AD-A038 479 MICHIGAN UNIV ANN ARBOR DEPT OF GEOGRAPHY F/G 15/5

ECONOMICS OF BARGE OPERATION ON INLAND WATERWAYS, CENTRAL THAIL--ETC(U)

NOV 73 P UATHAVIKUL NONR-1224(56)

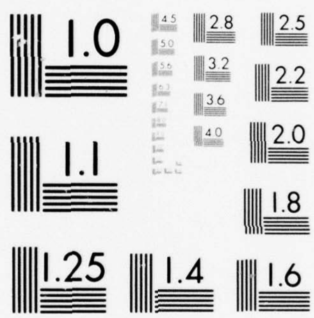
UNCLASSIFIED TR-2 NL

| OF |

AD A038479

END

DATE FILMED 5-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Economics of Barge Operation on Inland
Waterways, Central Thailand

Phaijayont Uathavikul

15 November 1973

Technical Report No. 2

Department of Geography
University of Michigan

Research Project Nonr 1224(56)
N.R. No. 388080

PREFACE

This report is one of a series of publications concerned with development topics in Southeast Asia. The research detailed in this report represents a portion of a larger study sponsored by the Applied Scientific Research Corporation of Thailand which dealt with an analysis of transportation systems in Thailand. This study, designated as Research Project 30, was the joint undertaking of the University of Michigan and the Applied Scientific Research Corporation of Thailand and was funded by the University from a research contract with the Geography Branch of the Office of Naval Research (Research Project Nonr 1224 (56) N.R. No. 388080). Research and analysis was conducted by both Corporation and dniversity personnel under the direction of Professor L. A. Peter Gosling, Department of Geography, University of Michigan. Coordination of the project publications and editorial assistance were provided by Catherine J. Baker. Inquiries regarding the publication series should be directed to the Department of Geography, University of Michigan, Ann Arbor, Michigan, U.S.A. The conclusions, opinions and recommendations of the various authors in these reports do not necessarily reflect the views of any of the sponsoring organizations.

This report, Economics of Barge Operations on Inland Waterways, Central Thailand was originally part of a Master's degree dissertation in Economics presented by Phaijayant Uathavikul. The author is an officer of the Applied Scientific Research Corporation of Thailand, seconded to

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Two

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
(6) Economics of Barge Operation on Inland Waterways, Central Thailand.

5. TYPE OF REPORT & PERIOD COVERED
(9) Technical rept.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
(10) Phaijayont Uathavikul

(11) 15 Nov 73

8. CONTRACT OR GRANT NUMBER(s)
Research Project
(15) Nonr-1224(56)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Department of Geography
University of Michigan
Ann Arbor, Michigan 48109

(12) 84p.

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
N.R. No. 388080

11. CONTROLLING OFFICE NAME AND ADDRESS
Dr. James S. Bailey, Code 462
Geography Branch
Office of Naval Research, Arlington, Va. 22217

12. REPORT DATE
Nov. 15, 1973

13. NUMBER OF PAGES
72

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Office of Naval Research, Resident Representative
Room 139, Cooley Building
University of Michigan
Ann Arbor, Michigan 48109

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
(14) TR-2

Distribution of this report is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unclassified

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Transportation, Barge, Inland Waterway, Thailand, Cost Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to provide a framework within which the economic costs of the various modes of transport common in Thailand can be compared. The concepts and various methods of arriving at transport costs are first summarized; one of these methods for determining water transportation costs put forth by U.N. experts is then applied after a modification of some factors in order to reflect the real cost situation in Thailand. These computations are based on an empirical study of both the towboat and

→ next page

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

228 712

UB

commercial barge industries in which the operating costs of the various components of each system are determined.

After comparing the operating costs of water transport derived from this study with those obtained in other studies for land transport modes, it is concluded that barge transport is from five to seven times more economical than truck transport and about twice as economical as rail transport. This conclusion is based solely on the advantages derived from the suitability of the geographic situation and the operating costs of the waterway transport system itself. It does not derive from comparisons of development and maintenance costs involved in the various modes of transport nor does it include secondary and social benefits, although these secondary and indirect costs and advantages are discussed and some cost figures are computed. If figures for these costs and benefits were to be included, the economic advantages of waterway transport would be even more pronounced.

the University of Michigan Project 30 research team. Khun Phaijoyant Uathavikul together with Khun Mit Pramuanvorachat, Dr. Phiphit Suphaphiphat and Khun Nipon Phanomkarm comprised the vital group of Thai scholars whose work was central to the completion of the project. This report, like all Project 30 publications, reflects their important contributions.

There are a variety of ways to measure the cost of competing transportation methods. The inclusion, exclusion or stress of various factors can change the cost calculations. To date, most transportation studies in Thailand have been oriented to justify major road development programs, and none have carefully examined the operating costs of competing water transport. Admittedly, our goal is to seek maintenance if not expansion of the water transport system, but we have attempted to avoid any slanting of our economic studies in that direction.

Khun Phaijayant's study, for the first time, attempts to cost all identified components of the water transport system; much of it involves data generated by our field surveys. His conclusions of the cost advantage of water transport are to be expected, but it is the dimension of that competitive advantage which has hitherto been unknown and which has been minimized in other transportation cost studies in Thailand largely because of lack of data and faulty assumptions regarding water transport operating cost. We believe this cost advantage justifies additional investment in improving the waterway systems and in increasing the efficiency of water transportation through various modest development measures.

L. A. Peter Gosling
Project Director

TABLE OF CONTENTS

Section | Page

LIST OF TABLES

LIST OF FIGURES

ECONOMICS OF BARGE OPERATIONS ON INLAND WATERWAYS, CENTRAL THAILAND

I. Background: Calculation of Transportation Costs

Transportation can be viewed as a process of organization in which all modes of transportation have some common characteristics in their spatial organization and their purposes. The spatial reference points[1] require locational references to at least two points. A transport line is organized to pass through space so that two or more locations can be linked.

Transportation has as its unique economic character the means to transfer utilities from one place at a particular time to other places in other times. The transferring increases the utility on a narrow scale of one economy, or on a broader scale, of the economies in the different parts of the world. Consumers of various kinds can increase their utilities and even their standard of living through development of transportation. The increment in utility can be differentiated into two distinct categories:

1. Place Utility
2. Time Utility[2]

Place Utility

The increment in utility can be derived from transferring goods and passengers from one place to another. In the case of goods, the utility of a particular good in consideration can be very low indeed if there is plenty of that good in one particular place. Consequently, if the goods can be distributed to the other places where scarcity of that good is realized, the increment in total utility can obviously be seen. However, this utility increment is subject to the cost of transportation of the goods--the high cost of transportation may offset any gain that can be derived from the process of distribution. In general, the increment in utility is negatively related to the cost of transportation of that good. Passengers, through various means of transportation, can increase their place utilities when their desires for being in other places are met.

Time Utility

Transportation can create time utility as well as place utility. However, the time utility is not so simple as it appears to be. In some cases, transportation time can reduce the time utility when the greater utility could be derived if the goods could be there earlier than the available transportation modes permit. In other words, the goods are unable to arrive in time for maximum usefulness. On the other hand, transportation process, at the same time, can act as storage and thus increase the time utility.[3]

The time utility and place utility are partly interdependent; the utility in each case is not only place utility or time utility, but is also the combination of both.

From an economic point of view, transportation of goods is an intermediate service, while the passenger transport for vacation and pleasure is viewed as a final service. Passenger transportation for work is classified as intermediate service, as in the case of goods transportation. The demands for intermediate services are derived demands. Transportation, in general, is not an end in itself, but a means to many ends. In many cases transportation can be an end in itself.

The effects of transportation on society, politics, and production of an economy are immense. On society, transportation makes it possible for the members of that society to improve their standard of living, social integrity and communication. Unity of the nation, national defense, and the social stability of a nation can be achieved through an efficient transportation system. On production, division of labor, economy of scale, stabilization of supply, concentration of production, etc., are made possible only if that economy can establish and maintain an extensive and economic system of transportation. There are many pieces of literature and studies that explore and analyze in detail the impact of transportation on society, politics, and production.[4] It is not the purpose of this paper to go into the details of that impact, even though their importance is obvious.

Measurement of Output

The output of transportation, like other outputs, must be produced in measurable units. There are quite a few different unit measurements of the output in the industry, and all of them relate to unit weight of cargo or to unit passenger. The standard unit of output is measured in terms of ton-miles or passenger miles.[5] This unit of output reflects weight or unit carried in relation with distance. The ton-mile or passenger-mile is a physical measurement and is neither a measure of profit nor economic efficiency.

Transportation Cost

As in other industries, transportation has its own production function which relates input of the industry to its output. This production function is subject to the changing technology over a period of time. However, the rates of change of technology in different modes of transportation need not be the same. Inland water transportation, in general, never realized a fast growth rate, or high rate of technological change, even though the international water transportation has realized a significantly high rate of change in cargo handling and power generating techniques.

Every production function requires input, and thus entails costs. Transportation costs in various studies and literatures are controversial in their classification and implementation. This study will summarize the concept of costs of transportation first, and then an attempt to adopt a framework of transportation cost for this empirical study will be done accordingly.

General Cost Concept

Transportation costs, in general, can be classified into fixed costs and variable costs.[6] The former in the short run are independent of levels of output throughout a given range of output change.

> It is impossible to assign any specific portion of these costs to a particular unit of output. A fixed cost must be imputed to the entire supply of the type or type of service with which it is associated.[7]

Variable costs, on the other hand, are subject to the levels of output with respect to a given technology or to a given production function.

Transportation cost can be divided into "Line Haul Cost" and "Terminal Cost." The former refers to cost that is incurred in providing a service from one point in space to the others; the latter is incurred at terminals of each point of origin and destination. The terminal cost includes all costs of terminal facilities and cargo handling. Both the line haul cost and terminal cost can be classified into fixed costs and variable costs, as in general cost principle division.[8] In transportation industry "Common Costs" and "Joint Costs" are frequently encountered.

> Common costs are outlays devoted to either of two or more classes of services which may be variably proportioned at the discretion of management, with the result that it is, in principle at least, possible to trace them to individual services. Joint costs, in contrast, are costs for which the proportions of output are not variable, so that supply in one class of service in a given amount results automatically in making available another class of service in some unalterable amount.[9]

Economic Cost

The employment of a scarce resource in one particular production will deny the availability of those resource units for other possible use. The alternative foregone figure of other kinds of output is the economic cost of that resource. The cost of using a scarce resource in one use is represented by what is foregone in terms of other things which that resource could produce in its most valuable alternative use,[10] or the second best output which the resource could be used to produce.

Economic cost of transport service is the value of the alternative, second best, products--the value foregone of resources used up in providing transportation. Resources used in providing the service possess some degree of versatility,[11] which is a general characteristic of raw materials for all productions. Equipment and structures used in providing transport services are the products of other resources or raw materials, and are counted as part of the economic cost of providing transportat service. However, if that equipment and those structures were already produced and they have no other uses aside from their uses in providing transport service, then their economic costs will be determined by the versatility of them in their specialized form, given that there are no replacement requirements, either because the resources are durable, or because circumstances have changed since their construction and it will not be economical to them when they are worn out.[12] If they are perfectly specialized and their designed roles do not enable them to produce any other kind of output, then their use in this role is at no cost in an economic sense.[13] In measuring the economic cost of transportation, it is the replacement cost, including an interest cost, rather than the original cost which indicates the economic cost of the equipments and structures.[14] The economic cost of the future investment in the equipment and structures, as in planning, is obviously estimated by the alternative products foregone of the resources used in constructing the equipment and structures. Measuring the economic cost of transportation is simpler than measuring its economic benefits. This is true in almost all industries. However, there is some confusion, and there are some debatable issues in measuring the economic cost of transportation. The controversial issues can be summarized as follows:

1. Should sales tax and other indirect taxes be included in the measuring economic cost of transportation?
2. Should shadow price instead of initial price of labor (wage) be used in economic cost estimation?
3. For the purpose of economic analysis, should a general inflation allowance be taken into account?

