Appendix F

Estimating Transport Costs

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There are a variety of measures commonly used for expressing the transport costs of a shipment or set of shipments. Shippers are most interested in measures, such as cost per shipment or cost per ton, that summarize the total costs they incur. However, transport costs vary with shipment size and length of haul. Accordingly, analysts find measures that reflect shipment size and/or length of haul to be more useful. These include cost per ton-mile, cost per shipment-mile, cost per container-mile, etc.

This appendix discusses sources of cost estimates for the truck, rail, water, and air modes.

F.1 Truck Costs

In general, truck costs rise with distance at a somewhat less than linear rate. However, for lengths of haul above 50 or 100 miles, truck costs increase only slightly more slowly than length of haul. Accordingly, cost per vehicle-mile is a particularly useful measure for analyzing truck costs.

Although the cost per mile of haul for intercity truck transport is relatively independent of length of haul, there are a number of other factors that influence this cost. These factors include:

- trailer type;
- configuration (number and sizes of trailers, number of axles, etc.);
- annual mileage of tractors and trailers;
- percentage of miles operated empty;
- payload;
- driver costs;
- fuel efficiency;
- type of vehicle ownership;

[redacted]

[1] Jack Faucett Associates, *The Effect of Size and Weight Limits on Truck Costs*, Working Paper, Revised October 1991, Appendix A.

[redacted]

	116,000	1.34	15%	1.55	75,500	12.3	4.10
Other Trailer Types							
Refrigerated Van (5 Axle 48′)	78,000	1.17	15%	1.36	48,100		5.65
Flatbed (5 Axle 48′)	78,000	1.08	25%	1.40	50,400		5.56
Tank (5 Axle 42′)	78,000	1.35	45%	2.36	53,400		8.85
Hopper (5 Axle 42′)	78,000	1.04	40%	1.67	53,400		6.21
Dump (5 Axle 36′)	70,000	1.02	40%	1.64	43,600		7.53

Source: Jack Faucett Associates, *The Effects of Size and Weight Limits on Trucks Costs*, Working Paper, Revised October 1991, Appendix A.

Exhibit F.2 Estimating Effects of Inflation

(1) Cost Component	(2) Data Source	(3) 1988 Value	(4) 1994 Value	(5) Growth Ratio 1988-1995[1]	(6) Weight[1]	(7) Contribution to Cost Change (5) x (6)
Drivers	U.S. Bureau of Labor Statistics (BLS), Occupational Earnings in all Metropolitan Areas, mean hourly pay for all drivers of tractor-trailers.	$12.24	$13.48[2]	1.145	28%	0.321
Vehicle	BLS Producer Price Index (PPI) for trucks over 10,000 lbs. GVW (Series 1106).	112.4	138.7	1.278	19%	0.243
Fuel	U.S. Department of Energy, Energy Information Administation, U.S. average retail diesel fuel price per gallon.	$1.25[3]	$1.126[4]	0.901	20%	0.180
Tires	BLS PPI for tires (Series 1201).	93.6	97.8	1.053	3%	0.032
Repair	BLS Consumer Price Index for automotive maintenance and repair (SE 49).	119.7	150.2	1.303	9%	0.117
Overhead	U.S. Bureau of Economic Analysis, Implicit GDP deflator (current dollar GDP divided by constant dollar GDP).	1.039	1.261	1.254	21%	0.263
					100%	
Overall Adjustment Factors						1.156

[1] See text.
[2] 1993 value.
[3] Model's forecast of 1995 fuel price in 1988 dollars.
[4] Average fuel price, week of May 8, 1995.

[redacted]
growth ratios and adding produces the overall inflation adjustment factor, 1.156, developed in Column 7.

It may be noted that the above adjustment procedure excludes the effects of changes in technology between 1988 and 1995. This exclusion is appropriate since the JFA cost estimates were intended to reflect forecasts of 1995 technology. However, additional use of this procedure to adjust the cost estimates to current dollars in some future year is not recommended. Such use of this procedure would not reflect the effects of future improvements in technology, and so it would tend to overstate the effects of inflation.

