance of the distribution function, it may be important to consider indirect costs. Indirect costs can also be fixed or variable costs as defined above. Examples of indirect distribution-related costs include—

- *Other personnel salary costs* involved in transport function (typically fixed costs): e.g., pickers and packers in the warehouse, transport managers, and general managers, depending on the extent of time they devote to transport functions.
- *Inventory handling resources:* e.g., warehousing and/or building resources (equipment, staff, space, security costs), information systems devoted to storing and managing the products to be transported/delivered or to scheduling and tracking shipment (including associated personnel costs and communications costs).

4. Calculate Relevant Fixed and Variable Costs

Until now, the major cost drivers have been identified (step 1), measured (step 2), and their major cost components identified (step 3). The focus in this step is to *calculate* the cost of these cost driver measures. The following sections describe general approaches for conducting this calculation.

The descriptions provide highlights of these approaches and of typical issues that may arise in doing these calculations. Several references are available to provide more detailed or specific description, and the reader is encouraged to look at these (see appendix C on costing). Box 4 provides an example.

3. This may also be a cost associated with total days for distribution if these are incurred at delivery locations.

Box 4: Example of Measuring and Assessing Costs Associated with Transport Cost Drivers

Building on the example in box 3, imagine that the following hypothetical, annual cost information was also available from the district accounting office regarding the vehicle used for contraceptive distribution:

1. Vehicle Fuel and Oil Expenses	$7,820
2. Vehicle Maintenance	$3,580
3. Vehicle Amortization	$4,000
4. Vehicle Registration	$287
5. Road Tax	$100
6. License Fees	$670
7. Vehicle Insurance	$1,430
8. Goods in Transit Insurance	$1,800
9. Driver's Salary and Benefits	$4,500

In addition, the transport department informed you that the vehicle logged 10,520 kilometers for the year. Also, per diem costs were not considered as a cost factor in this situation.

What is the total fixed cost associated with contraceptive distribution?
The answer is *$4,150*.

a. Given the information above, the total cost of the vehicle is the sum of line items 3 to 9 (i.e., $12,787).

b. Given that the vehicle is available for 228 days (box 3), the cost of a vehicle-day is $56.08 ($12,787/228). From box 3, it was found that 74 (73.1 rounded up) of those days a year would be necessary for contraceptive distribution; therefore, $4,150 (or 74 days x $56.08) of the total cost would be attributable to contraceptive distribution.

What is the variable cost associated with contraceptive distribution?
The answer is *$6,318*.

a. Given the information above, total variable costs equal $11,400, or the sum of line items 1 and 2.

b. In the absence of any additional information to estimate the unit variable costs, the variable cost per kilometer last year was $1.08 ($11,400 / 10,520 kms). From box 3, 5,850 kilometers needed to be covered to complete contraceptive distribution, with an associated cost of $6,318 (or 5,850 kms × $1.08 per km).

Note: Total contraceptive distribution costs would be $10,468 ($4,150 + $6,318).

a. Measuring Costs Associated with Number of Vehicles-Days

There are two inputs for calculating this measure of fixed cost: total vehicle related costs and number of vehicle days. The following section describes approaches for estimating the total cost of a vehicle. Information is typically available for all vehicles combined, i.e., for a fleet, but can be determined on a vehicle by vehicle basis and subsequently aggregated. Costs are quoted on an annual basis.

Cost	Approach
Depreciation costs (if vehicle is owned)	Various methods can be used to calculate the cost of depreciation,[4] but for the sake of simplicity, we suggest a simple straight-line approach for calculating depreciation costs. To do this, obtain the price paid to purchase the vehicle (cost of purchase) and divide the price by the years the vehicle is recommended for use. Typically, protocols exist for the number of useful years to apply for amortizing (or depreciating) the cost of a vehicle (e.g., 10 years for larger vehicles). In reality, a vehicle may be used for longer than its recommended useful life, especially in resource-constrained situations. The depreciation cost calculated in the suggested (theoretical) way can, therefore, be applied as a plug for the replacement cost of that vehicle (e.g., what it would cost that year if a vehicle was purchased in its place).
Cost of placing and maintaining the vehicle on the road	a. Record or calculate insurance costs. This refers to the annualized premiums that cover liability and/or collision on the vehicles, and damage or theft of goods-in-transit. b. Record the licensing and related fees (e.g., taxes, registration), as applicable. Estimates of these costs are usually acceptable.
Salary costs	a. List the title and number of drivers that work on operating the vehicles used for distribution, and note whether they are full-time or part-time. b. For each employee (or driver grade level), obtain the cost of salaries plus any benefits received. Benefits are typically expressed in monetary terms and include annual and sick leave, any employee retirement plan, medical and other health benefits, etc. Note that not all employees receive all benefits.
Vehicle pooling charges	Estimates include associated costs such as parking, garage charges, etc., as applicable, aggregated based on per vehicle charges or quoted for the fleet of vehicles.
Leasing costs	If a vehicle is leased (or contracted), obtain the average monthly or annual cost of leasing each vehicle.

Other possible costs to include in an estimate of the total cost of a vehicle are any damage repair charges on the vehicle for a given year and other leasing or contracting related charges.

