To my advior Fred,
with all my
compliments,
Nabil Safwat
Sept. 20, 82

THE SIMULTANEOUS PREDICTION OF EQUILIBRIUM ON LARGE-SCALE NETWORKS: A UNIFIED CONSISTENT METHODOLOGY FOR TRANSPORTATION PLANNING

by

Kamal Nabil Ali Safwat

B.S. Civil Engineering., Cairo University, Egypt
(1971)

Diploma, Institute of National Planning, Egypt
(1975)

M.S. Civil Engineering, Ohio State University
(1978)

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Civil Engineering
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Degree of

DOCTOR OF PHILOSOPHY

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 1982

Signature of Author ______________________
~~Department of Civil Engineering~~
August 1982

Certified by ______________________
Fred Moavenzadeh
Thesis Supervisor

Accepted by ______________________
Francois Morel
Chairman, Departmental Graduate Committee
Civil Engineering Department

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ABSTRACT

Existing transport planning methodologies which have been applied to hundreds of transport studies throughout the world for the past 30 years involve a sequential process for predicting short-run transport equilibria, often with four stages: trip generation, trip distribution, modal split and traffic assignment. Unfortunately, the sequential approach has an inherent weakness; its predictions need not be internally consistent. This deficiency has precipitated attempts to predict all four stages simultaneously. Review of previous studies illustrates the tradeoffs between behavioral and computational aspects of the transport equilibrium problem. None of these studies have been successful in addressing both issues.

In this thesis, a unified consistent framework for transportation planning (i.e. the STEM methodology) has been developed and applied to a real large-scale network, namely the intercity multimodal transport network of EGYPT.

The STEM methodology can predict trip generation, trip distribution, modal split, traffic assignment and the corresponding performance levels on realistic transport systems simultaneously with a convergent algorithm. The approach is reasonably efficient, in the computational sense, for large-scale applications.

Within this framework, trip generation can depend upon the system's performance through an accessibility measure that is based on the random utility theory of users' behavior. Trip distribution is given by the well-known logit model. Modal split can be given by a logit model or be user or system optimized. Traffic assignment can be user or system optimized.

System's performance is reflected through a set of link user perceived cost models as monotonically increasing functions of link flows.

In developing the STEM methodology, a family of Simultaneous Transport Equilibrium Models (STEMs) have been specified and a family of Equivalent Convex Programs (ECPs) have been formulated. By studying the qualitative characteristics of the ECPs, existence and uniqueness of equilibrium on the STEMs have been proven.

A convergent algorithm for the simultaneous prediction of equilibrium on the STEMs by solving the ECPs has been developed.

The applicability of the STEM methodology behaviorally and computationally has been assessed by actually designing and analyzing a real case study for passenger transport on the Egyptian intercity transport system.

Based on the findings of this thesis, further use and application of the approach to other intercity and urban transport studies throughout the world is strongly recommended.

Thesis Supervisor: Fred Moanvenzadeh

Title: Professor of Civil Engineering

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I. INTRODUCTION

During the last ten years, much of the research in transportation planning has focused on ways to improve predictive modelling. One of the most predominant themes of this research has been an effort to develop comprehensive models, and related computational procedures, for computing short-run transportation equilibria. These integrated models recognize that user decisions concerning trip frequency, destination, mode and route choices are inherently interrelated. By combining these user decisions, the models aim to provide better predictions of transportation system's performance (delay times, costs) and user travel behavior (demand patterns).

This trend toward integrated modelling contrasts sharply with earlier methods for predicting traffic equilibria. The earlier procedures, which have been applied to hundreds of transportation studies throughout the world for the past 30 years and still are in use today, have viewed transportation planning as a *sequential process* often with four stages--trip generation, trip distribution, mode, and route choice. The Detroit Metropolitan Area Traffic Study [1955], the Chicago Area Transport Study [1960] and the Cairo Urban Transport Study [1981] illustrate this practice, as do guidelines prepared by the U.S. Federal Highway Administration [1970, 1972] and the U.S. Urban Mass Transportation Administration [1976]. Unfortunately, the sequential approach has an inherent weakness; its predictions need not be internally consistent.

To explain this, we notice that performance on congested elements of the transportation system is dependent upon demand and vice versa.

Therefore, in any sequential process (whether using aggregate or disaggregate models), the performance or demand levels that one needs to assume as given inputs at any one stage need not agree with those that one determines as outputs from the other stages. This deficiency has precipitated attempts to predict demand and performance levels of all stages *simultaneously*.

Research intended to meet this objective of the simultaneous prediction of equilibrium has proceeded in three directions. One of these lines of investigation has significant computational advantages; the others permit richer modelling of user behavior. Regrettably, to date none of these approaches has generated models that are both behaviorally acceptable and computationally tractable for large-scale applications.

The first of the simultaneous approaches, which originates with the early seminal research of Beckman et al [1956], views the equilibrium model as an equivalent optimization problem that when solved yields the desired equilibrium solution. The primary advantage of this formulation is that the equilibrium problem becomes a convex optimization problem (assuming monotonicity of demand and performance) that can be solved efficiently by any of several convergent algorithms (Bruynooghe, Gibert, and Sakorovitch [1968], Bertsekas and Gafni [1981], Dembo and Klincewicz [1981], Leblanc [1973], Nguyen [1974, 1976a, 1976b], Golden [1975], and Florian and Nguyen [1974]). The main disadvantage of this formulation is behavioral. It requires strong modelling assumptions that frequently are unrealistic, particularly an assumption that demand between each origin-destination (O-D) pair depends solely upon the performance between that O-D pair.

The basic equivalent optimization formulation has several modelling enrichments. Evans [1976] extended the formulation to include trip distribution, assuming fixed trip generation and an entropy model for trip distribution. Using the fact that an entropy distribution model implies a logit mode-split model, Florian and Nguyen [1978] further extended the formulation to include modal split. Each of these extensions shares the computational advantages of the equivalent optimization formulation. Again, the deficiencies are behavioral; the entropy model is not based upon any behavioral principles. Moreover, those modelling extensions are rigid. Because the formulations incorporate entropy distribution and fixed trip generation, the models are not flexible enough to accomodate situations in which a goodness-of-fit test with observed data shows that the entropy model is not a correct functional form or cases in which the policies of interest to the analyst would have significant influences on total demand generated on the system.

The second simultaneous approach views the equilibrium conditions as a system of equations and inequalities to be solved directly. In this form, the equilibrium conditions can be interpreted as describing a nonlinear complementarity problem (Aashtiani and Magnanti [1981]) a stationary point problem (Asmuth [1978]), or a variational inequality problem (Smith [1979], Dafermos [1980]).

This approach has susbtantial behavioral advantages, but is limited computationally. It permits general demand or performance functions and yet insures existence and uniqueness of an equilibrium, even with only mild continuity and/or monotonicity assumptions imposed upon the data. In principle, this general model can be solved by convergent fixed point algorithms (Hearn and Kuhn [1977], Asmuth [1978]) or, by projection algorithms (Dafermos [1980, 1981], Pang and Chan [1981]). The fixed point algorithms are limited, however, to very small problems. Similarly, computational experience has suggested that the proposed projection algorithms are inefficient for this type of application (see Fisk and Nguyen [1980]). The general model can also be solved by an efficient Newton type algorithm (Aashtiani [1979]), but this algorithm only guarantees local convergence (Pang and Chan [1981]).

A third line of investigation enriches the modelling of user behavior by permitting user perception of performance to be stochastic. Sheffi and Daganzo [1980] view this stochastic equilibrium problem as a traffic assignment problem on an extended network and cast the model as an equivalent optimization problem. They use a disaggregate probit model for demand and combine both deterministic and stochastic assignment of trips to paths on the extended network. Although their algorithm is convergent (with some restrictions imposed upon the probit model specification) the procedure is limited in practice because it requires substantial computational effort for even modestly-sized problems.

This summary of previous studies illustrates the tradeoffs between the behavioral and the computational aspects of the problem of predicting internally consistent demand and performance patterns on transportation networks (i.e. the equilibrium problem). None of the previous models has been successful in addressing both issues.

Our goal is, therefore, to develop a methodology that comes closer to achieving both objectives. In specific terms, the goal of this thesis is: *"to develop a unified consistent methodology for transportation planning within which trip generation, trip distribution, modal split, traffic assignment and the corresponding performance levels can be predicted simultaneously for a set of behaviorally acceptable demand and performance models with a procedure that is guaranteed to converge to an equilibrium (that is proven to exist and to be unique) and that is computationally efficient for large-scale transportation networks."*

In spite of prevailing views of many researchers concerning the behavioral limitations of the usual optimization approach, we achieve this goal by adopting the following methodology:

(1) Specify a Simultaneous Transportation Equilibrium Model (STEM) which is based upon a meaningful theory of users' behavior and a set of behaviorally acceptable assumptions on demand and performance,

(2) Formulate an optimization problem (ECP) and show that under mild assumptions on demand and performance the (ECP) problem has a unique solution that is equivalent to the (STEM) model,

(3) Develop a convergent and computationally efficient procedure for the simultaneous prediction of equilibrium (SPND) through solving the (ECP) problem, and then,

(4) Apply this methodology to a real large-scale transportation system.

There are a countless number of (STEM) models that one would specify, but there is no guarantee that there exist (ECP) problems which can be formulated. Also, suppose that for some of these (STEM) models there exist (ECP) problems which may be formulated, there is no guarantee that convergent and computationally efficient algorithms can be developed for such (ECP) problems. Furthermore, suppose that there exist (ECP) problems which may be solved by convergent and computationally efficient algorithms, there is no guarantee that the corresponding (STEM) models are behaviorally acceptable. Given that we have chosen to adopt this approach the major problem becomes one of oscilating back and forth between specifying (STEM) models and formulating (ECP) problems with the objective of striking a balance between the behavioral and the computational aspects of the equilibrium problem. The second major challenge in this thesis is to actually apply our methodology and assess its applicability behaviorally and computationally.

The thesis is organized into two major parts. Part one is devoted to the development of the methodology and includes Chapters II, III, and IV. Part two involves the application of the proposed methodology to a real large-scale system, namely the intercity transport multimodal system of Egypt, and includes Chapters V, VI, and VII.

In Chapter II, we present the basic behavioral and modelling assumptions of a family of equilibrium models including the (STEM1) model. In Chapter III, we prove existence and uniqueness of equilibrium on the (STEM1) model by formulating an equivalent optimization problem (ECP1) and studying its qualitative characteristics. In Chapter IV we develop an algorithm for the simultaneous prediction of equilibrium on the (STEM1) model and test its validity on a small hypothetical example. This completes the development of the basic methodology.

In Chapter V we describe the basic features of the Egyptian intercity transport system with more emphasis placed on the issues related to passenger travel. In Chapter VI, we develop a specific case study with the objective of addressing a set of the major behavioral as well as computational issues. In Chapter VII, we actually apply the STEM methodology to address these issues and discuss the results of analysis both from the computational as well as the behavioral points of view.

Chapter VIII, includes summary and conclusions of the thesis.

PART ONE:

METHODOLOGY

II. A FAMILY OF SIMULTANEOUS TRANSPORTATION EQUILIBRIUM MODELS (STEM'S)

In this chapter we present the underlying theory and the basic asssumptions of a family of equilibrium models that describe users' travel behaviour in response to system's performance on a transportation network. We first introduce some notation:

(N,A), a directed graph (i.e., any transportation network) consisting of a set N of nodes and a set A of links;

i, an origin node in the set N;

j, a destination node in the set N;

ij, an origin-destination pair;

p, a simple (i.e., no node repeats) path in the network (N,A);

a, a link in the set A;

I, the set of origin nodes ($I \subseteq N$);

D_i, the set of destinations that are accessible from a given origin i ($D_i \subseteq N$):

R, The set of origin-destination pairs;

P_{ij}, the set of simple paths from origin i to destination j;

P, the set of simple paths in the network

$(P = \cup \{P_{ij} : i \varepsilon I, j \varepsilon D_i\})$

Now let us describe the basic assumptions for the different components of our STEM models.

2.1 USER UTILITY FUNCTIONS

We assume that a typical user travelling from a given origin i associates a utility υ_{ij} with each destination j in the set D_i of destinations perceived to be accessible from i. Because users do not usually have perfect information concerning the system and analysts cannot quantify all the factors that influence users' utilities, we assume that utility functions are random and may be decomposed into a measured (observed) utility component plus an additive random (error) term; that is,

$$\upsilon_{ij} = V_{ij} + \varepsilon_{ij}, \text{ for all } ij\varepsilon R \tag{2.1}$$

where

υ_{ij} = utility of travel from i to j;

V_{ij} = measured (observed) utility of travel from i to j; and

ε_{ij} = random (unobserved) utility of travel from i to j.

We further assume that the measured utility is a function of socioeconomic characteristics of both the destination (e.g., consumption levels, pupulation) and the user (e.g., income, profession, education) as well as the system's performance, and may be expressed as follows:

$$\begin{aligned} V_{ij} &= -\Theta u_{ij} + \sum_{\omega=1}^{W} \Theta_\omega g_\omega (A_{\omega j}) \\ &= -\Theta u_{ij} + A_j, \text{ for all } ij\varepsilon R. \end{aligned}$$

In this expression,

u_{ij} = the "perceived" cost of travel from i to j,

$A_{\omega j}$ = the value of the ω^{th} socio-economic variable that influences trip attraction at destination j;

$g_\omega(A_{\omega j})$ = a given function specifying how the ω^{th} socio-economic variable, $A_{\omega j}$, influences trip attraction;

A_j = the composite effect that the socio-economic variables which are exogenous to the transport system, have on trip attraction at destination j.

The quantities Θ and Θ_ω for $\omega = 1, \ldots, W$ are coefficients to be estimated.

Notice that Θ is a positive coefficient; the negative sign associated with it reflects the behavioral assumption that, everything else being equal, the utility decreases as travel cost increases.

During the time period required to achieve short-run equilibrium which we are predicting, the socio-economic activities in the system will remain essentially unchanged. Consequently, we assume that the composite effect of these acivities, A_j, is a fixed constant. That is, for a given specification of the socio-economic system, we assume that the observed utility of travel from i to j depends solely on the perceived travel cost, u_{ij}, that is,

$$V_{ij} \quad = \quad V_{ij}(u_{ij}), \text{ for all } ij\varepsilon R.$$

We will also assume that the perceived cost of travel from i to j on any route is the sum of travel costs on the links that comprise that route. We will elaborate on how transportation policies and the system's usage influence perceived travel costs as we present the basic assumptions concerning link cost functions, modal split, and traffic assignment.

2.2 ACCESSIBILITY

Accessibility is a term that is widely used, but rarely defined (and measured) rigorously and satisfactorily (Dalvi and Martin [1976]). In order to overcome this deficiency, Ben-Akiva and Lerman [1977] have defined accessibility as "some composite measure which describes the characteristics of a group of travel alternatives as they are perceived by a particular individual". They also have considered accessibility measures in the context of the random utility theory of users' behavior, which assumes that utility functions are random and that users are utility maximizers. Based on this theory, they have suggested that accessibility may be appropiately measured by the expected maximum utility to be obtained from a particular travel choice situation (other researchers such as Williams [1977] and Daganzo [1979] have also suggested and studied this measure).

Following this same line of thought, we define accessibility as a composite measure of the transportation system's performance and the socio-economic system's attractiveness as perceived by a typical user travelling from a given origin. Accessibility of an origin will then be the value of the expected maximum utility obtained by travelling from that origin; that is,

$$S_i = E\,[\max_{j \varepsilon D_i} \upsilon_{ij}], \text{ for all } i \varepsilon I \tag{2.3}$$

where

S_i = accessibility of origin i,

E = is the expectation operator, and the maximization is taken over all destinations D_i accessible from origin i.

Recall that the utility (as defined in section 2.1) has a random error term. In order to obtain an operational measure of accessibility, we must assume some probabilistic distribution for the random terms in the utility functions. A well-known and often used assumption in travel demand analysis is that the error terms are independent and identically distributed as a type-I extreme value distribution (we will elaborate on this assumption when discussing trip distribution). Making this assumption, the references cited earlier show that accessibility is given by the natural logarithm of the sum of exponentials of measured utilities to all accessible destinations; that is,

$$S_i = \ell n \sum_{j \varepsilon D_i} \exp\,(V_{ij}), \text{ for all } i \varepsilon I \tag{2.4}$$

where V_{ij} is given by (2.2).

2.3 TRIP GENERATION

We assume that trip generation is a function of socio-economic activities, socio-economic characteristics of the users, and the transport system's performance. Specifically, we assume that trip generation is given by a general linear model with the measure of accessibility as one of its variables. That is,

$$G_i = \alpha S_i + \sum_{\ell=1}^{L} \alpha_\ell f_\ell (E_{\ell i}) \qquad (2.5)$$

$$= \alpha S_i + E_i, \text{ for all } i \varepsilon I$$

where

G_i = the number of trips generated from i;

$E_{\ell i}$ = the value of the ℓ^{th} socio-economic variable that influences trip generation from origin i;

$f_\ell (E_{\ell i})$ = a given function specifying how the socio-economic variable $E_{\ell i}$, influences trip generation; and

E_i = the composite effect that the socio-economic variables, which are exogenous to the transport system, have on trip generation from origin i.

The quantities α and α_ℓ for $\ell = 1, \ldots, L$ are coefficients to be estimated.

As noted earlier, since the socio-economic activities are essentially unchanged in the short run, we assume that their composite effect, E_i, is a fixed constant. That is, for a given specification of the socio-economic system, we assume that trip generation is dependent solely on the system's performance as measured by the accessibility variable; that is,

$$G_i = G_i(S_i), \text{ for all } i \varepsilon I.$$

Since the accessibility variable S_i in our model is a natural logarithm (expression (2.4)), its value may vary, in theory, between $-\infty$ and $+\infty$. In practice, however, accessibility has some finite upper limit (i.e., the system's attractiveness when travel costs are zero throughout the system); we argue that it also has some finite lower limit. Specifically, we assume that our specification of the network, and particularly our definition of origins, implies that each accessibility variable is nonnegative. A sufficient, though not necessarily required, condition for S_i to be nonnegative is that the measured utility of travel from i to at least one destination j in the set D_i is nonnegative (i.e., $V_{ij} > 0$ for some $j \varepsilon D_i$). That is, at least one destination in the system is "attractive" to users at any given origin, an assumption that should be satisfied in many, if not all, realistic systems. Suppose to the contrary, that the minimum travel costs to all destinations in the set D_i are sufficiently large to give negative values for all measured utilities. Then either (i) no trips will be generated from i and thus, we might as well have deleted that origin from the analysis, or (ii) some trips must be generated from origin i regardless of the system's performance. In the later case, we assume that when accessibility in (2.4) becomes negative it no longer affects the number of trips generated; instead, the exogenous socio-economic composite variable E_i in (2.5) becomes predominant. That is, E_i trips must be generated due to socio-economic forces. Hence, we assume that accessibility is nonnegative and specified as follows.

$$S_i = \max \{0, \ell n \sum_{j \varepsilon D_i} \exp(-\theta u_{ij} + A_j)\}, \text{ for all } i \varepsilon I. \qquad (2.6)$$

2.4 TRIP DISTRIBUTION

Adopting the random utility theory of users' behavior, we say that the probability (PR_{ij}) that a typical user at any given origin i chooses to travel to any given desination j in the set D_i is equal to the probability that the utility of travel to j is greater than (or equal to) that of any other destination k in the set D_i. That is,

$$PR_{ij} = \text{Probability } [\upsilon_{ij} > \upsilon_{ik} \text{ for all } k \varepsilon D_i].$$

Different assumptions on the probabilistic distribution of the random (error) terms of the utility functions lead to different trip distribution models. Since we are assuming that the error terms are independent and identically distributed as type-I extreme value (Gumbel) distribution, trip distribution is given by the well-known "logit" model:*

$$T_{ij} = G_i \frac{\exp(-\theta u_{ij} + A_j)}{\sum_{k \varepsilon D_i} \exp(-\theta u_{ik} + A_k)}, \text{ for all } ij \varepsilon R. \tag{2.7}$$

Here T_{ij} equals the number of trips travelling from i to j.

The type-I extreme value distribution describes the limiting distribution of the largest value of n independent and identically distributed random variables as n becomes large, assuming that the common distribution has an upper tail that falls off "in an exponential manner" as in the normal distribution (see Gumbel [1958] for more details).

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* See, for example, Domencich and McFadden [1975] for the derivation of the logit model.

These assumptions are invoked frequently in travel demand analysis and the resulting "logit" model is known to be very robust, practical and analytically tractable. These desirable features account for the model's popularity. In addition, as we will demonstrate later, our logit distribution model is quite flexible and general, compared to other gravity models which may be viewed as special cases.

2.5 TRANSPORTATION SYSTEM'S PERFORMANCE

The performance of a transportation system may be viewed from the perspective of users, operators or owners of that system. As far as the prediction process is concerned, we look at the system's performance from the users' perspective. Users are mainly concerned with the levels of service of different elements of the system such as linehaul times, waiting delays, access and egress delays, out-of-pocket fares, safety, discomfort, etc. We assume that these performance measures can be reflected through a set of "perceived" cost functions which are dependent upon transportation policies and demand volumes. Thus, for a given specification of the transportation system, the perceived cost is a function of the flow over the network. Since the flow may be different on different links of the network, we define these cost functions at the link level. Let $C_a(F_a)$ be the perceived cost of a unit flow on link $a \varepsilon A$ as a function of the total flow (F_a) on that link. We assume that $C_a(F_a)$ is continuous and non-decreasing. The continuity assumption is a good approximation if the system is used by a large number of users, which is usually the case in practice. The monotonicity assumption is behaviorally sound in most practical applications. However, in some situations, where technology is responsive to the demand at peak times, the perceived costs might be decreasing as the link flows increase. Nevertheless, these assumptions are frequently invoked to reflect congestion effects on perceived costs.

2.6 MODAL SPLIT

Several alternative assumptions on modal split can be considered within our framework. Let m denote a mode and M_{ij} be the set of modes available for travel from i to j. Similar to our assumptions on trip distribution, we can assume that the probability (PR^m_{ij}) that a typical user travelling from a given origin i to a given desintation j chooses mode $m \varepsilon M_{ij}$ is equal to the probability that the utility of travel by mode m is greater than (or equal to) that by any other mode m' in the set M_{ij}. That is,

$$PR^m_{ij} = \text{Probability } [\upsilon^m_{ij} > \upsilon^{m'}_{ij} \text{ for all } m' \varepsilon M_{ij}]$$

Invoking our earlier assumptions on the probabilistic distribution of the error terms of the random utility functions, modal split can be described by the following logit model.

$$T^m_{ij} = T_{ij} \frac{\exp(-\Theta u^m_{ij} + A_j)}{\sum_{m' \varepsilon M_{ij}} \exp(-\Theta u^{m'}_{ij} + A_j)} \qquad (2.8)$$

where

T^m_{ij} = the number of trips travelling by mode m from i to j.

u^m_{ij} = the perceived cost of travel by mode m from i to j.

Alternatively we can assume that users choose the mode with the minimum perceived travel cost, or that modal split is such that the total travel cost in the system is minimized (see next section for more details).

2.7 TRAFFIC ASSIGNMENT

There are two main behavioral assumptions which may characterize trip assignment. The first is that each user is minimizing his own travel cost (user optimization). The second is that a central authority is minimizing the total travel cost for all users of the system under consideration (system optimization). Our methodology is flexible enough to consider either one of these behavioral assumptions.

A user optimized flow pattern corresponds to a situation where no user can be better off by unilaterally changing his path of travel. In mathematical terms, the total perceived cost of travel on all used paths between a given O-D pair are equal and not greater than those on unused paths. That is,

$$\sum_{a\varepsilon A} \delta_{ap} C_a(F_a) \begin{cases} = U_{ij} & \text{if } H_p > 0 \\ \geq U_{ij} & \text{if } H_p = 0 \end{cases} \tag{2.9}$$

$$\text{where } \delta_{ap} = \begin{cases} 1 & \text{if link a belongs to path p} \\ 0 & \text{otherwise} \end{cases}$$

A system optimized flow pattern corresponds to a situation where the "marginal" costs on all used paths between a given O-D pair are equal and not greater than those on unused paths. That is,

$$\sum_{a\varepsilon A} \delta_{ap} \frac{\partial\, TC_a(F_a)}{\partial F_a} \begin{cases} = U_{ij} & \text{if } H_p > 0 \\ \geq U_{ij} & \text{if } H_p = 0 \end{cases} \tag{2.10}$$

where

$TC_a(F_a) \quad = \quad F_a \cdot C_a(F_a)$ is the total cost of travel on link $a\varepsilon A$.

$\frac{\partial TC_a}{\partial F_a} \quad = \quad$ the marginal cost of travel on link $a\varepsilon A$.

These two assumptions imply that the behavior is deterministic. More realistically the users' behavior is stochastic as we have assumed for accessibility, trip distribution and modal split. However, in most practical applications where the system is congested, the deterministic assumption is in fact a "good" approximation of reality (see Sheffi and Powell [1978]).

2.8 A FAMILY OF STEM MODELS

Considering alternative assumptions for modal split and traffic assignment, we can specify a family of Simultaneous Transportation Equilibrium Models (STEM's). Probably the simplist STEM model, as far as notation is concerned, is the one that results from assuming that each user chooses the mode and route combination which minimizes his total perceived cost from the node of origin to the node of destination. Implied in this assumption is the possibility of transferring from one mode to another in the middle of any given trip. Combining the modelling ingredients of such a model, we can specify the following STEM1 model

(STEM1)

$$G_i = \alpha S_i + E_i, \qquad \text{for all } i \varepsilon I$$

$$S_i = \max \{0, \ell n \sum_{j \varepsilon D_i} \exp(-\theta u_{ij} + A_j)\} , \qquad \text{for all } i \varepsilon I$$

$$T_{ij} = G_i \frac{\exp(-\theta u_{ij} + A_j)}{\sum_{k \varepsilon D_i} \exp(-\theta u_{ik} + A_k)} , \qquad \text{for all } ij \varepsilon R$$

$$\left. \begin{array}{l} C_p = u_{ij} \text{ if } H_p > 0 \\ C_p \geq u_{ij} \text{ if } H_p = 0 \end{array} \right. \qquad \text{for all } p$$

where

$$C_p = \sum_{a \varepsilon A} \delta_{ap} \cdot C_a(F_a)$$

A more interesting STEM model would be to assume that modal split is given by a logit model and traffic assignment is user optimized; this results in the following STEM3 model.