In the famous report "Road User Benefit Analysis for Highway Improvements" by the American Association of State Highway Officials, taxes were included in its measurement of fuel costs.[15] The measurement of economic cost that includes indirect taxes cannot, and will not, reflect the real economic costs of the resources used, since all indirect taxes are transfer payments. This method of measurement fails to distinguish private cost from the public cost,[16] and overestimates the true economic cost of the service.

Shadow price of labor, in a country that has minimum wage laws or similar regulations, should be applied in economic cost calculations. Where the unemployment in the country is a never-ending problem, the minimum wage rates will alter the equilibrium of wages in the free labor market. Trade unions or labor unions may, and are likely, to set wages higher than the real cost of labor, if their collective bargaining power is strong enough. In this situation, the wages actually paid do not correctly measure the real costs of labour.[17]

For the purpose of economic analysis, a general inflation allowance of the project should not be included under cost. However, changes in relative prices of labor and raw materials should be allowed to the extent that they are foreseeable and likely to affect costs and benefits differently.[18]

Costs of Inland Water Transportation

From the study of "Transportation Research Forum,"[19] total costs in water transportation are divided into four categories:

1. Government expenditures for establishing and operating waterways;
2. Consequential costs to other forms of transportation and utilities;
3. Cost of using the waterways; and
4. Other costs falling on society as a whole or upon segments of it (social cost)[20]

The first category includes all costs to the government in providing the waterways. The most obvious costs in this group are facilities construction, waterway training, and development and maintenance of the waterways. Included in this category is the cost of administration of terminals, waterways and others.

The second category of costs includes those imposed upon other modes of transportation, and private utilities by reason of waterway developments and use.

The third category includes all the costs that the shippers or those who buy the transport services have to bear. Major cost items in this group are barge and tow-boat operating costs, terminal costs, inventory costs and cost in switching over to the use of water transportation.

The last group includes all social costs incurred by reason of waterway development and use. The social costs are different in different situations and different countries; they are subject to various exogenous variables in different periods of time.

Costs Adopted by United Nations Experts

The following cost formula has been adopted by United Nations experts Mr. Bernheim (France), Mr. Van Calsteren (Netherlands), and Mr. Francois (Belgium).[21]

General Formula

The rapporteurs put forward the following formula for the technical cost per net ton/km as a function of transport distance (d) and of the coefficient of traffic balance (v) by categories of waterway and craft:

$$Pl = \frac{D}{JT}\left(\frac{1}{k} + \frac{n}{d}\right) + \frac{B + x}{T} + \frac{D}{JT} \cdot \frac{V}{k'} + v\frac{B' + x'}{T} + \frac{C}{dT} + \frac{A}{dT}$$

Pl is the total technical cost per km for the transport of one ton of goods as part of a complete load of T tons, carried over a distance of d kilometers.

The different terms of this formula express concepts which will be explained below, along with the significance of the ltters comprising them.

The first term represents a part of the fixed annual expenditure D on a vessel in service, charged to the voyage in question (fixed annual expenditure is understood to mean expenditure which is practically independent of the distance covered by the vessel during the year).

The analysis of fixed annual expenditure D can be defined as:

$$D = s + a + c + e + f + r$$

where

s = crew's wages and corresponding social welfare charges;

a = hull insurance, civil liability, damage to third parties;

c = cordage and other gear;

e = annual maintenance and repairs;

f = general expenses (including wages of administrative staff of the transport undertaking and corresponding social welfare charges). For a private boat owner, general expenses are lower than for a company, but the same value is assumed for f, in order to allow for the fact that the self-employed boat owner must earn more than a paid crew;

r = depreciation, renewal of equipment and return on capital;

J = average number of operating days per year (number of days in year less number of days laid up, during which the craft in question cannot be operated,

--either for technical reasons connected with the waterway (closed to shipping) or with the vessel (repairs);
--or for legal or social reasons (holidays observed by shipping);

k = number of kilometers loaded run per day by the vessel on the route in question;

n = number of days per voyage delayed for chartering, loading or unloading or awaiting freight, for type of vessel in question;

d = transport distance in kilometers.

The second term, in which B = traction or propulsion expenses for loaded vessel per kilometer, and x = other current sailing expenses per kilometer of loaded run (such as pilotage, mileage bonuses to crew, petty expenses on voyage), represents current sailing expenses for the voyage in question.

The third and fourth terms represent expenditure for the mean empty run required for the transport operation in question. Here,

v = empty runs expressed as a percentage of loaded runs on the route in question;

k' = number of kilometers empty run per day by a vessel on the route in question;

B' = traction or propulsion expenses for empty vessel per kilometer;

x' = other current sailing expenses per kilometer empty run (such as pilotage, mileage bonuses to crew, petty expenses on voyage).

The third term is the part of fixed annual expenditure apportioned to the empty run.

The fourth term represents current sailing expenses for the empty run.

The fifth term in which h = terminal expenditure for berthing or movement in ports, represents the amount of these various expense items.

The sixth term in which C = real charges "corresponding to special obligations arising from the nature of the goods, the cost of which does not vary with distance," represents these charges.

The seventh term represents insurance (A) of the goods, if any.

To obtain the total cost of transport to be invoiced to the user so as to cover all expenses of the undertaking, the cost P1, which is the sum of the various expenditure items, must be increased by a coefficient of increase "I" (impot) representing the taxes on the transport charge.

Correctives

In some instances, technical and economic correctives of various kinds have to be made to the calculations in the resulting figures:

(a) While "distances (d, k, k') are reckoned in actual km. for all general studios of a system of waterways, a sample waterway, a traffic category, etc.," for detailed study of transport cost on a given waterway, it may be useful to adopt fictitious kilometric values for d, k, k', each individual trip on the waterway "being reckoned as an arbitrary number of kms. corresponding to the delay and expenses arising from the passage" (locks, tunnels, narrows, etc.);

(b) For many types of goods, the actual tonnage loaded T' is less than the tonnage of a full load T, so that in order to obtain the transport charge for a tonnage T' of goods loaded, it is necessary to multiply by the ratio $\frac{T}{T'}$, which the rapporteurs called the specific volume of the cargo and designated by the letter E;

(c) The goods carried may have characteristics which justify a freight increase factor M.

(d) Finally, brokerage must be allowed for by applying an increase factor F.

(e) On certain waterways in certain countries, there are also shipping dues, the rates G being generally chargeable per ton/km transported.

Hence, bearing these various correctives in mind, cost will be expressed as:

$$P2 = P1 \times E \times M \times F \times I + G .$$

This is the cost per net ton/km for a given route, class of goods and type of craft. But it is also possible to determine the average cost per net ton/km for a given group of routes, class of goods and type of craft.

Alternative Way of Expressing the Formula

The raporteurs pointed out that for certain studies it might be preferable to write the formula in the following form, N representing transport time in days and N' the duration in days of empty run required for transport operations:

Terms: 1st & 3rd; 2nd; 4th; 5th; 6th; 7th

$$P1 = \frac{D}{JT} \times \frac{N + n + N'}{d} + \frac{B + x}{T} + \frac{B' + x'}{T} + \frac{h}{dT} + \frac{C}{dT} + \frac{A}{dT}$$

Framework of Transportation Cost Applied in This Study

The economic cost of transportation in this study will follow the general cost concept and economic cost of the previous discussion. The sunk cost of each mode of transportation will not be included in the economic cost estimation. The formula adopted by the United Nations will be followed closely. However, some adjustments and rearranging have to be done according to different conditions and situations of the inland water transportation in the Central Plain of Thailand. As an example, wages of crews and social welfare charges[22] have been transferred from fixed annual expenditure (D) to be a variable in the variable category. The adjustments and variable arranging have been done in such a way that the computed economic cost will reflect the real cost situation in the study area.

Output of inland water transportation is measured in terms of standard output unit, i.e., in ton-km units. The drawback of this output measurement in the time series analysis is not a significant factor in this study, since it is a cross section analysis of costs of transportation by different modes in comparative static analysis.

The analysis of this study is based mainly on the quantitative approach. However, subjective analysis of factors which determine costs of transportation is applied as an adjustor, in order that the experiences of researchers and barge operators can be fully exploited.

Three different kinds of transport costs are of interest in this study, in order that it can fulfill the needs of various interest groups in the transportation industry in Thailand. They are as follows:

1. Operating costs of barges and tow-boats;
2. Transportation costs of barges and tow rates; and
3. Economic cost of inland water transportation.

The first category of cost is designed to reflect the costs of operation to barge and tow-boat operators. It includes all "out of the pocket cost" of the operators and their opportunity costs or their foregone earnings. This cost category is not, however, divided into terminal cost or line haul cost because facilities for inland water transportation, including terminal facilities in the Central Plain of Thailand are very inadequate. In fact, only a few are available, if any.

Transportation costs of barge and tow rates are so divided in order that costs from the points of view of shippers and barge operators, or cost of transport services in their interest, can be distinguished from the economic cost of transportation.

The economic cost of inland water transportation is designed for comparative study which concentrates on costs of providing different modes of transportation, from the economic point of view.

II. Tow-Boat Operation in the Central Plain[23]

Background

Before the Second World War an active tow-boat system had already played a key role in inland water transportation in the Central Plain. All of the tow-boats were equipped with wood burning steam engines. There were six major companies, with a total of 269 tow-boats, engaged in tow-boat business at that time. All of them served as passenger-cargo vessels as well as tow-boats. After the Second World War the system faced a major setback from the shortage of firewood and its skyrocketing prices. Most of the company-owned, as well as privately owned tow-boats, went bankrupt or dramatically decreased their activities. Diesel engines, from that time on, have become the single source of power for tow-boats.

General Operation

The tow-boat system in the Central Plain can be subdivided into two major groups according to their operations: They are long-haul tow-boats, and short-haul tow-boats.

Long-Haul Tow-Boats

The main function of tow-boats in this group was to serve in long-haul barge activities. They were equipped with relatively high powered engines. This group can be further divided, geographically, into three subgroups.

The most important of them are the ones that serve between Bangkok and various places in the upper region of the Central Plain, up to Uttoradit. Waterways used in their activities were Chao Phraya River; Supan and Noi Rivers; Ping and Nan Rivers and their tributaries. Tow-boats in this group assembled their tows at Samsen, Bangkok for the trips upstream. The loaded barges in tow from the various places in the upper Central Plain were also dropped at Samsen. Samsen has long been the most important and the most active barge assembly place in inland water transportation of the whole area.