For the purpose of future price adjustments, it is recommended that the Producer Price Index (PPI) for nonlocal trucking or one of its subcomponents be used. This price index (PCU4213) was initiated by the Bureau of Labor Statistics in June 1992. Its subcomponents include indexes corresponding to agricultural trucking (#1), LTL general freight (#311), and truckload general freight (#312).

stations and sites involved. The Transportation Consulting Group charges $3,900 for a site license for TL/CIS and $250 per update.

[redacted] estimating the costs of truckload movements. In MicroTOCS, the basic costing unit is a truckload shipment from a particular origin to a particular destination. The shipment costs can be reported in a variety of ways, including: total operating cost per mile; total cost per mile; total cost per ton; and total cost per ton-mile. Total cost includes equipment capital cost, while operating cost does not. All costs exclude loading and unloading costs and the cost of any associated waiting time. However, empty return ratios are reflected in the cost estimates.

Linehaul operating costs are estimated as consisting of: driver costs; fuel costs; miscellaneous costs; tires; maintenance; user taxes; and administrative and overhead. The estimates of tire and maintenance costs distinguish the tractor and trailer components; and insurance costs and licensing and permit charges are also distinguished. Total costs include all operating costs plus capital costs for tractors and trailers.

The operation of the system requires the user to move through a series of menus specifying model inputs. The first menu requires specification of

[2] Some other firms that have developed proprietary models for estimating truck costs are IBI Group (Toronto), Peat Marwick Stephenson & Kellogg (Toronto), and Trimac Consulting Services (Calgary, Alberta).

[redacted]

TL/CIS has a module designed to provide the interactive costing of specific loads and trips by means of an on-screen "input log" which the user completes to describe a particular move. This input log gives the user the flexibility to select from a choice of over 100 different driver and equipment configurations.

transportation equipment is 9.01 cents per ton-mile. This high rate occurs primarily because of the low density of assembled motor vehicles (which average only 22 tons per carload as compared to an average of 66 tons per carload for all commodities). The lowest average rates are for coal and farm products (particularly grain), both of which are frequently shipped by unit train, qualifying for significant volume discounts.

A Software Package

This section discusses a software implementation of the ICC's Uniform Rail Costing System (URCS). The package, MicroURCS, was developed by Snavely, King & Associates (of Washington, D.C.). Its price varies with the specific configuration (PC versus mainframe version); amount of railroad-specific cost data purchased; amount of technical support needed; whether any consulting services are required to prepare data for input into the model or to interpret results; and the number of work stations and sites involved.

For each shipment, the minimum information required of the user by MicroURCS consists of commodity, tonnage shipped, railroads used, and

Exhibit F.3 Average Rail Rates per Ton-Mile for Selected Commodity Groups

STCC Code and Commodity Group		Cents per Ton-Mile (1992 Dollars)
01	Farm Products	2.19¢
11	Coal	2.10
14	Nonmetallic Minerals	2.98
20	Food Products	2.92
24	Lumber and Wood Products	2.89
26	Pulp and Paper Products	3.93
28	Chemical Products	3.90
29	Petroleum and Coal Products	4.03
32	Clay, Concrete, Glass, and Stone Products	3.59
33	Primary Metal Products	3.18
37	Transportation Equipment	9.01
40	Waste and Scrap Materials	3.83
42	Empty Shipping Containers	3.83
46	Miscellaneous Mixed Freight	2.91
All Commodities		**3.03¢**

[redacted]

shipper. The program also requests information on the specific railroads in the route, the mileage on each railroad, the origin and destination, and any special handling required at the origin or destination. As previously observed, default values can be used for all inputs except commodity, tons, and mileage by railroad.

[redacted]

characteristics of the shipment. This involves determination of whether the specific shipment is part of a multi-car shipment. Switching costs at origin and destination are reduced by 75 percent for unit-train movements and by 50 percent for other multi-car shipments. This section of the

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equipment, particularly for coastal operations. Inland barges typically are moved in multi-barge tows which may combine barges for several shippers. For example, an upper Mississippi tow operator may pick up grain, fertilizer and chemical barges at various points on the upper river for transfer to operators on the lower Mississippi at an interchange point. On the other hand, dedicated services will shuttle between a limited number of river points, with the towboat often waiting with the barge for the return.