(STEM3):

$$G_i = \alpha S_i + E_i \qquad \text{for all } i \varepsilon I$$

$$S_i = \max \left\{0, \ \ell n \sum_{j \varepsilon D_i} \sum_{m \varepsilon M_{ij}} \exp(-\theta u_{ij}^m + A_j)\right\}, \text{ for all } i \varepsilon I$$

$$T_{ij} = G_i \frac{\sum_{m \varepsilon M_{ij}} \exp(-\theta u_{ij}^m + A_j)}{\sum_{k \varepsilon D_i} \sum_{m' \varepsilon M_{ik}} \exp(-\theta_{ik}^{m'} + A_k)} \text{, for all } ij \varepsilon R$$

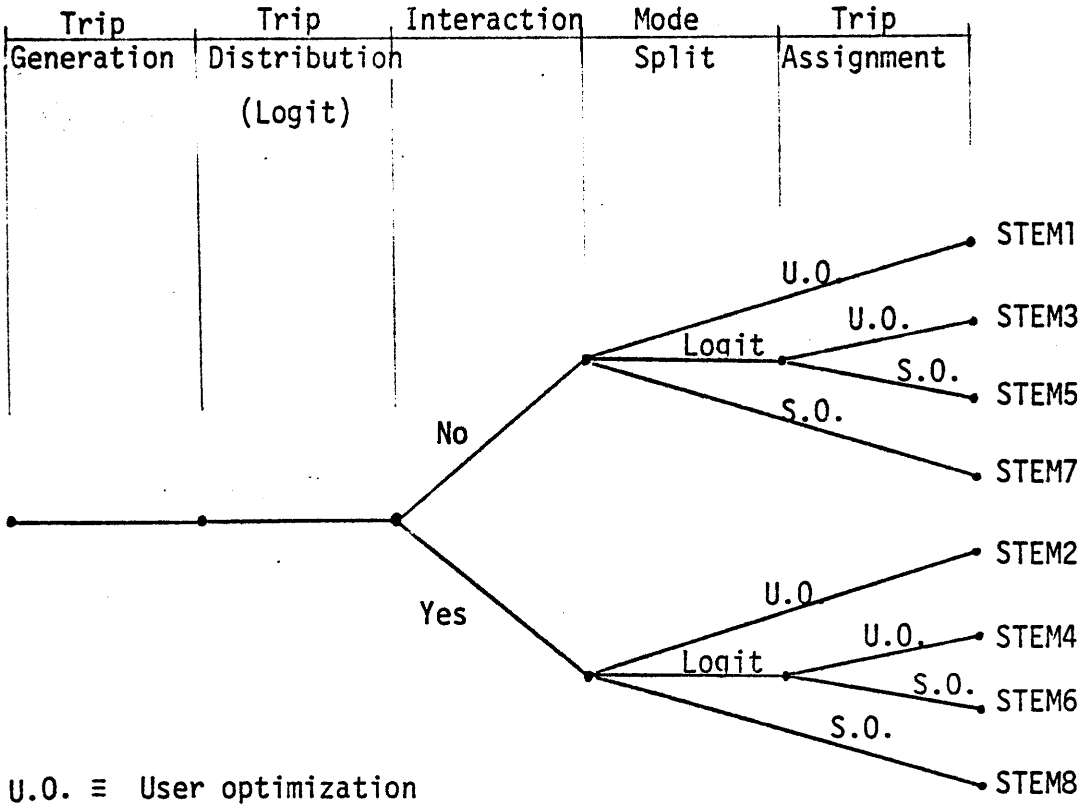
$$T_{ij}^m = T_{ij} \frac{\exp(-\theta u_{ij}^m + A_j)}{\sum_{m' \varepsilon M_{ij}} \exp(-\theta u_{ij}^{m'} + A_j)} \text{, for all } m$$

$$\left.\begin{array}{l} C_p^m = u_{ij}^m \quad \text{if} \quad H_p^m > 0 \\ C_p^m > U_{ij}^m \quad \text{if} \quad H_p^m = 0 \end{array}\right. \qquad \text{for all } m \text{ and } p$$

where

$$C_p^m = \sum_{a \varepsilon A} \delta_{ap} \cdot C_a^m(F_a^m)$$

In fact we can specify as many as eight STEM models within our approach, as depicted in Figure 2.1. Models such as STEM5 and STEM7 are particularly useful when analyzing transportation systems owned by central



U.O. ≡ User optimization

S.O. ≡ System optimization

Figure 2.1 A Family of STEM Models

authorities where system optimized flow patterns are more likely to occur. In cases where the system is used by different types of users that interact with each other in the usage of the system or where several modes on the same link interact in using that link, the link cost functions will be nonseparable. That is, a given cost function will depend upon the vector of flows of the interacting users or modes. In such cases we require the link cost functions to be convex and their Jacobian matrix to be symmetric. A more elaborate discussion of these assumptions will be presented as we develop the case study on the Egyptian intercity system (see Chapter VI). However, as we continue the theoretical development of the basic methodology in the following two chapters we will consider the (STEM1) model for simplicity.

2.9 SPECIAL AND LIMITING CASES

In this section we illustrate the generality and the range of applications of the STEM models. Let us consider the STEM1 model. We first show that a singly constrained gravity model with an exponential delay function may be used within the STEM1 model to describe trip distribution. This trip distribution model is a special case of the more general logit model. We also show that the STEM1 model can be used to appoximate as closely as desired any given doubly constrained gravity model with fixed productions and attractions.

Let $D_j > 0$ be the number of trips attracted to destination j. Also let $A_j = \ell n D_j$. Then the distribution model (2.7) becomes

$$T_{ij} = G_i \frac{D_j e^{-\theta u_{ij}}}{\sum_k D_k e^{-\theta u_{ik}}}$$

This is a gravity model with an exponential delay function.

Now suppose that the number of trips generated at an origin i, $O_i > 0$, is fixed, the number of trips D_j attracted to any j is fixed, and that

$$\sum_i O_i = \sum_j D_j.$$

We show that by a judicious choice of the data A_j, α and E_i, the STEM model approximates these productions and attractions as θ approaches 0.

First note that if all costs C_a are nonnegative, then all u_{ij} are nonnegative. Thus, if $\theta > 0$,

$$S_i = \ell n \sum_{j\varepsilon D_i} e^{-\theta u_{ij} + A_j} \leq \ell n \sum_{j\varepsilon D_i} e^{A_j}.$$

Therefore,

$$\sum_i G_i < K \equiv \sum_i (\alpha \ \ell n \sum_{j\varepsilon D_i} e^{A_j} + E_i).$$

Assuming that $C_a(F_a)$ is continuous implies that

$$K' = \max_{i,j} \max_{0 \leq F_a \leq K} \min_{p\varepsilon P_{ij}} C_p(F)$$

exists. Here P_{ij} denotes the set of available paths joining origin i and destination j and $C_p(F) = \sum_a \delta_{ap} C_a(F_a)$. Since $u_{ij} \leq C_p(F)$ for any $p\varepsilon P_{ij}$, $0 \leq u_{ij} \leq K'$. Therefore,

$$- \theta u_{ij} + A_j \leq A_j,$$
$$- \theta u_{ij} + A_j \geq -\theta K' + A_j,$$

and as θ approaches 0,

$$-\theta u_{ij} + A_j \rightarrow A_j.$$

Consequently,

$\exp(-\theta u_{ij} + A_j)$ approaches $\exp(A_j)$ and $S_i = \ln \sum_{j \epsilon D_i} e^{-\theta u_{ij} + A_j}$ approaches $\ln \sum_j e^{A_j}$ as θ approaches zero. Thus

$$T_{ij} = (\alpha S_i + E_i) \frac{\exp(-\theta u_{ij} + A_j)}{\sum_k \exp(-\theta u_{ik} + A_k)}$$

approaches

$$T^*_{ij} = (\alpha \ln \sum_j e^{A_j} + E_i) \frac{\exp(A_j)}{\sum_k \exp(A_k)} .$$

Now let $A_j = \ln D_j$, let $\alpha > 0$ be chosen sufficiently small so that $\alpha \ln \sum_j D_j < O_i$ for all i, and let $E_i = O_i - \alpha \ln \sum_j D_j$. Then

$$\sum_j T^*_{ij} = \alpha \ln \sum_j D_j + E_i = O_i \qquad \text{for all } i$$

and $$\sum_i T^*_{ij} = (\sum_i O_i) \frac{D_j}{\sum_k D_k} = D_j \qquad \text{for all } j.$$

Therefore for $\theta > 0$, but sufficiently small, the STEM1 model approximates the doubly constrained gravity model as closely as desired.

III. EXISTENCE AND UNIQUENESS OF EQUILIBRIUM

In this chapter we formally prove existence and uniqueness of equilibrium on the STEM models introduced in the preceding chapter. We achieve this by formulating an optimization problem (ECP1) and showing that under mild assumptions on demand and performance the (ECP1) problem has a unique solution that is equivalent to the (STEM1) model. We also show that (ECP1) is a convex program ; a great advantage as far as the computational aspects of the equilibrium problem is concerned (see next chapter).

3.1 AN EQUIVALENT CONVEX PROGRAM (ECP1)

Consider the following optimization problem (ECP1):

Minimize $Z(S,T,H) = J(S) + \psi(T) + \phi(H)$

Subject to:

$$\sum_{j \varepsilon D_i} T_{ij} = \alpha\, S_i + E_i\ , \quad \text{for all } i \varepsilon I \tag{3.1}$$

$$\sum_{p \varepsilon P_{ij}} H_p = T_{ij}\ , \quad \text{for all } ij \varepsilon R \tag{3.2}$$

$$\begin{aligned} S_i &\geq 0\ , && \text{for all } i \varepsilon I \\ T_{ij} &\geq 0\ , && \text{for all } ij \varepsilon R \\ H_p &\geq 0\ , && \text{for all } p \varepsilon P \end{aligned} \tag{3.3}$$

where

$$J(S) = \frac{1}{\theta} \sum_{i \varepsilon I} \left[\frac{\alpha^2}{2} S_i^2 + \alpha\, S_i - (\alpha\, S_i + E_i)\, \ell n(\alpha\, S_i + E_i)\right],$$

$$\psi(T) = \frac{1}{\theta} \sum_{i \varepsilon I} \sum_{j \varepsilon D_i} [T_{ij}\, \ell n\, T_{ij} - A_j\, T_{ij} - T_{ij}],$$

$$\phi(H) = \sum_{a \varepsilon A} \int_0^{F_a} c_a(w)\, dw, \text{ and}$$

$$F_a = \sum_p \delta_{ap} H_p \quad . \qquad (3.4)$$

The constraints (3.1) and (3.2) are the flow conservation equations on the transport network, stating that the number of trips distributed from a given origin to all possible destinations should equal the total number generated from that origin and that the number of trips on all paths joining a given origin-destination pair should equal the total number distributed from that origin to that destination. The constraints (3.3) state that all the decision variables should be nonnegative as postulated earlier. The expression (3.4) defines the link-path incidence relationships stating that the flow on a given link equals the sum of flows on all paths sharing that link.

The objective function Z has three sets of terms. The last of these, $\phi(H)$, corresponds to the familiar transformation introduced by Beckmann et al [1956]. The second set of terms, $\psi(T)$, is similar to those used by Evans [1976] and by Florian and Nguyen [1978], as well as in other related models. The first set of terms, J(S), is new. In fact, what distinguishes our formulation from other models is the definition of the accessibility measure S_i, its introduction as a decision variable in the optimization problem, and the specification of the first set of terms J(S) in the objective function of (ECP1).

The importance of the (ECP1) optimization problem is that even with very mild assumptions imposed upon the problem data, it is a convex program which has a unique solution that is equivalent to the (STEM1) equilibrium model.

We first show that (ECP1) has a solution.

Theorem 3.1 (Existence)

Suppose that $\theta > o$, $\alpha > o$, $E_i > 0$ *for all* $i \varepsilon I$, *and that each performance function* $C_a\ (F_a)$ *is real valued and nondecreasing over the domain* $F_a \geqslant o$. *Then (ECPI) has a solution.*

Proof: we need the following definition and two theorems from Ortega and Rheinboldt [1970]:

Definition: If $g\colon D \subset R^n \rightarrow R^1$, then any nonempty set of the form $L(\gamma) = \{X \varepsilon D | g(X) \leqslant \gamma\}$, $\gamma \varepsilon R^1$, is a level set of g.

Thm 4.2.2. (p. 98): If $g\colon D \subset R^n \rightarrow R^1$ is continuous and has a compact level set, then there exists an $X^* \varepsilon D$ such that $g(X^*) \leqslant g(X)$ for all $X \varepsilon D$.

Thm 4.3.2 (p.104): Let $g\colon D \subset R^n \rightarrow R^1$, where D is unbounded. Then all level sets of g are bounded if and only if $\lim_{k\rightarrow\infty} g\ (X^k) = +\infty$ whenever $\{X^k\} \subset D$ and $\lim_{k\rightarrow\infty} \|X^k\| = +\infty$ (the proofs are in Ortega and Rheinboldt (1970)). Where g is any real-valued function of the vector X, D is its domain, R^n is the n-dimentional real space, $\{X^k\}$ is a sequence of X, and $\|.\|$ is a norm on R^n.

Now we need to show that the objective function Z is continuous and that the $\lim_{k\rightarrow\infty} Z(S^k, T^k, H^k) = +\infty$ whenever the sequence $\{S^k, T^k, H^k\}$ is defined within its domain such that the $\lim_{k\rightarrow\infty} \|S^k, T^k, H^k\| = +\infty$. First it is easy to see that J(S) and $\psi(T)$ are continuous. Also the integral in $\phi(H)$ implies its continuity. Thus, Z is continuous.

To see that the norm condition is also satisfied, notice that any sequence $\{S_i^k\}$ whose $\lim_{k\rightarrow\infty} S_i^k = +\infty$ implies that J(S) approaches $+\infty$

because of the dominance of its quadratic terms provided that θ, α, and E_i for all $i \varepsilon I$ are positive as postulated. The same is true for $\psi(T)$ since $T_{ij} \ell n T_{ij}$ approaches $+\infty$ as T_{ij} does. Also $\phi(H)$ is increasing because $C_a(F_a)$ is nondecreasing and any sequence $\{H^k\}$ such that $\lim_{k\to\infty} H^k = +\infty$ implies $\phi(H)$ approaches $+\infty$.

Let $T_{ij} \ell n T_{ij} = o$ whenever $T_{ij} = o$, then the domain of Z is closed and thus the above two theorems imply that (ECP1) has a solution.

Theorem 3.2 (Convexity and Equivalency)

Suppose that $\theta > o$, $E_i \geqslant \alpha > o$ *for all* $i \varepsilon I$, *and that each performance function* $C_a(F_a)$ *is real valued, continuous and nondecreasing over the domain* $F_a \geqslant o$. *Then (ECPI) is a convex program whose optimality conditions are equivalent to the (STEM1) model.*

proof: Since C_a is nondecreasing, its integral is convex (see Theorem 3.4.5 in Ortega and Rheinboldt [1970]) and thus $\phi(H)$ is convex since it is the sum of convex functions. Also $\psi(T)$ is convex since its Hessian is a semi positive definite matrix provided that θ is positive and $T > o$ as postulated. To see that J(S) is also convex let

$$J(S) = \frac{1}{\theta} \sum_i J_i(S_i) \text{ where}$$

$$J_i(S_i) = \frac{\alpha}{2} S_i^2 + \alpha S_i - (\alpha S_i + E_i) \ell n (\alpha S_i + E_i)$$

It is easy to see that the second derivative of $J_i(S_i)$ is $\alpha\left(1 - \frac{\alpha}{\alpha S_i + E_i}\right)$. Thus, a sufficient, though not necessary, condition for this second derivative to be non-negative is that $\alpha < E_i$; a condition to be satisfied for each term in the set J(S), as postulated. Hence, the objective function Z is convex since it is the sum of convex functions. Observe that all the constraints of (ECP1) are linear. Hence (ECP1) is a convex program and its Kuhn-Tucker conditions for optimality are necessary and sufficient.

Such conditions exist if the objective function Z is differentiable at the optimum solution. Notice that Z is not differentiable only whenever there is some $T_{ij} = o$. Thus, we need to show that this cannot occur at any optimum solution. Let $X^k = (S^k, T^k, H^k)$ be any feasible solution with $T^k > o$ (such a solution always exist since $E_i > o$ for all $i \varepsilon I$), and X^* be an optimum solution with some $T^*_{ij} = o$. Clearly any solution $X(\eta) = \eta X^k + (1 - \eta) X^*$ is also feasible. Let us evaluate the derivative of Z with respect to η.

$$\frac{dz}{d\eta} = \frac{1}{\theta} \sum_i [\alpha S_i(\eta) - \alpha \, \ell n \, (\alpha \, S_i(\eta) + E_i)] \, (S_i^k - S_i^*)$$

$$+ \frac{1}{\theta} \sum_i \sum_j (\ell n \, T_{ij}(\eta) - A_j)(T^k_{ij} - T^*_{ij})$$

$$+ \sum_a \delta_{ap} \cdot C_a[F_a(\eta)] \, (H^k_p - H^*_p)$$

Whenever η approaches zero, this derivative approaches $-\infty$ implying that $Z(X^k) < Z(X^*)$ and that X^* is not optimal; a contradiction. Thus, at the optimum solution $T_{ij} > o$ for all $ij \varepsilon R$ and the K-T conditions exist. Hence we can derive them to prove equivalency between (ECP1) and (STEM1).

The Lagrangian function may be written as follows:

$$\mathcal{L} = Z(S,T,H) + \sum_{i \varepsilon I} \gamma_i \, (\sum_{j \varepsilon D_i} T_{ij} - \alpha S_i - E_i) + \sum_{ij \varepsilon R} u_{ij} \, (T_{ij} - \sum_{p \varepsilon p_{ij}} H_p) + \sum_{i \varepsilon I} \lambda_i (-S_i)$$

$$+ \sum_{ij \varepsilon R} \pi_{ij} \, (-T_{ij}) + \sum_{p \varepsilon p} w_p (-H_p)$$

where γ_i for all $i \varepsilon I$, u_{ij} for all $ij \varepsilon R$, λ_i for all $i \varepsilon I$, π_{ij} for all $ij \varepsilon R$ and

w_p for all $p \varepsilon P$ are the dual variables of the (ECP1) problem.

The optimality conditions may now be derived as follows:

$$\frac{\partial \pounds}{\partial S_i} = \frac{1}{\theta} \{\alpha\ S_i - \alpha\ \ell n(\alpha S_i + E_i)\} - \alpha\ \gamma_i - \lambda_i = 0, \text{ for all } i \qquad (3.5)$$

$$\frac{\partial \pounds}{\partial T_{ij}} = \frac{1}{\theta} \{\ell n\ T_{ij} - A_j\} + \gamma_i + u_{ij} - \pi_{ij} = 0 \qquad \text{for all } ij \qquad (3.6)$$

$$\frac{\partial \pounds}{\partial H_p} = \sum_{a \varepsilon A} \delta_{ap}\ C_a(F_a) - u_{ij} - w_p = 0 \qquad \text{for all } p \qquad (3.7)$$

$$S_i(\lambda_i) = 0 \quad \text{and} \quad \lambda_i > 0 \qquad \text{for all } i \qquad (3.8)$$
$$T_{ij}(\pi_{ij}) = 0 \quad \text{and} \quad \pi_{ij} > 0 \qquad \text{for all } ij \qquad (3.9)$$
$$H_p\ (w_p) = 0 \quad \text{and} \quad w_p > 0 \qquad \text{for all } p \qquad (3.10)$$

First of all, notice that the constraint (3.1) of the (ECP1) problem implies the trip generation of the (STEM1) model. From (3.9) and the fact that $T_{ij} > o$ for all $ij \varepsilon R$ at the optimum solution, we have $\pi_{ij} = o$ for all $ij \varepsilon R$. Hence (3.6) implies that,

$$T_{ij} = \exp\ (-\theta\gamma_i)\ \ \exp(-\theta u_{ij} + A_j) \qquad (3.11)$$

Multiplying (3.5) by $\frac{\theta}{\alpha}$ we obtain

$$-\theta\gamma_i = \ell n(\alpha S_i + E_i) - S_i + \frac{\lambda_i}{\alpha} \qquad (3.12)$$

Substituting the right hand side of (3.12) in (3.11) implies that,

$$T_{ij} = (\alpha S_i + E_i)\ \frac{\exp(-\theta u_{ij} + A_j)}{\exp(S_i - \frac{\lambda_i}{\alpha})} \qquad (3.13)$$

Suming (3.13) over all $j \varepsilon D_i$ and considering the constraint (3.1) in the (ECP1) problem, we can see that,

$$\exp(S_i - \frac{\lambda_i}{\alpha}) = \sum_{j \varepsilon D_i} \exp(-\theta u_{ij} + A_j) \qquad (3.14)$$

The optimality condition (3.8), implies that whenever $S_i > o$, we have $\lambda_i = o$ and (3.14) reduces to:

$$S_i = \ell n \sum_{j \varepsilon D_i} \exp(-\theta u_{ij} + A_j) > 0 \qquad (3.15)$$

Also whenever $S_i = o$ we have $\lambda_i > o$ implying that the right hand side of (3.15) is a negative value, and thus accessibility is always given by,

$$S_i = \max \{0 \ , \ \ell n \sum_{j \varepsilon D_i} \exp(-\theta u_{ij} + A_j)\} \quad \text{for all } i \varepsilon I \qquad (3.16)$$

as postulated in our (STEM1) model. In either case (that is, whenever $S_i = o$ or $S_i > o$), (3.14) always hold at optimality implying that (3.13) is given by

$$T_{ij} = (\alpha S_i + E_i) \cdot \frac{\exp(-\theta u_{ij} + A_j)}{\sum_{k \varepsilon D_i} \exp(-\theta u_{ik} + A_k)} \qquad (3.17)$$

Which is indeed the "logit" trip distribution of the (STEM1) model.

It remains to show that the optimum solution of (ECP1) implies a user optimized modal split and traffic assignment on the (STEM1) model. This can be easily seen from the optimality conditions (3.7) and (3.10), which imply that,

$$C_p = \sum_{a \varepsilon A} \delta_{ap} \cdot C_a(F_a) = u_{ij} \qquad \text{whenever } H_p > 0 \qquad (3.18)$$

Because in this case we have $W_p = o$. Also,

$$C_p > u_{ij} \qquad \text{whenever } H_p = 0 \qquad (3.19)$$

Because in this case $W_p > o$.

Thus, (ECP1) and (STEM1) are indeed equivalent.

3.2 EXISTENCE AND UNIQUENESS OF EQUILIBRIUM:

In the preceding section we have formulated an optimization problem (ECP1) that was proven to have a solution that is equivalent to our (STEM1) equilibrium model. We also showed that the (ECP1) problem is a convex program. In this section we use these results to prove existence and uniqueness of equilibrium on the (STEM1) model.

Theorem 3.3 (Existence and Uniqueness)

Suppose that $\theta > o$, $E_i \geqslant \alpha > o$ *for all* $i \varepsilon I$, *and that each performance function* $C_a\ (F_a)$ *is real valued, continuous and nondecreasing over the domain* $F_a \geqslant o$. *Then the Simultaneous Transportation Equilibrium model (STEM1) has an equilibrium. If* $E_i > \alpha$ *for all* $i \varepsilon I$ *and* C_a *is strictly increasing for all* $a \varepsilon A$, *then the (STEM1) model has a unique equilibrium.*

proof: Theorems 3.1 and 3.2 imply the existence of equilibrium on the (STEM1) model. To prove uniqueness we only need to show that the objective function of the (ECP1) problem is strictly convex. The assumption of $E_i > \alpha$ for all $i \varepsilon I$ implies strict convexity of $J(S)$, and the assumption of C_a being strictly increasing for all $a \varepsilon A$ implies strict convexity of $\phi(H)$. It is easy to see that $\psi(T)$ is strictly convex provided that $T_{ij} > o$ for all $ij \varepsilon R$ as demonstrated earlier. Hence Z is strictly convex and uniqueness of equilibrium on the (STEM1) model follows immediately.

IV. THE SIMULTANEOUS PREDICTION OF EQUILIBRIUM

In the preceding two chapters we have addressed the behavioral aspects of the equilibrium problem. In this chapter we focus on the computational issues of the problem. More specifically, our objective here is to develop a procedure for the simultaneous prediction of equilibrium in our STEM models. Such a procedure should be guaranteed to converge to the unique equilibrium (that is proven to exist) and be computationally efficient for large-scale transportation networks. We achieve this goal through solving the (ECP1) problem since its solution is equivalent to our (STEM1) equilibrium model.

4.1 THE (SPND1) ALGORITHM

The equivalent convex program (ECP1) is a nonlinear programming problem (NLP) which may be solved by several methods; a good review of these methods may be found in Zangwill [1969].