Of the other two subgroups in this category, one operated from Bangkok to the East by way of Sansab-Dhakhai-Bang Khanak Canals, and Prakanong-Praves Canals to Bang Pakong-Prachin River; the other one operated to the west to Bangkok by way of Bhasicharean-Damnern Saduak Canals, and Sapasamit-Mahachai-Thathin Canals to Tachin and Meklong Rivers. The former had suffered from the continuous decline in the traffic, since the highway system in that region was developed around 1950. At the time of study, the traffic in that region was so low that only a few tow-boats were operating in the area.

The traffic to the west of Bangkok had declined considerably. However, the tow-boats in this area still enjoyed a heavy enough traffic to operate efficiently. On the Bhasicharean-Damnern Saduak Canal route, one company and two organized groups of private tow-boats monopolized the entire traffic that moved through this route. In the other route all traffic was served by private tow-boats.

Short-Haul Tow-Boats

Even though the long haul tow-boat operation is one of the most important in the whole picture of inland water transportation in the Central Plain of Thailand, the significance of the short-haul tow-boats service is so great that it has to be included in the study. The long-haul tow-boats dropped the tows of loaded barges at the Samsen main assembly place, and from there on, barges that had to unload their cargoes at various storages along both banks of the Chao Phraya River in the Bangkok area had to depend on services of the short-haul, local, tow-boats. After unloading, all the barges had to be towed back to Samsen, to await long-haul tow-boats. Most of the short tow-boats that were equipped with relatively low powered engines could afford to have only two to three barges in each tow. In transhipment of all export and import cargoes to and from ocean liners, freighters and coastal vessels; the services of the short-haul tow-boats to the lighters were the most important.

Short-haul tow-boats in the Bangkok area were known as "Rua Tong." They would roam around the area most of the time, searching for clients, thus, their services were usually at hand for the barges and lighters. Barges in the Bangkok area that operated to the east and west of Bangkok, had to depend on the services of these short-haul tow-boats, as did those that operated to the upper part of the plain.

Operation Specific

Some details of the long-haul tow-boat operation of each sub-group have to be included in this study in order that some insight into the development of the system operation can be secured.

Those tow-boats that operate between Bangkok and the upper region of the Central Plain arrange the tow charges and number of barges in tows through tow-boat brokers at Samsen for the upstream trips. The rotation-trip system is imposed on all tow-boats that operate out of Samsen in order that the cut-throat competition can be brought under control. Regularity of the services is made possible by this arrangement. It was estimated, in the survey, that there are about 150 tow-boats that operate out of Samsen. The waiting time of the tow-boats averages seven days. However, from the survey of the tow-boat operators in 1967, the number of trips per month was found to be a function of the distance and travel time of each trip. The average number of trips in thirty-day periods of the samples is 12 trips. The number of barges in

TABLE 1

ESTIMATED NUMBER OF TOWS LEAVING BANGKOK ON EACH ROUTE OF TOW-BOATS OPERATING OUT OF SAMSEN IN 1967 IN WET SEASON AND DRY SEASON

Route	Average Number of Tows Leaving Bangkok in One Day	
	Wet Season	Dry Season
Bangkok - Nakorn Sawan	2-4	2-4
Bangkok - Tapanhin	1-2	1-2
Bangkok - Pittsanulok	1	0
Bangkok - Sukhothai	2-3	0
Bangkok - Tharua, C. Ayuthaya	5	5
Bangkok - Pamoke, C. Ayuthaya	2	2
Bangkok - Banpan, C. Ayuthaya	2	2
TOTAL	15-18	12-15

Source: Project 30.

tow both upstream and downstream in average was between seven and eight, while the average maximum capacity of hauling was 11 loaded barges. According to the agreement of the tow-boat operators and the brokers, the service charge of brokers was 10% of the gross revenue of tow-boats in each trip. However, in practice, brokers always charge more than 10%, since they get complete control over all activities in Samsen.

It has to be noted here that on the trips back to Bangkok of tow-boats that operate out of Samsen, they had to find barges and set the rate by themselves. In other words, they operated as free agents on the trips back to Bangkok.

On the west of Bangkok in the Bhasi Charean-Damnern Saduak Canals to the Tachin and Meklong Rivers, tow-boats usually did not pass through locks on the canals. A tow-boat of one company and/or group dropped the tow at one end of the locks for another tow-boat of the same company and/or group to reassemble the tow on the other end. The main reason behind this practice is to cut down the operating cost by not paying lock fees.

Tow-boats that operated to the east of Bangkok belonged to two companies that had been operating in the area since before the Second World War. The total number of tow-boats declined from nearly one hundred boats, in the past, to approximately ten in 1967 and 1968. One company had the right of way on the Sansab-Dhakhai-Bangkanak canals to Bang Pakong-Prachin River. The other company operated on the Prakanong-Praves route to Bang Pakong-Prachin River. One tow-boat on each route towed barges through the entire route, and picked up and dropped barges along the way.

Tow Rate

The tow charge, in general, is based on travel time and distance, convenience of the waterway, number of barges in tow, size of barge load, capacity of barge, and the position of the barge in the tow. All these factors were directly and positively related to the tow rates that the tow-boats charged. In practice, however, all these factors were not explicitly calculated by the tow-boat operators. Experience and the going rates, together with the bargaining situation of the barges and tow-boats, determined the rate of each trip.

The estimated tow rates by radius distance, 100 km for each interval, are presented in the table below.

TABLE 2

ESTIMATED TOW RATE PER TON BY RADIUS DISTANCE FROM BANGKOK
(Samsen - 0 km)

Radius Distance (kilometers)	Rate per Ton (Baht)	Rate per Ton-km[a] (Baht)
0 - 100	1.48	.0296
100 - 200	4.53	.0302
200 - 300	5.16	.0206
300 - 400	8.00	.0229
400 - 500	9.05	.0200
500 - 600	12.05	.0227
600 and over	13.13	.0218

Source: Derived from Tow-Boat Questionnaires and Barge Questionnaires, Project 30.

[a]See Appendix A1, p. 61.

Operating Cost of Tow-Boats

The operating cost of tow-boats in this study was derived from data generated by Project 30; a more detailed account of that data will appear in a later report. The following items are included in the estimation of tow-boat operating cost: depreciation, capital charge, crew expense, fuel and oil expense, and maintenance and equipment costs.

Depreciation

The average cost of a tow-boat, derived from the tow-boat study of Project 30, is 49,385 Baht, and the average life span of a tow-boat is 58.5 years. A straight line depreciation method is used in calculating annual depreciation in this study. The average depreciation of a tow-boat is 844.18 Baht per year.

Capital Charge

The normal capital charge in the study Vehicle Operating Costs[24] was 14 per cent of the initial cost. However, in the study of Project 30, the capital charge of inland water vessels tends to be higher than 14 per cent. The capital charge of 20 per cent is adopted in this study. The annual capital charge, on half of the initial value, is 4,938.50 Baht. In the Thailand Transportation Coordination Study, the annual capital charge was estimated as 15 per cent on half of the initial value of the tow-boat. The annual charge of that study was 4,500 Baht.[25]

Crew Expense

The average wage of one crew is 471 Baht per month. According to Navigation Law,[26] three crews are required in tow-boat operation, thus, the average total labor expense per month is 1,413 Baht, which amounts to 14,130 Baht for 10 months. The estimated operating time of a tow-boat in this area is 10 months, due to maintenance time for two months a year. This expense does not include foods, which are provided free to the crews. An allowance of 200 Baht per month, or 2,000 Baht for 10 months, is included. The estimated crew expense thus becomes 16,130 Baht.

Fuel and Oil Expense

This estimate is obtained from Thailand Transportation Coordination Study. Fuel and oil allowance was estimated to be 15,822 Baht per year (10 months).

Maintenance and Equipment Costs

The average hull maintenance of a tow-boat is 2,429 Baht per year. This average includes costs of dry docking, labor, and material. Cost of engine repair amounts to 5,825 Baht, in average, per year.

The only major item of tow-boat equipment is rope, which is averaged to be 833.3 Baht annually. The allowance for others is estimated to be about 50 Baht per year: therefore, the total equipment expense is 883.3 Baht per year.

Other Expenses

This item includes license charge, business tax, lock fees, R.I.D. fees,[27] unofficial payments (tea money), mooring and docking expenses, and broker charge. An estimate based on the study comes out to be 6,523 Baht per year. This estimated cost is the average operating cost of tow-boats of all routes, of all sizes, and of both long-haul and short-haul tow-boats. The differences in size, route operation area and other related factors obviously affect the operating cost of each individual tow-boat. Some adjustment would have to be done if the operating costs of tow-boats in different routes and sizes were of interest.

TABLE 3

ESTIMATED TOW-BOAT OPERATING COST PER YEAR
(in Baht)

Cost Category	Estimated Cost Per Year
Depreciation Allowance	844.18
Capital Charge	4,938.50
Crew Expense	16,130.00
Fuel and Oil Expense	15,822.00
Maintenance and Equipment Costs	9,137.30
Other Expenses	6,523.00
Total Operating Cost Per Year	53,394.98

Source: Project 30, Tow-Boat Questionnaires and Tow-Boat Study.

The estimated tow rate, on the other hand, can be presented in the form of a graph, as in Figures 1 and 2. It should be noted that tow charges for different radius distances are not significantly different.

This is due to the severe intermodel competition of the tow-boat system in the Central Plain. The lower rate does not provide too much room for the rate to reflect the distances. The estimated rates are subjected to some adjustments if rates for some specific points in space are of interest. As an example, the tow rate of a loaded barge from Thambon (district) Nongsaikao, C. Lopburi to Bangkok, a distance of 178 km, is 8.75 Baht per ton, while the average tow rate of 100-200 km interval is 4.53 Baht per ton. This is due to the irregularity and small volume of commodity that flows from this place. The number of barges in tow is very small, thus the rate has to be high enough for the tow-boat to cover its operating cost.