Deep-sea operations are primarily distinguished by the combination of vessel type and operating pattern. "Tramp" operations are based on single voyages moving one or more commodities, often on a single charter basis. Bulk and high-volume or seasonal breakbulk commodities typically move in this fashion. Tramp operations generally include full shipload lots and empty deadhaul legs between discharge and load ports. Some vessels may be dedicated to a particular cargo flow (e.g., Alaskan oil carriers), or may shift between trade routes and commodities on a seasonal or market-driven basis (e.g., tramp refrigerated vessels).

"Liner" operations are based on multi-commodity markets using multiple vessels in fixed port rotations and schedules. These services are designed for containerized and general breakbulk cargoes, and typically make multiple port calls over a coastal range. For example, a North Atlantic carrier might operate four vessels with weekly calls at Charleston, Baltimore and New York in the U.S. and Felixstowe and Rotterdam in Europe. A single voyage for each vessel would take 28 days. Container operators also maintain inland distribution systems for their containers, which must also be considered in a costing analysis.

Cost Elements

Total transport costs can be estimated from a combination of physical characteristics, operating and productivity factors, and unit cost elements. The physical characteristics relate to items such as vessel type, cargo handling equipment, and commodity density. Operating and productivity factors include vessel and cargo processing time, fuel efficiency, and vessel speed. The unit costs are typically based on volume or time and are combined with operating estimates to generate total system costs.

Inputs for water transportation costing can be categorized:

- vessel;
- voyage and port;
- cargo-related; and
- inland and other.

Vessel-related inputs encompass physical and cost characteristics which apply regardless of the voyage or service patterns (with some exceptions). The physical characteristics of the vessel affecting costs include:

- [illegible]
- manning requirements;
- safety characteristics (for annual repair and insurance estimates); and
- annual operating availability (for allocating annual costs).

The cost inputs associated with the vessel include:

- capital or lease cost (on annual or other basis);
- annual insurance (hull and machinery, personnel and injury);
- maintenance and repair (periodic and overhaul);
- supplies and stores;
- crew costs;
- fuel; and
- administrative/overhead.

Annual costs for capital/lease, maintenance and insurance are generally specific to a particular type of vessel, but may vary with the type of utilization (e.g., high risk voyages). Supplies and stores and crew costs can be estimated on an annual or daily basis. Unit fuel costs vary with fuel type and the point of purchase. Administrative and overhead costs typically are estimated as a percentage of all other costs (perhaps excepting capital costs).

Sources for vessel data include: Lloyd's Registry of Shipping (and an associated on-line database); the U.S. Maritime Administration; special industry reports by Drewry Shipping Consultants of London; and various industry journals (such as *Containerization International, Lloyd's Shipping Economist, Marine Log, Maritime Reporter and Engineering News*, and *Waterways Journal*). As with other costs, costing for international operations should consider the effect of currency exchange rates when appropriate.

Voyage and port inputs are specific to a particular use of a vessel, varying by trade route and commodity market. The vessel itinerary dictates many of the cost and time factors and is defined by the specific port calls, the voyage length, and the time or distance under low-speed operations (e.g., canal transit). Vessel itineraries frequently change, sometimes requiring a definition of a prototypical voyage for analysis.

acteristics, equipment type and stevedoring practices). The term "port delay" is typically used to denote an unusual circumstance (e.g., berth congestion) which extends the port time, but may be applied to the entire port time in some cases.

Costs which are specific to a voyage itinerary include vessel tolls and port-related charges applied to the vessel (often based on size) and the cargo transferred (mostly based on type and volume). Vessel-related port costs include dockage and pilotage, while cargo-related costs include wharfage and cargo handling costs. Some port costs are fees assessed by the port as reimbursement for use of public facilities. Most cargo handling costs in deep-sea trades are charged by private stevedores based on the required

[redacted]

charges include stevedoring, terminal handling, equipment rental, and container stuffing and stripping. Practices for port charges may vary by U.S. coast and for foreign countries. Bulk and domestic barge operations typically utilize private terminals, often with no public port involved. Costs for these operations must be estimated from private sources.