In particular, ECP1 involves minimizing a convex objective function Z subject to a set of linear constraints, and feasible-direction methods (originally due to Zoutendijk [1960]) are best suited for such a problem (as will be seen shortly). Beginning with an initial feasible solution, any feasible-direction method generates a sequence of feasible solutions. At a given iteration the method involves two main steps. The first step determines a direction for improvement. The second step determines an optimum step size along that direction. The current solution is then updated and the process is repeated until a convergence criterion is met. In mathematical terms, consider the following NLP problem:

$$\underset{x \varepsilon X}{\text{Minimize}}\ f(x)$$

where: X is the set of feasible points,

x is a vector of decision variables,

and f(x) is a nonlinear objective function.

Given an initial solution $x^o \varepsilon X$, the method generates a sequence $(x^o, x^1, \ldots, x^r, \ldots, x^\infty)$ where $x^r \varepsilon X$; $r=0,1,\ldots$. At a given iteration r, the current solution is x^r. A direction for improvement d^r is determined. Then f is minimized along d^r yielding a new feasible solution $x^{r+1}=x^r + \lambda^* d^r$ where λ^* is a scalar defining the optimum step size along the direction d^r. The process is repeated until, for instance, the improvement in the solution is negligible (shortly, a more elaborate explanation will be provided).

Three main comments are now in order. The first is that there are well-known standard algorithms for solving the one-dimensional minimization problem (i.e. the second step of the above method) to determine the optimum step size λ^* along d^r, such as the golden-section and Bolzano search (see Zangwill [1969]). The second comment is that there is no standard procedure for determining a feasible direction d^r (i.e. the first step of the above method). The third comment is that the above method may not always converge to the optimum solution.

Thus, if we choose to solve ECP1 with a feasible-direction method, there are two main challenges to face, namely the efficient determination of d^r at each iteration and the guarantee of convergence.

In 1956, Frank and Wolf proposed an algorithm for solving quadratic programming problems. In their procedure, a feasible direction is determined by linearizing the objective function at a given feasible solution

X^r and solving the resulting linear programming problem (LP) with the well-known simplex method. Let the solution to the LP be y^r, then $d^r = (y^r - X^r)$ is the feasible direction at the r^{th} iteration. They proved the convergence of the procedure given the constraint set is bounded and the objective function is convex.

To have a greater understanding of how the procedure works, consider a problem with two decision variables X_1 and X_2 (see Figure 4.1). We assume that the problem has three inequality constraints in addition to the non-negativity constraints of X_1 and X_2; this defines the feasible region shown in Figure 4.1. The procedure starts with an initial feasible solution x^0. Solving the linearized problem yields the solution y^0 which defines a direction $d^0 = (y^0 - x^0)$ for improvement. The objective function is minimized along d^0 to yield a new solution x^1. The process is repeated to obtain x^2, x^3, x^4,... until the optimum solution x^* is reached.

In our case, however, the resulting LP would have very large number of constraints and decision variables, and solving it with the simplex method may be practically infeasible.

In 1973, Leblanc proposed an efficient algorithm for solving the equivalent convex program of the traffic assignment problem with fixed demand. The resulting LP, in such a case, may be decomposed into a set of shortest path problems which can be solved efficiently by any of the well-known shortest path algorithms, such as Dijkstra's [1959]. Considering the case of elastic demand, almost the same efforts for solving the resulting LP subproblem are involved (see Nguyen [1976]). Combining trip distribution, modal split and trip assignment, the direction-finding involves solving a set of shortest path problems in addition to a Hitchcock transportation problem at each iteration (see Florian and Nguyen [1978]).

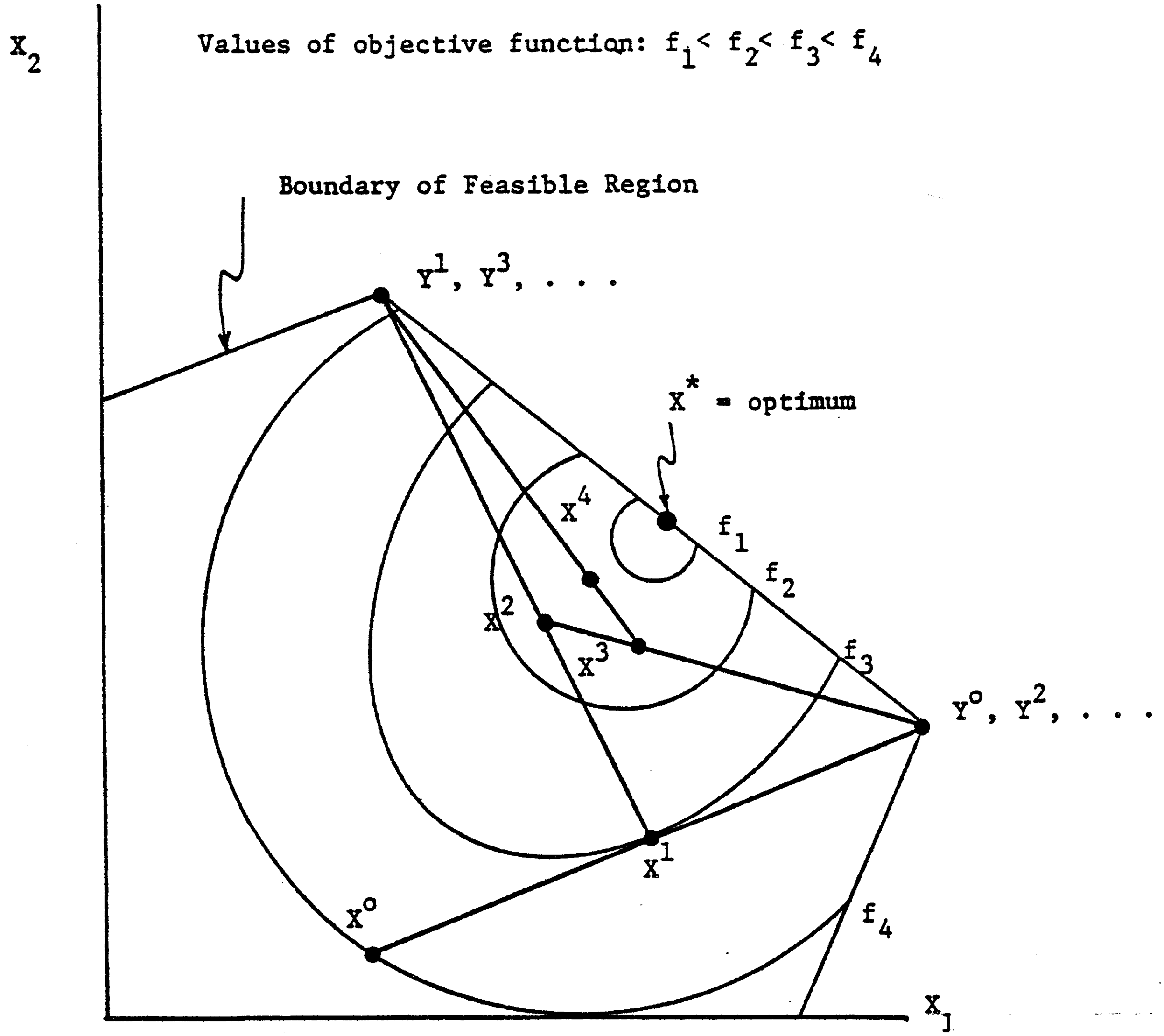


Figure 4.1 The Frank - Wolf Method

One might speculate that combining trip generation, trip distribution, modal split and trip asignment (as in our case) would result in more efforts for direction-finding compared to the above combined model which excludes trip generation, since we are adding more variables and relaxing some assumptions.

It turns out that we are more than fortunate, in the sense that: relaxing some restrictions may not cost us more computations, and in fact, may save us some (probably considerable) costs!

As we will see shortly, at any give iteration the direction-finding in our algorithm is almost as efficient as in Leblanc's algorithm for the assignment problem with fixed demand, and is certainly more efficient than in the case of combining trip distribution, modal split and assignment.

4.1.1 Determining a feasible direction d^r

Consider the equivalent convex program ECP1.

Let $S = (\ldots\ldots, S_i \ldots\ldots)$ be the vector of accessibility variables, $T = (\ldots, T_{ij}, \ldots)$ be the vector of trip distribution variables, $H = (\ldots, H_p \ldots.)$ be the vector of path flows, and $X = (S,T,H)$ be the vector of all decision variables in ECP1.

Suppose that $X^r = (S^r, T^r, H^r)$ is a feasible solution to ECP1 at a given iteration r. Let us linearize the objective function Z at X^r by a first order Taylor's expansion, i.e. for any vector y

$$Z_L(Y) = Z(X^r) + \nabla Z(X^r).(Y-X^r) = [Z(X^r) - \nabla Z(x^r)X^r] + \nabla Z(X^r)Y.$$

Now, consider the linear programming problem of minimizing $Z_L(Y)$ subject to the original constraints of ECP1. We notice that $Z_L(Y)$ involves a constant term which may be dropped without effecting the solution of the

LP problem.

Let $y = (\ldots\ldots,L_i,\ldots\ldots;\ldots\ldots,D_{ij},\ldots\ldots;\ldots\ldots,B_p,\ldots\ldots)$

$= (L,D,B)$ be the vector of all decision variables for the resulting LP problem (say LP1) where L, D and B have the same dimensions and definitions as S,T and H respectively.

Then LP1 may be expressed, in terms of the new set of variables as follows:

LP1: Minimize $Z_1^r = \nabla Z(X^r)Y$

$$= \sum_i \nabla J_i(S_i^r).L_i + \sum_{ij} \nabla\psi_{ij}(T_{ij}^r).D_{ij} + \sum_a \nabla\Phi_a(H^r).V_a$$

Subject to:

$$\sum_{j\varepsilon D_i} D_{ij} = \alpha L_i + E_i \quad \text{, for all } i\varepsilon I \tag{4.1}$$

$$\sum_{p\varepsilon p_{ij}} B_p = D_{ij} \quad \text{, for all } ij\varepsilon R \tag{4.2}$$

$$V_a = \sum_{ij} \sum_{p\varepsilon p_{ij}} \delta_{ap}.B_p \quad \text{, for all } a\varepsilon A \tag{4.3}$$

$$L_i \geq 0 \quad \text{, for all } i\varepsilon I$$

$$D_{ij} \geq 0 \quad \text{, for all } ij\varepsilon R \tag{4.4}$$

$$B_p \geq 0 \quad \text{, for all } p\varepsilon P$$

where

$$\nabla J_i(S_i^r) = \frac{\alpha}{\Theta}[S_i^r - \ell n\,(\alpha S_i^r + E_i)]$$

$$\nabla\Psi_{ij}(T_{ij}^r) = \frac{1}{\Theta}[\ell n\, T_{ij}^r - A_j]$$

$$\sum_a \nabla\Phi_a(H^r) = \sum_a C_a(F_a^r)\,[\sum_{ij} \sum_{p\varepsilon p_{ij}} \delta_{ap}]$$

$$= \sum_{ij} \sum_{p\varepsilon p_{ij}} [\sum_a \delta_{ap}.C_a(F_a^r)]$$

Let $\alpha C_i^r = \nabla J_i(S_i^r)$

$$, \quad C_{ij}^{r} = \nabla\Psi_{ij}(T_{ij}^{r})$$
$$\text{and } C_{p}^{r} = \sum_{a} \delta_{ap} . C_{a}(F_{a}^{r})$$

Then, LP1 may be written as follows:

$$\text{Minimize } Z_1^r = \alpha \sum_i C_i^r \cdot L_i + \sum_{ij} C_{ij}^r \cdot D_{ij} + \sum_{ij} \sum_{p\varepsilon P_{ij}} C_p^r \cdot B_p$$

subject to: (4.1), (4.2), (4.3) and (4.4)

There is no doubt that LP1 is very large, even for moderate transportation networks, and solving it by the simplex method may be practically infeasible. The admittedly large size of LP1 is mainly due to the large number of the decision variables B_p (i.e. there are as many variables B_p as the number of paths in the network). Fortunately, LP1 may be simplified considerably.

We first notice that, by definition, at iteration r C_p^r is a fixed travel cost over some path $p\varepsilon P_{ij}$ between some O-D pair $ij\varepsilon R$. We claim that, at the optimum solution of LP1, all the demand from i to j, D_{ij}, should be flowing over the minimum cost (shortest) path, $p^{*}\varepsilon P_{ij}$, for all $ij\varepsilon R$. Suppose otherwise, then the objective value of Z_1^r may be decreased by re-routing the flow from other non-shortest paths to the shortest ones, implying that we were non-optimal.

Hence we can replace $\sum_{p\varepsilon P_{ij}} C_p^r \cdot B_p$ in the objective function of LP1 by $U_{ij}^r \cdot D_{ij}$, for all $ij\varepsilon R$ where U_{ij}^r is the minimum cost of travel from i to j. In fact we have already solved for the vector of path flows B, and we may remove the constraints (4.2), (4.3) and the nonnegativity constraints $B > 0$ in (4.4).

The above idea has been suggested and used before, by other researchers. (Bruynooghe et al [1968], Leblanc [1973], etc.).

As a result of the above simplification, LP1 becomes the following LP2.

LP2: Minimize $Z_2^r = \alpha \sum_i C_i^r L_i + \sum_{ij} (C_{ij}^r + u_{ij}^r)\, D_{ij}$

Subject to:

$$\sum_{j \varepsilon D_i} D_{ij} = \alpha\, L_i + E_i \qquad \text{, for all } i \varepsilon I$$

$$L_i \geqslant o \qquad \text{, for all } i \varepsilon I$$

$$D_{ij} \geqslant 0 \qquad \text{, for all } ij \varepsilon R$$

There is no doubt that LP2 is considerably smaller than LP1, and it might be practically feasible to solve it by the simplex method. But, since we have to solve it repeatedly, one would expect such a procedure to be inefficient for large-scale problems. Thus, it is of great importance to find an efficient (if not extremely efficient) procedure for solving LP2, if we are interested in analyzing large-scale systems.

It turns out that we can achieve our goal. In fact, the basic contribution of this chapter is in developing an efficient procedure for solving the above LP2.

Let us first write LP2 in terms of the number of trips O_i generated from origins $i \varepsilon I$ and the number of trips D_{ij} distributed from i to j, for all $i \varepsilon I$ and $j \varepsilon D_i$. Recall that,

$$O_i = \alpha L_i + E_i \tag{4.5}$$

implying that $L_i = \frac{1}{\alpha}(O_i - E_i)$

Thus, $\alpha \sum_i C_i{}^r L_i = \alpha \sum_i C_i{}^r \cdot \frac{1}{\alpha}(O_i - E_i)$

$$= \sum_i C_i{}^r \cdot O_i - \sum C_i{}^r E_i \tag{4.6}$$

The quantity $\sum_i C_i^r \; E_i$ in (4.6) is a constant at a given iteration r, and hence can be dropped from the objective function Z_2^r without affecting the solution of LP2. Also by the definition of (4.5) above, we can easily replace the right hand side of (4.1) by O_i for all $i \varepsilon I$. And LP2 becomes the following LP3.

LP3: Minimize $Z_3{}^r = \sum_i C_i^r \cdot O_i + \sum_{ij} w_{ij}^r \cdot D_{ij}$

Subject to:

$$\sum_j D_{ij} = O_i \qquad , \text{ for all } i \varepsilon I \qquad (4.7)$$

$$O_i \geq E_i \qquad , \text{ for all } i \varepsilon I \qquad (4.8)$$

$$D_{ij} \geq 0 \qquad , \text{ for all } ij \varepsilon R$$

where

$$w_{ij}^r = C_{ij}^r + u_{ij}^r \qquad , \text{ for all } ij \varepsilon R$$

(4.7) <=> (4.1) by the definition of (4.5)

(4.8) <=> $L_i \geq o$, for all $i \varepsilon I$

Hence, LP3 <=> LP2.

Now, we claim that, at the optimum solution of LP3, all the trips generated from a given origin $i \varepsilon I$, O_i, should be flowing over the shortest path to a desintation j^* such that $w_{ij}^r{}^* = \min_{j \varepsilon D_i} \{w_{ij}^r\}$. Suppose otherwise, then the objective value of Z_3^r may be decreased by shifting the trips, going to other destinations $j \varepsilon D_i$ where $w_{ij}^r > w_{ij}^{*r}$ to that destination $j^* \varepsilon D_i$ where w_{ij*}^r is the minimum among all destinations accessible from a given origin $i \varepsilon I$, implying that we were non-optimal. This is true for each $i \varepsilon I$. In mathematical terms, our claim may be expressed as follows:

$$\sum_{ij \varepsilon R} w_{ij}^r D_{ij} = \sum_{i \varepsilon I} \sum_{j \varepsilon D_i} w_{ij}^r \cdot D_{ij} > \sum_{i \varepsilon I} w_{ij*}^r \cdot O_i$$

Thus, we may replace $\sum_{j\varepsilon D_i} w_{ij}{}^r D_{ij}$ in the objective function $Z_3{}^r$ by $w^r_{ij^*}\cdot O_i$ for each $i\varepsilon I$. Consequently we can remove the constraints (4.7) and the non-negativity constraints $D > o$, since we have already solved for the vector D.

Then LP3 becomes the following LP4,

$$\text{LP4: Minimize } Z_4{}^r = \sum_i (C^r_i + w^r_{ij^*})\cdot O_i$$

$$\text{Subject to:} \quad O_i \geq E_i \quad , \text{ for all } i\varepsilon I$$

where LP4 <=> LP3.

Now, the above LP4 is a trivial mathematical program, but unbounded from above. So we may simply impose an upper bound on each variable to ensure finite solutions, by adding the following constraints

$$O_i < M_i \qquad , \text{ for all } i\varepsilon I$$

where M_i is a sufficiently large number (e.g. maximum trip generation from origin i assuming zero transport cost anywhere on the network).

Thus, we end up with the following trivial linear program, LP5,

$$\text{LP5: Minimize } Z_5{}^r = \sum_i U_i{}^r\cdot O_i$$

$$\text{Subject to:} \quad E_i \leq O_i \leq M_i \quad , \text{ for all } i\varepsilon I$$

$$\text{where } U^r_i = C^r_i + w^r_{ij^*} \qquad , \text{ for all } i\varepsilon I$$

An optimum solution to LP5 is $O^r = (\ldots, O^r_i, \ldots)$

$$\text{where } O_i{}^r = \begin{cases} E_i \text{ if } U_i{}^r \geq 0 \\ \\ M_i \text{ otherwise} \end{cases}$$

The corresponding optimum solution to LP1 is $y = (L , D , B)$, where

$$L_i^r = \begin{cases} o \text{ if } U_i^r > 0 \\ \frac{M_i - E_i}{\alpha} \text{ otherwise} \end{cases} \quad , \text{ for all } i \varepsilon I$$

$$D_{ij}^r = \begin{cases} O_i^r \text{ if } j = j^* \varepsilon D_i \\ o \text{ otherwise} \end{cases} \quad , \text{ for all } ij \varepsilon R$$

$$B_p^r = \begin{cases} O_i^r \text{ if } p = p^* \varepsilon P_{ij^*} \\ o \text{ otherwise} \end{cases} \quad , \text{ for all } p \varepsilon P_{ij}, \text{ for all } ij \varepsilon R$$

The path flows may be decomposed into link flows using the link-path incidence relationship (4.3) as follows:

$$V_a^r = \begin{cases} \sum_i \delta_{ap^*} . O_i^r \text{ if link "a" belongs to path } p^* \text{ between some } ij^*. \\ o \text{ otherwise} \end{cases}$$

Hence the feasible direction at iteration r is the vector $d^r = (y^r - X^r)$ with the following components:

$$\begin{aligned} d_i^r &= L_i^r - S_i^r &&, \text{ for all } i \varepsilon I \\ D_{ij}^r &= D_{ij}^r - T_{ij}^r &&, \text{ for all } ij \varepsilon R \\ d_a^r &= V_a^r - F_a^r &&, \text{ for all } a \varepsilon A \end{aligned}$$

Thus, given a feasible solution $X^r = (S^r, T^r, F^r)$ at some iteration r in the procedure, a feasible direction d^r is determined as follows:

Step 1.1 Update link costs by calculation $C_a^r = C_a(F_a^r)$ for all $a \varepsilon A$.

Set i=1 in an ordered set of origins I.

Step 1.2 Find the minimum tree from i to all $j \epsilon D_i$. [Use Dijkstra's algorithm]. Let u^r_{ij} be the cost over the shortest path from i to j.

Step 1.3 Calculate $w^r_{ij} = \frac{1}{\theta} [\ell n\ T^r_{ij} - A_j] + u^r_{ij}$, for all $j \epsilon D_i$.

Step 1.4 Determine j^* such that $w^r_{ij*} = \min_{j \epsilon D_i} \{w^r_{ij}\}$

Step 1.5 Calculate $U^r_i = \frac{1}{\theta} [S^r_i - \ell n\ (\alpha S^r_i + E_i)] + w^r_{ij*}$

Step 1.6 Store the shortest path from i to j^*. If i < I , then $i \leftarrow i+1$ and go to Step 1.2. Otherwise, continue.

Step 1.7 Find an optimum solution to LP1, $y^r = (L^r, D^r, V^r)$ and a feasible direction $d^r = (y^r - X^r)$ as described above.

The main computational efforts in the above direction-finding algorithm is associated with finding the set of shortest paths from all origins to all destinations in Step 1.2, which is identical with that of the traffic assignment problem with fixed demand. The additional calculations in Steps 1.3 - 1.5 are insignificant compared to Step 1.2. Step 1.7 is just loading the shortest paths to the most "needy" destinations with the total demand, which is almost identical to the all-or-nothing loading procedure.

Thus, at any given iteration the above direction-finding procedure appears to be almost as efficient as that of the standard traffic assignment problem; undoubtedly, a very fortunate result.

We refer to this procedure as the Shortest Path to the Needy Destination or "SPND1" algorithm as dictated by its direction-finding.

4.1.2 Minimization Along Direction d^r

This is the second main step in any feasible-direction method. In this step, an optimum step size λ^* which minimizes the objective function Z along the feasible direction d^r, is determined. This is achieved by solving the following one-dimensional minimization problem:

$$\text{Minimize } Z^r(\lambda) = \sum_i J_i(S_i{}^r + \lambda d_i{}^r) + \sum_{ij} \psi_{ij} (T_{ij}{}^r + \lambda d_{ij}{}^r) + \sum_a \int_0^{(F_a{}^r + \lambda d_a{}^r)} C_a(w)\, dw \qquad \text{Subject to: } 0 \leq \lambda \leq 1.$$

As mentioned earlier there are well-known standard algorithms from solving the above problem such as the Golden section and Bolzano search. The first involves evaluating the function $Z^r(\lambda)$ at each iteration while the later involves evaluating the derivatives. We choose the second method (i.e. Bolzano search) since in our case it is easier to evaluate the derivatives of the objective rather that the function itself.

4.1.3 Updating

Let λ^* be the optimum step size determined by solving the above one-dimensional search. Then, the new feasible solution for the next iteration X^{r+1} is as follows:

$$S_i^{r+1} = S_i^r + \lambda^* d_i^r \quad , \text{ for all } i\varepsilon I$$

$$T_{ij}^{r+1} = T_{ij}^r + \lambda^* d_{ij}^r \quad , \text{ for all } ij\varepsilon R$$

$$F_a^{r+1} = F_a^r + \lambda^* d_a^r \quad , \text{ for all } a\varepsilon A$$

where $Z(X^{r+1}) < Z(X^r)$.

4.1.4 Convergence Criterion

As mentioned earlier, the above algorithm converges to the optimum (equilibrium) solution provided that the objective function is convex (or is concave when maximizing), the constraints are linear and the feasible region is bounded (see Frank and Wolf [1956]). Indeed, these assumptions are satisfied in our ECP1 problem and thus, the (SPND1) algorithm is guaranteed to converge to a unique optimum.

There are several convergence criteria which may be used as a stopping rule for the algorithm. A criterion may be based on the properties of the optimum solution (e.g. stop when the objective value becomes sufficiently close to its minimum) or the equilibrium solution (e.g. stop when the flow values are sufficiently close to equilibrium). Since we are primarily interested in computing equilibrium rather than the optimum, let us consider the following criterion:

Stop if: (1) $|G_i^{r+1} - G_i^r| < \varepsilon_i$ for K_i% of origins $i \varepsilon I$.

(2) $|T_{ij}^{r+1} - T_{ij}^r| < \varepsilon_{ij}$ for K_{ij}% of O-D pairs $ij \varepsilon R$.

(3) $|F_a^{r+1} - F_a^r| < \varepsilon_a$ for K_a% of links $a \varepsilon A$.

Where ε_i, ε_{ij} and ε_a are three small positive values (i.e. tolerance limits) and K_i, K_{ij} and K_a are three high percentage values (i.e. confidence levels). The idea is simply to stop whenever the changes in most of the flow variables between two successive iterations are sufficiently small. The particular choice of whether to use (1), (2), and/or (3), and of the value of ε's and K's will depend on the purpose of analysis and computational budget constraint. A more thorough search for the best convergence criterion is presented in Chapter VII.

4.1.5 Initialization

To determine a feasible direction d^r we have always assumed that we are given a feasible solution. Hence, the starting step in the algorithm is to find an initial feasible solution X°. There are many ways of doing this. It seems a sensible initial solution would be as follows:

Step 0 (Initialization)

Step 0.1 Assume that the network is empty and calculate the link costs, i.e. set $F_a^\circ = 0$ and calculate $C_a^\circ = C_a(0)$, for all $a \varepsilon A$. Set $i=1$ in an ordered set of origins I

Step 0.2 Find the shortest tree to all $j \varepsilon D_i$.