FIGURE 1

Tow Rate Per Ton by Radius Distance
(Bangkok - 0 km)

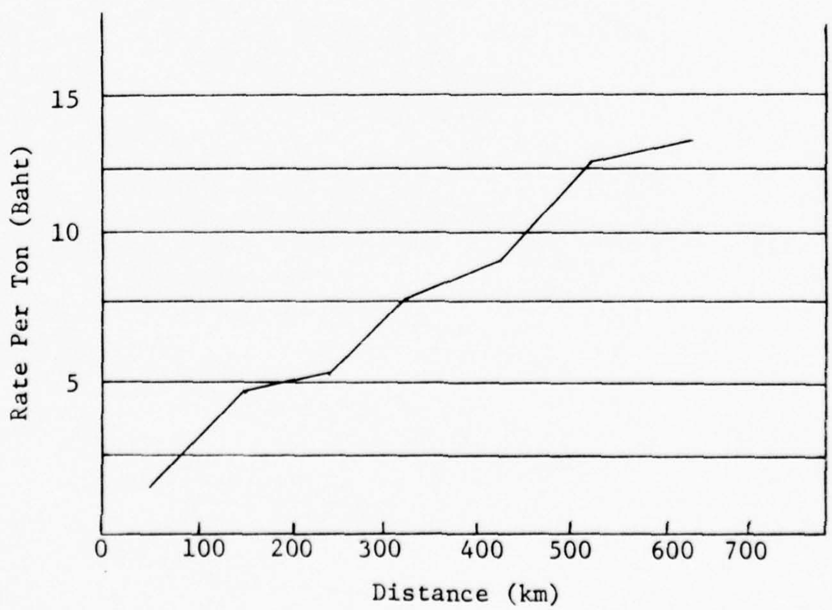
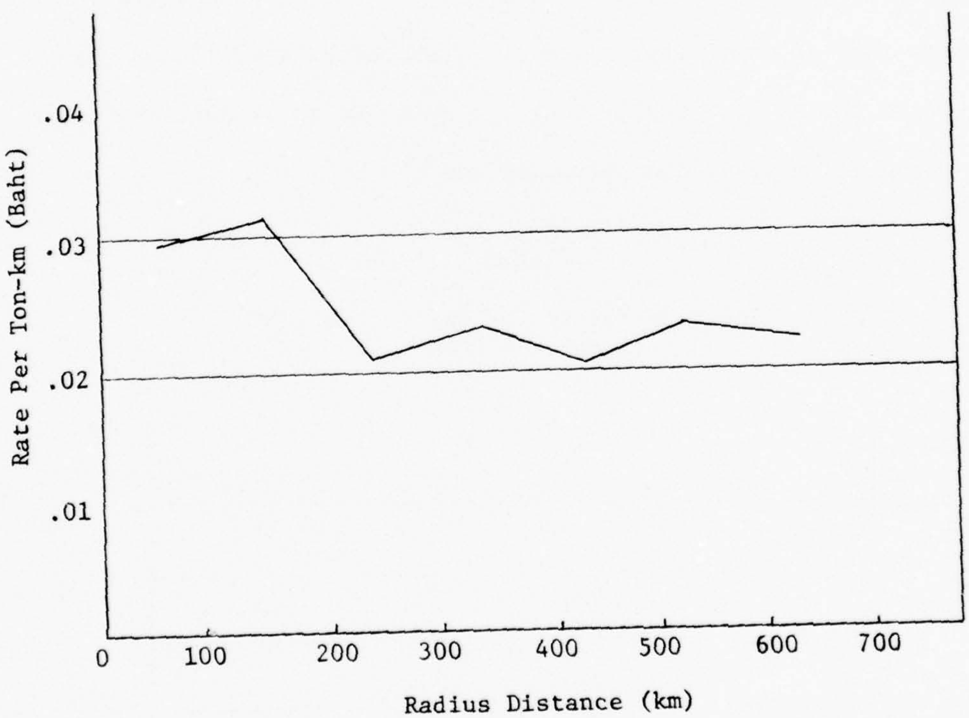


FIGURE 2

Tow Rate Per Ton-Km by Radius Distance
(Bangkok = 0 kilometer)



III. Barge Line Operation

Barge activities in inland water transportation in the Central Plain of Thailand date back about 100 years. Before the time of steam engine tow-boats, barges were very small and had to depend on sails and oars for their movement. When steam engine tow-boats were made available, the activities of barges in inland transportation increased significantly, and their impact on transportation was felt by governments in that period. Most of the waterway development and maintenance was done before the Second World War. Inland water transportation had once been the most important means of transportation in the country. At the present time, the relative importance of the inland water transportation has declined, since other means of transportation have been greatly developed. However, its importance and impact on freight movements is still far too significant to be overlooked by the authorities. The impact of the barge on agricultural produce and construction material shipments is demonstrated in the volume of these bulky goods transported by water. The most important transport units engaged in inland water transportation are barges of various sizes.

General Operation

Barge line operation in the area is rather primitive in character. Barge operators have to depend on their own experiences in searching for freights. There is no other way for them to find out where and how to get cargoes, besides their experiences and information that they obtain from friends. The lack of up-to-date information regarding distribution in different times and seasons of the year, and the number of waiting barges at each location decreases the efficiency of the barge line operation. Most of the barge operators, since only their own experiences count, have a strong tendency to operate in their specific areas and with the shippers they know. However, in practice, the efficiency of the barge line operation is rather high; we shall return to this point later.

There were about 10,000 barges in active operation in 1967-68. A large number of them were small size barges. However, the tendency towards larger size ones has been continuing. Economics of size has been realized by both the barge operators and the shippers. For some commodities for which large barges play the important role in their transportation, transport rates have been reduced in recent years. As an example, maize that is transported from Changwat Lopburi to Bangkok is cheaper in rate in recent years if it is transported by large barges. In fact, even in the same time period transport rates on maizes charged by small size barges from Lopburi to Bangkok are 3 Baht per sack (100 kgs), while those of large barges are 2.50 Baht. The lower rates of the large barges are, however, more dependent on other factors than are the lower operating costs. The economy of size is the factor that makes the lower transport rates possible.

Facilities for loading and unloading cargoes, in general, are very poor, and unnecessarily long periods of time are spent in this operation. From the study of Project 30, Barge Questionnaire, the lay-over time and the waiting time of barges averages about 15 days at both ends. Labor expenses in this transaction are customarily paid by shippers, and an excess of labor supply has kept the going rates very low.

The interrelationship of barge and tow-boat operation will not be repeated in this chapter. However, some details of barge line operation have to be explicitly stated here. The strings of barges are, in nearly all occasions, pulled by tow-boats. The push-towing practice is very rare indeed. The larger barges are always positioned in front of the line and they have to pay extra tow charges of ten to twenty Baht. Navigation problems are left to the tow-boat operators; any damages arising while they are in tow are supposed to be the responsibility of the tow-boat. Compensation for those damages have to be paid by the tow-boat operators.

One major drawback of the barge line operation is the practice of shippers, especially rice shippers, of using barges as free floating storages. At their destinations, barges have to wait for ten to fifteen days for cargoes to be unloaded without any compensation. It is quite common for them to be kept waiting for unloading for thirty to forty days. The handicapped bargaining position of barges stems from their ownership status. In the Central Plain, more than 90 per cent of 10,000 barges are privately owned; the intermodel competition of barges at all major loading points is so severe that cutthroat competition is quite common. Being privately owned, barge operators cannot set up any rules to improve the situation. It is very interesting to find that they cannot group together to exercise collective bargaining power, even when strong common incentives of long-term mutual benefits are present. Short-term individual benefits seem to motivate barge operators in their operations more than any other factor. The insufficient information, supply of barge service, and low substantial income level of barge operators can be realistically set up as explanatory variables in their attitudes toward long-term benefits.

Specific Route Operation

The most important route of the barge line operation is the one that connects the Upper Central Plain and the Northern region to the Bangkok area. In the wet season, loaded barges from the former region can travel all day and night between Nakorn Sawan and Bangkok. Above Nakorn Sawan, night running is not a common practice. Main waterways of this route are the Ping, Nan and Chao Phraya Rivers. In the Ping and Nan Rivers, sometimes tow-boats have to pull lines of barges from behind, in opposite directions in order to offset swift currents in the wet season. In most parts of the Chao Phraya River, barges can be assembled into double-tow, i.e., two strings of barges are assembled side by side. It is more convenient for the tow-boat operator to maneuver a short, double-tow than a long single-tow of the same number of barges. The advantage of the strong current in the wet season is that the travel time of the barge is reduced significantly. Waterways used in the wet season provide another significant reduction in the relative travel time. On the rivers, the only lock is a modern one at the Chao Phraya River. Time spent by barges passing through the lock is shortened by modern facilities that can handle a large number of barges at one time. The conveniences of the waterways strengthen the competitive position of barges considerably. Most grains produced in these regions are transported to markets by water in the wet season.

In the dry season, the travel times of barges from the Upper Central Plain is increased three to four times over that of the wet season by the inconveniences of waterways. The main waterways used in the dry season are the Chao Phraya River, Supan and Noi rivers. The Chao Ched Canal is the most important waterway, and makes it possible for barges to travel from the Supan and Noi Rivers to the main Chao Phraya River. From below Nakorn Sawan to above Chainat the Chao Phraya River is very convenient for both day and night running. Just above Chainat, loaded barges have to divert from the main river and take either the Supan or Noi River for their Southward trips to Bangkok. On the Supan River and Chao Ched Canal they have six locks to pass through, whereas on the Noi River they have only four locks. However, the popular and more convenient waterway is the Supan River. Only a handful of small barges prefer the Noi River to the Supan River. This is due to the unnavigable channels of the Chao Phraya River between Chainat and Singburi, and below Singburi and Ayuthaya. The Chao Ched Canal leads the barges back to the main river at Bangsai. The limitations of the waterways in the dry season weaken the competitive position of barge service to an extent that commodities that used to be transported by barges from the northern area have to depend on other means of transportation. The navigable waterways in the dry season have been reduced from over 3,000 kilometers to 1,103 kilometers. In this route the operable region of barges is reduced to less than half that of the wet season. Night running is possible only on the Chao Phraya River, from below Nakorn Sawan to Chainat and between Ayuthaya and Bangkok.

On the east and west sides of the Bangkok area, wet season routes and dry season ones are the same. The main waterways in these regions are semi-artificial and artificial ones. Night operation on these routes is possible, however, locks on the routes usually do not operate twenty-four hours. Thus, night running is possible only in some sections of the routes.

Commodity Specialization

There are some barges that carry only specific commodities all year round. It is possible for them to specialize in carrying these commodities because of the consistently high volume of commodity flow.

Sand Barges

The volume of sand transported by barges is large enough for a large number of barges to specialize only in sand shipment all the year round. Most of the sand barges that specialize in carrying land-filling sand are of a large size. These barges operate on the Chao Phraya River, from Bangsai to Bangkok. These large size barges are designed to operate only in rivers where there are no small locks. The limitations of these barges on the other waterways are very severe, since the widths of nearly all locks on the navigable waterways are six meters. The short waterway distance between Bangsai and Bangkok makes it possible for these barges to operate up to 12 to 14 round trips in a months' time. The sand barges are the heaviest loaded barges of them all, the average load of sand was nearly 50 per cent greater by weight than cargoes of similar type barges.[28] Tow-boats that serve sand barges are not included in any categories of the tow-boats discussed in the previous chapter. By agreement, one tow-boat serves one group of barges all year round. In a period of time, tow rate is determined once and for all. The average tow rate for a round trip from Bangsai to Bangkok is 3 Baht per cubic meter. Sand is dredged from the riverbeds at a rate of 4 Baht per cubic meter.

Cement Barges

To carry cement, barges have to make contracts or agreements with the cement shipper companies which, in turn, have contracts with cement producers. A rotation system is applied among barges engaged in this activity. Most cements are shipped from A. Tharua, C. Ayuthaya, on the Pasak River to Bangkok. The average load of a cement barge is the same as that of barges of similar class that carry other cargoes. Tow-boats serving these barges are provided by the contractors.

Rice Barges

Rice barges, in general, are small in size. Rice shippers would not like to tie all their capital, i.e., rice, in one large barge. The two main reasons for this practice are: minimize risk of accidental loss, and precaution against ill practices of the barge operators. Most of the barges that specialize in rice carrying do business with only one or two rice millers and/or rice shippers. Personal relationship is a most important factor in this business. The layover times of the rice barges are the highest among barges that engage in specialized cargoes.

The inward trips of barges to Bangkok are always loaded, while the outward bound barges are generally empty. In the study[29] based on the river surveys of Project 30, 48 per cent of the total moving barges that originated from Bangkok were empty.