After the total cost of a vehicle or a fleet is determined, to calculate the cost of a vehicle-day, divide this cost by an estimate for the total number of days a vehicle can be on the road. For example, if total vehicle costs are U.S.$100,000 and total available vehicle-days are 228 days (see box 3), then total cost per vehicle day is U.S.$438.60 per vehicle day. Still, the idea of estimating the total number of days requires some consideration. The suggested approach of using the total possible number of days that a vehicle is available for use (e.g., in a year) arrives at a somewhat theoretical cost per vehicle-day. In other words, the approach does not consider the possible reality that a vehicle is not used 100 percent of the time it is available (although this is the most efficient use of capital or *fixed* resources). Traditional fixed cost analysis suggests that the unit cost of a fixed asset (e.g., the unit cost here is the cost per vehicle-day) is reduced as the asset is used to its maximum capacity (see the glossary and appendix A). This suggests that a more realistic approach to estimating the cost of a vehicle-day is to continuously adjust the measure to take into account the actual number of days the vehicle is used. Doing this also reveals how efficiently a vehicle is being used; costs would be lower when the vehicle is used to its full capacity. However, the approach is necessarily more complex than the one proposed earlier, as it requires a method for tracking and assessing actual vehicle utilization. This can be done through vehicle transport logs, for instance. See the Uganda case study (Vian 2003a) for an example and further consideration of this issue.

4. See reference on costing in appendix C.

b. Measuring Costs Associated with Total Kilometers

The next section describes some suggested approaches for calculating variable costs associated with distance cost drivers, in particular, total kilometers.

Cost	Approach
Fuel costs	If an analysis is being done to determine the existing costs of a transport system, ideally, information on fuel costs expended would be tracked and should correspond or be related to the total distance traveled by each vehicle for distribution activities. However, typically, it is not easy to obtain complete information on fuel expenditures or to separate distances traveled by a vehicle for distribution versus other activities. Two approaches are suggested when trying to determine a reasonable estimate of distribution fuel costs. The choice of the approach will depend on the primary objective of the analysis, the type of data available, and the time available to collect and mine it. a. *Estimates based on actual fuel expenditures:* This approach suggests calculating a unit cost of fuel per distance (kilometer) traveled using information on actual total costs expended on fuel for the fleet of vehicles and the total distance covered by this fleet, in a corresponding window of time (e.g., a year). This approach assumes that data is available for the total distances traveled using the vehicles in the fleet. Unit costs per kilometer can then be calculated by dividing the total fuel costs by the total distance traveled. The total fuel expenses for distribution activities can then be backed out by multiplying this unit cost by the total distance traveled for distribution-related activities, obtained from the information on vehicle use above. For vehicles that are used for distribution for only part of their time on the road, the total distance traveled by the vehicle could be prorated in proportion to the time they were used for distribution. For example, if a vehicle was being used three out of five days for distribution, the total distance covered by the vehicle could be multiplied by 3/5 or 60 percent to obtain an approximate estimate of the distance covered for distribution. Other more reasonable estimation approaches can also be used and explained based on the analyst's knowledge of the information available on vehicle use. b. *Estimates based on average fuel running costs (hypothetical approach):* Alternatively, an estimated unit cost of fuel per kilometer can be calculated and used to estimate the total cost of fuel for the distance traveled for distribution activities. The unit running cost of fuel is calculated as follows: Average cost of fuel per liter ÷ Average kilometers covered per liter As above, this unit cost of fuel is multiplied by the total distance traveled for distribution-related activities, obtained from estimates based on the distances in delivery routes and frequency of deliveries and/or trips required. The average cost of fuel per liter (or price of fuel) can be expressed per gallon or any other quantity that corresponds to the fuel efficiency measure, i.e., the average distance covered per quantity of fuel. Adjustments or assumptions may be necessary where fuel prices fluctuate significantly during the time of the analysis; an average can be used for average fuel costs per liter or high and low estimates can be used to calculate a range for total fuel costs. The fuel efficiency (distance covered per quantity of fuel) of a vehicle is often a function of the size of the vehicle (lower for larger vehicle) and the type of road traveled (e.g., higher for well-paved roads and highways, and lower for roads that require frequent starts and stops or changes in speed). An average rate for fuel efficiency can be used or this formula can be calculated for total distances to be covered over different road types (e.g., for total distance on tarmac, plus total distance on dirt roads).

b. Measuring Costs Associated with Total Kilometers (cont'd)

Cost	Approach
Vehicle maintenance costs:	Vehicle maintenance includes activities like oil changes, tires changes, etc. The longer a vehicle is on the road, the greater the need to ensure proper maintenance and the higher the related maintenance expenses. This fact makes maintenance costs vary in proportion to the total distance traveled by the vehicle over a given period of time (e.g., a year). The challenge of measuring maintenance-related costs are similar to the ones faced for fuel costs because it is difficult to separate maintenance costs incurred as a result of distribution-related activities versus other activities that involve the use of the vehicle fleet. Two measurement approaches are proposed: c. *Using information on actual maintenance expenses:* Similar to the approach for estimating fuel costs in this way, this approach requires an estimate of the actual costs spent on maintenance-related costs. To obtain a unit cost per kilometer of maintenance-related costs, this figure is divided by the total distance traveled by vehicles that received maintenance. To determine the total maintenance costs, the unit cost is then multiplied by the relevant distance traveled for distribution costs. d. *Estimates based on expected or typical maintenance costs (hypothetical)*: This approach relies on being able to calculate a unit cost per kilometer for maintenance inputs based on an accepted or reasonably defined maintenance protocol per vehicle type. To derive the unit cost per kilometer— Average cost of oil or tire change ÷ Average number kilometers covered between oil or tire changes For tire changes, more than one tire may need to be changed within a certain travel distance; the average cost estimate for a tire change in the formula should, therefore, include the cost of changing all the affected tires. To estimate the total cost of kilometers, the estimated cost per kilometer is multiplied by the total distance (to be) traveled in the distribution system.

c. Measuring Costs Associated with Total Days

The following describes an approach for measuring the variable costs associated with the total days factor.