Step 0.3 Assign the total demand generated from i (say, E_i) to alternative destinations and links as follows:

$G_i^\circ = E_i$ (That is, $S_i^\circ = 0$)

$$T_{ij}^\circ = G_i^\circ \frac{\exp(-\theta u_{ij} + A_j)}{\sum_{k \varepsilon D_i} \exp(-\theta u_{ik} + A_k)} \qquad \text{for all } j \varepsilon D_i$$

$$F_a^\circ = \begin{cases} F_a^\circ + \sum_{j \varepsilon D_i} \delta_{ap^\circ} \cdot T_{ij}^\circ & \text{if link "a" belongs to shortest path } p^\circ \text{ from } i \text{ to } j. \\ F_a^\circ & \text{otherwise} \end{cases}$$

Step 0.4 If $i < I$, then $i \leftarrow i+1$ and go to Step 0.2.

Otherwise the initial feasible solution is

$X^\circ = (S^\circ, T^\circ, F^\circ)$, where

$S^\circ = (\ldots\ldots, 0, \ldots\ldots;\ \forall\ i \varepsilon I)$

$T^\circ = (\ldots\ldots, T_{ij}^\circ, \ldots\ldots;\ \forall\ ij \varepsilon R)$

$F^\circ = (\ldots\ldots, F_a^\circ, \ldots;\ \forall\ a \varepsilon A)$

In Chapter VII, we will see that this initialization procedure is modified to account for the special feature of the Egyptian transport system.

4.2 VALIDATION OF THE (SPND1) ALGORITHM

To test the validity of the (SPND1) Algorithm we developed a computer code for the procedure. The code is essentially an extension of a computer program for traffic assignment with fixed demand developed earlier by Shlomit and Tarem [1980].

The (SPND1) program is about 1000 executable lines; more than one fourth of its statements belongs to the main program while the rest constitute twenty subroutines and three functions. A listing of the program including the necessary modification dictated by our case study is given in Appendix A.

A hypothetical example was constructed to test the validity of the algorithm. In this example, the network consists of 5 nodes and 15 links as shown in Figure 4.2. A list of the link data is given in Table 4.1; for each link the following informations are given: Name of the "from" node, name of the "to" node, length, and two coefficient values for the cost function assuming linear functions for all links. One of the nodes is assumed to be intermediate, the rest are origins and/or destinations defining 8 origin-destination pairs in the network as shown in Table 4.2. The demand models are assumed to be calibrated and the resulting parameter are as follows:

$E_i = 10$ for all origins

$A_j = 10$ for all destinations

$M_i = 40$ for all origins

$\alpha = 2, \theta = 0.5$

The computer program was run to predict equilibrium on the above hypothetical system. The equilibrium solution is shown in Table 4.3.

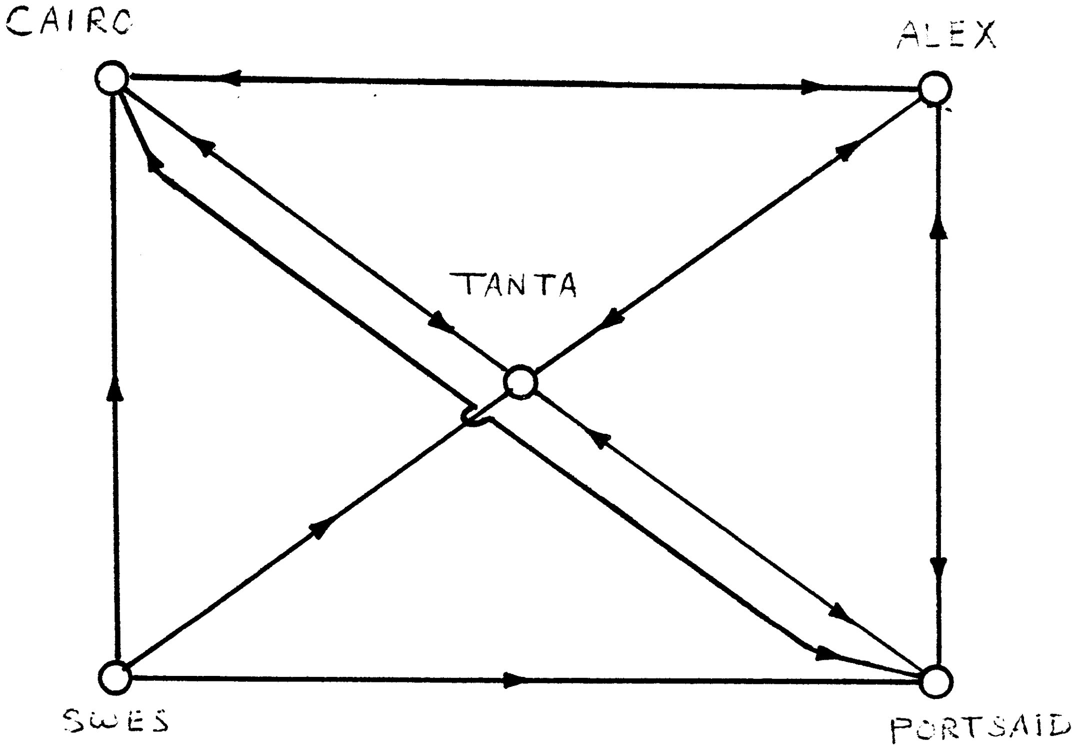


Figure 4.2 A Hypothetical Network Example

Table 4.1 Hypothetical Link Data

LINK NO.	FROM	TO	LENGTH	C_a^1	C_a^2
1	Cair	Alex	10.00	10.	2.0
2	Cair	Tant	7.00	0.0	3.0
3	Cair	Prts	12.00	10.	2.0
4	Tant	Alex	7.00	5.0	2.0
5	Tant	Prts	8.00	5.0	2.0
6	Alex	Cair	12.00	5.0	3.0
7	Alex	Tant	6.0	5.0	2.0
8	Alex	Prts	14.0	10.	2.0
9	Tant	Cair	6.0	4.0	3.0
10	Prts	Cair	14.0	10.	2.0
11	Prts	Tant	7.0	3.0	2.0
12	Swes	Cair	16.0	10.	1.0
13	Swes	Tant	18.0	4.0	2.0
14	Swes	Prts	12.0	3.0	3.0
15	Prts	Alex	14.0	4.0	2.0

Link Cost Function $C_a = C_a^1 + C_a^2 * F_a$

Table 4.2 List of Origin-Destination Pairs

No.	Origin	Destination
1	Cair	Alex
2	Cair	Prts
3	Alex	Cair
4	Alex	Prts
5	Prts	Cair
6	Swes	Alex
7	Swes	Cair
8	Swes	Prts

The procedure was required to stop whenever the changes in link flows between successive iterations were negligible or whenever the number of iterations reached ten.

The final results shown in Table 4.3 are those of the 8th iteration.

One of the main observations about the performance of the (SPND1) algorithm is that the value of the objective function is monotonically decreasing. However, the rate of convergence decreases as the number of iterations increases indicating the existence of what is known as the tailing-off phenomenon (see Figure 4.3). This is a well-known property of the Frank-Wolf procedure in general. The idea is that you gain a lot during the early iterations in the procedure, but you don't gain much more as you proceed.

The other main observation is that a convergence criterion based on the flow values may not be satisfied monotonically; that is, at some iteration such a criterion might be satisfied for, say, 70% of the links, while at the next iteration only, say, 50% of the links might be satisfying it. Thus our results are quite sensitive to the convergence criteria we might use as stopping rules for the procedure (more elaborate discussion on this issue may be found in Chapter VII).

Nevertheless, the results of our hypothetical example appear to be quite reasonable at the 8th iteration. That is, you might find positive flows on paths with higher than the minimum perceived costs but most of the flows will be using the shortest paths, indicating that the user optimization principle is reasonably satisfied.

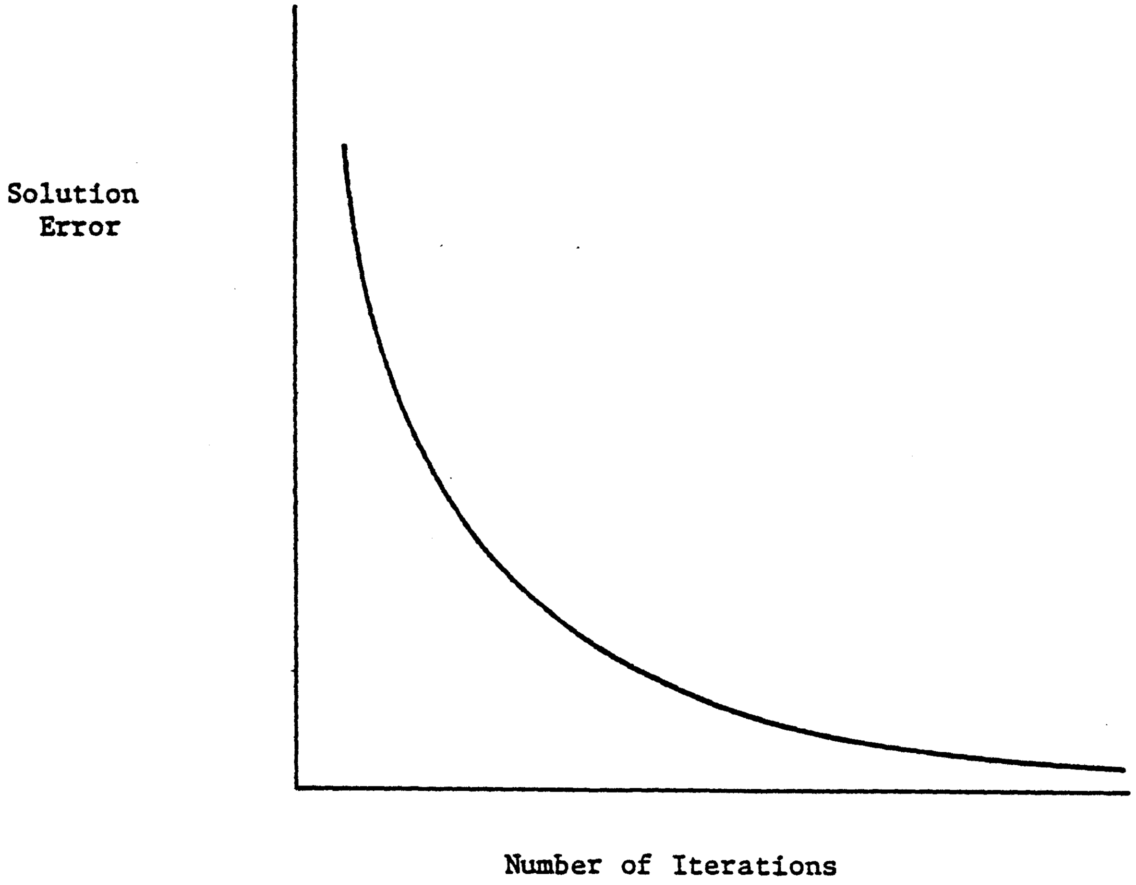


Figure 4.3 Convergence Properties of the SPND Algorithm

Table 4.3 Equilibrium Pattern (8th iteration)

```
TOTAL TRAVEL COST =    1029.60
TOTAL TRAVEL DISTANCE =    724.975


TRIP GENERATION:
================

ORIGIN     TRIP GENERATION    ACCESSIBILITY
------     ---------------    -------------
CAIR           12.442             1.221
ALEX           12.807             1.404
PRTS           12.217             1.109
SWES           14.563             2.282


TRIP DISTRIBUTION:
==================

ORIGIN   DESTINATION    TRIP DISTRIBUTION     MINIMUM PERCEIVED COST
------   -----------    -----------------     ----------------------
CAIR         ALEX             7.022                 17.771
CAIR         PRTS             5.420                 18.788
ALEX         CAIR             5.828                 22.485
ALEX         PRTS             6.979                 18.407
PRTS         CAIR            12.217                 19.649
SWES         ALEX             2.632                 20.659
SWES         CAIR             8.088                 17.555
SWES         PRTS             3.843                 16.129


TRIP ASSIGNMENT:
================

LINK    FROM    TO        FLOW       COST
----    ----    --        ----       ----
   1    CAIR    ALEX      5.923     21.946
   2    CAIR    TANT      2.125      6.376
   3    CAIR    PRTS      4.394     18.788
   4    TANT    ALEX      3.198     11.396
   5    TANT    PRTS      3.801     12.602
   6    ALEX    CAIR      5.828     22.485
   7    ALEX    TANT      2.775     10.550
   8    ALEX    PRTS      4.204     18.407
   9    TANT    CAIR      3.102     13.306
  10    PRTS    CAIR      9.649     19.649
  11    PRTS    TANT      2.569      8.137
  12    SWES    CAIR      7.555     17.555
  13    SWES    TANT      2.632      9.263
  14    SWES    PRTS      4.376     16.129
  15    PRTS    ALEX      0.533      5.066
```

PART TWO:

APPLICATION

In the preceding chapters (part one) of the thesis we have developed a methodology for transportation planning that simultaneously predicts equilibrium on large-scale networks. In the coming chapters (part two) we actually apply this methodology to a real large-scale system, namely the intercity transport system of Egypt.*

Our objective in this part of the thesis is to assess the applicability of the STEM methodology from the computational as well as the behavioral points of view. Computationally, we are mainly interested in finding out the best convergence criterion and evaluating the efficiency of the approach. Behaviorally, we are mainly concerned with assessing the ability of the STEM model to represent actual behavior and to predict behavioral changes in response to policy changes on transport systems.

The convergence criterion to be used as a stopping rule for the iterative prediction process is, by necessity, based on the algorithmic procedure itself. Therefore, we expect our findings in this regard to be, more or less, general and independent from any special characteristics of the application under consideration.

The computational efficiency of the algorithm depends upon several factors. Some of these factors are general such as network size (i.e.

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*An extended and more general version of the STEM methodology developed in this thesis is currently being applied to the overall movements of passengers and freight on all three major modes, highway, railway and waterway on the intercity transport system of Egypt. The application is done through a joint project between MIT and Cairo University in cooperation with the Egyptian Ministry of Transport. The project is sponsored by the U.S. Agency for International Development through the Technology Adaptation Program directed by Professor Fred Moavenzodeh at MIT. The author has been working as a research assistant on that project for the last four years. Occasionally we will be referring to this project as the Intercity Model or Intercity Project 982 .

number of origins, destinations, O-D pairs, nodes and links) and the nature of the algorithm itself (e.g. the tailing-off phenomenon), and others are dependent upon the special features of the system under consideration such as the steepness of cost functions and the values of demand parameters. Therefore, we expect our findings concerning computational efficiency not to be as general as those pertaining to the convergence criterion. This should not lead us to underestimate the usefulness of our computational results because learning about the influence of systems' special features on computational efficiency may be considered equally important. As a matter of fact, the analysis of systems with such special features may be looked upon as extreme or worst-case analysis and hence would add another dimension to our computational (as well as behavioral) results. We still do believe, however, that useful conclusions about the expected general performance of the procedure can be drawn. For example, suppose that the system under consideration has very steep cost functions. The performance of the approach in this case may, in a sense, represent a "lower bound" on its computational efficiency and hence we may conclude that the general performance of the algorithm is expected to improve when applied to other systems with more "general" features.

It should be mentioned at this point that there is no clear cut definition that would enable us to declare a given procedure to be "efficient" and another to be "inefficient". However, one may think of a "wide" range of "efficient" algorithms beyond which there exist a class of inefficient procedures. Within the range of efficient algorithms we may think of relative efficiency by comparing alternative algorithms. We have to be careful though in comparison since the "cost" of computation and the "benefit" generated by different approaches may both be different. Of course in cases where the comparison is made between two procedures to solve the same problem, the concept of relative efficiency is perfectly valid. Based on the theoretical development in the first part of the thesis we can note that our algorithm falls into the domain of "efficient" procedures since we are solving a convex program and moreover, the computational effort spent at any given iteration in the process is almost identical with that of the standard traffic assignment algorithm for fixed demand problems. The concept of relative efficiency, as defined above, may not be perfectly valild in our case since we are developing a methodology with some distinguished behavioral features making the comparison more difficult. Therefore, in analyzing our results we will try to be careful in evaluating the computational efficiency of our approach.

The ability of the STEM methodology to represent actual behavior on transportation systems depends upon several factors related to the state-of-the-art of modelling behavior on transport systems, the behavioral assumptions of the STEM methodology itself, the data and assumptions associated with modelling the behavior of the system under consideration, and any special behavioral features of that system. The state-of-the-art of behavioral modelling of transport systems represents the domain within which the STEM models exist. That is, our STEM methodology do not involve an improvement over existing behavioral transport theories and models, it rather selects those "acceptable" theories and models in the field and combines them in an internally consistent manner. Therfore, the existing state-of-the-art of behavioral transport theories and models forms an "upper bound" on the ability of the STEM methodology to represent travel behavior. It should be mentioned at this point that the state-of-the-art does not provide us with a well defined theory of trip generation and trip distribution behavior which may be applied to large-scale systems. This represents one of the major limitations on the behavioral ability of our methodology.

As far as the STEM methodology itself is concerned, its behavioral assumptions, though acceptable, do not necessarily represent the best in the field. Actually there are equilibrium models that are behaviorally superior to our STEM model but are not, computationally. In fact, the central theme of this thesis is based on recognizing the trade-offs between the behavioral and the computational aspects of the problem of predicting behavior on transport systems. The major challenge in the thesis is the ability to strike a balance between both considerations of the problem. Therefore, we expect our STEM model to stand somewhere in the "middle" of the range of "behaviorally acceptable" transport planning models.

To assess the behavioral applicability of the STEM models we have to apply it to a real transport system. This involves modelling travel behavior on that system. The behavioral modelling of any given transport system involves an additional set of assumptions implied in the specification and calibration of different components of the STEM model. These assumptions are, in a sense, related and influenced by the availability of relevant data on that system. Therefore, we expect the set of assumptions and data used in modelling the behavior on any given system to affect the ability of the STEM model to represent behavior on that given system. Furthermore, any given transport system would have a number of special behavioral features that may be peculiar to our STEM model and thus may not be accurately modelled. Therefore, we expect the existence of such special features to introduce some difficulties in modelling the system and hence in the ability of our methodology to represent actual behavior on that system.

The ability of the STEM model to predict behavioral changes in response to policy changes depends upon its ability to represent actual behavior and its ability to represent alternative policies. These are influenced by the factors mentioned above. Therefore, we expect the assessment of this issue to be almost completely dependent on the preceding one.

The above discussion of the behavioral issues seems to imply that our behavioral results may be greatly influenced by the special features of the system under consideration. In fact, this implication appears to be particularly true in our application since the Egyptian intercity transport system involves several special features whose influence is expected to override that of other general features of the system. Therefore, we expect our behavior results to be less general and hence less conclusive in terms of the assessment of the behavioral applicability of the STEM methodology. This should not lead us to underestimate the importance of the expected results. In fact we do believe that learning about the behavioral ability of the STEM model to accommodate different special features may be as important as learning about its "general" behavioral ability.

Based on these expectations about the degree of generality and conclusiveness of our results, we expect the computational findings to be more general (and hence more conclusive) compared to the behavioral analysis. Again, the importance of the less general and less conclusive results should not be undermined. After all, recall that this is the first application of a general transport equilibrium model to a real large-scale system.

The application of the STEM methodology on the intercity passenger transport in Egypt is described in the next three chapters. In chapter V, we describe the main features of the Egyptian intercity transport system with a special emphasis on the major issues related to passenger transport. In chapter VI we focus on the behavioral modelling of passenger transport on the Egyptian system and design a case study. In chapter VII we actually perform the analysis to address the major computational and behavioral issues of the application and evaluate the results.

V. INTERCITY PASSENGER TRANSPORT IN EGYPT

The Egyptian intercity transport system consists of three major networks: highway, railway and waterway. In addition there is a pipeline network used exclusively for liquid hydrocarbons (crude oil and petroleum products) and natural gas. Since the waterway network is mainly used for freight transport, we will limit our description to the other two networks which are shared by both passengers and freight. Furthermore, since we are mainly concerned with passenger transport, more emphasis will be placed on issues and problems related to passenger traffic.

We first describe the infrastructure and its related problems, then discuss the issues related to traffic movements, transport fleets, tariffs and costs, and transport management. It should be mentioned at this point that no attempt is made to address all of these issues within this thesis; they are described here, however, to help the reader becoming more familiar with the basic features of the system under consideration. In addition, some of these issues, though not directly addressed in our case study developed in the next chapter, have indirect impacts on some of our assumptions in the case study and on interpretations of results.

5.1 HIGHWAY AND RAILWAY NETWORKS

The highway network has a total length of about 28,500 km (15,000 km paved and 13,500 km unpaved), located mainly along the Nile River in Upper Egypt, condensed in the Delta region with connections to the major cities along the Suez Canal, and extended along the Red and the Mediterranean seas. The NEDECO* study classifies the roads into three categories; primary roads, connecting capitals of governorates, main seaports and industrial areas; secondary roads, connecting marakez with capitals or with the primary road network; and other (tertiary) roads, connecting smaller towns and villages to the primary and secondary roads.

In 1979* almost 3,100 km of the paved roads (27% primary and 44% secondary) were in "poor" condition requiring immediate rehabilitation; about 3,670 km (44% primary and 20% secondary) were in "fair" condition requiring rehabilitation within 5 to 10 years. In addition, the pavements now considered to be in "good" condition are likely to deteriorate fairly quickly. The severity of the problem of having 3,100 km in poor condition is lessened by the fact that most of these roads are not primary while, on the other hand, most of the intercity transport volumes (i.e. about 80%) are using primary roads.

The fact that almost half of the total road length is unpaved represents a major problem especially during periods of heavy rain fall (mainly in northern parts of the country). In addition, the very fact that these roads are unpaved, greatly decreases the accessibility to and from cities and villages located on them. This, consequently, discourages socio-economic development projects to be established in such locations. It is said that there is a general policy to pave roads provided that budget is available.

The road network is not connected to about 1,314 villages (32% of the total number of villages in Egypt). Policies for connecting these villages with the existing network are set by the localities based on the relative importance of the villages with respect to the governorates, each within

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* This is phase II of Egypt National Transport Study conducted between 1979 and 1981 by Netherlands Engineering Consultants (NEDECO). The main products of the study [(including phase I (1975-1977)] were the creation of a comprehensive data base, the development of a national transport plan for the period up to 1987 and a prospective long term master plan from 1987 until the year 2000.

its jurisdiction. Local authorities are required to inform the Highways and Bridge Authority (HBA) periodically with the names of those villages that have been connected, lately, to the network. There is a ministrial decree of having a representative from HBA in each governorate council to facilitate communications between them. How efficient these policies are implemented is unknown.

There is no adequate safety for traffic movements on the road network. This issue appears not to be related to the infrastructure while in fact it does. Reasons are related to inadequate shoulder widths, lack of traffic signs and road marks, and the existance of constructions within the right-of-way. Road design standards are available but not actually implemented.

The main railway network is owned by the Egyptian Railway Authority (E.R.) and has a total route length of about 3,260 km, excluding the Sinai lines. The Ministry of Industry owns an iron-ore line from Baharia Oasis to Tebbin (346 km) and is financing a new line between Qena and Safaga (240 km) presently under construction. The total length of branches, sidings and yards is 2,144 km; of which 1,555 km is estimated to be "in operation". The main network has 951 km of double track; this includes 583 km (of the main line) between Asiut (in Upper Egypt) and Alexandria (at the Mediterranean Sea) through Cairo (at the apex of the Delta Region); 53 km between Tanta (on the main line) to Mansoura; 201 km between Banha (on the main line) and Ismailia, then between Ismailia and Suez along the Suez Canal; 25 km of electrified suburban line between Cairo and Helwan; and 15 km of suburban line eastward from Cairo. The network is classified into three Classes I, II and III according to speed limits and gross tonnage carried per day.

The railway embankments, especially in northern areas, are constructed from weak soils with no facilities for drainage. This causes the ballast bed to sink into the embankment, and hence, to be useless. The problem is a major one, since 915 km of Classes I and II have "poor" ballast beds; the above being the main reasons. There is a policy of using better ballast types and gradations, renewal of ballast bed and reinforcement of weak embankments. However, the issue is not yet resolved, posing a serious problem before decision makers of the system.

About 820 km of Classes I and II lines have old 47 kg/m rails and 430 km of Class I lines have 52/54-g/m rails with an age over 20 years,* requiring immediate renewal. There is a general policy which was set a long time ago (i.e. since 1956) for the annual renewal of 250 km of track, including renewal of ballast bed. Sleepers are to be renewed according to their type (i.e. wooden: every 20 years, iron: every 35 years, and concrete sleepers: every 60-70 years). Associated with sleeper replacement is partial renewal of ballast bed. Some officials say that about 40% of the track is not currently renewed because of budget constraints.

About 95% of the network had mechanical signalling systems installed about 50 years ago. This does not cause a problem except on lines with heavy traffic volumes, which is indeed the case on many of the existing lines (e.g. Alexandria-Cario). The policy is simply to install electrical signalling systems on such lines [see NEDECO (1981) Annex V].

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*The expected average lifetime, according to the ER standards, is 20 years.

5.2 TRANSPORT MOVEMENTS

The intercity transportation system of Egypt is used to transport passengers among different urban, rural and industrial centers of socio-economic activities, and goods among different centers of production, consumption, imports and exports. In 1979, the system transported about 15.3 billion ton-kilometers (corresponding to about 90 million tons) of freight and 34.5 billion passenger-kilometers (representing almost 584 million trips) on all modes of the system.