Sources for voyage itineraries include Lloyd's on-line databases, the Journal of Commerce Shipcards and other service listings. Port operating characteristics and non-public cargo handling costs must typically be developed through private interviews; although, in most cases, costs and operating factors will be common by general cargo type over a particular port range. Fees charged by ports usually are available from port tariffs, although tariff rates may not apply to high-volume users. Worldwide port mation on port tariffs, facilities and rules.

Cargo-specific inputs affecting cost and time factors include physical, market and packaging characteristics. The physical stowage and load characteristics determine the utilization of vessel and container capacity, while the handling and storage requirements dictate the type and cost of port facilities and equipment. The market characteristics include the balance of flow which determines port handling time and costs, as well as load factors for liner operations and required vessel size for tramp operations (including backhaul opportunities). When cargo is palletized or containerized, the cargo weight/unit relationship affects cargo handling factors.

The cost of container and pallet systems may also be included in the cost analysis. Pallet costs are based on an allocated share of the unit cost for reusable units and the total costs for one-way pallets. Container system costs can be estimated by calculating capital and operating costs for a fixed ratio of containers to available vessel capacity ("slots"). For example, a service of four vessels with a capacity of 800 twenty-foot equivalent container units (TEUs) might require three containers for every TEU of capacity or a total of 7,200 TEUs. The "additional" containers are either resting in a port or involved in the inland transit.

A final cargo-related cost which may be considered is the inventory cost which measures the financial cost of "holding" the commodity during the transit period. While this cost is not included in the transport rate or typically calculated at all, it provides a basis for measuring the impact of delays and changes in transit time, including changes resulting from changes in mode and/or route. Inventory costs can be calculated based on the average value per weight or container unit, combined with interest rate which reflects the cost of the capital required to hold the commodity for the period of transport.

[illegible]

Sources for cargo-related physical inputs include *Thomas' Stowage* (which provides weight-to-volume ratios on a commodity basis) and cargo flow statistics which cover both weight and volume data (e.g., PIERS and Census sources described in Appendix C). Data for major commodity flows may also be available through Drewry and other industry sources. Flow patterns can be measured from traffic statistics (available from PIERS, Census and individual ports). Other data must be generated from interviews or general commodity or water transportation sources.

The final category of costs is for inland transport which can be estimated using the appropriate modal costing methodology or assumed at a fixed unit cost if not influenced by the new facility. A key consideration for many general cargoes is the split between rail and truck flows. This information is not generally available but may be collected through a survey or interview process or approximated from a disaggregation by geographical region (i.e., rail vs. truck hinterlands).

[redacted]

amortization of the current sale value over the expected lifetime minus scrap value.

- *Allocation of Fixed Costs* – The volatility of water transportation markets often creates a disparity between rates and fully allocated costs due to the method for allocating fixed costs. It is often useful to segregate marginal and fixed costs in the analysis, and also to consider current industry conditions.

- *Definition of Cargo Capacity* – While most capacities are stated in weight terms, volume-based restrictions apply for many breakbulk and containerized commodities. It is critical that vessel loading reasonably reflect the cargo mix, particularly when comparing different vessel types.

- *Allocation to Backhaul Flows* – Many waterborne services are designed for one-way movements of specific commodities (e.g., vehicles or bananas) or may have a natural imbalance in one direction. The backhaul leg is often considered secondary to the main cargo flow and is often sold on a marginal cost basis. In such cases, an equal allocation of fixed costs among all traffic understates the costs in the headhaul direction. (The service would probably exist with no backhaul traffic, in which case, the headhaul traffic would be assigned all fixed costs). Various adjustments include assigning only the marginal costs of cargo handling to the backhaul or calibrating the assignment of fixed costs based on the relative market rates in each direction.

Typical Costs

Deep-Draft Vessels

Exhibit F.4 shows some typical costs for deep-draft vessels by type and vessel size. The costs per hour are a weighted average of fiscal year 1995 Corps of Engineers estimates for vessel costs at sea and in port and exclude port fees and tolls.[3] (The only difference between at-sea and in-port costs is fuel consumption, which represent less than ten percent of total costs.)