Cost	Approach
Travel or overnight allowances (per diem) costs	The recommended and simplest approach for estimating the running cost of total days required for distribution is to use an estimate of allowance costs per day. This unit cost is then multiplied by the number of people who are involved in distribution activities and are eligible to receive an allowance, and by the total number of days required to complete the distribution. A distinction can be made between total number of days without overnight stay and those requiring an overnight (e.g., owing to the nature of the delivery route). The latter typically requires a higher allowance rate per person. Note also that different personnel (e.g., the driver versus the person who travels with the driver but is responsible for unloading the vehicle at a delivery point) involved in distribution may be eligible for different allowance rates. These differences can/should be taken into account when calculating total cost of allowances. As with the fuel and maintenance costs above, it may be possible to use actual expenditures data to assess these costs for an existing system. However, the assumptions required to attribute portions of total allowance expenditures to just those incurred for distribution activities tend to be more complicated and somewhat unrealistic (unless the organization uses an activity-based type of accounting system).

5. Assess Unit Costs and Total Costs

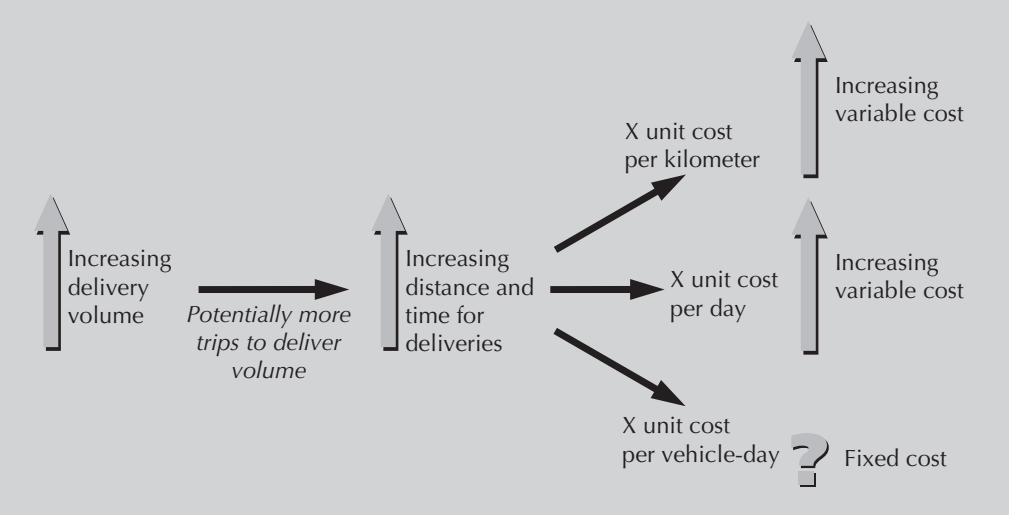
Unit costs can be used to assess the effect of changing an aspect of the system and measuring its impact on costs, e.g., the effect of changing an aspect of a cost driver. Until this step of the guide, unit costs have been expressed for both fixed and variable cost types and for transport systems have been expressed on a—

- per vehicle-day,
- per kilometer, or
- per day basis.

Therefore, unit costs provide a link between the cost of a logistics system and the design (and performance) of that system. The design of the logistics system becomes a major driver of the level of resource utilization.

For example, consider figure 3, assessing the impact of increasing the volume of deliveries while keeping the same number of vehicles available for distribution (i.e., keeping capacity constant).

Figure 3.
Assessing the Cost Impact of Increasing the Volume of Deliveries



Potentially, more trips would be needed to make the deliveries, which would increase the distance covered. Distance can be multiplied by the estimate of unit cost per kilometer (see step 4) to calculate the increase in total variable cost of fuel. More distance to cover may involve more time for the vehicle to be on the road. The additional time could be multiplied by the cost per day to calculate another element of total variable costs. Unit fixed costs (cost per vehicle-day) may actually decrease from increased vehicle utilization (vehicles would be on the road for more time, therefore, fixed costs would be divided by a higher number of vehicle-days on the road). This would be true up to the point where vehicle utilization does not exceed the available vehicle-days that the vehicle can be on the road. See box 4.

6. Analyze Decisions

We mentioned in the basic definitions section of this guide that several approaches are available for analyzing costs and making decisions. Table 4 presents some examples of the types of transport problems that an analyst might come across; a preliminary outline details the possible approaches to addressing them. The level of effort (LOE) required to analyze a particular problem clearly depends on several factors, including the degree of rigor required in the analysis, the level of decision making required (strategic versus operational), and the access to information for analysis. LOE typically assumes a two-person team.