Barge Operating Cost

The operating cost is determined by various factors that affect the variable costs of the operation. The following factors are included in the estimation of barge operating cost: tow charge, crew expense, lock fees and user charge, docking and mooring fees, loading and unloading expenses, travel time and layover time, maintenance cost, depreciation, capital charge, load capacity, taxes and other minor expenses that relate to the operation. These factors are grouped into four categories. They are:

1. Variable Cost Per Round Trip
2. Maintenance Cost
3. Depreciation and Capital Charge
4. Taxes and Others

The Variable Cost Per Round Trip is then transferred into "Variable Cost Per Ton-Km." The same is done with the second, third and fourth. The operating cost per ton-km, then, can be derived by adding the two estimated costs per ton-km.[30] The average operating costs, in ton-km by commodity, are shown in Table 4.

TABLE 4

BARGE OPERATING COST PER TON-KM BY COMMODITY

Commodity	Average Operating Cost Per Ton-Km
Maize	.05700
Paddy	.06624
Rice	.06624
Rice and Paddy	.06744
Cement	.04440
Gravel and Stone	.06959
Sand	.07838

Source: Project 30, Barge Questionnaire

Factor Evaluation

In calculating the operating cost of barges in this study, the factors that determined the cost are derived from questionnaires. Barges that carried the same commodity were grouped together, and the operating cost of each barge was then estimated separately. The average operating cost per ton-km is obtained by a method of simple arithmetic mean. The reason for applying the simple arithmetic mean is that the sample size of barges, by commodity, is not large enough to permit full use of a weighted mean. Moreover, if it is weighted by size or load capacity of the sample, very complicated and hard to solve problems will arise and tend to bias the average operating cost per ton-km. These problems would result from less than full load operation, and number of different sizes of barges engaged in some commodities in a specific period of time, and volume of each commodity that flows in that period. Instead of using a weighted mean or other objective evaluations, a subjective analysis of the factors, mentioned earlier, is applied for each individual barge in order that the most realistic and truly representative barge operating cost can be derived from the samples. Even though the subjective analysis, built in as an adjustment factor, is open to various kinds of criticism, it is the best kind of adjustment that can bring the experience and inside knowledge of the researcher into positive use, especially when a constraining time is imposed. It seems to be generally known among statisticians that a cost restraint of sample size makes it uneconomical, in most cases, to have a large sample size. The nature of barge operation in the Central Plain permits a small sample size of barges engaged in active operation of each commodity transportation.

Tow Charge

Tow charge is subject to distance, convenience of waterway, number of barges in tow, size of barge, commodity, season and number of tow-boats in each assembled area. The distance, convenience of waterway, and seasonal factors are correlated. On the other hand, the seasonal factor is explained by exogenous variables, such as the level of rainfall. One important factor that cannot be explicitly spelled out in any objective analysis is a bargaining factor which is determined by various factors, including personal relationship. Tow charge from an origin to Bangkok, given all factors besides the bargaining one, constant, can be significantly different for each barge in different tows. In the same tow the rate charged for some barges of the same size and load, can still differ significantly. In this study, the factor is recognized, and thus, each barge is evaluated separately.

Crew Expense

There is no general pattern in hiring crews in the barge operation. Wage rates are different from barge to barge and for different trips of the same barge. Moreover, since families of barge operators live in the barges, members of the families automatically act as crews of the barges. It cannot be generalized in average number of crew members required for each size and each type of barge, and the only appropriate way to examine the crew expense is to consider and evaluate each sample separately. An opportunity cost of the barge operator is estimated and included in this expense. The average wage of unskilled labor in the construction industry is used as the alternative foregone figure of the barge operator. The rationale behind this average wage is that most of the barge operators do not have the experience necessary to be skilled labor in other kinds of activities; only a few reported in barge questionnaires to have had any other experience besides barge operation. The average wage used as an alternative foregone earning estimation in this study is 10 Baht per day.

Lock Fees and User Charge

This factor has been standardized by the Royal Irrigation Department (RID). It depends on the width and length of barges that operate in irrigation canals, and those that use the facilities of locks. Vessels equipped with inboard and outboard engines have to pay different rates; these rates are subject to the horsepower of the equipped engines. Different routes and different areas of operation are other factors that dictate this expense of the barge operator. The cost of lock fees and user charges of some barges can be zero, while those of other barges may be very high. It can be seen that a separate evaluation of each barge operating cost is far better than a gross estimated figure from studies[31] which did not take routes, and origins of different commodities into consideration.

Docking and Mooring Fees

This variable is a function of layover time and commodity carried. The former, in general, is correlated with the latter which, in turn, is a function of market prices in Bangkok and the export market. However, the differences in the expenses of barges of different sizes and of different lengths of time are insignificant.

Loading and Unloading Expenses

These expenses are usually paid by shippers, but for some commodities barge operators have to pay some parts of them. This factor, in general, does not affect the operating cost of the barge, and can be reasonably discarded from the analysis. However, this variable is included in the operating cost per ton-km in order that this cost by commodity can reflect the real cost of operation of the barge in shipping various commodities.

Travel Time and Layover Time

Travel time is, aside from distance, determined by waterways used in different seasons of the year. Besides wet and dry seasons, the beginnings and ends of wet and dry seasons have to be taken into consideration. The variable directly affects the waterways used through different water level, and indirectly determines travel times of barges from various origins to Bangkok. The impacts of this variable on travel times of barges that carry different commodities and different operational areas varies. Moreover, in some areas barges of different sizes are unequally affected by this variable. Layover time of barge is determined by market price in Bangkok and that of exported market, as mentioned earlier in the docking and mooring fees evaluation. The complicated problem of transferring the time spent into money values arises when this occupancy time is evaluated in this study. An estimation of 10 Baht per day, 24 hours, is used as a rough measurement of both layover time and travel time.

Maintenance Cost

At first glance, the maintenance cost seems to be a function of short-haul and long-haul operation. However, a careful study will show that the true variables of the Maintenance Cost are: the commodity that a barge usually carries, its area of operation, the taste and preference of the barge operator, the place that the maintenance is carried out, and the age of the barge. Given that prices of materials are constant, the most important variable is average income of the barge and its income in that particular period. Another variable is the size of the barge and the material used in hull construction. All these variables play important roles in explaining the difference in the maintenance cost of each barge. The separate evaluation of each barge is believed to be a more correct approach.

Depreciation Charge

Life spans of barges of all sizes were differently estimated by barge operators. In over three hundred questionnaires taken, the life spans of barges varied from less than 50 to over 100 years. In this study an estimate of 80 years was derived from averaging the sample life spans, and through subjective evaluation concerning the nature of barge maintenance and long experience of some barge operators. Depreciation is assumed to be a constant amount throughout the life span, or in other words, depreciation is assumed to be linear. It is further assumed that after 80 years the economic value of a barge is zero. The initial value of a barge will determine the estimated value of depreciation charge of each barge. The problem of used barges and resale is solved by adopting as the resale value the initial price of that barge; the life span and economic life of that barge, are then reduced by the number of years it had been in use. It can be seen in this case that separate evaluation of each barge is a necessity.

Capital Charge

It is hard to estimate this variable in an underdeveloped country like Thailand. Financial institutions of the country are not developed to the level that an official interest rate is a true rate in the market. In the inland water transport industry, the going rate is estimated to be somewhat high. However, a capital charge of 14 per cent is adopted: This rate is the same as that used in Vehicle Operating Costs.[32]

Load Capacity

Load capacities of a new design barge and an old design one are significantly different. Load capacity of the former is greater than that of the latter, even though the registry tonnages are the same. The advantages of the former are on registration fee, lock fee and user charge; but there is no advantage gained in tow charge. The advantages on other items included in barge operating cost are realized by barge operators.

Taxes and Minor Expenses

Taxes are based on estimated incomes of barge operators and a lump sum tax is collected by various government agencies annually. Inefficiency in tax collecting makes a significant difference in actual tax payments among barge operators. The actual expenses are used in this study. Other minor expenses of barges are very diverse. These expenses include tea-money and other expenses of the same nature.

Barge Transportation Cost

Transportation costs of barges are expenses to shippers and income to barge operators. The inland water transportation industry has realized severe intermodel and intramodel competition. Transport costs of different commodities cannot be so high that excess profits, besides economic profits, can be realized by barge operators. In practice, the margin of profit in the barge business is so narrow that many barge operators--to be precise, over 80 per cent out of nearly four hundred sampled--predicted that the future of barge business would be very poor as a result of a continuous decline in transportation rates. Many of them would like to quit their barge activities whenever and wherever there was a chance. Transportation costs by commodity and radius distance are shown in Table 5.

To transform the transportation costs per sack given in Table 5 to costs per ton, one can simply multiply them by 10 (one ton = 1,000 kgs = 10 sacks). In order that a profit margin can be derived from this study, transportation cost by radius distance of each commodity is provided in Table 6.

Among major agricultural products, rice is the most expensive commodity to transport. The transportation cost of rice from each distant point is higher than that of paddy and maize. Transportation cost per ton-km of rice, like that of maize and paddy, declines in uneven decreasing rates. In the distance intervals of 300-400 and 400-500, the rates per ton-km of all the commodities are the same or nearly the same; then they decline again after 500 kms. The higher transportation rates of rice, and the fluctuation in the decreasing transportation rates in ton-km of all the commodities, can be explained by the following factors: size of the barge engaged in rice transportation; and inconvenient waterways of the route that connects the Upper Central Plain and Northern Province provinces to Bangkok.

TABLE 5

TRANSPORTATION COST BY COMMODITY AND RADIUS DISTANCE
1967-1968
(Baht per sack: 1 sack = 100 kgs)
(Bangkok = 0 Km)

Radius Distance (Kilometers)	Transportation Cost Per Sack		
	Maize	Rice	Paddy
0 - 100	Na[a]	1.603	1.850
100 - 200	2.247	2.522	2.500
200 - 300	2.730	3.960	3.800
300 - 400	3.900	4.555	4.111
400 - 500	4.488	5.735	4.900
500 and over	5.387	6.763	5.595

Source: Derived from Barge Questionnaire, Project 30.

[a]No maize had been transported to Bangkok from places less than 100 kilometers away.

TABLE 6

BARGE TRANSPORTATION COST PER TON-KM
BY COMMODITY AND RADIUS DISTANCE
1967-1968
(Bangkok = 0 km)

Radius Distance (Kilometers)	Transportation Cost Per Ton-Km (Baht)		
	Maize	Rice	Paddy
0 - 100	Na[a]	.3223	.3000
100 - 200	.1652	.2062	.1882
200 - 300	.1342	.1779	.1370
300 - 400	.1257	.1344	.1249
400 - 500	.1255	.1346	.1246
500 and over	.0965	.1165	.0944

Source: Derived from Barge Questionnaire, Project 30.

[a]No maize had been transported to Bangkok from places less than 100 kilometers from Bangkok.

Barges engaged in rice transportation, in general, are classified as small size barges. As was mentioned before, rice shippers would not like to tie all their capital in one large barge. Personal relationships between barge operators and rice shippers, in the shippers' point of view, is a precaution factor against risk. Risk can be minimized, in one aspect, if the shippers can screen barge operators and do business only with those who can be trusted. The barges, however, still have to be small, even though the shippers can find qualified barge operators. In general, they have good reasons for paying higher prices, and in practice they have done so, without any objective analysis of any kind.