For tankers and dry-bulk vessels, costs per ton-mile were estimated by assuming an average load factor (ratio of cargo weight to deadweight tons) of 60 percent and that 20 percent of time is spent in port. For general cargo vessels, the corresponding assumptions were an average load factor of 75 percent and 40 percent of time in port. For containerships, costs per 20-foot equivalent container unit (TEU) mile were estimated assuming an 80 percent load factor (relative to TEU capacity) and 20 percent of time in port.

The cost estimates in Exhibit F.4 show very large cost advantages for foreign-flag vessels relative to U.S.-flag vessels and substantial economies of scale for the larger vessels (though large vessels, of course, are limited to routes generating high traffic volumes and serving harbors with adequate channel depth).

Inland Barges

Exhibit F.5 shows some typical costs for operating inland barges. The costs per hour for barges and towboats are fiscal year 1995 Corps of Engineers estimates.[4] The costs per ton-mile are derived assuming an overall average operating speed of 10 knots (upstream and downstream) and

[3] U.S. Army Corps of Engineers, Institute of Water Resources, *FY 1995 Planning Guidance: Deep Draft Vessel Costs*, Fort Belvoir, Virginia, December 1994.

[4] U.S. Army Corps of Engineers, Institute of Water Resources, *FY 1995 Estimated Towboat and Barge Costs*, Draft, Fort Belvoir, Virginia, no date.

Tanker – Non-Double Hull					
20,000	14	$1,592	1.184¢	$639	0.475¢
50,000	14	1,953	0.581	815	0.243
90,000	14	2,270	0.375	975	0.161
150,000	14	2,625	0.260	1,162	0.115
265,000	14	3,128	0.176	1,440	0.081
Tanker – Double Hull					
20,000	14	$1,452	1.080¢	$583	0.434¢
50,000	14	1,981	0.589	826	0.246
90,000	14	2,519	0.417	1,075	0.178
150,000	14	3,185	0.316	1,386	0.138
265,000	14	4,228	0.237	1,880	0.106
Dry Bulk					
15,000	14	$1,093	1.084¢	$393	0.390¢
40,000	14	1,430	0.532	561	0.209
80,000	14	1,820	0.339	759	0.141
120,000	14	2,136	0.265	820	0.114
200,000	14	NA	NA	1,204	0.090
General Cargo					
11,000	17	$1,059	1.259¢	$412	0.490¢
20,000	17	1,393	0.910	542	0.354
30,000	17	1,721	0.750	667	0.291

Container

[illegible]

(TEUs)	(Knots)	per Hour	TEU-Mile	per Hour	TEU-Mile
600	17	$909	14.85¢	$544	8.88¢
1,200	17	1,154	9.43	768	6.28
2,000	18	1,517	7.02	1,101	5.10
2,800	19	1,984	6.22	1,527	4.78
4,000	20	2,293	4.78	1,811	3.77

[1] Excludes port fees and tolls.

Source: Study team estimates and data from U.S. Army Corps of Engineers, Institute of Water Resources, *FY 1995 Planning Guidance: Deep Draft Vessel Costs*, Fort Belvoir, Virginia, December 1994.

[redacted]

[redacted]
easily correlated with specific traffic flows.

The following discussion addresses general cost elements used in air passenger costing as applied to air freight operations for a combination or charter carrier. (The dedicated closed systems of integrated carriers are not included in this analysis.) Air freight costs can be estimated based on the following categories of inputs:

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[5] Jack Faucett Associates, *Goods-Movement Energy Efficiency: Overview*, prepared for the California Energy Commission, Sacramento, November 1982, p. 51.

[redacted]
stated as a percentage of all other costs.

[redacted]
in both directions. Aircraft freight capacity for combination vessels can vary based on the service area (affecting fuel requirements) and passenger load (e.g., baggage load). Operating capacities are available from various aviation industry sources, as well as from the manufacturer. As with ves-

sel operations, it is critical that the impact of volume-measured commodities on available capacity be considered.