Some general guidelines are beneficial when you assess various design features of a logistics system and their impact on cost drivers, and total costs:

1. *Linking unit costs and total costs implies linking the cost drivers (as defined, for example, for transport in table) with the costs associated with these cost drivers (as defined in table 2 for transport)*. One approach is to systematically map this link for each of the cost drivers. As another example, consider the network of links between delivery points, a cost driver related to total kilometers. Changing assumptions related to the network would mean changing the distance between delivery points; this, in turn, would mean changing the distance traveled to cover the points and potentially the time taken to do so (e.g., based on the various road conditions and links). Various calculations (or sensitivity analysis) can now be performed to assess the impact of network design on the cost of total kilometers or, for example, the total cost of fuel.
2. Implicit in the above, *keeping track of assumptions made when conducting cost analysis increases the value of the analysis*. Assumptions are made about various aspects of cost analysis. They relate to the measures of cost drivers (e.g., the number of operating days the vehicle can be on the road or the average speed of a vehicle), as well as the elements that are part of assessing costs (e.g., the choice of the approach to measure the cost of fuel or the value of a vehicle). Assumptions include factors that are considered as given in the cost analysis. They also include factors that are held constant in the course of the analysis in order to avoid making the analysis too complex, and in the absence of more accessible information (e.g., assumptions about the average price of fuel in a given year to estimate the unit cost of fuel). Documenting these assumptions is a systematic way of allowing anyone who considers the analysis to understand its premise and its results. Clearly stated assumptions enable decision makers who are interested in applying the results to a different situation to carefully assess whether the assumptions hold in that situation. Then, assumptions are easier to test and modify if needed, and then assess their impact on the final results.

Table 4: Possible Cost Analysis Approach to Various Transport Problems

Financial Analysis Objective	Approach…	Estimated LOE—2-person team
1. Measure what it costs currently to run a transport/distribution system,[5] and what is achieved (performance matrix).	• Conduct basic transport costs analysis; include analysis of level of resource utilization and unit cost analysis. • In addition, consider analyzing key logistics performance indicators (e.g., timeliness, lead time, level of stockouts, etc.).	10 days in field, with 5 days pre- and post-field work.
2. Measure the current efficiency of fleet utilization and identify areas for cost reduction.[5]	• Conduct basic transport cost analysis as above, aiming as much as possible to use actual expenditure information to complete analysis. • Analyze specifically factors that drive specific components of basic transport analysis, e.g., breakdown time that the vehicle is off the road. • Analyze actual costs versus expected costs based on the *ideal* design and operation of the logistic system (e.g., for fuel cost).	10 days in field, with 5 days pre- and post-field work
3. Assess how best to route deliveries while minimizing costs (and meeting performance targets).[6]	• Conduct basic transport analysis to determine unit costs of running transport system. • Analyze and compare possible routing options based on estimates or measurement of distances to be covered, days required, and possibly size of vehicle that can be used; consider constraints that will be faced given the existing fleet (vehicle-days). Calculate costs under each option. • Run scenario analyses on different routes and possibly vehicle size.	15 days in field, with 5 days pre- and post-field work
4. Compare costs of alternate systems, including outsourcing.[7]	• Describe the alternate systems being compared. • Conduct basic transport analysis for systems that are being compared, typically focusing on analyzing the effects of the factors that will differ among alternatives. • Run sensitivity analyses to anticipate the effect on total costs of changing key drivers in each alternative.	15–20 days in field, with 5 days pre- and post-field work, depending on the degree of rigor required in private sector analysis (e.g., whether cost estimations are acceptable).
5. Determine the cost effect of increasing volume/frequency of demand or integrating supply chains.[8]	• Describe the alternate systems being compared. • Conduct basic transport analysis for systems that are being compared, typically focusing on analyzing the effects of the factors that will differ among alternatives. • For analyzing integrated versus vertical system, conduct assessment of volume and delivery size and schedules and then assess their impact on cost (by changing relevant cost drivers). Volume assessments require sufficient time.	15–20 days in field, with 5 days pre- and post-field work, depending on the degree of rigor required (e.g., whether cost estimations are acceptable). Team of 2 strongly recommended.
6. Determine whether the transportation/distribution system is recovering its cost.[9]	• Perform a basic transport cost analysis (still recommended). • Develop appropriate measures for allocating costs to revenue sources and compare with revenue. • Analyze sources and levels of revenue versus costs.	10–15 days in field, with 5 days pre- and post-field work
7. Assess cost tradeoffs: inventory holding costs versus transport running costs.[10]	• Conduct basic transport analysis combined with similar analysis for warehousing/holding costs. • Analyze impact of key cost drivers on both inventory holding and transport costs. • Note: Inventory holding cost analysis not developed in this guideline.	15 days in field, 5 days pre- and post-field work

5. For example, see Uganda case study (Vian 2003a).
6. See example or route optimization analysis in Ghana in (Gyimah and Healy 2003).
7. See example of private sector outsourcing cost analysis in (Abdallah and Wilson 2002). Incremental cost analysis approach for comparing alternate transport design can be found in Uganda case study (Vian 2003a).
8. See Zimbabwe case study (Vian 2003b). Also refer to model developed in Egypt (Abdallah and Wilson 2002).
9. See example of cost recovery analysis in Uganda cost study (Vian 2003a) and original report (Abdallah, Healy, and O'Hearn 2002).
10. See report on cost of various logistics functions developed in Ghana (Huff-Rousselle and Raja 2002).