The constant rates existing in the distance intervals of 300-400 and 400-500 kms of all major agricultural commodities can be explained by the hazardous waterways in the mentioned route. Major loading points of these products with distances of over 300 kilometers are in the Upper Central Plain and Northern regions. Around Nakorn Sawan area, which is about 316 kms from Bangkok, the waterways are very inconvenient in the dry season. Sand bars and hazardous channels at the beginning of the Chao Phraya River are some of the most troublesome obstacles of inland water transportation. In the wet season, when the Ping and Nan Rivers are navigable, the strong currents and the twisting of the rivers cause many troubles to barge line operation. Barges that operate on this route in the wet season can go upstream as far as Uttoradit,[33] and the commodities outflow from that area are relatively small when compared to those that flow out from Pittsanulok[34] and Pichit.[35] Most of the barges are clustered around Pichit and Pittsanulok to tap the commodities outflow from these places; however, the inconvenience of the waterways prevents the lower rates per ton-km in the 400-500 kms interval. The interplay of these variables forces the rates to be the same in 300-400 and 400-500 kms intervals. Over 500 kms, however, the impacts of commodities flow and seasonal supply of barges more than offset the impact of inconvenience of the waterways. The rates per ton-km in this open interval decline considerably.

Profit margins per ton-km of barges that engage in major agricultural products are shown in Table 7. They are derived from the surpluses of transportation costs per ton-km over operating costs of barges in the same unit.

TABLE 7

ESTIMATED PROFIT MARGIN IN TON-KM OF BARGE OPERATOR
BY COMMODITY AND RADIUS DISTANCE

Radius Distance (Kilometers)	Profit Margin in Ton-Km (Baht)		
	Maize	Rice	Paddy
0 - 100	Na[a]	.2561	.2338
100 - 200	.1082	.1399	.1219
200 - 300	.0772	.1117	.0708
300 - 400	.0687	.0682	.0587
400 - 500	.0685	.0684	.0584
500 and over	.0395	.0503	.0282

Source: *Derived from* Transportation Cost and Operating Cost Per Ton-Km, Barge Questionnaire, Project 30.

[a]No maize had been transported to Bangkok in this interval.

Barge Line Efficiency

"An indication of efficiency is the number of barges in motion at any one time compared to the total number of barges."[36] The percentages of moving barges at different points of time can be used as index numbers for comparison purposes. However, the number of total moving barges includes the moving barges that do not carry any cargo, which accounted for over 17 per cent in average of River Survey 1 and 2 (November, 1967 and February, 1968). It is noted by the mentioned study that in February the per cent of moving barges showed an increase of 2.5 percentage points over that in November. This increase can be attributed to the increase of transportation requirements after the paddy harvest season.

The study showed that large and medium barges operated more efficiently than did the small barges. The finding of this study, which is based on the study of Project 30, is presented in Table 8.

TABLE 8

MOVING BARGES AS AN ESTIMATED PER CENT OF TOTAL BARGES
(Per cent of total barges)

Type of Craft	Survey 1	Survey 2	Average 1 & 2
Small Barge	13.5	18.0	15.5
Medium Barge	23.5	23.0	23.4
Large Barge	21.2	25.6	22.1
Self-propelled Barge	25.2	23.0	24.5
All Barges	16.7	19.2	17.7

Source: Charles R. Nelson, Commercial Water Transportation in Central Thailand, Draft Report (Bangkok, August 15, 1967), Table 2, p. 12 (based on the study of Project 30).

If the factors concerning the turnover time of barges were taken into consideration, then it can be seen clearly that the fficiency of barge line operation can be increased significantly. The factors are: travel time, layover time, time spent in loading and unloading, and commodities flow. They are discussed briefly in this study.

It was mentioned earlier in this section that travel time is a function of waterways used and distances of loading places from Bangkok.

If the waterways were improved and facilities on the artificial and semi-artificial waterways were developed, then the travel time of barges would be significantly decreased. However, the impact of shortened travel time cannot be realized if the layover time is not reduced. One way of reducing the layover time is to make shippers responsible for any extra time waiting to unload cargoes. Time spent in waiting for cargoes at the loading point cannot be easily reduced. The volume of commodities flow, which depends on various exogenous variables, cannot be increased overnight. In the short run, however, if water transportation can reduce the travel time significantly, it is believed that the volume of commodities flow by water transport will responsively increase. The shortened travel time will decrease the operating costs of barges and should more than offset the cost of shippers using barges as free storage, if the charge of extra waiting time for unloading is not too high.

IV. Advantages of Inland Water Transportation

The importance of inland water transportation in the Central Plain of Thailand can be seen from the volume of major commodities that were transported by water. The intricate and extensive waterway system in this area has never been a heavy burden to the government and the taxpayers. All the development of the waterways was a by-product of the multipurpose projects. However, in recent years the advantages of water transportation from both logistic and economic points of view have been partly realized by the government. Some important studies concerning inland water transportation have been made in the period of 1966-1968.[37] To be specific, the advantages of inland water transportation are: the area of waterways, supply of vessels used in inland water transport, maintenance and development cost of waterways, operating cost and transportation cost of barges.

Waterways

The Central Plain is very level and flat, and the river basin in this area has a gradient of about 1:10,000. This geographical advantage makes it possible for the extensive waterways to be of great use, since the problem of strong currents is hardly significant to the water transport. The intricate waterway system provides a wide range of transportation and communication in the wet season. In the dry season, the limit of the waterways can be easily eliminated, if some minimum level of waterway development and maintenance is done. One of the best systems of waterways, provided by nature, is not fully exploited by the authorities in this region. The waterways in this region need not be constructed and maintained as do those basic requirements of land transportation, i.e., highways and railways. The costs of construction of the basic requirements in inland water transportation are relatively very low per unit distance in the Central Plain. Moreover, from the logistic point of view, waterways are indestructible, unlike those of land transportation.

Supply of Vessels

Inland water vessels are constructed locally, and nearly all the materials used in the construction are domestic materials. The supply of vessels can be increased in a rather short time without a huge drainage of foreign exchanges, which, in most of the underdeveloped and developing countries is rare. In the region where inland water transport plays an important role in overall transportation industry, the security of low-cost supply of vessels is one of the most important factors in determining the regularity and consistency of services and their rates. In a normal situation, the advantages that can be derived from the secure, domestic supply of transport units are not readily visible. However, in a crisis, when the supply of transport units imported from other countries is not available, then the setback of the transportation system can be instantly felt. If the alternative foregone by foreign exchanges that have been used to purchasing transport units from the other countries is taken into consideration, then the advantages of the cheap, domestic supply of transport units will further be stressed. The secondary benefits that can be derived from the domestic production of vessels are many, such as that of boat builders, local employment, and so on.

Low Maintenance and Development Cost of Waterways

The waterways in the Central Plain of Thailand are underdeveloped and poorly maintained. The estimated government expenditure in locks, maintenance, and river training amounted to only 6.4 million Baht in 1964 and 29.1[38] million Baht in 1967. The expenditures declined to less than 23 million Baht in 1969. In highway construction and maintenance, the expenditures were 630.0 million Baht in 1964 and 2142.9 million Baht in 1968.[39] If the volumes of commodities that were transported by water and the number of barges[40] were taken into consideration, then the expenditures on the waterway maintenance would be insignificant. Moreover, the expenses of lock maintenance are a rather common cost in nature. The main purpose of locks is water supply control for irrigation. The cost of waterway development and maintenance has been very low for a long time, and even if an efficient waterway system had been developed and maintained, the cost of maintenance and development would be relatively low in this area where nature has already provided a tremendous water supply and extensive waterway system in one of the best possible geographical situations.

Barge Operating Costs of Inland Water Transportation, A Micro Analysis

A micro analysis that concentrates on the operating and transportation costs of commercial transport units can provide benefits to all that engage in transportation industry. The benefits of the study can be much further realized if a comparative study, in micro sense, can be conducted in such a way that the operating and transportation costs of different kinds of transport units, engaged in highway, railway, and waterway, are compared, and a productive portrait of advantages can be drawn. In this study, barge operating cost as well as transportation cost in ton-km are compared to those of truck and freight trains.

Truck Operating Cost

Truck operating cost, in general, is the function of size and weight, fuel and oil expenses, depreciation charge, interest or capital charge, crew expense, truck occupancy and working time, maintenance and others. In the study of Vehicle Operating Cost,[41] the operating speed and the road surface were very important factors that affected the operating cost of trucks. The operating costs of trucks per ton-km are shown in Table 9.

Operating Cost of Freight Trains

In the study of Thailand Transportation Coordination Study,[42] the operating cost of the freight train per train-km was 31.94 Baht. The operating cost per ton-km of the freight train was .083 Baht. The

TABLE 9

ESTIMATED TRUCK OPERATING COST PER TON-KM
BY SIZE, ROAD SURFACE, AND SPEED

Speed and Road Surface	Small Truck[a]	Large Truck[b]
Paved, speed 56 k.p.h.	.1677	.1948
Gravel, speed 40 k.p.h.	.2356	.3107
Earth, speed 32 k.p.h.	.3226	.5206

Source: Derived from the study of Vehicle Operating Costs, p. 12, Table 2(2).

[a]Assumption of full load truck, 5 tons.

[b]Assumption of full load truck, 10 tons.

cost per ton-km was derived from 255.1 million Baht freight line haul costs divided by 247.0 million loaded freight car kilometers, and divided by 12.5 tons per load.

The operating cost of barges per ton-km comes out to be the cheapest among the important transportation modes in the Central Plain of Thailand. The operating cost per ton-km of barges is about five to seven times less than that of trucks of different speeds and road surfaces. In comparison with that of trains, the cost per ton-km of barges comes out to be about half that of the freight train with a 12.5 ton load. It should be pointed out that the relatively cheap operating cost of barges is not the result of waterway development and maintenance. The advantages of the inland water transport are solely derived from the suitable geographical situation and the nature of the transport itself.

It has been proven that the operating cost of barges for rice transport will be significantly reduced if the waterways development in central Chao Phraya River had been carried out.[43]

Transportation costs of trucks and freight trains, or their rates charged, are summarized in this study to show the advantages shippers derive in transporting a unit of commodity via water transportation.

Truck and train transportation costs are obtained from the Thailand Transportation Coordination Study.[44] They are presented in Table 10.

TABLE 10

APPROXIMATE CLASS 1[a] "L.T.L."[b] TRUCK RATES BY DISTANCE CATEGORIES

Distance Category	Average Transport Cost Per Ton-Km (Baht)	
	L.T.L. Rates	Truck-Load Rates[c]
Under 100 km	1.246	0.938
101 - 200 km	0.921	0.680
201 - 300 km	0.678	0.508
301 - 400 km	0.594	0.445
401 - 500 km	0.574	0.431
501 - 600 km	0.526	0.394
601 - 700 km	0.488	0.366
Over 700 km	0.471	0.353
Average	0.538	0.436

Source: Derived from Table 80, p. 358 of Thailand Transportation Coordination Study

[a]Class 1 = various food products, grains, lumber, stone, and rock, brick, etc.)

[b]L.T.L. = less than truck load. [c]Truck-Load = 5 tons.

Transportation costs by rail had been estimated, by the study, in terms of Baht per net ton-km. The transportation costs per net ton-km of agricultural and domestic products (Class 4, 5, 6) and of construction materials (Class 8) are shown in Table 11.