Existing modes for intercity passenger transport are private car, taxi, bus and rail. Historically, rail was the dominant mode. In recent years, however, the Egyptian Railway (ER) has been quickly losing its position in favor of the increasingly competing mode (the taxi). Table 5.1 shows the passenger-kms produced in 1974 and 1979 by each mode in the system. In 1974, the system produced 23.5 billion passenger-kms, of which 55% was produced by ER, 22.5% by taxi, 14.5% by bus and 8% by private car. In 1979, the system produced 34.5 billion passenger-kms (that is, an increase of 12 billion pass-kms compared to 1974); only 0.9 billion of this increase was absorbed by rail while 6 billion (that is, half of the increase) was attracted to taxi. As a result, modal shares completely changed; the ER share dropped from 55% to only 40% while the biggest jump was in the taxi from 22.5 to 33%. The bus share had a modest increase from 14.5% to 18% and that of private car had a slight change from 8% to 9%. It might be worth mentioning that, although the ER still was the dominant mode in terms of pass-kms produced in 1979 as can be seen easily from the above statistics of Table 5.1, in the same year the taxi had the largest share in terms of the number of passenger trips (36%) followed by the ER (30%) as shown in Table 5.2.

Table 5.1

PASSENGER TRANSPORT (1974 and 1979)

Mode	PASS.-KMS (BILLION), 1974	PASS.-KMS (BILLION), 1979
Private Car	1.9 (8.0%)	3.0 (9.0%)
Taxi	5.3 (22.5%)	11.3 (33.0%)
Public Bus	3.4 (14.5%)	6.4 (18.0%)
Railway	12.9 (55.0%)	13.8 (40.0%)
Total	23.5 (100.0%)	34.5 (100.0%)

Table 5.2

PASSENGER TRANSPORT (1979)*

MODE	PASS. (MILLION)	PASS.-KMS (BILLION)	AVERAGE DISTANCE (KMS)
Pri. Car	47.3 (8.0%)	3.0 (9.0%)	63
Taxi	215.8 (37.0%)	11.3 (33.0%)	52
Public Bus	146.3 (25.0%)	6.4 (18.0%)	44
Railway	174.2 (30.0%)	13.8 (40.0%)	79
Total	583.7 (100.0%)	34.5 (100.0%)	59

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* NEDECO (1981)

This trend of the ER losing its dominance in favor of the taxi, is currently underway and is expected to continue for the next five years as predicted by NEDECO (1981). They predicted a further decline of the ER modal share from 40% in 1979 to 24% in 1987, in spite of an estimated increase of its volume (in absolute terms) from 13.8 to 17.5 billion pass-kms.

These facts and predictions are striking because the people are shifting to the more expensive mode of travel.

The main reasons for this counter intuitive behavior are related to the poor level of service and the limited fleet carrying capacity of the ER (and Bus). On the other hand, the taxi, unlike bus and rail, is more flexible and responsive to demand.

5.3 TRANSPORT FLEET

Passengers and goods on the Egyptian intercity system are transported by different types of vehicles and trains.

By the end of 1979, the total motor vehicle fleet for passenger and freight on the highway network was slightly more than 485,000 vehicles. The highway fleet increased dramatically during the period 1975-1979, particularly the trucking fleet, whose rate of increase was 25.4% per year; the average annual rates of increase for private cars, taxis and buses were 16.6%, 11%, and 11.6% respectively.

The number of public buses increased from 5,080 (1975) to 6,067 (1979), while that of private buses increased from 4,462 to 8,758; that is, the private bus fleet doubled during the period 1975-1979 while the public bus fleet increased only by one fifth during the same period. It should be added that the bulk of the increase in the private bus fleet is not used for intercity passenger travel which is still dominated by the 4 public bus companies. However, there is a general policy of reinforcing intercity bus travel whether it be by expanding the existing public companies or allowing for other bus companies to operate in the system (let it be public, private or whatever).

As far as the railway fleet is concerned, NEDECO (1981) states that between 20 and 30% of all rolling stock registered as bookstock, in 1979, was beyond repair. Officials add that by 1982, about 82% of the bookstock will be beyond repair requiring replacement. The average availability of the net effective stock ranges from 60% for non-air-conditioned coaches to 77% for locomotives. The average availability for freight cars is not known and is guessed by NEDECO (1981) to be 40-50%. Railway fleet capacity is mainly constrained by the availability of tractive power. In July 1976, only 889 trains were run while 2,699 were cancelled, 2,614 of them for lack of locomotives.* The apparent low availabilities of different fleet components are due to inadequate and poor-quality maintenance. To resolve these issues, new locomotives have been ordered and a new maintenance procedure is now being implemented by TRANSMARK**. However the railway fleet problems have not yet been solved.

Third class travellers represent more than 95% of all trips by train and more than 90% of passenger-kms produced. However, the quality of service and maintenance of third class coaches is poor. Four hundred new non-air- conditioned coaches were purchased to compensate for the previous 60% availability of such coaches. Nevertheless, this managerial attitude of "purchase" rather than "maintenance" is costly and should be altered in the future.

5.4 TARIFFS AND COSTS

Transport tariffs could be used as powerful tools to influence the level and distribution of demand volumes on the system; to assure adequate revenues for operations, maintenance and expansion of transport facilities; to help achieve redistribution of income; and to help control congestion.

At present, the potential power of pricing policies has not been utilized in the intercity transport system of Egypt. The main reason is the overriding

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* The Egypt National Transport Study, Phase I, 1977.

**TRANSMARK

influence of capacity and/or operational constraints (in railway and waterway modes) on transport movements. Such constraints exist because of many reasons such as limited investments, inadequate poor quality maintenance practices, lack of sufficient skilled motivated labor and management, etc. These factors, in addition, caused levels of service on these two modes (particularly the railway) to deteriorate considerably over time, requiring greater costs of investment, maintenance and operation to provide a reasonable level of service or even to keep the level of service from further deterioration. In addition, everything else being equal, the costs of providing a given service level increased considerably over time, just due to inflation (e.g. in fuel price). On the other hand, because of those capacity constraints on railway and waterway, demands shifted to the more expensive modes of travel (i.e. trucks for freight and taxis for passengers), resulting in a great loss of revenues to the "constrained" modes especially the railway. This created a gap between costs and revenues which widened more and more over time, reflecting a serious problem to decision makers of the Egyptian Transport system.

The problem can be explained more by looking at Table 5.3 which shows revenues and costs of intercity passenger transport by rail, bus and taxi in 1979. The revenues generated per pass-km were estimated at an average of 2.37 milliems for rail, 6.65 milliems for bus, and 12.40 milliems for taxi. These statistics indicate clearly that the ER has extremely low tarrifs compared to other modes. This is striking because supposedly the ER should be attracting almost all passenger demand but the reality is that people are shifting away to the most expensive public mode.

The severity of the problem facing the ER is evident given the fact that its financial costs incurred in providing passenger service was more than double the generated revenues in 1979 indicating a large deficit (see Table 5.3). If we add to this the fact that at least 60% of the ER revenues in 1979 were generated from passenger services, we can clearly see how important this problem is to the ER, and hence to the Egyptian Ministry of Transport. The problem is becoming even more serious over time due to the rapid increase of transport demand on the system. Statistics, available for the period 1974-1979, show an average of 9% annual rate of increase of the total pass-kms produced by the system.

Table 5.3

REVENUES AND COSTS OF INTERCITY PASSENGER TRANSPORT IN EGYPT (1979)

MODES	SERVICE TYPES	REVENUES (MM. PER PASS.-KM)		FINANCIAL COSTS (MMS. PER PASS.-KM)	
Railway	Airconditioned	2.37	4.94	6.41	19.9
	Non-Airconditioned		2.14		5.22
Bus (52 Seats)		6.65		6.65	
Taxi		12.40		12.40	

It should be mentioned at this point that the policy of the government was, until the approval of the new ER law by the People's Assembly late in 1980, to subsidize the ER for all its losses, regardless of the system's performance. This policy may have created an atmosphere for less motivation and dedication to restore the mode. In fact it might have created some incentive to keep tariffs as low as they were, regardless of costs, so that more subsidies may have been generated. Now under the new law, the ER will propose to the government its "preferred" tariff structure estimated according to the actual costs incurred. The government would either approve or reduce the proposed tariffs, and in this case will have to pay the difference as revenues to the ER.

The implementation of the new E.R. law is undoubtedly one of the major issues that decision makers and planners of the Egyptian transport system at the ministry as well as the E.R. are faced with. Proposing high tariffs by the E.R. without sufficiently increasing their level of service and relaxing their capacity constraints may result in considerable loss of its demand (depending on demand elasticities), and hence its revenues, without receiving subsidies; a situation which might be even worse than before. Proposing lower tariffs by the E.R. implies lower investment maintenance, and operations costs which would mean that either they are becoming cost-efficient or they are implementing modest development plans or both. The government, through the Ministry of Transport (MOT), on the other hand, would like to approve the tariff structure which minimizes its obligations toward the E.R. (i.e. payment of the difference) and at the same time be socially acceptable.

5.5 ORGANIZATION AND MANAGEMENT

One of the main characteristics of the Egyptian government system is its high degree of centralization and bureaucratic control; the transport system is no exception. This centrality has led to a tendency to channel too many projects and decisions to the top of the transport planning system. In many cases neither the time nor the relevant data are available 'at the top' to make effective well-studied decisions. In addition, bureaucracy is manifested in a great number of agencies, laws and regulations which are in some instances, inconsistent and conflicting.

One clear example of conflict is the presidential decree No. 72 of 1975 which commissioned the Ministry of Housing and Reconstruction to:

- Provide comprehensive regional planning for reconstruction of the Canal Zone, Sinai, the Western Desert and the Red Sea.
- Implement plans and policies of national reconstruction and other ones in areas that should be specified by the decision of the President.
- Raise the standard of utilities in Greater Cairo and Alexandria (except for transport and communications) and other cities as stipulated by Cabinet decision.

These powers imply areas of conflict with both the Ministry of Transport and certain Governorates. According to Law No. 43 of 1979, Governorates are charged with constituting and supervising all public utilities and services (except these considered to be national utilities by a decision of the Prime Minister). Such conflicts are, supposedly, to be resolved by the Deputy Prime Minister of Services.

Another example of conflict, at least in theory, exists within the Ministry of Transport. Both the Department of Plans (belonging to the operations and budget sector) and the Transport Planning Authority (TPA) are supposed (according to the law) to carry out the responsibility of formulating general transport plans, setting priorities for plan execution, coordinating these plans and following-up implemented projects. Moreover, the Department of Transport Planning within the Ministry of Planning claims the same responsibility [see NEDECO (1981), Annex VIII]. However, some officials say that in practice, there is no conflict and that the main responsibility of planning lies within the TPA; the Ministry of Planning evaluates such plans in the context of the National development plan of the country.

Bureaucratic control still exists in the process of transport planning. On the top of the TPA is the High Council for Inland Transport consisting of 40 members representing nearly all sectors of transportation, including representatives of several Ministries (e.g. finance, planning, national economy, agriculture, defense) and industries, and some outside experts. Officially, this "high" council is concerned with the formulation of transport strategies and policies. Practically, however, given the large nember of its members, the fact that some of them are remotely related to policy making, and its twice-yearly meetings, only very broad policies and strategies may be communicated (but not practically discussed) among its members. Furthermore, even this council does not have the ultimate decisive power regarding transport strategies and policies. Since May 1980, the Deputy Prime Minister for Services (supervising the Ministries of Transport, Maritime Transport, Housing and Reconstruction, Irrigation, and Tourism and Civil Aviation) holds such a power. It is not clear how efficient such a Ministerial committee would be, given the fact that it consists of very busy Ministers, and that in-depth discussions of a comprehensive transport plan are unlikely to take place in such meetings.

As far as comprehensive planning is concerned, NEDECO (1981) concluded that the existing legal framework for transport planning cannot ensure an effective systematic development of comprehensive plans. "The system functions on the basis of lists of projects which are alotted to annual budgets. These budgets are - in turn - largely dictated by the financial means available. Only in the case of large projects multi-year forecasts and feasibility studies are made, very seldom however within the context of a comprehensive plan...As most projects are originating from and generated by actual problem situations (bottom-up approach) these tend to be confined to one specific mode of transport, leaving the connection with other modes almost out of consideration...One of the serious drawbacks of the existing situation is the lack of experienced transport planners/economists in the planning agencies and TPA...Closely related to the lack of experienced professional staff is the absence of well-established procedures of continuous and periodical data collection, - processing and - recording." [NEDECO (1981), Annex XIII, Chapter 2]. The study proposed a modified organizational structure and a training program with the objective of strengthening the position of the TPA as the main agency for the development of comprehensive transport plans.

Finally, the existing civil service regulations impose severe constraints on the management of the transport sector. Salaries of professionals are inadequate; promotions are slow and are often not based on performance; regulations prohibit the discharge of permanent employees, Ministries and public sectors are required to provide jobs for a set quota of university graduates, etc. Consequently, most of the skilled professionals and workers would tend to leave the sector, and those who are still there do not have enough motivation and/or skills to perform their duties optimally.

VI A CASE STUDY

In the preceeding chapter we have described the basic features of the Egyptian intercity transport system with a special consideration for issues related to passengers. In this chapter we develop a case study that is relevant to addressing the major issues of our application. In the next chapter we formally define the specific set of issues to be addressed, perform the analysis, and evaluate the results. The objective in this and the next chapter is to assess the applicability of the STEM methodology computationally and behaviorally.

Modelling the system (or designing the case study) involves four major tasks. The first is the definition of passenger types-choice sets mapping; the second is the specification of modal split and traffic Assignment behavior and network representation; the third is the development of cost functions; and the fourth is the calibration of demand functions. The following is a detailed description of each of these tasks.

6.1 PASSENGER TYPES-CHOICE SETS MAPPING

Passengers are obviously non-homogeneous in many respects and hence may not be treated as one type. Categorization may be based upon income, education, profession, etc. It seems that income is the most appropriate basis for identifying passenger types especially on the Egyptian system.

Transport services are also different in their level of service attributes such as travel time, tariff, comfort, safety, etc. In fact, service types on the Egyptian system are designed such that each would be suitable for a particular income level. For example, there are three types of passenger trains for intercity travel: diesel units, express train and local train. Diesel units include first and second class airconditioned service, they stop only at Governorate Capitals, and they of course have the highest fare on rail; this type of service is most suitable for high income passengers. On the other hand, local trains are composed of third class non-airconditioned cars, they stop at almost every town and village on their routes, and have the lowest fare on the whole system; this type of service is meant to be for low income passengers. Express trains are composed of all types of services on rail (i.e. I-AC, II-AC, II and III classes), they stop at Governorate Capitals and other major cities (i.e. Marakez) but not all towns and villages, and they have different levels of fares depending on the type of service; this type of service is mainly designed for middle income people with provisions for high and low income passengers. The same is true for intercity bus service [see NEDECO (1981), Annexes IV and V].

Thus it appears quite appropriate to assume the existence of some "mapping" between passenger types (e.g. income groups) and choice sets (e.g. service types).

To identify such a mapping we assume that there are three passenger types in the system: high income, middle income and low income groups. We also assume that the service types available in the system are: auto, taxi, Lux bus (an aggregation of several bus services which may be considered "excellent", "good" or "sufficient"), normal bus (an aggregation of two bus services which are considered "moderate" and "poor"), diesel units, express train and local train.

Based on the "quality index" associated with each service type [NEDECO (1981)], discussions with Egyptian transport experts and our own experience and knowledge of the system, we can identify the required mapping as shown

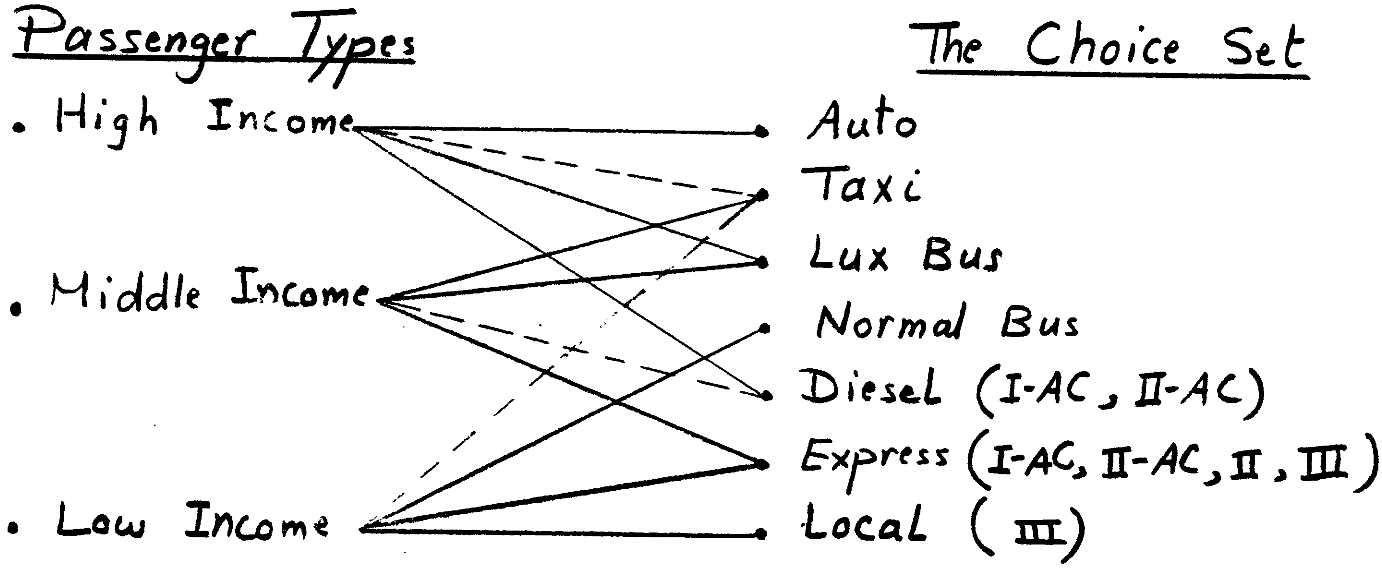

Figure 6.1 Passenger Types - Choice Sets Mapping

in Figure 6.1. In the figure solid lines indicate main modes and dotted lines indicate modes which may be chosen by the particular passenger group whenever capacity is consumed on the main modes.

We may further refine our mapping by defining another mapping within selected services such as express train and diesel units. Within express train we may assume that high income uses I-AC only, middle income uses II-AC and II classes and low income uses III-Class only. Within diesel we may assume that middle income group would use II-AC.

Thus our mapping may be summarized as follows:

-low income group may choose among: local train, express train (III-Class only), normal bus and taxi.

-Middle income group may choose among: express train (II-AC and II classes), taxi, Lux bus and Diesel (II-AC class only).

-High income group may choose among: Auto, diesel, lux bus, express train (I-AC class only) and taxi.

In our case study we will be focusing on low income passengers, since they represent about 80% of rail users, 75% of bus users and more than 65% of all users in the system (see section 6.4 of this chapter for sources and calculations of these statistics).

6.2 MULTIMODAL COMPOSED NETWORKS

Within our framework (see Chapter II), modal split can be user optimized (i.e. each user chooses the mode which minimizes his own perceived cost), system optimized (i.e. modal split is such that the total travel cost of all users on all modes is minimized), or given by a logit model. Traffic assignment can be user or system optimized. To decide on the particular assumptions on modal split and traffic assignment in the Egyptian system, we need to gain more understanding of users' behavior in that system.

We first notice that passengers travel as individuals or in small groups and thus, it is more appropriate to assume that each user is trying to minimize his own perceived cost rather than being concerned with minimizing the total travel cost of all users in the system. Hence, in our case study, traffic assignment is assumed to be in accordance with the user optimization principle.

As far as modal split is concerned, it can either be user optimized or in accordance with logit.

The logit assumption has the advantage of considering the "randomness" in the system due to imperfect knowledge of users about the system and/or inability of analysts to capture all factors that influence users' utilities. However, it seems that logit may not be the most appropriate assumption to represent modal choice behavior on the Egyptian network. Discussion with Egyptian transport experts revealed the fact that "transfer" between modes in the middle of any given trip may occur frequently and thus, should be considered in the analysis. If we accept the logit assumption, we would have to represent any possible transfer between any two modes and a "new mode" in the logit formulation.

This creates a number of problems; first, we don't know in advance these possible "new modes" and thus, we cannot simply identify them; second, even if we could identify some of these "new modes" we would be neglecting other possibliities and thus restricting the "transfer" behavior in the system; third, and most important, if we are able to include all possible "new modes" in our logit formulation we would expect the logit assumptions of independence among alternative modes to be violated (since the new modes are essentially combinations of the original ones). Furthermore, the Egyptian system is more or less stable over time as far as the mode choice set is concerned and users are expected to have good information about the characteristics of different modes in the system, and thus their mode choice behavior may, in a sense, be deterministic.

Therefore, because of all of the above reasons we assume that modal split is user optimized. In other words, modal split and traffic assignment on the Egyptian intercity system are assumed to be in accordance with the user optimization principle of user travel behavior.

This assumption has implications on the multimodal network representation. A given link on the actual network may be used by different modes (e.g. taxi and bus may use the same highway link). This implies that the cost of traversing that link is not unique; causing a problem in finding the shortest paths on the network. The idea is, then, to create as many copies of that link as the number of modes using it and to associate a unique cost function with each copy. Transfer between modes may occur at different cities (i.e. nodes) on the actual network. At a given node of transfer, there are costs of loading and unloading for each transfer activity. This implies, again, that the cost of traversing that node is not unique, and hence we need to create as many copies of that node as the number of modes passing through it in addition to loading and unloading links between each of these copies and the original node in the network. If we extend this basic idea to the entire network, we will create what may be referred to as the "multimodal composed network." An example of such a composed network is shown in Figure 6.2. In this figure there are two modes: express train and normal bus, and three zones where transfer between modes can take place. The composed network in the figure consists

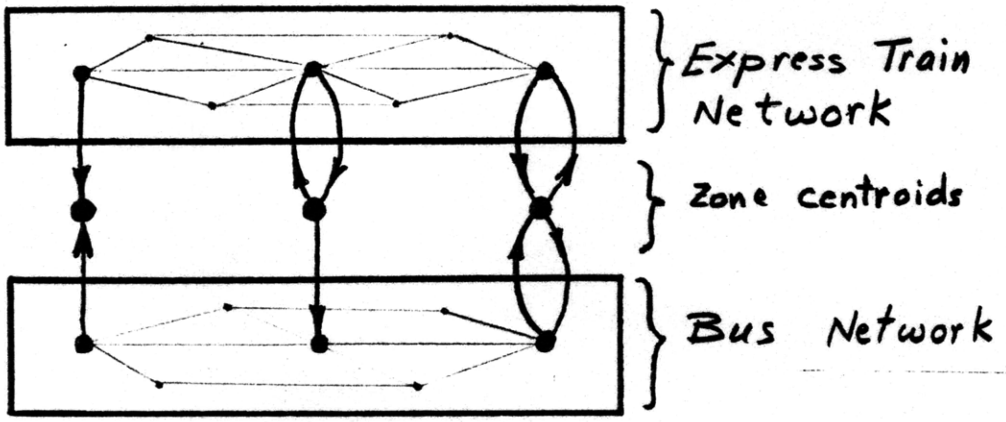

Figure 6.2 A Composed Network

of two modal networks connected through the three zonal centroids with loading and unloading links that reflect our behavioral assumptions about transfer between these two modes at each of these three zonal centroids. For example, the rightmost zone is assumed to be a point of loading and unloading for both modes while the leftmost zone is assumed to be a point of unloading from both modes only (i.e. a destination but not an origin). The middle zone is a point of loading and unloading for express train and only of loading for bus. In fact, invoking alternative assumptions about loading and unloading for different modes in the choice set at different zones in the system, allows us to analyze a variety of situations within our framework.

In our case study we have created four major modal networks: express train, local train, taxi and normal bus. The normal bus service is provided through four regional intercity public bus companies: East delta, Middle delta, West delta and Upper Egypt. Essentially, we have created a network for each of these companies. Figures 6.3 through 6.9 depicts these seven modal networks.