3. *Where possible, perform a sensitivity analysis to build a better understanding of major factors or assumptions that drive the results of a cost analysis.* Sensitivity analysis or what-if scenario analysis allows the analyst to measure how projected results may vary along with changes in the key assumptions on which the projections are based. Sensitivity analysis is also a check on the results of the analysis to make sure that all factors that might affect the stability of a decision have been considered and their impact anticipated. For instance, sensitivity analysis can be based on variations in the estimate of total distance or days (both measures of the distance cost driver in transport cost analysis). For a discussion of sensitivity analysis applied to transport analysis (Vian 2003a).
4. As highlighted earlier, *both fixed and variable costs related to the logistics system should be considered.* The trade-off between these two costs is often at the core of decisions to be made related to the logistics system (e.g., whether or not to outsource, how to manage buyer and supplier type negotiations, etc.). One way to do this is to consider the impact of cost drivers on both fixed and variable costs when linking unit costs and cost drivers.
5. *While the definition of what constitutes fixed and variable costs is standard, the determination of what to include or not include in measuring these costs depends on the situation and organizational structure, in addition to the objective of the analysis.* This guideline means that a general prescriptive approach to measuring costs of a logistics system is less useful. Instead, it is important to recognize that all costing is local and needs to be considered in the context where it is being completed. For instance, the cost of vehicles may be considered as part of fixed or variable costs, depending on whether the organization owns its vehicles or hires vehicles for specific deliveries or distances. Another type of example has to do with whether or not to include a cost item in measuring costs. *A cost analysis should focus on costs that are expected to change as a result of the changes being considered* (rather than assessing all costs). In a situation where alternatives are being compared, for instance, analysis should focus on what is different between the different options being considered, and then measure costs to assess this difference. This approach is sometimes called incremental cost analysis (Vian 2003a).
6. *A basic cost analysis approach in logistics management is to compare expected costs against actual costs* of systemic or functional costs. Expected costs are projections of what logistics costs should be under the best case or ideal scenario, where the logistics system or logistics function (e.g., transport or warehousing) operate as planned. Comparing actual logistics costs against expected costs highlights areas where costs deviate significantly from the ideal; this, in turn, triggers an analysis of costs and logistics practices to investigate interventions for minimizing deviations.
7. *A note on contracting (or outsourcing)*: This is an area of interest in the logistics management field as organizations try to reduce the cost of owning and managing capital assets (often with high opportunity costs) and attempt to outsource to outside firms the functions

performed with these assets. The implication for the cost analysis framework that was described earlier is that some of the costs we have defined as fixed costs would likely be shifted to being variable costs and be treated accordingly. For example, the cost of vehicle-days described in previous examples would be replaced with an estimate of leasing costs that may vary based on the period of time a vehicle is being leased to make deliveries. If distribution is contracted out altogether (e.g., for a period of time) however, contracting-related costs may replace the cost of vehicle-days; contracting costs may be considered fixed costs. Definitions of the appropriate cost driver would still be needed.

Appendix A

Glossary

Accounting cost. (e.g., depreciation allowance) Artificial costs applied to reflect the real value of a product or service at a given time; cost is not *actually incurred*.

Activity. Usually defined with a verb and noun, an activity consumes human and financial resources of a department and feeds into the output of the department. Also classified as primary, secondary, value added, and non-value added.

Activity-based costing (ABC). System of accounting that focuses on activities such as the fundamental cost objects, and uses the costs of these activities as building blocks for compiling the cost of other cost objects (such as a product, service, or department).

Average cost. Total cost divided by output (quantity of product produced) or a denominator.

Benefit. Advantage in dollar terms resulting from an (various) action(s).

Capital cost. Expenditure required for financing permanent or semi-permanent capital goods (e.g., buildings, machinery, equipment, transportation means). In questionable cases, capital goods are those goods that are used for more than a year.

Cost-effectiveness analysis. A technique for comparing the costs and the effectiveness of alternative ways of achieving the same objective.

Cost-benefit analysis. A technique for comparing the monetary cost and monetary outcome of alternatives. Unlike cost-effectiveness analysis, the effect is expressed in monetary terms.

Cost-utility analysis. A procedure that compares the cost of alternatives with subjectively derived ratings of those alternatives. It is used when comparing alternatives in different sectors (e.g., health versus education) when effectiveness cannot be measured uniformly across alternatives.

Cost driver. Factor that affects the cost of an activity. Influenced by the frequency and intensity of the demands placed on resources, the state (condition) of available resources (e.g., frequency of orders in a logistics system; level of knowledge of logistics staffs).

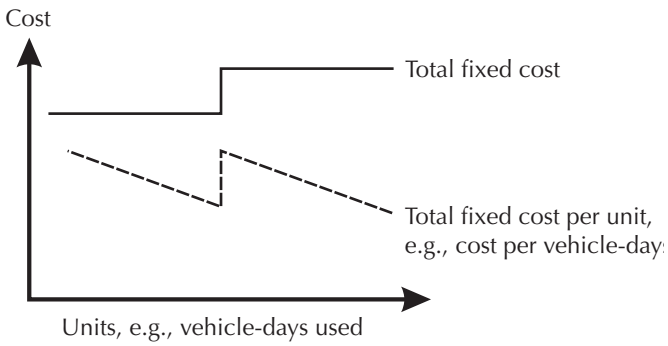
Direct cost. Cost that is explicitly identifiable with a particular service or area. Examples of direct medical costs are hospital supplies, labor costs for medical personnel, and pharmaceuticals.