TABLE 11

AVERAGE CHARGE PER NET TON-KM BY GROUP OF COMMODITY AND RAIL DISTANCE
(Baht)

Rail Distance (Kilometers)	Group of Commodity by Class Class 4	Class 5	Class 6	Class 8
100	.2750	.2100	.1950	.1300
300	.2000	.1700	.1417	.1300
500	.1650	.1460	.1230	.1300
700	.1450	.1314	.1114	.1300
900	.1328	.1222	.1033	.1300

Source: Derived from Table 70, p. 338 of Thailand Transportation Coordination Study.

The relative transportation costs per ton-km of barges are far below those of trucks in all radius distances. At first glance, the transportation costs of barges and freight trains give the impression that they are not significantly different. However, it must be realized that the transportation costs of rail, or its freight charges, did not include the costs of transshipments from truck to rail and from rail to truck at terminals. The loading and unloading costs were not included in the computation of rail transportation costs in the Thailand Transportation Coordination Study. These transshipment costs will, at least, increase the transportation costs of freight trains, from the shippers' point of view, considerably. If the convenience of a door-to-door service of barges, without any extra cost (which is possible only in this study area) were taken into consideration, then the difference between the two costs would be strongly pronounced. This advantage of barge transport is aided by the location of storage facilities in the Bangkok area. Almost all of them are located close to, if not on, the main rivers. Barges can unload direccly to storages and warehouses. MOreover, barges can be used, according to custom and general practice, as storages without any extra costs. When spaces of the warehouses are not immediately available, barges are used as free floating storage in almost all cases.

Economic Cost of Barge Transportation

Economic costs of the transportation industry are of controversy in various study and text books. In this study, a concept of initial resources used up by each mode of transportation and their alternatives are adopted. The economic cost in this study is divided into two major categories: private cost and social cost. Each category can be further subdivided into direct and indirect costs. In this study the economic cost of barge transportation is computed, while those of rail and truck transports are obtained from the study of Wilber Smith Associates and Lyon Associates, Inc., Thailand Transportation Coordination Study.

The private cost of barge transportation includes the initial value of the barge as an estimate of resources used up by private, its alternative products foregone, resources used up in the operation and their alternative products foregone or opportunity costs.

These variables are systematically divided into direct and indirect private costs. The former consists of the initial value of the barge and expenses incurred in the operation, while the latter is composed of the opportunity costs of the initial value of the barge, time spent in operation, foregone earning of barge operator. It can readily be seen that the private cost of barge transportation can be derived from the operating cost of the barge, which includes all the variables discussed above, except the estimated value of the barge. A representative value of a barge was estimated by the TTC study to be 40,000 Baht.[45] In estimating the opportunity cost of this value, a capital charge of 14 per cent has already been adopted into the operating cost of the barge.[46] The ton-km per barge per year was estimated to be 163,200 ton-km.[47] Thus, an estimation of .0062 Baht per ton-km of the initial value can be derived from a division of the initial cost of the barge by the total ton-km of the barge over its economic life, which has been estimated to be 40 years.

It has to be pointed out that the barge is a non-self-propelled vessel; external power is needed for its activities. The economic cost of a tow-boat as an external power unit has to be taken into consideration, or the estimated economic cost of barge operation will be underestimated. However, in this study the economic cost of external power units which includes economic benefits is already taken care of. It is implicitly included in the operating cost of the barge as expense for the external power unit, tow-boat. The expense of the barge, on the other hand, is an income of the tow-boat that rationally must cover the economic cost of that external power unit. In the situation that the intramodel and intermodel competition are severe, the income of tow-boats can be assumed to be the same as the economic cost of the external unit power for each barge.

The private economic costs of barge transport per ton-km by commodity are shown in Table 12.

TABLE 12

ESTIMATED PRIVATE ECONOMIC COST OF BARGE TRANSPORTATION PER TON-KM BY COMMODITY

Commodity	Private Economic Cost of Barge Transport Per Ton-Km (Baht)
Maize	.06320
Paddy	.07244
Rice	.07244
Rice and Paddy	.07364
Cement	.05060
Gravel and Stone	.07579
Sand	.08458

Source: Derived from Table 4, p. 35.

Public expenditure on waterways and facilities was estimated to be about 500 Baht per barge annually by the TTC study.[48] However, this estimation did not include the alternative foregone of the resources used. An estimate of 8 per cent per year as the opportunity cost is adopted in this study. This rate is based on the non-risk interest rate of government bonds. Therefore, the estimated public cost or social cost for barge transportation is 540 Baht per barge annually. When this estimate is transferred into expenditure per ton-km per barge, the transferred value does not significantly alter the private economic cost of barge transportation. The public expenditure on waterways and facilities per ton-km per barge is estimated to be .0033 annually.[49] The economic costs of barge transportation are presented in Table 13.

TABLE 13

ESTIMATED ECONOMIC COST OF BARGE TRANSPORTATION PER TON-KM BY COMMODITY

Commodity	Economic Cost of Barge Transport Per Ton-Km (Baht)
Maize	.06650
Paddy	.07574
Rice	.07574
Rice and Paddy	.07694
Cement	.05390
Gravel and Stone	.07909
Sand	.08788

The economic costs of freight train and truck transportation were estimated by the TTC study to be 1.0400 Baht per freight car-kilometer, and 1.9813 Baht per truck-kilometer.[50] It is necessary to transfer the unit costs to be costs per ton-km. The economic costs of freight train and truck transportation are .10400 and .09813 Baht per ton-km respectively.[51]

It can be clearly seen that the economic costs of barge transportation are significantly lower than those of freight train and truck transportation. It has to be noted that in the TTC study, the estimated economic cost of trucks was somewhat underestimated.[52] The resource costs involved in providing highway facilities was estimated to be 0.4955 Baht per vehicle kilometer, which measures the lower boundary of truck cost responsibility for highway facilities and maintenance.[53]

From both micro and macro analysis, the inland water transportation in the Central Plain of Thailand is the cheapest means of transportation. If the developments that could shorten travel times of barges in the Central Plain were implemented, the impact of inland water transportation on the economy would be tremendous. Primary and secondary benefits should be taken into consideration in cost-benefit analysis of the inland water transport. However, it is not an immediate purpose of this study to delve deeply into the cost-benefit study. Time constraint, insufficient data at this stage of study, and budget constraint are factors that make any further study at the present time impossible.

APPENDIX A

A1. Tow Rate

Original information is obtained from Tow-Boat Questionnaire and Barge Questionnaire. Raw data is grouped under different origins and one destination, Bangkok; then they are rearranged according to radius distances of 100 kilometers each, from those origins to Bangkok. Detailed information is mostly derived from Barge Questionnaires. Loaded barges are charged according to commodities. Weight and volume of the commodity are considered in setting the rate, but they are not explicitly calculated by either tow-boat operators or barge operators. A standardized unit--sack--of grain provides a convenient measurement of weight of different grain type commodities. Each sack of rice, maize and other grains, except bean,[1] contains exactly 100 kgs. Construction materials such as sand and gravel are charged by volume; a metric unit is widely used in setting the rate. There is one exception of units used in transporting construction materials; cement is charged by unit ton or unit bag of 50 kgs. Other commodities are charged by either weight or volume: Which one will be applied depends on their convenience. On some occasions, various kinds of commodities are charged by unit barge, as in the case of kapok. All these units, except those of barge loaded unit, are transferred into unit ton. Unloaded barges are commonly charged by barge unit, according to size and distance and their places in the tow. However, the differences that stem from the places in the tow are highly insignificant for unloaded barges.

All tow rates[2] for each group of commodity, i.e., grain and construction material, of each origin are averaged by the method of weighted arithmetic mean; frequency of each class of tow rate is used as weight in the calculation. In nearly all loading places there is no complicated problem of group of commodity in the calculation of average tow rate, since the construction materials and grains usually flow from different origins to Bangkok.

All these average tow rates are, then, rearranged according to radius distances. The tow rates in each radius distance, for all commodities, are then averaged by method of simple arithmetic mean.

Tow rate per ton-km is obtained by dividing the rate per ton by the midpoint of each distance class.

A2. Tow-Boat Operating Cost

The operating cost per year is derived from tow-boat questionnaires, and some expenses are obtained from the Thailand Transportation Coordination Study by Wilber Smith Associates and Lyon Associates, Inc.

Depreciation

An average value of tow-boat, hull and engine, is obtained from a sample size of 27 tow-boats. Their values range from 11,200 to 245,000 Baht. Life span of tow-boats is obtained in the same way, with a built-in subjective adjustment. Straight line depreciation, i.e., constant amount of depreciation per year, is used. It is assumed in this calculation that the economic value of a tow-boat equals zero after 58.5 years, which is the life span of a tow-boat. An annual depreciation is obtained by dividing the average initial value of the tow-boat by the economic life span of the tow-boat.

Capital Charge.--An annual capital charge of 20 per cent on half of the initial value of the tow-boat is used in the study. By depreciation charge, the value of the tow-boat in each consecutive year is reduced, with a constant rate of depreciation per year; half of the initial value of the tow-boat is a very good approximate value for a more convenient calculation.

Crew Expense.--The calculation of this expense is a straightforward one. An average of expense per one crew is obtained from the same sample size as that of depreciation.

Fuel and Oil Expense.--As mentioned in Tow-Boat Operation, this expense is obtained from the *Thailand Transportation Coordination Study*.

Maintenance and equipment costs and other expenses are straightforward calculation. All data is obtained from samples and a simple arithmetic mean is applied.

APPENDIX B

B1. Barge Operating Cost

Raw data is obtained from the Barge Questionnaire. The sample size is as large as 415 questionnaires of all commodities and barge sizes. Raw data is first classified into small groups by commodity, origin and destination (Bangkok), and operating route. Data from each barge is then separated into four different subgroups: variable cost per round trip, maintenance cost, depreciation and capital charge, taxes and others.[1]

Variable Cost Per Round Trip.--This includes the following variables: tow rate, labor expense, lock fee and user charge, docking and mooring fee, loading and unloading expenses, travel time and lay-over time.

Maintenance Cost.--This subgroup includes all maintenance costs in a year. Expenses on equipment are included in this group. It is subdivided into Minor Maintenance (Kan Num), Major Maintenance (Kan Pi), and Equipment Expense.

Depreciation and Capital Charge.--This is divided into depreciation charge and maintenance charge.

Taxes and Others.--This is divided into two minor groups as before.

Expenses of each barge for variables in the first subgroup are added together. The total variable cost per round trip, then, is transferred into variable per ton-km.

Maintenance cost, depreciation and capital charge, taxes and others are altered to be a sum of costs per ton-km for each barge. Transferring method will be discussed later in this appendix.

Variable Treatment

Some raw data must be transferred from other units to money units before tabulating into the subgroups. These variables are: travel time, and layover time. As has been mentioned, 10 Baht per day is adopted in this study.[2]

Depreciation charge of barge is, as before, treated as a constant unit over time. It is obtained by dividing half of the initial value of the barge by the life span of barge.

Capital charge is treated in the same manner as that of towboats. However, the capital charge of 14 per cent is applied in this case.

Transferring Method

Variable Cost Per Round Trip.--The total variable cost per round trip (TVC) is divided by the product of loaded distance and total weight of cargo in the trip (LD x TX), $\frac{TVC}{LD \times TW}$. The distance in this case is counted only when the barge is loaded; in other words, only the distance of the loaded barge from its origin to Bangkok is counted. The outbound trip of the unloaded barge from Bangkok is considered as a prerequisite for other loaded trips of the barge. The distance is based on the actual distances of rivers and canals used in the trip. The result is the required variable cost per ton-km.