Notice that Egypt's map in any of these figures contains 24 major nodes; each is identified with a 4-character name. These nodes represent the centroids of 24 non-overlapping traffic zones. This zoning system is based on that proposed by NEDECO (1981), Accepted by the Egyptian Ministry of Transport and adopted by the Intercity project (1982). NEDECO's zoning system consists of 29 zones defined such that the boundaries of traffic zones coinside with those of the 25 Governorates of Egypt* except for four large Governorates where each is divided into two traffic zones. Table 6.1

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*Egypt is divided into 25 administrative geographical areas; each is called a Governorate

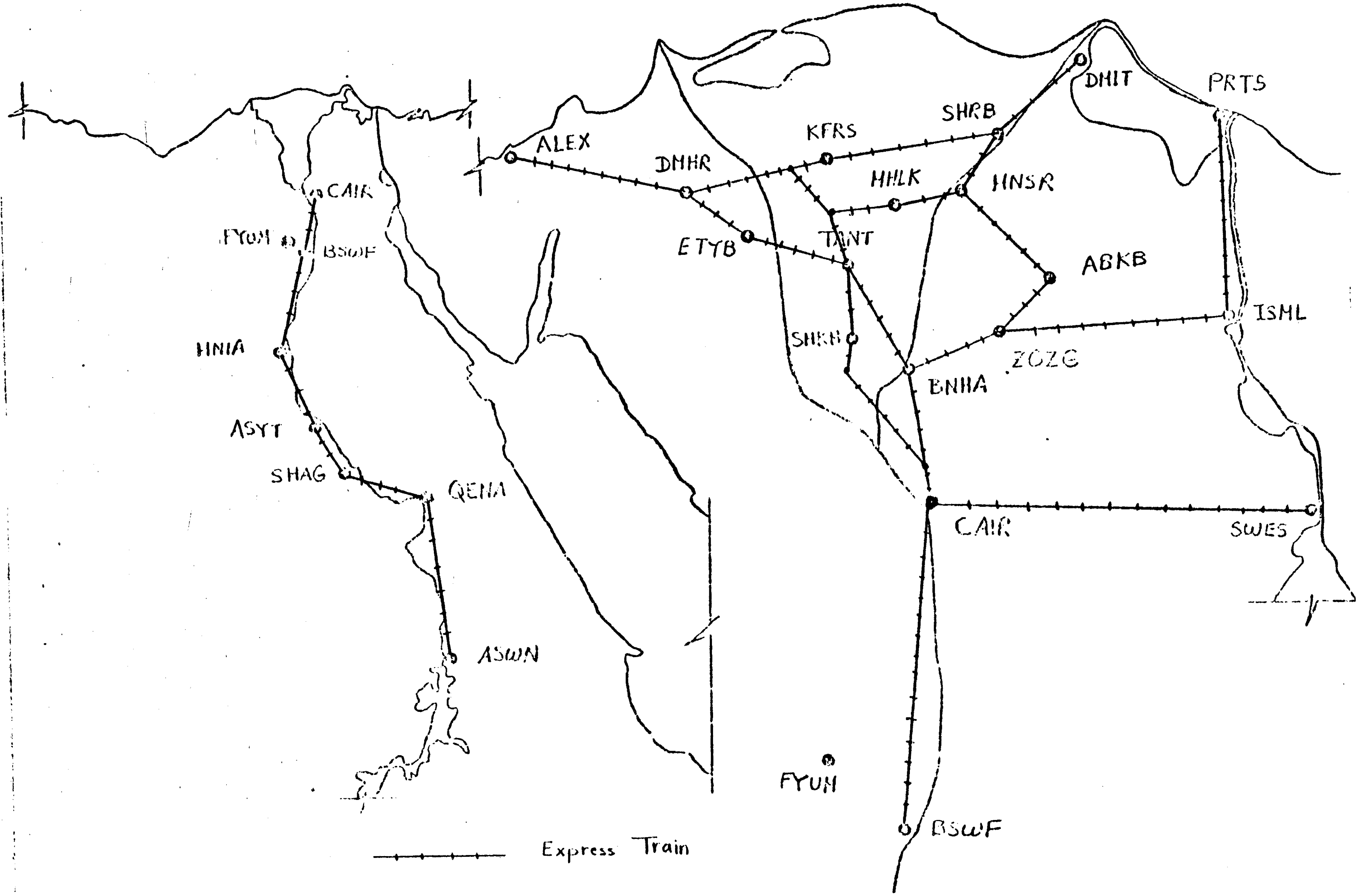

Figure 6. 3 Express Train Network

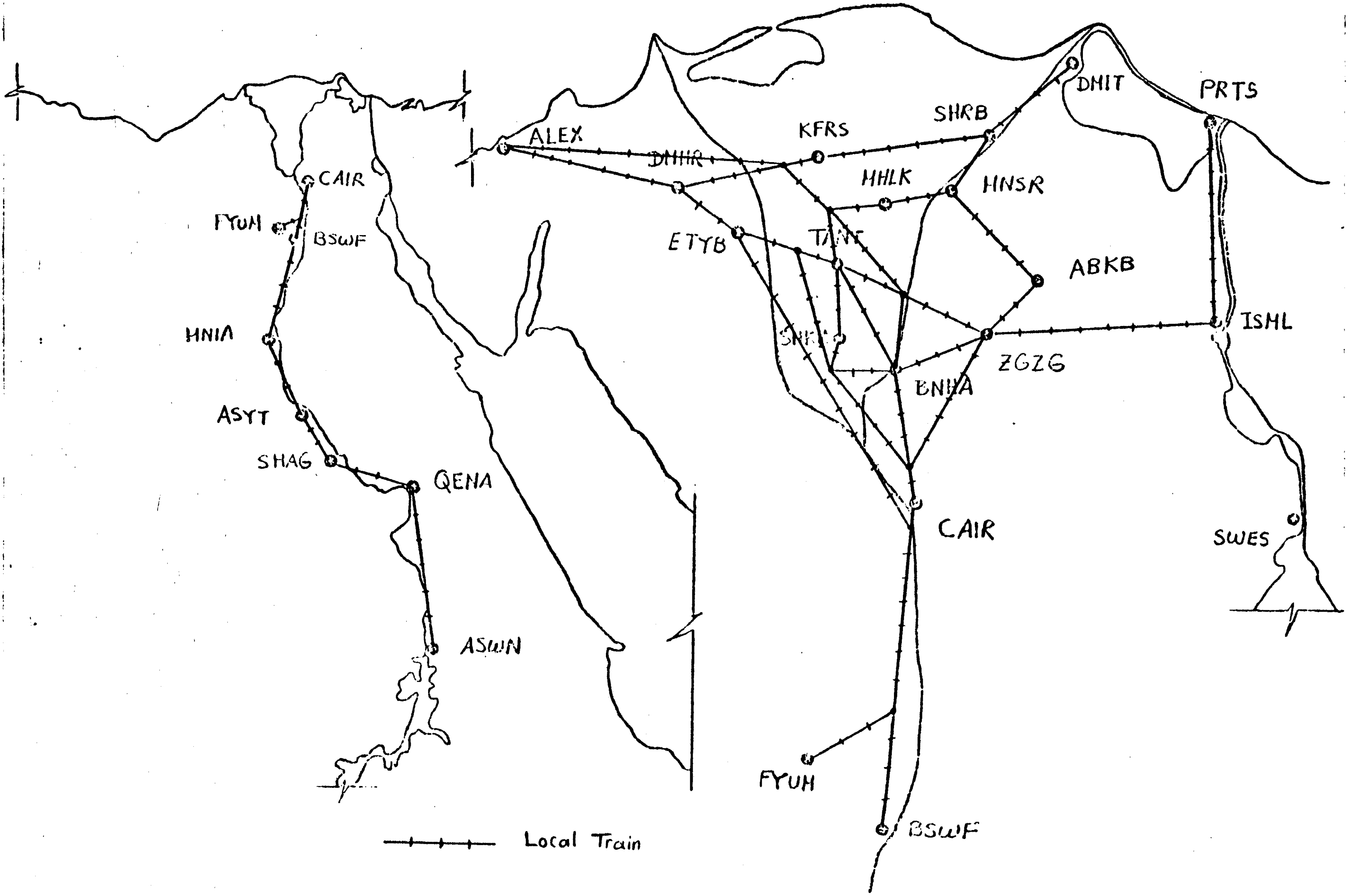

Figure 6.4 Local Train Network

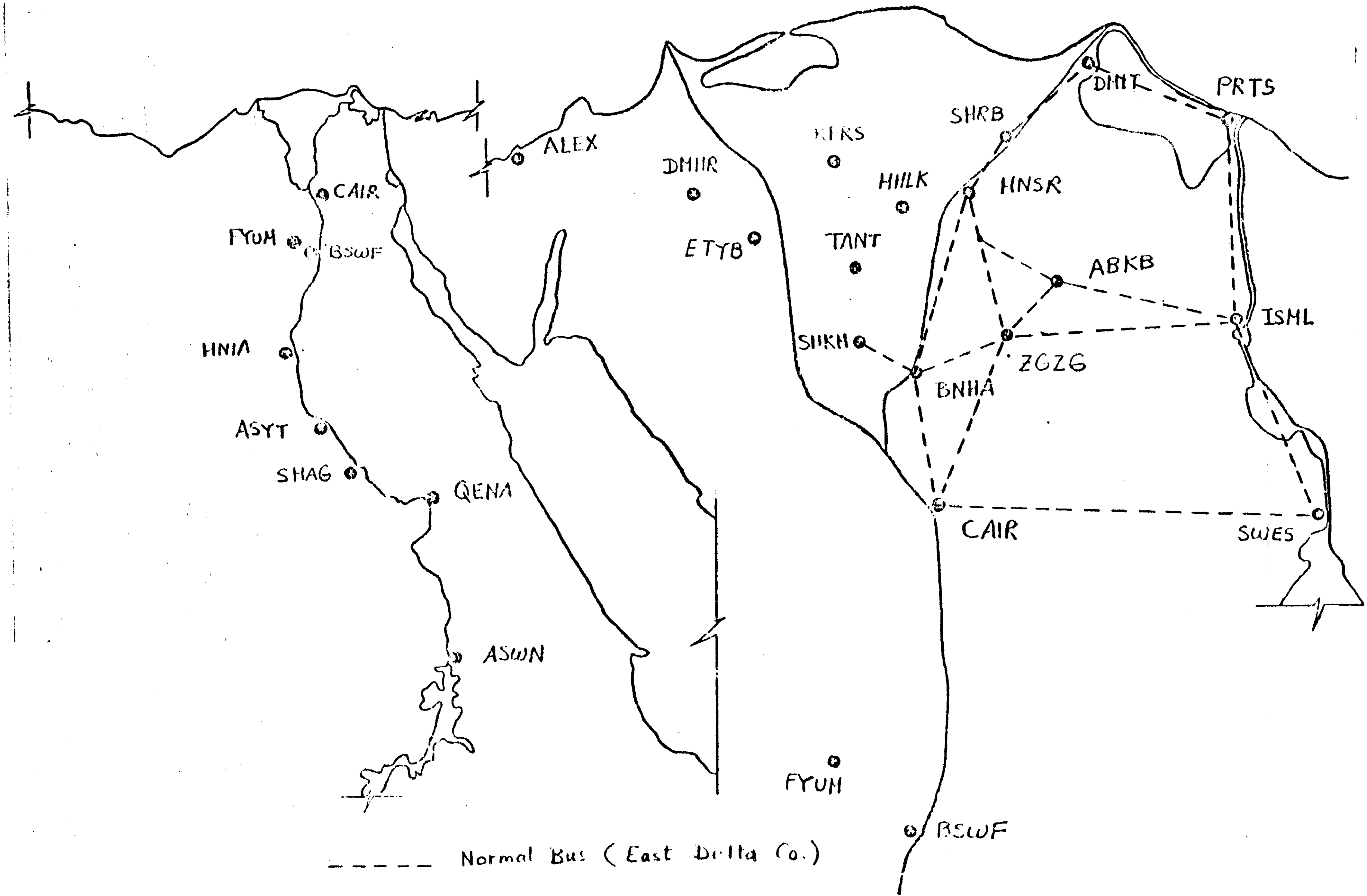

Figure 6.5 Normal Bus Network (East Delta Co.)

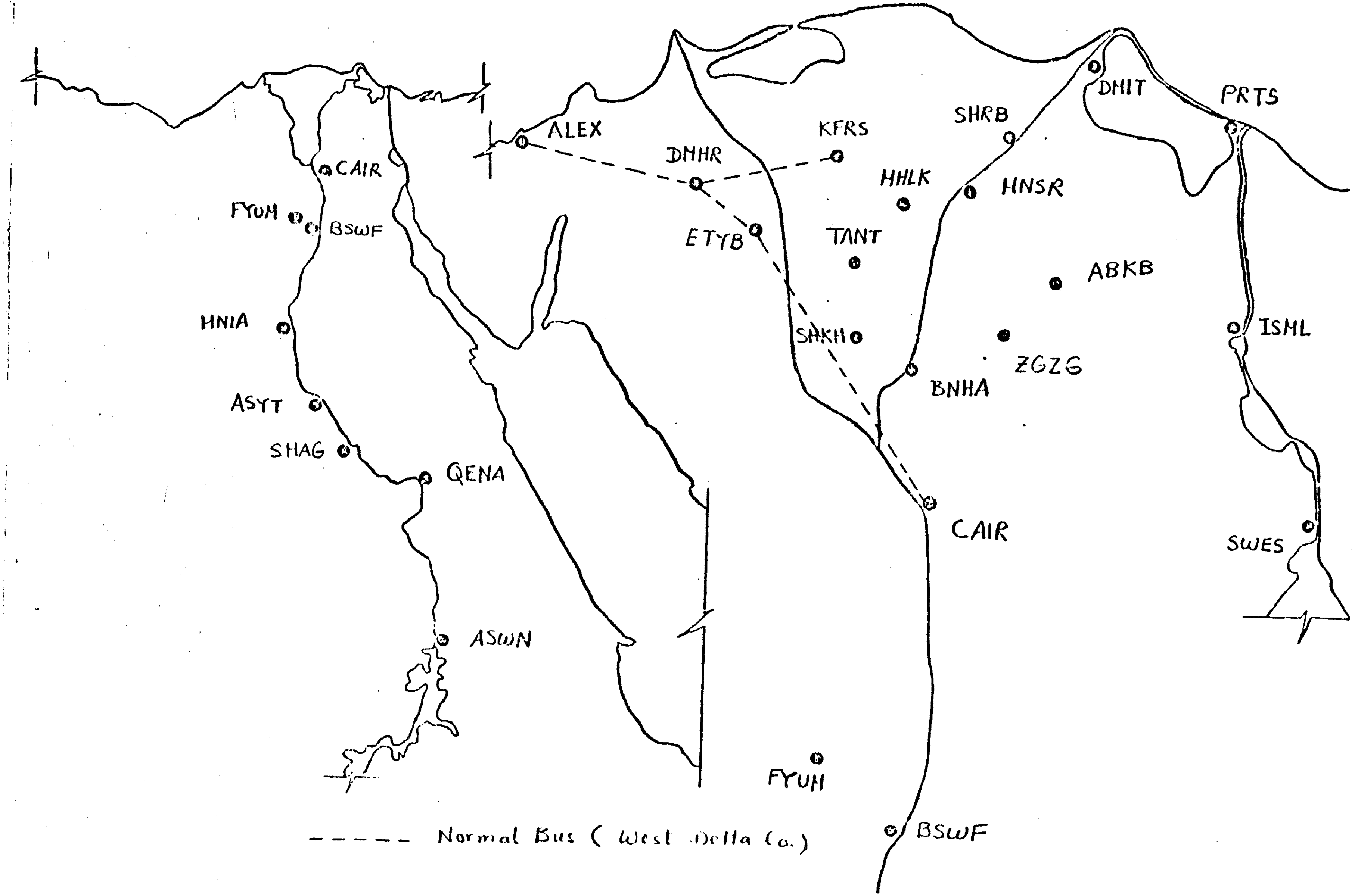

Figure 6.6 Normal Bus Network (West Delta Co.)

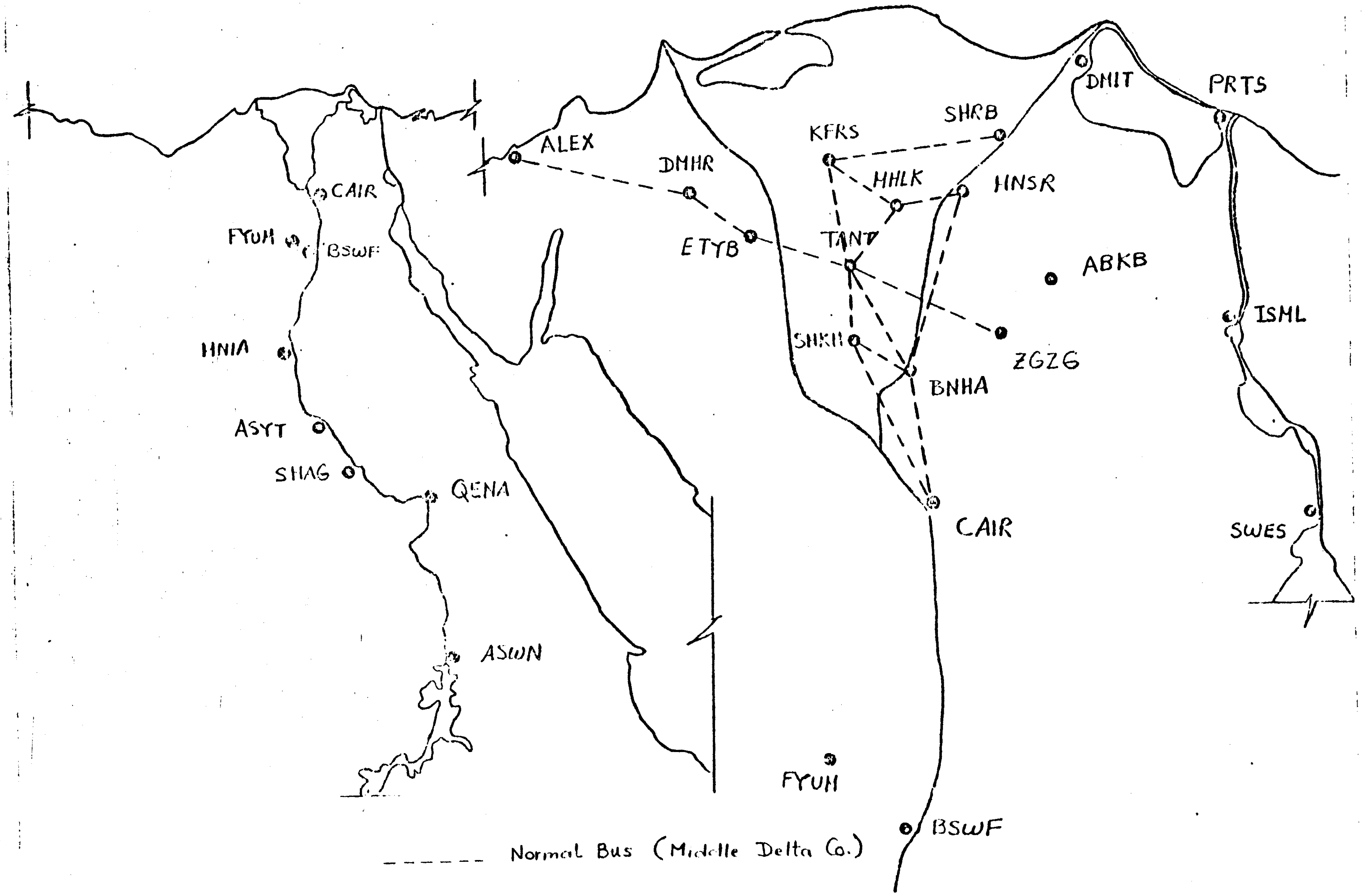

Figure 6.7. Normal Bus Network (Middle Delta Co.)

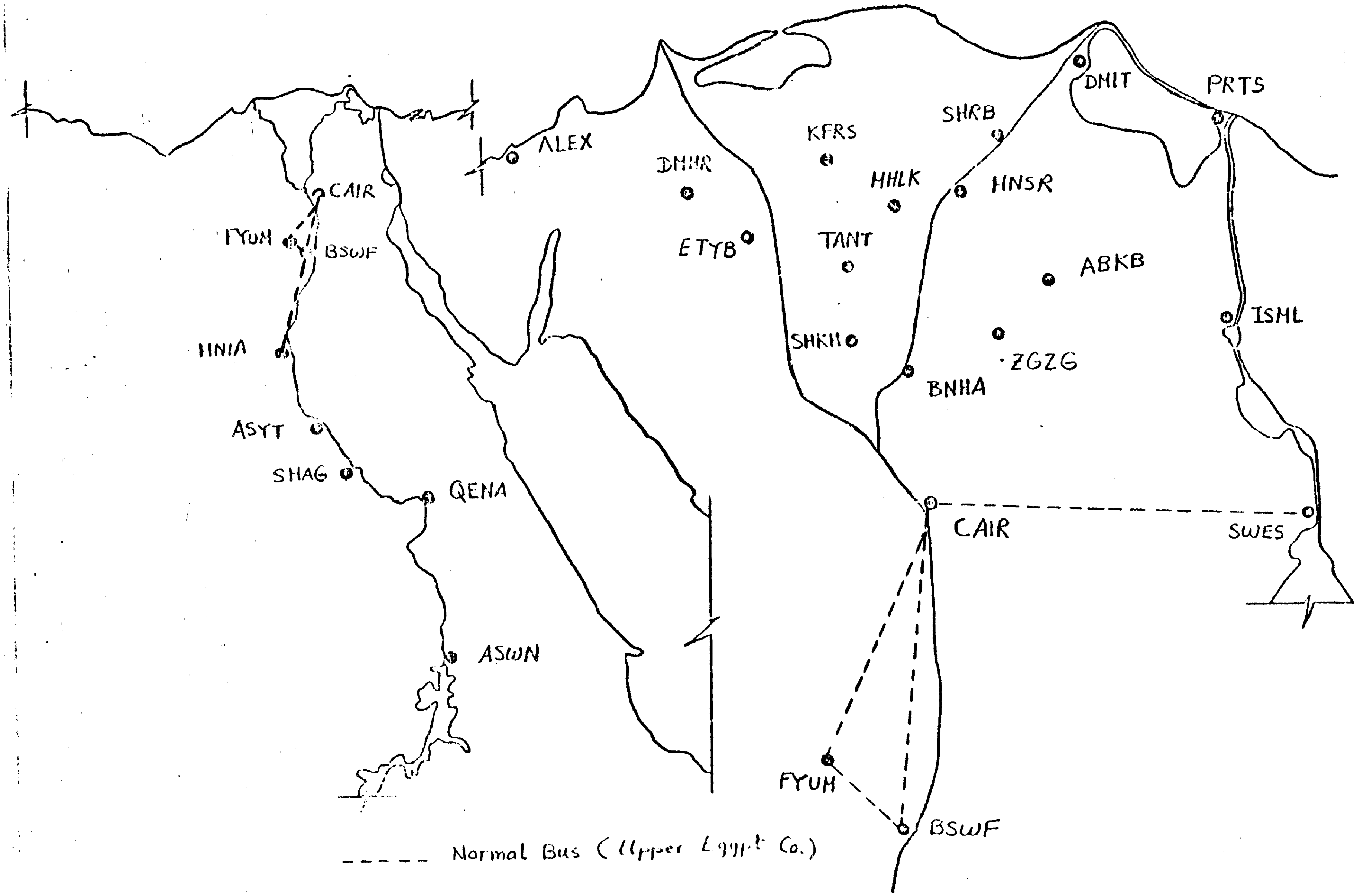

Figure 6.8 Normal Bus Network (Upper Egypt Co.)

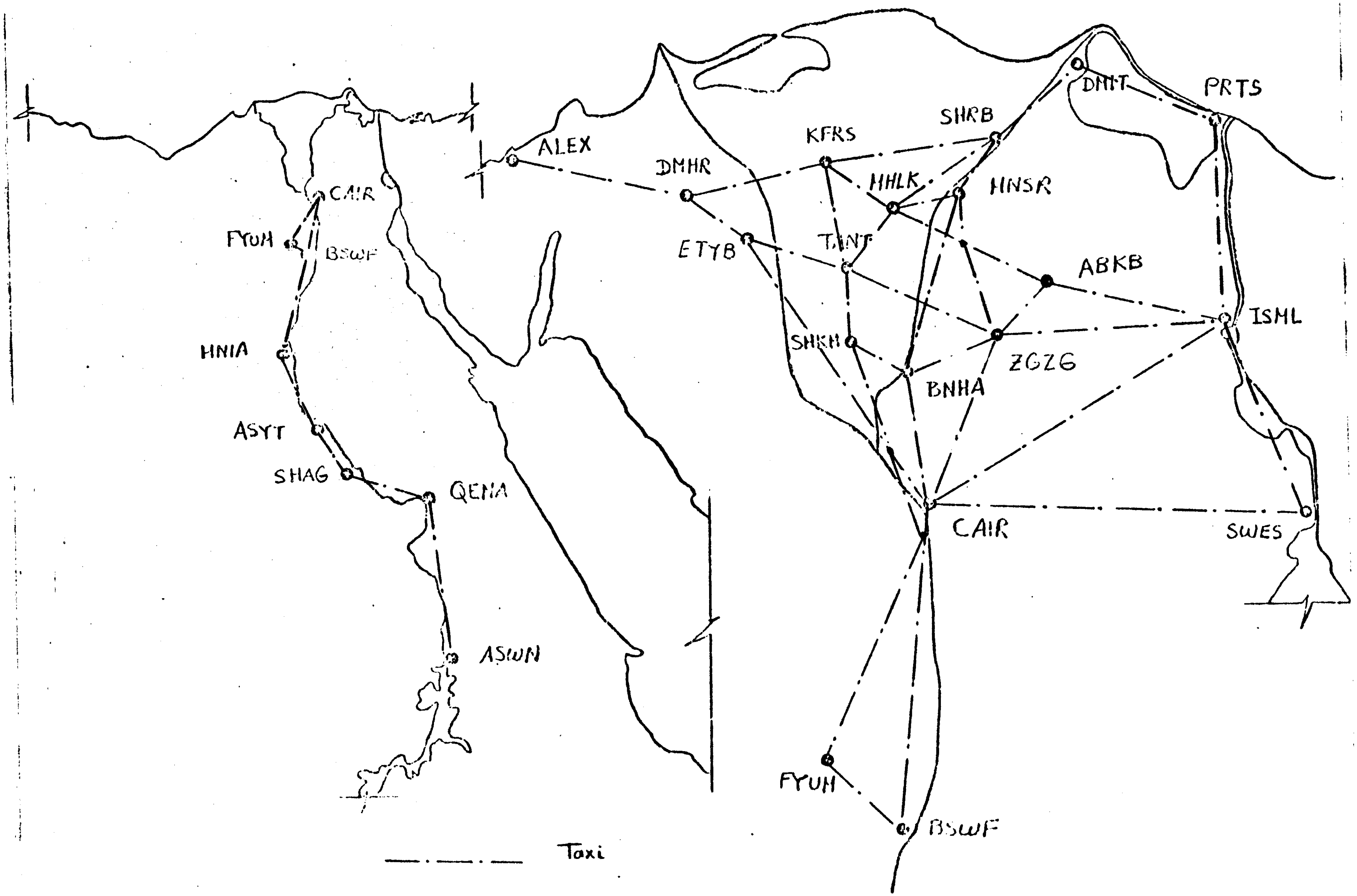

Figure 6.9 Taxi Network

shows the names of these 29 cities and Governorates (or portions of) that they represent. The table also shows the correspondence between our 24 zones defined by their abbreviated names and NEDICO's 29 zones. Essentially we have omitted four zones which have negligible passenger traffic; these are New Valley (in the western desert), Port of Safaga (on the Red sea coast), Sinai, and Marsa Matruh (on the Mediterranean sea near the Libyian boarders). In addition, we have combined Giza and Cairo-CBD into one traffic zone (i.e. Cairo) since both belong to one physical socio-economic center; that is, Greater Cairo Region.