Driver. *see* Cost driver.

Economic or opportunity cost (e.g., value of employee's time engaged in work outside of primary job duties). The value of benefits forgone by using resources to provide alternate products or services.

Effect. Change among individuals, families, or communities as a result of an activity, project, or program.

Fixed cost. Cost that does not vary with quantity or volume of output provided in the short-run (typically, one year). These costs usually vary with time but not with quantity or volume of service provided; may include rent, equipment, equipment lease payments, and some wages and salaries. Illustrative graphic for transport cost:



Hidden cost. Cost that is not directly incurred but occurs due to morbidity, premature mortality, or loss of productivity. Morbidity costs include goods and services not produced by the patient because of illness. Mortality costs include goods and services the person could have produced had the illness not occurred and had the person not died prematurely. Also refers to cost to society resulting from poor quality (*see* Indirect cost).

Incremental cost. Cost that differs among alternative courses of action.

Indirect cost. Cost that cannot be easily identified in the product or service (e.g., electricity, executive salaries, insurance). Also called overhead.

Investment cost. Resources expended one time initially to launch a specific intervention or program.

Monetary or financial cost (e.g., wage rate of employees). Actual expenses incurred for an input or to provide a product or service, at a given time.

Non-value added activity. Activity that is not required to meet internal or external customer requirements. Usually a redundant activity (e.g., unnecessarily repeating a step in a process) or an unproductive activity not contributing to the output of a departmental or organization (e.g., unnecessary staff waiting time).

Obvious cost. Generally, cost that is most easily and directly seen as being incurred (see also Direct cost).

Recurrent cost. Resources used and replaced within one year's time (e.g., personnel salaries, medicines, supplies, gasoline, drugs, electricity, and food).

Return on investment. Amount of total cost benefits achieved by an intervention over the incremental cost of that intervention.

Running cost. *See Variable cost.*

Sensitivity analysis. Investigation into how projected results vary based on changes in the key assumptions on which the projections are based.

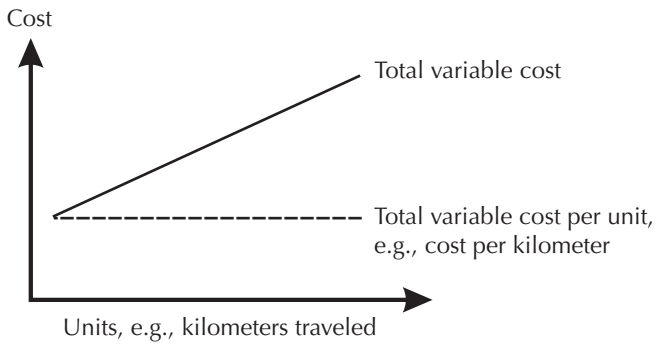
Shadow prices (e.g., donated time and equipment). Costs applied to subsidize goods and services when their true value is not the same as listed.

Unit cost. Cost of one unit of output (e.g., cost per product or service).

Utility. (Perception of) satisfaction from consuming a specific bundle of goods and services (subjective).

Value-added activity. Activity that meets internal or external customer requirements. The example is—"*perform root canal* in a dentistry department" (also *primary activity*).

Variable cost. Cost that varies with changes in output volume, such as the raw material required to provide a service. Illustrative graphic for transport cost:



Vehicle-days. Number of days vehicle is available for operation (for example, in a year), allowing for planned or unplanned vehicle downtime (e.g., for vehicle maintenance, major holidays, driver availability, repair).

Appendix B

Major Steps in Cost Analysis in Logistics Systems

Step	Example
1. Define major factors that influence fixed and variable costs.	
• Determine what resources are involved in carrying out the logistics function you are assessing, and understand how those resources are being used.	For example, cost drivers of transport costs are— ➔ *Capacity:* size and number of distribution vehicles that are accessible ➔ *Distance:* how much vehicles will be used
• Describe factors that have an impact on the fixed and variable resources/costs that you are concerned about, i.e., costs will change as a result of changes in these factors. These factors are called *cost drivers*.	Another factor that influences these cost drivers is the *design of the logistics system*: including the inventory level in the system, frequency of order, and delivery routes in a logistics system.
2. Assess variables that affect cost drivers.	
• First, define appropriate measures of the cost drivers. These measures will be the basis for a cost analysis.	For transport, the following measures can be defined: ➔ For *capacity:* number of vehicle-days ➔ For *distance:* total distance (e.g., # of kms) total days to cover kms
• Assess variables that will affect cost drivers and use these variables to measure cost drivers. Variables link the resources used in a logistic system with the design of the distribution system.	For transport, table 1 outlines the variables that can be analyzed for transport cost drivers. The main variables related to the *design of the logistics system* should also be understood (including volume of products, distribution frequency, and delivery route).
• In this step, understand how the distribution system works, how the products move through the system. Conduct a logistics assessment, as appropriate.	Some sampling of sites may often be necessary. General guidelines include— • *If possible, stratify survey sites and survey all major site types.* • *Sample to facilitate a reasonable projection of results.* • *Use estimates where precise measures cannot realistically be collected.*
3. Define relevant fixed and variable costs. Describe fixed and variable resources that are associated with logistics cost drivers.	For transport cost driver, examples of fixed cost include depreciation and driver salary costs. Examples of variable costs include fuel and per diem (or lunch allowance) costs. Table 3 breaks down these costs in more detail.
4. Calculate relevant fixed and variable costs. Calculate the cost of cost driver measures. Use general approaches for conducting this calculation. Several references are available to provide more detailed or specific description, and you are encouraged to look at these (see appendix C).	See relevant section for detailed examples.