Maintenance Cost.--All the maintenance costs are obtained in terms of expenses per year. In order to obtain the expenses per ton-km, the total distance that the barge traveled in that year has to be calculated from the raw data of the barge questionnaire. This is done by arranging all trips of that barge into groups of different origins and destinations. Then, distance in each group of origin and destination can be straightforwardly calculated. Total weight of cargo carried in that year is more complicated to measure. However, barges in general, always carry cargoes to their full loads and the cargoes they carry can be obtained from the questionnaire. Thus, an estimation of total weight of cargoes, carried during the year by each barge, can be computed. Load capacities of the barge for different kinds of cargo are considered to be the loads of that barge for different trips of different cargoes. Numbers of trips, carrying different cargoes, multiplied by load capacity for each particular cargo will provide subtotal weights of different cargoes carried in the year. The total weight can be obtained by adding these subtotals together. To transfer total maintenance cost per year into maintenance cost per ton-km, the former has to be divided by the product of total distance and total weight of that year. The method of calculation is presented in equation form below.

$$\text{Maintenance cost per ton-km} = \frac{TMC}{TD \times TW}$$

Where $TD = (LC_i \times T_i)$

and $TW = (D_{je} \times T_{je})$

TMC = Total maintenance cost per year

TD = Total distance of operation in that year

TW = Total weight of cargoes carried in that year

LC_i = Load capacity of that barge for commodity (i)

T_i = Number of trips carrying commodity (i) in that year

D_{je} = Distance from origin (j) to destination (e)

T_{je} = Number of trips from origin (j) to destination (e)

Depreciation and Capital Charge.--In order to obtain the depreciation and capital charge by ton-km, the total charge is divided by the product of total distance and total weight of the barge in the same manner as discussed in maintenance cost per ton-km calculation.

Taxes and Others.--The expenses on taxes and others per ton-km are obtained in the same manner.

Operating Cost Per Ton-Km.--It is the sum of all expenses in the four subgroups in transferred unit, ton-km. The average operating cost per ton-km by commodity is a weighted arithmetic mean[3] of operating costs, by commodity, of barges that operate from each specific origin to Bangkok.

Operating Cost Per Ton-Km by Commodity and Radius Distance.--Average operating costs by commodity per ton-km of barges that operate from various origins to Bangkok are arranged into groups of radius distance, 100 km for each interval, according to the distances of those origins from Bangkok. Then, they are averaged to be representatives of barge operating cost per ton-km, by commodity and radius distance.

B2. Barge Transportation Cost

Raw data is obtained from barge questionnaires. They are arranged according to origin and Bangkok destination, and by commodity. An average transport cost is obtained by the weighted mean method, as in computing barge operating cost. These transport costs are computed in terms of ton-km in the same manner as before. It has to be noted here that the distance used in computing the average transport cost is a loaded distance of the barge. Then they are rearranged by radius distances, and transport costs per ton-km by commodity and radius distance are calculated as in barge operating cost.

FOOTNOTES

[1]Emery Troxel, Economics of Transport (New York: Rinehart & Company, Inc., 1955), p. 7.

[2]William L. Grossman, Fundamentals of Transportation (New York: Simmons-Boardman Publishing Corp., 1959), p. 1.

[3]Grossman, ibid., p. 2.

[4]Truman C. Bigham, Transportation, Principles and Problems (2nd ed.; New York: McGraw-Hill Book Co., Inc., 1952); John B. Lansing, Transportation and Economic Policy (New York: The Free Press; London: Collier-MacMillian Limited, 1966); Hugh S. Norton, Modern Transportation (Columbus, Ohio: Charles E. Merrill Books, Inc., 1963).

[5]Hugh S. Norton, Modern Transportation Economics (Columbus, Ohio: Charles E. Merrill Books, Inc., 1963), p. 107.

[6]Ibid., p. 108.

[7]W. J. Baumol, et al., "Costs and Rail Charge," in Transport--Selected Readings, ed. by Denys Munby (Penguin Books, 1968), p. 118.

[8]A. M. Milne, The Economics of Inland Transport (London: Sir Issac Pitman & Sons, Ltd., 1955), pp. 123-24.

[9]Baumol, op. cit., pp. 118-19.

[10]Milne, op. cit., p. 110.

[11]Ibid., p. 113.

[12]Ibid., p. 116.

[13]Milne, op. cit., pp. 115-16.

[14]Ibid., p. 115.

[15]Hans A. Adler, "Economic Evaluation of Transport Projects," in Transport Investment and Economic Development, ed. by Gary Fromm (1965), p. 175.

[16]Ibid.

[17]Ibid., pp . 175-76.

[18]Ibid., p. 177.

[19]Transport Research Forum, Fifth Annual Meeting, 1964, "Cost Data for Inland Waterways" (The Richard B. Cross Co., 1964), p. 76.

[20]Ibid., p. 76

[21]United Nations Economic Commission for Europe, Inland Transport Committee, Compiled by Andre Brunet, Chairman, A Conspectus of the Work of the Costing Experts, 1955. Mr. Bernheim (France), Mr. Van Calsteren (Netherlands), Mr. Francois (Belgium), "The Problem of Cost in the Inland Transport Industry," pp. 132-36.

[22]As "s" in the United Nations formula. It is one variable used in computing, D--fixed annual expenditure.

[23]This section will depend entirely, or nearly entirely, on the Tow-Boat Questionnaires of Project 30. Otherwise, the source of information will be indicated.

[24]T. P. O. Sullivan & Partners, Department of Highway, Vehicle Operating Costs (Bangkok, 1967), p. 5.

[25]Wilber Smith Associates and Lyon Associates Inc., op. cit., p. 270.

[26]Harbor Department.

[27]Royal Irrigation Department charges tow-boats that operate in irrigation canals and/or water level controlled canals according to horsepower of the equipped engine of the tow-boat.

[28]Charles R. Nelson, op. cit., p. 19.

[29]Ibid., p. 16.

[30]See Appendix B1, pp. 64-68.

[31]As in the study by Wilber Smith Associates and Lyon Associates, Inc., Thailand Transportation Coordination Study.

[32]Sullivan & Partners, op. cit., p. 5.

[33]Distance between Uttoradit and Bangkok is 691 kilometers.

[34]Distance between Pittsanulok and Bangkok is 535 kilometers.

[35]Distance between Pichit and Bangkok is 452 kilometers; between Tapan Hin, a most important loading place in Pichit, and Bangkok is 416 kilometers.

[36]Charles R. Nelson, Commercial Water Transportation in Central Thailand, Draft Report (Bangkok, August, 1967), p. 11.

[37]Harbor Department and National Statistic Organization Study; the Thailand Transportation Coordination Study; the study done by a Joint Venture of the University of Michigan and the government of Thailand.

[38]Wilber Smith Associates and Lyon Associates, Inc., op. cit., Table 58, p. 286.

[39]Ibid., Table 21, pp. 90-91.

[40]It was estimated by the study of Project 30 that there were about 10,000 barges engaged in inland water transport activity.

[41]Sullivan & Partner, op. cit., pp. 9-11.

[42]Wilber Smith Associates and Lyon Associates, Inc., op. cit, pp. 193 and 305.

[43]Peter Ingold, The Role of River Training in the Improvement of Inland Water Transportation in Central Thailand (Ph.D. dissertation, The University of Michigan, Geography Department, 1973).

[44]Wilber Smith Associates and Lyon Associates, Inc., op. cit., pp. 356, 338.

[45]Ibid., p. 272.

[46]See page 41.

[47]Wilber Smith Associates and Lyon Associates, Inc., op. cit., p. 271.

[48]Ibid., p. 283.

[49]This is obtained by dividing the public expenditure per barge per year by total ton-km per barge per year, which is equal to 163,200 ton-km.

[50]Wilber Smith Associates and Lyon Associates, Inc., op. cit., pp. 311-15.

[51]The TTC Study in this analysis used ten-ton capacity for both freight train and truck (TTC Study, p. 314).

[52]Wilber Smith Associates and Lyon Associates, Inc., *op. cit.*, p. 313.

[53]*Ibid.*, p. 311.

Appendix A

[1]One sack of bean weighs 120 kgs.

[2]Rate that each barge is charged, by ton, from that origin.

Appendix B

[1]Raw data for this subgroup is analyzed and computed before it is tabulated into the group.

[2]See Factor Evaluation, pp. 35-36 and Travel Time and Lay-Over Time, p. 39.

[3]Weighted by the frequency of barge size of the samples.

ABSTRACT

The purpose of this study was to provide a framework within which the economic costs of the various modes of transport common in Thailand can be compared. The concepts and various methods of arriving at transport costs are first summarized; one of these methods for determining water transportation costs put forth by U.N. experts is then applied after a modification of some factors in order to reflect the real cost situation in Thailand. These computations are based on an empirical study of both the towboat and commercial barge industries in which the operating costs of the various components of each system are determined.

After comparing the operating costs of water transport derived from this study with those obtained in other studies for land transport modes, it is concluded that barge transport is from five to seven times more economical than truck transport and about twice as economical as rail transport. This conclusion is based solely on the advantages derived from the suitability of the geographic situation and the operating costs of the waterway transport system itself. It does not derive from comparisons of development and maintenance costs involved in the various modes of transport nor does it include secondary and social benefits, although these secondary and indirect costs and advantages are discussed and some cost figures are computed. If figures for these costs and benefits were to be included, the economic advantages of waterway transport would be even more pronounced.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Two	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Economics of Barge Operation on Inland Waterways, Central Thailand	5. TYPE OF REPORT & PERIOD COVERED: Technical
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Phaijayont Uathavikul	8. CONTRACT OR GRANT NUMBER(s): Research Project Nonr-1224(56)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of Geography, University of Michigan, Ann Arbor, Michigan 48109	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N.R. No. 388080
11. CONTROLLING OFFICE NAME AND ADDRESS: Dr. James S. Bailey, Code 462, Geography Branch, Office of Naval Research, Arlington, Va. 22217	12. REPORT DATE: Nov. 15, 1973
	13. NUMBER OF PAGES: 72
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Office of Naval Research, Resident Representative, Room 139, Cooley Building, University of Michigan, Ann Arbor, Michigan 48109	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of this report is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unclassified

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Transportation, Barge, Inland Waterway, Thailand, Cost Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to provide a framework within which the economic costs of the various modes of transport common in Thailand can be compared. The concepts and various methods of arriving at transport costs are first summarized; one of these methods for determining water transportation costs put forth by U.N. experts is then applied after a modification of some factors in order to reflect the real cost situation in Thailand. These computations are based on an empirical study of both the towboat and

228712

commercial barge industries in which the operating costs of the various components of each system are determined.

After comparing the operating costs of water transport derived from this study with those obtained in other studies for land transport modes, it is concluded that barge transport is from five to seven times more economical than truck transport and about twice as economical as rail transport. This conclusion is based solely on the advantages derived from the suitability of the geographic situation and the operating costs of the waterway transport system itself. It does not derive from comparisons of development and maintenance costs involved in the various modes of transport nor does it include secondary and social benefits, although these secondary and indirect costs and advantages are discussed and some cost figures are computed. If figures for these costs and benefits were to be included, the economic advantages of waterway transport would be even more pronounced.