Also notice that the specification of links in the modal networks shown in Figures 6.3 through 6.9, involves link-aggregation process aiming at reducing the multimodal network size. That is, a given modal link in these figures may represent a given path on the actual network. This aggregation process was done by Egyptian transport experts within the Intercity project (1982). The author reviewed their aggregated networks and introduced minor modifications to the highway network; the resulting modified aggregated networks are those shown in Figures 6.3 - 6.9 and used in this thesis.

To form a multimodal composed network we need to make assumptions about loading and unloading at different zonal centroids in the system. In our case study we assume that loading and unloading for a given mode may take place at all zonal centroids served by that mode. This assumption implies almost no restriction on transfer between modes wherever it is feasible to do so; this allows us to find out, from the analysis, the most important points of transfer in the system.

In order to achieve the objectives of our case study we have specifed three multimodal composed networks; the first includes express and local

Table 6.1 The Zoning System

	NEDECO's Zoning System		our zoning system
	Zone (Governorate) name	zone centroid	abbreviated names
1	Cairo Central Business District	CAIRO-CBD	CAIR
2	Giza	Giza	
3	Galyubia	Banha	BNHA
4	Sharkia (South)	Zagazig	ZGZG
5	Sharkia (North)	Abu-Kebir	ABKB
6	Dakahlia (East)	Mansoura	MNSR
7	Dakahlia (West)	Sherbin	SHRB
8	Domiat	Domiat	DMIT
9	Port Said	Port Said	PRTS
10	Ismaillia	Ismaillia	ISML
11	Swes	Swes	SWES
12	Minufia	Shebin El-Kom	SHKM
13	Gharbiya (South)	Tanta	TANT
14	Gharbiya (North)	Mahalla Kubra	MHLK
15	Kafr El-Shaikh	Kafr El-Shaikh	KFRS
16	Beheita (South)	Etay Baroud	ETYB
17	Beheira (North)	Damanhour	DMHR
18	Alexandria	Alexandria	ALEX
19	Western Desert	Marsa Matrah	--
20	Sinai	E-Swes Tunnel	--
21	El-Fayum	Fayum	FYUM
22	Bani-Swaif	Bani-Swaif	BSWF
23	El-Minia	Minia	MNIA
24	Asyut	Asyut	ASYT
25	New Valley	New Valley	--
26	Sohag	Sohag	SHAG
27	Qena	Qena	QENA
28	Aswan	Aswan	ASWN
29	Red Sea Coast	Port Safaga	--

trains only, the second includes bus in addition to express and local trains, and the third includes taxi as well. Below is a brief description of the size of each of these composed networks.

MULTIMODAL COMPOSED NETWORKS

	MODES INCLUDED	# LINKS*	# NODES
1.	Express and local trains	244	90
2.	Express, Local and bus	394	125
3.	Express, Local bus and taxi	534	152

A list of all the links in the third composed network (which include the others as subsets) with the user cost inputs for each link (see next section) are shown in appendix B.

6.3 USER PERCEIVED COST FUNCTIONS

In any transport system there are three major "actors" whose interactive actions determine the performance of that system; these are users, operators and owners of that system. Users represent transport demand and they are mainly concerned with the levels of service of different elements of the system such as linehaul travel times, waiting delays (e.g. at terminals), access and egress delays (i.e., loading and unloading), out-of-pocket fares, safety, discomfort, etc. Operators are those who provide transport modes for the users. An operator is mainly concerned with operation, investment and maintenance of his own fleet with the objective to attract as many users as possible and/or to maximize his net profits. Owners are those who provide the infrastructure for the benefit of users

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* # links includes loading and unloading links.

and operators. They are mainly concerned with the size and condition of their networks with the objective to accommodate the weights and sizes of existing and anticipated traffic.

System's performance may, then, be defined according to the perspective of each of these actors. In predicting equilibrium it is natural to define performance from the users' point of view.

As indicated in Chapter II, we assume that users perceive the system through a set of "generalized" cost functions defined at the link level and are dependent upon owners' and operators' policies as well as the system's usage. For a given set of owners' and operators' policies, link user cost is a function of the usage of that link.

For a given trip, average perceived cost may include the following cost components,

average user cost = travel time cost
+ tariff cost
+ cost of delay at intermediate nodes
+ loading and unloading cost

The first three cost components are incurred on the linehaul modal links while the fourth is incurred, by definition, on loading and unloading links as defined in the multimodal composed network.

Below, is a description of each of the above cost components; we indicate the basic assumptions involved in its calculation and the owner's and operators' policies which might be reflected through its value.

It should be mentioned at this point that one of the major problems in the Egyptian intercity system is the existence of fleet capacity constraints on rail and bus services. In fact, according to our knowledge, the state-of-the-art has yet to provide us with a satisfactory solution to this problem.* Nevertheless, we have attempted to provide an "approximate" solution by letting travellers perceive very high costs on those elements where fleet capacity has been exceeded assuming that the constraint may be reflected at the link level. This is reflected through an additional term in the user cost function (see subsection 6.3.5)

6.3.1 Travel Time Cost

For a given user type (in our case, low income group), travel time cost of traversing a given modal link is the multiplication of the "average" travel time of traversing that link (on that mode) by the "value of time" for that user type. That is,

$$TTC^k_{am} = VT^k \cdot TT_{am}$$

where TTC^k_{am} = travel time cost as perceived by user type "k" traversing link "a" on mode "m". (in £.E.)

VT^k = value of time of user type k (in £.E/Hour)

TT_{am} = average travel time of traversing link "a" on mode "m" (in hours)

As far as the value of time is concerned, NEDECO (1981)** has developed the following relationship between the value of time and average annual

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* A specific definition of the problem and a description of how it may be resolved theoretically is provided in subsection 6.3.5.

**NEDECO (1981) conducted a modal split survey on the Cairo-Banha-Tanta-Damanhour-Alexandria Corridor (its area of influence contains nearly one half of the total population in the Delta). The sample size was 1716 passengers. The survey was conducted in 1979 and is considered to be the main source of information about passenger characteristics and travel behavior on the Egyptian intercity system.

income,

VTM = 1.2+0.0026Y

where VTM = value of time (in milliems/minute)

Y = average annual income (in £.E.)

Therefore, to estimate VT (in £.E./hour) for the low income group in our case study we need to obtain a reasonable estimate of their average income. The modal split survey of NEDCO provides us with modal shares and average income of users of each mode. Our passenger types-choice sets mapping indicates that the main choices of low income people are third class train and normal bus. Table 6.2 shows the split of low income passengers between these two modes and the average annual income of users of each mode [this table is extracted from NEDECO (1981), Annex II, pages 3.27 and 3.29].

Table 6.2 Modal split and average income of low income passengers

mode	modal split %	average annual income (£.E.)
Normal bus	37	598
Third class train	63	450

Based on this table, the average annual income of low income passengers is estimated at 505 (£.E) and consequently, their value of time is estimated at 0.15078 (£.E./Hour).

The average travel time on a given link depends upon a number of factors related to the link itself, the mode used to traverse that link, traffic congestion, and operating regulations.

Factors related to the link may include # of lanes, lane and shoulder width, right of way, grade, pavement condition, etc., for highway; and track type (i.e. single or double), track condition, grade, etc, for railway. We assume that such factors may be reasonably captured through the link (and track) classification suggested in the Intercity project (1982) and shown in tables 6.3 and 6.4. Notice that this classification also captures the operating regulations pertaining to maximum and practical speed limits.

Factors related to the mode of travel may include weight, size, horse power, age, condition, etc, for highway vehicles; and length, weight, tractive power, etc., for trains. We assume that the effect of these modal charactersitics on average travel time may be taken into consideration through a set of "modal speed factors" defined as follows [see Intercity Project (1982)],

mode	speed factor (SF)
Taxi	0.9*
Normal bus	0.7
Express train	0.75
Local train	0.7

*This is assumed to include any delay at intermediate nodes.

These speed factors may be multiplied by link speeds to obtain "modal speeds." Notice that operating regulations pertaining to priorities of express over local trains is, in a sense, reflected through the difference between their speed factors.

Table 6.3

HIGHWAY NETWORK

CLASSES

```
CLASS NAME                DESCRIPTION
--------------------      -----------------------------------------------------
A_12_X_3.75_M             12 X 3.75 M -- 1750 PCE/HR/LANE --   PAVED SHOULDERS
B__8_X_3.75_M              8 X 3.75 M -- 1750 PCE/HR/LANE --   PAVED SHOULDERS
C__6_X_3.75_M              6 X 3.75 M -- 1750 PCE/HR/LANE --   PAVED SHOULDERS
2P_4_X_3.75_M              4 X 3.75 M -- 1750 PCE/HR/LANE --   PAVED SHOULDERS
2__4_X_3.75_M              4 X 3.75 M -- 1700 PCE/HR/LANE -- UNPAVED SHOULDERS

3P_2_X_3.75_M              2 X 3.75 M -- 1650 PCE/HR      --   PAVED SHOULDERS
3__2_X_3.75_M              2 X 3.75 M -- 1600 PCE/HR      -- UNPAVED SHOULDERS
4P_2_X_3.50_M              2 X 3.50 M -- 1110 PCE/HR      --   PAVED SHOULDERS
4__2_X_3.50_M              2 X 3.50 M -- 1080 PCE/HR      -- UNPAVED SHOULDERS
5P_2_X_3.25_M              2 X 3.25 M -- 1090 PCE/HR      --   PAVED SHOULDERS

5__2_X_3.25_M              2 X 3.25 M -- 1050 PCE/HR      -- UNPAVED SHOULDERS
6P_2_X_3.00_M              2 X 3.00 M -- 1050 PCE/HR      --   PAVED SHOULDERS
6__2_X_3.00_M              2 X 3.00 M -- 1020 PCE/HR      -- UNPAVED SHOULDERS
7__4_X_3.25_M__URBAN       4 X 3.25 M --  750 PCE/HR/LANE -- URBAN DIVIDED
```

```
                                                        FREE-FLOW   SPEED AT     LINK
                                     WIDTH   SHOULDERS    SPEED     CAPACITY   CAPACITY
HIGHWAY CLASS              TYPE       (M)       (M)     (KM/HR)     (KM/HR)    (PCE/HR)
--------------------     -------    -----   ---------  ---------   --------   --------
A_12_X_3.75_M            DIVIDED    45.0       5.0        100.         55.      21000.
B__8_X_3.75_M            DIVIDED    30.0       5.0        100.         55.      14000.
C__6_X_3.75_M            DIVIDED    22.5       5.0        100.         55.      10500.
2P_4_X_3.75_M            DIVIDED    15.0       5.0        100.         55.       7000.
2__4_X_3.75_M            DIVIDED    15.0       0.0        100.         55.       6800.

3P_2_X_3.75_M            TWO-WAY     7.5       2.0         95.         50.       1650.
3__2_X_3.75_M            TWO-WAY     7.5       0.0         95.         50.       1600.
4P_2_X_3.50_M            TWO-WAY     7.0       2.0         95.         50.       1110.
4__2_X_3.50_M            TWO-WAY     7.0       0.0         95.         50.       1080.
5P_2_X_3.25_M            TWO-WAY     6.5       2.0         90.         50.       1090.

5__2_X_3.25_M            TWO-WAY     6.5       0.0         90.         50.       1050.
6P_2_X_3.00_M            TWO-WAY     6.0       2.0         75.         45.       1050.
6__2_X_3.00_M            TWO-WAY     6.0       0.0         75.         45.       1020.
7__4_X_3.25_M__URBAN     DIVIDED    13.0       6.0         40.         30.       3000.
```

Table 6.4

RAILWAY NETWORK

TRACK CLASSES

TRACK CLASS	DESCRIPTION	TYPE	PRACTICAL SPEED (KM/HR)	DAILY OPERATING HOURS	BALLAST (TONS/KM)
TRACK-1	DOUBLE TRACK -- EXCEEDS 100 KPH OR 80000 TPD	DOUBLE	100.	24.0	3600.
TRACK-2	SINGLE TRACK -- EXCEEDS 100 KPH OR 40000 TPD	SINGLE	100.	24.0	1800.
TRACK-3	DOUBLE TRACK -- EXCEEDS 60 KPH OR 30000 TPD	DOUBLE	60.	24.0	3000.
TRACK-4	SINGLE TRACK -- EXCEEDS 60 KPH OR 15000 TPD	SINGLE	60.	24.0	1500.
TRACK-5	SINGLE TRACK -- BELOW 60 KPH OR 15000 TPD	SINGLE	40.	24.0	1200.
TRACK-6	SINGLE TRACK -- BELOW 60 KPH AND 15000 TPD	SINGLE	40.	12.0	1200.

As far as traffic congestion is concerned, we assume that, on railway, it has been captured through the definition of "practical speeds" on different track classes. On highway, it seems that most of the network is practically not congested. NEDECO calculated the flow/capacity (V/C) ratios for about 80 intercity road-sections; 80% of these road sections were having (V/C) ratios less than 0.5 indicating stable (unrestricted) flow conditions and that there is hardly any interaction between the individual vehicles in the flow; 11% of these road sections were having (V/C) ratios between 0.5 and 0.75 indicating the existence of some restrictions on the operating speeds of fast vehicles (e.g. taxis); 5% of the road sections were having (V/C) ratios between 0.75 and 0.9 indicating more restrictions on the operating speeds of all but slowest vehicles; 4% of the road sections were having (R/C) ratios above 0.9 indicating that congested flow conditions will arise during the peak hours (i.e. at most two hours during the day). [see NEDECO (1981) Annex IV pages 4.37 - 4.41]. Therefore, we can safely assume that traffic congestion on the Egyptian intercity highway network is not a problem and may be neglected in our analysis.

Hence, average travel time on modal links will be calculated as follows:

$$TT_{am} = L_a/(S_a.SF_m)$$

where

L_a = Length of link a [km]

S_a = average speeds on link a (i.e., free-flow speed on highway and practical speed on railway). [KPH]

SF_m = speed factor of mode "m"

6.3.2 Tariff Cost (TF):

Tariff (or out-of-pocket) cost of traversing a given modal link is calculated from the tariff per unit distance multiplied by the length of that link. That is,

$$TF_{am} = TF_m \cdot L_a$$

where

TF_{am} = total tariff cost on mode "m" traversing link "a" (£.E.)

TF_{am} = tariff per unit distance on mode "m" (£.E./km)

This implies that unit tariffs are independent of the actual distance travelled, an assumption that does not hold in the Egyptian system where tariffs are distance dependent. However, it was necessary to assume some "average" unit tariff since we do not know the actual distance travelled by any of the users of the system. Based on the actual tariff structure and the observed trip length distribution of differenct user types, the Intercity Project (1982) calculated a "linearized" tariff structure (see table 6.5). In table 6.5, the entry charge for any given mode is the value of the linearized tariff at zero distance, we assume that such a cost is incurred when entering that mode and added to costs on all loading links of that mode. Also, in table 6.5, notice that we have assumed that the linearized tariff of express train is 10% higher than that of local. This assumption is based on a review of actual fares of III-class on express train compared to local train.

Table 6.5 Passenger Tariffs

Mode	Entry Charge	per km tariff	Source
Local Train	0.027	0.0019	*
Express Train	0.0297	0.00209	Assumed (+10%)
Normal Bus	0.03893	0.0022	*
Intercity Taxi	0.15	0.00675	*

*Source: Intercity Model (1982)

6.3.3 Cost of Delay at Intermediate Nodes

Recall that a given modal link may represent a path on the actual network. This implies the possibility of stopping at any of these intermediate nodes when traversing that link. In fact, the major distinction between express and local trains is that the first only stops at "major cities and towns" while the later stops at all towns and villages. In order to account for these intermediate stops in our analysis, we need to identify all cities, towns and villages in the system, specify for each mode those nodes that it stops at and the average delay incurred in each stop. In the Intercity Project (1982), nodes were classified according to their level of importance into three categories: Governorate capitals, marakez (i.e., major cities and towns) and villages. Express train service is assumed to stop at Governorate capitals and Marakez only, while local trains are assumed to stop also at villages. The delay incurred at each stop is assumed to be 0.2, 0.15, and 0.10 (hour) for Governorate capital, Marakaz, and village respectively. Table 6.6 summarizes these assumptions.

Table 6.6 Delays at Stations*

Train stops at		Station	Delay (Hr)
Express	Local		
✓	✓	Governorate	0.2
✓	✓	Markaz	0.15
x	✓	Village	0.10

*Source: Intercity Model (1982)

As far as other modes (i.e., Taxi and bus) is concerned we assume that their speed factors capture delays at intermediate nodes as well.

Of course, the cost of these delays (for express and local trains) is calculated by multiplying the delay incurred in traversing a given link by the value of time.

6.3.4 Loading and Unloading Cost

The cost of loading and unloading includes the cost of waiting time (for loading only) and the cost of travel between the actual point of origin (or destination) and the terminal (of the mode under consideration) at the zone of departure (or arrival).

Average waiting time for scheduled modes (i.e., bus, express train and local train) depends upon the expected time for purchasing a ticket (if purchased before departure), the expected crowding of the mode at departure, the expected delay of departure compared to the scheduled time, and the schedule frequency. The expected time for purchasing a ticket depends upon the advantages associated with obtaining a ticket before departure such as reserving a seat or not paying a prespecified fine on-board, and the expected delay on the queue. The expected crowding of the mode will determine the amount of time a given passenger would be willing to spend at the terminal (most probably waiting in the mode) before departure time. The expected delay of departure depends upon several management and operating constraints on the mode. The schedule frequency may greatly influence the expected waiting time and hence mode choice. For example, suppose that a given mode has a frequent daily service while another has a non-frequent weekly service. The expected waiting time for the first mode is far less than that for the second. This may be captured in our model through the expected waiting time on loading links as a function of the service frequency provided that we invoke appropriate assumptions about service and passengers' arrival behaviors. Considering all of the above factors we expect the average waiting time for scheduled modes to increase as the number of passengers increases.

This may not be the case for the non-scheduled mode (i.e., the taxi). Because it is more flexible and responsive to demand, a given taxi would be filled with passengers quicker at higher levels of demand than at lower levels. On the other hand, one might argue that waiting time for the taxi increases as demand does, because at higher levels of demand there would be more chance of not finding a taxi standing at the terminal at the time of arrival of any given random passenger while the opposite is true at lower levels of demand. Which senario is closer to actual behavior is dependent on the "responsiveness" of taxi to demand. Assuming that the taxi is very responsive to demand, the first arguement would be more appropriate and vice versa.

The average cost of travel to/from the terminal from/to the point of origin/destination depends upon so many factors that are not directly related to intercity transport such as the distribution of intercity passengers within any given zone, intra-zonal travel cost between different locations of passengers and different modal terminals and the passenger type under consideration. As the size of the zone becomes larger and its population becomes more dense we expect loading and unloading cost to increase.

Estimating the above costs (for waiting time and intrazonal travel) appears to be a tedious task. In general we need to estimate 96 (i.e., 24 zones x 4 modes) values for waiting time and 96 values for intrazonal travel costs (assuming that it is the same for loading and unloading at a given zone). Each value requires a considerable amount of information about the zone under consideration. As of now the information available to us from the Intercity project (1982) is the average delay of loading and unloading for the four modes at different zones and is shown in table 6.7. Essentially they assume that waiting time is 1, 1, 0.5 and zero (hour) for local train, express train, bus and taxi respectively; and this applies to all zones. Intrazonal delay is assumed to vary for different zones and modes. The basis for these assumptions are not known and the information provided may be considered, as far as the author is concerned, as "crude" estimates. Nevertheless, these estimates are used in our case study. On loading links we multiply loading delays (from table 6.7) by the value of

Table 6.7 Loading/Unloading Delays (Hr)*

Zone	Local Train		Express Train		Normal Bus		Taxi	
	Loading	Unldg.	Loading	Unldg.	Loading	Unldg.	Loading	Unldg.
ALEX	1.7	0.7	1.7	0.7	1.2	0.7	0.7	0.7
DMHR	1.7	0.7	1.5	0.5	1.6	1.1	0.7	0.7
ETYB	2.2	1.2	1.9	0.9	2.3	1.8	1.2	1.2
KFRS	1.8	0.8	1.6	0.6	1.7	1.2	0.8	0.8
MHLK	1.0	0.1**	1.0	0.1**	0.5	0.1**	0.1	0.1**
TANT	1.2	0.2	1.2	0.2	0.7	0.2	0.2	0.2
SHKM	1.4	0.4	1.3	0.3	1.0	0.5	0.4	0.4
BNHA	1.2	0.2	1.2	0.2	0.8	0.3	0.2	0.2
CAIR	1.3	0.3	1.3	0.3	0.8	0.3	0.3	0.3
ZGZG	1.4	0.4	1.3	0.3	1.1	0.6	0.4	0.4
ABKB	1.3	0.3	1.2	0.2	0.9	0.4	0.3	0.3
MNSR	1.7	0.7	1.5	0.5	1.5	1.0	0.7	0.7
SHRB	1.4	0.4	1.3	0.3	1.1	0.6	0.4	0.4
DMIT	1.1	0.1	1.1	0.1	0.7	0.2	0.1	0.1
PRTS	1.2	0.2	1.2	0.2	0.7	0.2	0.2	0.2
ISML	1.1	0.1	1.1	0.1	0.7	0.2	0.1	0.1
SWES	1.2	0.2	1.2	0.2	0.7	0.2	0.2	0.2
FYUM	1.2	0.2	1.1	0.1	0.8	0.3	0.2	0.2
BSWF	1.4	0.4	1.3	0.3	1.1	0.6	0.4	0.4
MNIA	1.9	0.9	1.7	0.7	1.8	1.3	0.9	0.9
ASYT	1.6	0.6	1.4	0.4	1.3	0.8	0.6	0.6
SHAG	1.6	0.6	1.5	0.5	-	-	0.6	0.6
QENA	2.4	1.4	2.0	1.0	-	-	1.4	1.4
ASWN	1.8	0.8	1.6	0.6	-	-	0.8	0.8

* Source: Intercity Model (1982)

** assumed

time (estimated in subsection 6.3.1) and add the entry change (from the linearized tariffs of subsection 6.3.2). The cost on unloading links is the multiplication of unloading delays and the value of time.

6.3.5 Fleet-Capacity-Constraint Cost

As indicated earlier, fleet capacity constraints on railway and intercity bus is a major problem in the Egyptian transport system and cannot be ignored in our analysis. According to our knowledge there exists no satisfactory solution to this problem in the available literature. In this subsection we will attempt to provide an "approximate" solution to the problem. In our discussion we will focus on the railway where the problem is more serious than it is on the bus; also it turns out that its solution for railway is more challenging, as will be seen shortly.

The railway passenger fleet includes different components (e.g., I and II class airconditioned cars, II and III class non-airconditioned cars, different types of locomotives) and is owned by the Egyptian Railway Authority (ERA). The size, condition, and operation of fleet components depend upon the investment, maintanence and operating policies of the ERA (i.e., the railway operator). The fleet capacity constraint is, by definition, a characteristic of the individual fleet components but is realized at the operator level. In other words, whether the capacity of a given fleet component is constrained or not depends upon the operator's policies related to that component in response to the current demand. To be more specific, recall that tractive power is the major fleet capacity constraint on rail (see chapter V). Locomotives are used to pull trains composed of different types of cars and classes carrying different types of passengers. Therefore, the required tractive power will depend upon the demands of different types of passengers, the train composition and schedule. The available tractive power, on the other hand, depends upon the investment, maintenance and allocation of tractive power to different service types. If the required tractive power happened to exceed the available, the capacity of that component is considered to be constrained.

The most accurate approach to deal with this problem is to introduce a set of constraints to the optimization problem. A given fleet capacity constraint in the mathematical formulation would be as follows:

$$\sum_{a} \sum_{m} TT_{am} \cdot N_{amc} < T_c$$

where

T_c = available hours of component "c"

N_{amc} = required number of components "c" to accommodate flow of of all passenger types on mode "m" traversing link "a".

TT_{am} = travel time of traversing link "a" by mode "m"

The required number of components "c", N_{amc}, is generally a non-convex non-concave function of the vector of flows of all user types on mode "m". Therefore, the addition of such constraints to the optimization problem will create computational difficulties in terms of efficiency and convergence.

An approximate solution to the problem is to introduce a term in the link user cost function that drives the user cost to a very high value whenever the fleet capacity is exceeded. Such a term might, in general, be of the following form:

$$FCC^{k}_{am} = \delta \left(\frac{FLOW}{CAPACITY}\right)^{\beta}$$

where

FCC^k_{am} = fleet-capacity-constraint cost as perceived by user type "k" travelling on link "a" by mode "m",

δ and β are positive constants

This term is very similar to the usual congestion term on cost functions except that the constants δ and β are to be determined to reflect very low values whenever the flow/capacity ratio is less than one and very high value wherever the ratio exceeds one. That is, δ should be as small as possible and β as large as possible. In addition, the "capacity" in this expression refers to the fleet and not the link per se.

The choice of values for δ and β affects the steepness of the cost function which would have implications on the computational efficiency of the prediction process; the steeper the cost function is, the more computer time would be requied to achieve a given level of accuracy. On the other hand, our accuracy of representing the fleet capacity constraint increases as the cost function becomes steeper; that is, as δ decreases and β increases. In our case study we assume a "sufficiently" small value for δ (i.e., δ=0.1) and a sufficiently large value for β (i.e., β=20). It may be useful to mention at this point that similar approximations to deal with the problem of hard link capacity constraints have been suggested by several researchers such as Daganzo [1977] and Hearn [1979].