Step	Example
5. Assess unit costs and total costs. Determine unit costs of major cost drivers; unit costs can be used to assess the effect of changing an aspect of a cost driver and measure its impact on costs.	Unit cost associated with transport cost drivers include— • cost per vehicle-day • cost per kilometer or • cost per day. For example, consider the network of links between delivery points, a cost driver related to total kilometer. Changing assumptions related to the network would mean changing the distance and delivery route; this, in turn, would mean changing the distance traveled to cover the points and potentially the time taken to do so. Various calculations (or sensitivity analysis) can now be performed to assess the impact of network design on the *cost of total kilometers,* or, for example, the total cost of fuel.
6. Analyze decisions. • The level of effort (LOE) required to analyze a particular problem depends on several factors, including the degree of rigor required in analysis, the level of decision making required (strategic versus operational), and the access to information for analysis. • Systematically try to map the link between cost drivers and the costs associated with these cost drivers. • Keep track of assumptions made when assessing unit or total costs. • Where possible, perform sensitivity analysis on the results of a cost analysis. • Always try to consider both fixed and variable costs related to the logistics system. • Remember that the definition of fixed and variable costs is a *local* one, and needs to be relevant to the organization and the objective of the cost analysis. • Use a widespread cost analysis approach in logistics management that compares expected costs against actual costs.	See table 4 for examples of transport cost analysis problems.

Appendix C

References

Relevant DELIVER Document References

Abdallah, Hany, and Edward Wilson. July 2002. "Estimating the Cost of Contraceptive Distribution Systems to Governorate Level Warehouses, Country: Egypt." Technical Assistance Record July 8–July 26, 2002. Arlington, Va., John Snow, Inc./DELIVER.

Abdallah, Hany, Mike Healy, and Timothy O'Hearn. December 2002. *Uganda: Assessment of Costs of Distribution to Health Sub-Districts*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Alt, David, and Marilyn Noguera. July 2002. *Zimbabwe: HIV/AIDS Commodities Transport Assessment*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Gyimah, Peter and Mike Healy, February 2003. *Ghana: Transportation Study. (multiple parts)*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Huff-Rousselle, Maggie, and Sangeeta Raja. 2002. *Ghana: Estimating the Cost of Logistics in the Ministry of Health Supply System*. Arlington, Va.: Family Planning Logistics Management (FPLM)/John Snow, Inc., for the U.S. Agency for International Development.

John Snow, Inc./DELIVER. 2002. *Logistics Indicators Assessment Tool*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

John Snow, Inc./DELIVER. 2002. *Logistics System Assessment Tool*. Arlington, Va.: DELIVER/John Snow, Inc., for the U.S. Agency for International Development.

O'Hearn, Tim, and Mike Healy. March 2003. *Nigeria: Assessment of the Transportation System and Distribution Costs for Family Planning Commodities*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Sarley, David, Hany Abdallah, Raja Rao, Joycelyn Azeez, Peter Gyimah, and Bertha Garshong. July 2003. *Ghana: Pharmaceutical Pricing Study, Policy Analysis and Recommendations*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Vian, Taryn. 2003a. *Uganda: Assessing the Costs of Distribution to Health Sub-Districts. A Case Study in Financial Analysis*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Vian, Taryn. 2003b. *Zimbabwe: Assessing the Cost of Transporting HIV/AIDS Commodities: A Case Study in Financial Analysis*. Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

Costing

Creese, Andrew, and David Parker, eds. 1994. *Cost Analysis in Primary Health Care: A Training Manual for Programme Managers*. Geneva: World Health Organization.

Hanson, Kara, and Lucy Gilson. 1993. *Cost, Resource Use and Financing Methodology for Basic Health Services—A Practical Manual*. New York: UNICEF, Bamako Initiative Unit.

Horngren, Charles, Srikant Datar, and George Foster. 1997. *Managerial Cost Accounting*. Upper Saddle River, NJ: Prentice-Hall.

Janowitz, Barbara, and John H. Bratt. 1994. *Methods for Costing Family Planning Services*. New York: United Nations Population Fund.

Management Sciences for Health. 1998. *CORE: A Tool for Cost and Revenue Analysis*. Boston, Mass.: Management Sciences for Health.

Reynolds, Richard, and K. Celeste Gaspari. 1986. "Cost-Effectiveness Analysis" PRICOR, Monograph Series, Methods Paper No. 2. Chevy Chase, Md.: Center for Human Services.

Cost Analysis and Approaches for Logistics

Abt Associates, Bill and Melinda Gates Children's Vaccine Program, TRANSAID Worldwide, World Health Organization, and Riders for Health. February 2001. "Transport In Primary Healthcare: A Study To Determine The Key Components Of A Cost Effective Transport System To Support The Delivery Of Primary Health Services." N.p.

Ansari, Shahid, Janice Bell, Thomas Klammer, and Carol Lawrence. 1997. *Target Costing: Version 1.0*. N.p.

Casteneda-Mendez, Kicab. 1996. *Value-Based Cost: Management for Healthcare: Linking Costs to Quality and Delivery*. Limited, NY: Division of the Draus Organization.

Cox, Andrew. 2001. "Managing with Power: Strategies for Improving Value Appropriation from Supply Relationships." *The Journal for Supply Chain Management*, Spring 2001: 42–47.

Cox, Andrew. 2001. "Understanding Buyer and Supplier Power: A Framework for Procurement and Supply Competence." *The Journal for Supply Chain Management*, Spring 2001: 8–15.

DPS International Global Logistics Solutions: see web site, www.dps-int.com, for interesting products and publication on transport-related cost analysis.

Ellram, Lisa. 1995. "Activity-based Costing and Total Cost of Ownership: A Critical Linkage." *Journal of Cost Management*, Winter 1995:22–30.

Hartley, Janet. 2000. "Collaborative Value Analysis: Experiences from the Automotive Industry." *The Journal for Supply Chain Management*, Fall 2000: 27–32.

Napolitano, Maida and the Staff of Gross & Associates. 1994. *The Time, Space & Cost Guide to Better Warehouse Design—A Hands-on Guide to Help You Improve the Design and Operations of Your Warehouse or Distribution Center*. New York: Distribution Center Management.

Player, Steve, and David Keys, eds. 1995. *Activity-based Management: Arthur Andersen's Lessons from the ABM Battlefield*. New York: MasterMedia Limited.

Sakurai, Michikaru. 1989. "Target Costing and How to Use It." *Journal of Cost Management*, Summer 1989: 39–50.

Shields, Michael D., and S. Mark Young. 2000. "Managing Product Life Cycle Costs: An Organizational Model." *Journal of Cost Management*, Fall 2000: 39–51.

Speh, Thomas. 1990. *A Model for Determining Total Warehousing Costs for Private, Public and Contract Warehouses*. Oak Brook, Illinois: Warehousing Education and Research Council. DCW-USA, Inc.

Appendix D

Sample Tools for Collecting Relevant Information

Variable Costs

Potential Sources of Information: Finance and/or Accounting Department; Transport Unit or Cost Center; Estimates from individuals knowledgeable of the vehicles.

Data on Actual Expenditures

Cost Type	Last Six Month's Costs	Source of Funds
Fuel		
Vehicle maintenance		
Tires		
Other, specify		
Other, specify		
Total		

Data to Estimate Costs

		High	Low
➔ Average cost of fuel per liter or gallon		_____	_____
➔ Distance covered per liter or gallon			
		Highway or paved, low traffic	Traffic or unpaved road
Vehicle Type 1 : _____		_____	_____
Vehicle Type 2 : _____		_____	_____
Vehicle Type__: _____		_____	_____
➔ Oil Change Protocol	A	Every _____	kilometers
Cost of average oil change	B	_____	
Average cost of oil change per km	B/A	_____	
➔ Tire Change Protocol	A	Every _____	kilometers
Number of tires	B	_____	
Cost of average tire change	C	_____	
Average cost of tire change per km	(B*C)/A	_____	

➔ Average Travel Allowance (day only per diem)

Driver _____
Packer _____
Other _____

➔ Average Night Allowance (overnight per diem)

Driver _____
Packer _____
Other _____

Possible other costs: overtime costs (for driver, packer, other)

Fixed Costs

Potential Sources of Information: Finance and/or Accounting Department; Transport Unit or Cost Center; Estimates from individuals knowledgeable about the vehicles; Human Resources Department

Data on Vehicles and Personnel

Please list below the delivery resources available to you:

Type of Vehicle	Size	Number of Type	Average Age	% Dedicated to Distribution	Own or Contract	Condition (e.g., fair to excellent)
1.						
2.						
3.						
4.						
5.						

For each vehicle

	If Contracted	If Owned	
Vehicle	Average leasing and other contract charges (e.g., per month)	Average cost of purchase*	Average depreciation cost (e.g., per month)*
1.			
2.			
3.			
4.			
5.			

* May be adjusted into current year dollars

** Simple depreciation: Cost of purchase/ average expected life of vehicle (refer to available protocol)

List the number and title (or grade or category) of drivers and permanent staff dealing with operating vehicles (e.g., pickers/packers) and note their salary and employment status (full or part-time).

Employee Category	Full or Part-time	Salaries and Benefits (e.g., annual)	Source of Funds
1.			
2.			
3.			
4.			
5.			
Total			

Data on Actual Expenditures

The table below lists various direct costs of operating a delivery service. Please indicate the actual costs that you have incurred over the last six months in each category. Also indicate the funding for each category.

Cost Type	Last Six Month's Costs	Source of Funds
Vehicle pool charges		
Vehicle licenses, test fees, etc.		
Vehicle insurance		
Accident damage repairs		
Other, specify		
Total		

Factors Related to Design of Logistics System

Potential Sources of Information: Warehouse and/or Distribution Unit.

Product Name	Unit Form*	# of Units Per Package	Package Dimensions (meters) *Length*	*Width*	*Height*
1.					
2.					
3.					
etc.					

* e.g., tablets, capsules, vials, ampoules, tins, boxes, etc.

Data on Distribution Volume

Data on Frequency:

Type of inventory control system (e.g., general pull versus push, forced ordering): _____

Min-max levels by levels in logistics system: _____

Delivery schedule by level in the logistics system: _____