In the flow/capacity ratio, "capacity" refers to the available fleet capacity for a given user type on a given modal link. For the scheduled modes (i.e. bus, express train, and local train) fleet capacity may be calculated given the passenger types-choice sets mapping, train composition, load factors and the daily schedule. Table 6.8 shows this information and how the calculations may be carried out. The output of these calculations should give us the number of a given passenger type which can be transported daily on different modal links given the modal schedules.

Table 6.8 Fleet Capacities

#	Item	Local Train	Express Train	Normal Bus	Intercity Taxi
1	# Components/train	6 III class	5 III class	-	-
2	# Seats/Component	304	304	69	-
3	Load factor	1.5	1.0	1.26	1.29
4	Occupancy per train or vehicle	2736.	1520.	87	5.7*
5	# Vehicles/link	See Schedules, Intercity Model			**
6	Fleet Capacity	(# of vehicles/link).(occupancy per vehicle)			

Source of Information: Intercity Model (1982)

* Source: NEDECO (1981)
**Calculated as shown in subsection 6.3.5

As far as the taxi is concerned, its fleet capacities on different links is much more difficult to obtain since the taxi has no schedules, it is rather responsive to demand. Fortunately, in our case study the taxi is not one of the major modes and we expect it to carry only the demand which exceeds the fleet capacity of the other three modes. Therefore, a rough estimate of the taxi's fleet capacities would be sufficient for our purpose. Our task (see table 6.8) is to obtain a reasonable estimate of the number of taxis which would be available to travel on each link of the network. From the Intercity project (1982) we know highway link capacities (in PCE/Hr) and average daily operating hours for the taxi (i.e., daily operating hours = 6.7 hrs). It remains to estimate average percentage of taxis (in PCE/Hr) on different highway links. NEDECO (1981) calculated vehicle composition on highway in 1979 and the PCE* factors for different vehicle types. Based on their results, we calculated average % taxis on highway links (at 12.2%) as shown in table 6.9. We assume that, since the taxi is responsive to demand, the number of taxis on any given link may increase until that link approaches its capacity given the average vehicle composition.

Table 6.9 Highway Vehicle Composition

Vehicle	% Highway Vehicle Composition	PCE* Factor	% PCE (calculated)
Auto	20	1	8.8
Taxi	28	1	12.2
Pick-up	11	1	4.8
Bus	5	4.7	10.2
Single Truck	25	3.1	33.8
Truck Combinations	11	6.3	30.2

That is, the maximum number of taxis on any given link may be estimated at

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* Passenger Car Equivalence

12.2% of the capacity of that link. In specific terms,

taxis/Link = Link capacity (PCE/hr)
X daily operating hours
X % taxis on that link (% PCE/hr)

In the flow/capacity ratio, "flow" refers to the number of a given passenger type on a given modal link. The "flow" value is a variable obtained from the traffic assignment results on the multimodal composed network at any given iteration in the prediction process. Whenever the "flow" exceeds "capacity" on a given link at a given iteration, the cost of that link at the next iteration will be very high indicating that portion of the flow should be shifted to another unconstrained link. These adjustments in the flow pattern continue until we arrive at a state of equilibrium where demands on different modes are practically feasible (i.e., within the available fleet capacity) and at the same time in accordance with the behavioral assumptions of the system (see chapter II).

Inputs to all of the above terms in the perceived user cost functions (obtained as indicated above) for all links in the multimodal composed networks are presented in appendix B.

As a final comment in this section, notice that our cost functions are separable (i.e, non-interacting). Maintaining this characteristic of cost functions is essential for our approach to predict an "exact" equilibrium. We were able to maintain this separability because the Egyptian intercity system is not congested with traffic (in the usual sense) and because we were able through our passenger-choice set mapping to separate the effects of fleet capacity constraints on low income passengers from others'. In other applications, however, especially in urban areas, interaction due to traffic congestion among several modes, would be an issue that should be explicitly addressed. In these situations we can still use the STEM methodology provided that the user cost functions are convex and their Jacobian matrix is symmetric. The convexity assumption may not be restrictive in many situations since it conforms with congestion characteristics especially on highway networks. The symmetry assumption implies that the congestion effect that one additional passenger (say, on bus) has on, say, an auto user is identical with the congestion effect that an addition auto user has on a bus passenger. This is an unrealistic assumption since auto and bus are quite different in terms of their congestion effects on each other, their occupancy rates, their speeds, etc. The violation of this assumption as would be expected in practice, implies that our pedictions do not converge to the exact equilibrium; instead, we would obtain an approximate solution. The magnitude and direction of the bias will depend upon the asymmetry of the Jacobian matrix. One would expect, for instance, that in cases of weak interactions and/or interactions between "similar" modes, the results would be reasonably close to the exact equilibrium. Also the violation of the symmetry assumption may imply non-uniqueness of the results. As a matter of fact it is very interesting to investigate these points in future applications of the STEM methodology.*

6.4 DEMAND FUNCTIONS

As indicated in chapter II, we assume that trip generation is given by

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*The STEM methodology is currently being aplied within the Intercity Project (1982) assuming the existence of interactions in the system. The results of this application should be quite useful in that respect.

a general linear model and trip distribution is given by a logit model. To apply the STEM methodology to any transport system we need to calibrate these demand models. That is, we need to specify each demand function and estimate α, α_ℓ for ℓ=1,...L of the trip generation model and θ, θ_w for w=1,...w of the trip distribution model, for each passenger type (see chapter II). The calibration approach consists of two steps. In the first step, a logit distribution model is calibrated. In the second step, a general linear trip generation model is calibrated with the accessibility variable calculated from the distribution model calibrated in the first step.*

As indicated earlier, our ability to represent demand behavior is constrained by the lack of a well-defined theory of trip generation and trip distribution behavior. On the Egyptian system we are constrained more by the lack of appropriate data as will be seen shortly.

Within these constraints we present the basic assumptions and results of the calibration of these demand models for our case study. We start by identifying the data available for calibration then discuss the calibration of the trip distribution model and finally introduce the results of the trip generation model.

6.4.1 Data for Calibration

Calibration using disaggregate data is thought to produce better results than using aggregate data, because in the later case we are losing some variability in the data due to aggregation. However, on the Egyptian system disaggregate data is not available and we have to calibrate our

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*Recall that accessibility equals the natural logarithm of the denominator of the trip distribution model.

demand models with the available aggregate data, this is expected to introduce some aggregation bias in our results.

The main types of data required for calibration are O-D matrices of trips and costs, and socio-economic data of passengers and zones. Our main source of data is NEDECO (1981).

O-D matrices are available for auto, taxi, bus and rail trips in 1979 (see appendix C). The highway O-D matrices (i.e., for auto, taxi and bus) are obtained in part from the in-bus and roadside surveys done in October 1979. The missing data is synthesized from the 1976 O-D matrices by fitting a doubly-constrained gravity model. The railway O-D matrix is obtained in part from the available data on registered passengers for the month of January 1979. The movement of "other passengers", which may represent about 50% of total railway passenger transport, is estimated based on sample survey. As far as the reliability of these O-D matrices is concerned, we notice that some items are synthesized and some others are estimated from a sample survey. This weakens their reliability. Egyptian transport experts believe, however, that these are the most reliable values which they could obtain.

O-D cost matrices are not available. Instead an O-D distance matrix is used for calibration (see appendix C).

The only available socio-economic data is the zonal population divided into urban and rural (see appendixc C). This indicates that we are very poor in terms of the availability of socio-economic explanatory variables for our demand functions. Limited data on the socio-economic characteristics of passengers is available in the modal split survey on the Cairo-Alexandria corridor. As will be seen shortly, we use this limited data to estimate the portion of low income passengers on different modes of travel.

6.4.2 Trip Distribution Model

The calibration results of the trip distribution model will depend upon the type and quality of data, number of observations used for estimation, number of parameters to be estimated, definition of passenger types and model specification.

As indicated in preceding subsection, the available trip distribution matrices are not reliable, and there is no socio-economic data available for calibration except for population.

The number of observations to be used in calibration is very large and the number of parameters to be estimated is very low (given the limitation in explanatory variables), and hence we expect to obtain reliable estimates for the model parameters given the input information.

As far as passenger types is concerned, we have already divided passengers into three categories and focused on low income group. The available O-D matrices of trips are given by mode and not by passenger type. Thus, in order to have a meaningful correspondence between any modal and passenger-type results we need to obtain a reasonable estimate of modal split particularly for the low income passengers. The modal split survey conducted within NEDECO in 1979 provides us with table 6.10 indicating the modal shares of different service types (i.e., disaggregated modes) which are classified according to a "quality index" reflecting their levels of service. According to our passenger types-choice sets mapping (see section 6.1), the main services in the choice set of low income passengers include fast bus (aggregated and classified as normal bus in our choice set definition), and third class train (including III-class on express trains), we assume that these types of service are mainly designed for low income people or alternatively that low income passengers are mostly captive to these services. Hence, with simply calculations based on the modal shares of table 6.10 we estimate that low income group constitute about 80% of rail passengers and about 75% of bus riders. The estimate of low-income rail passengers based on the modal split survey is strengthened by the fact that about 79% of passenger-kms produced by rail in 1979 belongs to III-class passengers as shown in table 6.11.

The model specification is very much affected by the lack of a well defined theory of trip distribution behavior and of the lack of relevant explanatory variables particularly on the Egyptian intercity system. It seems that the starting point to overcome this defficiency is to conduct a trip distribution survey for selected origins and destinations in the system. The second stage would be to develop a regional socio-economic data base which include the most important variables that influence trip distribution behavior in the Egyptian system. In fact such variables would be very useful for other regional planning studies as well. Of course such efforts would constitute a complete study by itself and is yet to be done.* Nevertheless, given the current lack of theory and supportive variables, the model specification used in the Intercity Project (1982)** is as follows:

$$T_{ij} = G_i \frac{\exp(-\theta_o d_{ij} + \theta_1 \ell_n D_j)}{\sum_k \exp(-\theta_o d_{ik} + \theta_1 \ell_n D_k)}$$

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* the same applies to trip generation

**the specification and calibration using modal O-D matrices of trip distribution model were performed by Abdel Nasser (1982) of Cairo Univ.

Table 6.10 Modal split on Cairo-Alexandria Corridor*

Quality index		Main modes	pct	
1. "Excellent"	:	Lux Pullmann	0.4	3.0
		Super Lux Pullmann	0.4	
		First class train airco	2.2	
2. "Good"	:	Flight Pullmann	0.2	4.6
		Second class train airco	4.4	
3. "Sufficient"	:	Arrow	0.5	18.4
		First class bus	6.8	
		Taxi	11.1	
4. "Moderate"	:	Fast bus	22.4	26.5
		Second class train other	4.1	
5. "Poor"	:	Normal bus	3.3	47.2
		Third class train	43.9	

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*Modal split survey, National Transport Study, phase II (NEDECO), 1981.

Table 6.11 E. R. passenger-kms, 1979

	E. R. passenger-kms, 1979 (millions)	
I-Class	507	(3.5%)
II-Class	2431	(17.5%)
III-Class	11065	(79%)
*Source: NEDCO (1981)	1400	(100%)

where

d_{ij} = distance between i and j (km)

D_j = number of trips attracted to j (per day)

Θ_o and Θ_1, are parameters to be estimated

There are three comments related to the specification of this distribution model. The first is that the only attractiveness variable used is the number of trips attracted to different destinations and not even the population variable; this was thought to be more appropriate (given the lack of theory and data) since the variable D_j represents the resultant of the effects of all "unobserved" variables in addition to population. The second is the inclusion of D_j in a natural logarithmic form; this form has been suggested by Lerman (1975) particularly for variables that measure the "size" of destinations. We may assume that D_j is a "size" variable in the sense that each trip in D_j is presumably attracted to a given attraction point within the destination j and consequently it is reasonable to assume that D_j is a proxy variable for the number of attractive activities in that destination (i.e., elemental destination in Lerman's terminology), which in turn may be considered as the "size" of attraction of that destination. The third comment is that distance is used to reflect impedence between O-D pairs; of course this is a very simplified representation of O-D costs which implies perfect correlation between perceived user cost and distance, an assumption that is not necessarily true and that need to be corrected for.

The above trip distribution model has been calibrated within the Intercity Project (1982) by Abdel-Nasser of Cairo University for each of the four major modes: auto, taxi, bus and rail. The estimates of θ_o and

θ_1 were based on minimizing the sum of squares errors between predicted trips given by the above model (T_{ij}) and observed trips shown in appendix C. That is,

$$\text{Minimize } F(\theta_0,\theta_1) = \sum_{ij} (T_{ij} - T^o_{ij})^2$$

The Gauss Least-squares method was used to solve the above unconstrained minimization problem. The calibration results are shown in table 6.12. In table 6.12, the values between brackets are the t-statistics of the usual t-test; notice that those values are very high indicating a very high confidence that the true values of θ_0 and θ_1 are significantly different from zero.

To obtain the corresponding calibration results for the low-income-passengers trip distribution model we calculate a weighted average of θ_0 and θ_1 where the weights correspond to the modal split of low income group between bus and rail. That is,

$$(\theta_0)_{\text{Low}} = \frac{0.75}{0.75+0.80}(\theta_0)_{\text{Bus}} + \frac{0.80}{0.75+0.80}(\theta_0)_{\text{Rail}}$$

The same applies to θ_1. The results of this calculation implies the following values of θ_0 and θ_1 for low income people:

$\theta_0 = 0.01402$

$\theta_1 = 1.1044$

Table 6.12 Modal calibration results of trip distribution models

mode	model parameters	
	θ_0	θ_1
Auto	0.014279 (20.40)	1.130864 (28.94)
Taxi	0.020746 (29.97)	1.048772 (28.96)
Bus	0.013261 (13.33)	1.172638 (50.36)
Rail	0.014730 (21.25)	1.040413 (23.36)

The attraction variable, A_j, may then be calculated as follows:

$$A_j = 1.1044 \ \ell n \left[\frac{0.75}{1.55} (D_j)_{Bus} + \frac{0.80}{1.55} (D_j)_{Rail}\right] \text{ for all } j$$

Table 6.13 shows the calculated attraction of all destinations in the system.

It remains to estimate the parameter θ such that $\theta_o d_{ij} = \theta U_{ij}$ where U_{ij} is the minimum perceived cost of travel between i and j. This requires obtaining a reasonable estimate for U_{ij}, then θ may be calculated for selected O-D pairs; a weighted average of those θ values would be our estimate of θ for low income users. We assume that U_{ij} is the minimum O-D cost at free flow conditions obtained from our initial solution. That is, we calculate link user costs at zero flows and find out the shortest paths

Table 6.13 Attraction of all destinations (A_j)

No.	Destination	Attraction
1	DMHR	10.52950
2	ETYB	9.64800
3	KFRS	10.29700
4	MHLK	10.16300
5	TANT	11.65900
6	SHKM	11.51100
7	BNHA	12.26200
8	CAIR	13.08300
9	ZGZG	11.03100
10	ABKB	9.55400
11	MNSR	10.92000
12	SHRB	10.32100
13	DMIT	9.64560
14	PRTS	8.83300
15	ISML	9.85770
16	FYUM	10.38750
17	BSWF	10.39200
18	SWES	8.80574
19	MNIA	9.82340
20	ASYT	10.10730
21	SHAG	9.82340
22	QENA	9.61220
23	ASWN	8.69430
24	ALEX	11.23350

between all O-D pairs in the system; the resulting O-D costs are shown in table 6.14. We select six major O-D pairs in the system (each having Cairo as its origin and all represent about 76% of total trips generated from Cairo); we calculate θ and the number of trips distributed, for each of these six O-D pairs; the results are shown in table 6.15. The parameter θ is then estimated as the weighted average of the six values of table 6.15 where the weights correspond to the number of trips distributed between different O-D pairs. That is,

$$\theta = 1.50714$$

Before ending this subsection we need to define our set of O-D pairs in the system. We make no constraints on O-D movements; that is, we assume that a traveller at a given origin can choose to go to any other zone in the system. This implies that the number of O-D pairs is 24 x 23 = 552. Notice that there are many constraints one can impose on transport movement in the system just by redefining the set of O-D pairs.

Table 6.15 θ and observed trips for selected O-D pairs

O-D	θ	T_{ij}^{o}
CAIR-ALEX	2.053	8,579.
CAIR-BNHA	1.368	56,886.
CAIR-TANT	1.81	7,316.
CAIR-SHKM	1.38	11,031.
CAIR-ZGZG	1.533	8,931.
CAIR-BSWF	1.912	4,106.
		96,849.

6.4.3 Trip Generation Model

As indicated earlier, we assume that trip generation is given by a general linear model, (see chapter II), that is, Table [illegible].14 Initial O-D matrix of minimum perceived costs

TO FROM	ALEX	DMHR	ETYB	KFRS	MHLK	TANT	SHKM	BNHA	CAIR	ZGZG	ABKB	MNSR	SHRB
ALEX	0.000	0.598	0.804	0.865	0.841	0.744	0.895	0.959	1.263	1.042	1.403	1.053	1.250
DMHR	0.598	0.000	0.493	0.683	0.660	0.562	0.714	0.777	1.082	0.860	1.211	0.872	1.069
ETYB	0.804	0.493	0.000	0.664	0.637	0.513	0.704	0.747	1.023	0.850	1.139	0.862	1.008
KFRS	0.865	0.683	0.664	0.000	0.405	0.476	0.628	0.691	1.007	0.774	1.135	0.617	0.639
MHLK	0.827	0.646	0.623	0.391	0.000	0.248	0.399	0.463	0.779	0.546	0.759	0.335	0.555
TANT	0.744	0.562	0.513	0.476	0.262	0.000	0.316	0.380	0.695	0.463	0.824	0.474	0.671
SHKM	0.895	0.714	0.704	0.628	0.413	0.316	0.000	0.333	0.628	0.529	0.613	0.625	0.804
BNHA	0.959	0.777	0.747	0.691	0.477	0.380	0.333	0.000	0.502	0.389	0.473	0.614	0.664
CAIR	1.263	1.062	1.023	1.007	0.793	0.695	0.628	0.502	0.000	0.694	0.778	0.970	1.020
ZGZG	1.042	0.860	0.850	0.774	0.560	0.463	0.529	0.389	0.694	0.000	0.361	0.554	0.604
ABKB	1.403	1.211	1.139	1.135	0.773	0.824	0.613	0.473	0.778	0.361	0.000	0.526	0.576
MNSR	1.053	0.872	0.862	0.617	0.349	0.474	0.625	0.614	0.970	0.554	0.526	0.000	0.439
SHRB	1.250	1.069	1.008	0.639	0.569	0.671	0.804	0.664	1.020	0.604	0.576	0.439	0.000
DMIT	1.620	1.313	1.241	1.025	0.802	0.953	0.933	0.793	1.149	0.733	0.705	0.568	0.406
PRTS	1.898	1.716	1.673	1.322	1.193	1.319	1.181	1.041	1.345	0.929	0.830	0.845	0.683
ISML	1.644	1.373	1.301	1.376	1.137	1.013	0.854	0.714	1.019	0.602	0.503	0.809	0.858
SWES	2.016	1.835	1.776	1.760	1.545	1.448	1.245	1.105	0.753	0.993	0.895	1.199	1.250
FYUM	2.092	1.911	1.853	1.836	1.622	1.524	1.457	1.331	0.829	1.523	1.607	1.799	1.850
BSWF	2.082	1.743	1.672	1.841	1.507	1.384	1.407	1.150	0.902	1.351	1.542	1.734	1.814
MNIA	2.778	2.439	2.367	2.537	2.203	2.080	2.103	1.846	1.598	2.047	2.238	2.429	2.510
ASYT	3.398	3.060	2.988	3.157	2.823	2.700	2.723	2.466	2.218	2.668	2.858	3.050	3.130
SHAG	3.909	3.571	3.499	3.668	3.334	3.211	3.234	2.977	2.729	3.179	3.369	3.561	3.641
QENA	4.693	4.355	4.283	4.453	4.119	3.995	4.019	3.762	3.513	3.963	4.154	4.345	4.426
ASWN	5.861	5.523	5.451	5.621	5.287	5.163	5.187	4.930	4.681	5.131	5.322	5.513	5.594

O-D MATRIX (CONTINUED)

	DMIT	PRTS	ISML	SWES	FYUM	BSWF	MNIA	ASYT	SHAG	QENA	ASWN
ALEX	1.620	1.898	1.644	2.016	2.092	2.082	2.776	3.398	3.906	4.693	5.861
DMHR	1.313	1.716	1.373	1.835	1.911	1.743	2.439	3.060	3.568	4.355	5.523
ETYB	1.241	1.673	1.301	1.776	1.853	1.672	2.367	2.988	3.496	4.283	5.451
KFRS	1.025	1.322	1.376	1.760	1.836	1.841	2.537	3.157	3.665	4.453	5.621
MHLK	0.768	1.179	1.123	1.531	1.608	1.493	2.189	2.809	3.317	4.105	5.273
TANT	0.953	1.319	1.013	1.448	1.524	1.384	2.080	2.700	3.208	3.995	5.163
SHKM	0.933	1.181	0.854	1.245	1.457	1.407	2.103	2.723	3.231	4.019	5.187
BNHA	0.793	1.041	0.714	1.105	1.331	1.150	1.846	2.466	2.974	3.762	4.930
CAIR	1.149	1.345	1.019	0.753	0.829	0.902	1.598	2.218	2.726	3.513	4.681
ZGZG	0.733	0.929	0.602	0.993	1.523	1.351	2.047	2.668	3.176	3.963	5.131
ABKB	0.705	0.830	0.503	0.895	1.607	1.542	2.238	2.858	3.366	4.154	5.322
MNSR	0.568	0.845	0.806	1.199	1.799	1.734	2.429	3.050	3.558	4.345	5.513
SHRB	0.406	0.683	0.858	1.250	1.850	1.814	2.510	3.130	3.638	4.426	5.594
DMIT	0.000	0.442	0.769	1.160	1.978	1.943	2.639	3.259	3.767	4.555	5.723
PRTS	0.442	0.000	0.492	0.883	2.174	2.075	2.771	3.391	3.899	4.687	5.855
ISML	0.769	0.492	0.000	0.556	1.846	1.704	2.399	3.020	3.528	4.315	5.483
SWES	1.160	0.883	0.556	0.000	1.389	1.616	2.273	2.971	3.479	4.266	5.434
FYUM	1.978	2.174	1.846	1.389	0.000	0.420	1.077	1.989	2.497	3.285	4.453
BSWF	1.943	2.075	1.704	1.616	0.420	0.000	0.934	1.570	2.078	2.865	4.033
MNIA	2.639	2.771	2.399	2.273	1.077	0.934	0.000	0.986	1.494	2.281	3.449
ASYT	3.259	3.391	3.020	2.971	1.989	1.573	0.986	0.000	0.790	1.577	2.745
SHAG	3.776	3.902	3.531	3.482	2.500	2.081	1.497	0.793	0.000	1.094	2.262
QENA	4.555	4.687	4.315	4.266	3.285	2.865	2.281	1.577	1.091	0.000	1.617
ASWN	5.723	5.855	5.483	5.434	4.453	4.033	3.449	2.745	2.259	1.617	0.000

$$G_i = \alpha S_i + E_i \qquad \text{for all } i$$

where G_i and S_i are variables to be predicted within the STEM methodology, and α and E_i for all i are constants to be estimated and input to the prediction process. Recall that E_i may in general be the summation of a number of terms, each reflects the effect that a given socio-economic variable has on trip generation. Also, recall that the accessibility variable, S_i, is assumed to be non-negative. This implies that whenever the system becomes more accessible (i.e., S_i increases) we expect more trips to be generated, and whenever the system becomes non-attractive we expect socio-economic forces to become predominant and that E_i trips must be generated due to these forces.

Our objective in this subsection is to estimate the sensitivity of demand to the accessibility of the system (i.e., the parameter α) and the minimum number of trips which must be generated due to socio-economic forces (i.e., E_i for all i) on the Egyptian intercity system.

Factors which would affect our estimation have been discussed in the preceding subsection. Here we only need to emphasize the lack of well defined theory for trip generation behavior and the lack of relevant explanatory variables. We expect that the development of such a theory and socio-economic data base would be among the major tasks related to the application of the STEM methodology on the Egyptian system and elsewhere.

In our case study, we are given the observed trip generation by auto, taxi, bus and rail (see appendix C). We calculate trip generation of low income passengers as the weighted average of bus and rail passengers similar to what we did in the preceding subsection. That is,

$$(G_i^o)_{Low} = \frac{0.75}{1.55}(G_i^o)_{Bus} + \frac{0.80}{1.55}(G_i^o)_{Rail}$$

The corresponding accessibility, S_i^o, is calculated as the natural logarithm of the denominator of the trip distribution model.

As far as the value of E_i is concerned, we assume that the "majority" of low income passengers observed on the system are motiviated primarily by the socio-economic environment. That is, there is a large portion of low income passengers who must travel for socio-economic reasons. However, there is no data available to help us estimate that portion and it seems that we have to make a "reasonable" guess. We assume that this portion is about 90%. This should be considered as a rough estimate of E_i, that is,

$$E_i = 0.90\ G_i^o \qquad \text{for all } i$$

The parameter α may now be calculated for each origin as follows:

$$\alpha_i = \frac{G_i^o - E_i}{S_i^o} \qquad \text{for all } i$$

Table 6.16 shows the values of G_i^o, S_i^o, E_i and α_i for our 24 zones, calculated as described above. In table 6.16, we observe that α_i is large for the major generators of traffic in the system; that is, Cairo, Banha, Shebin Kom and Alexandria. For the remaining zones the value of α_i is less than about 200. Therefore, given the wide variability of α_i among zones we expect our demand results to be sensitive to our choice of α, a large value would result in over estimation of trip generation from zones with low α_i and vice versa. In our case study, we assume that α=200; this would lead to underestimating total demands from the major generators. For the purposes of our case study, these rough estimates of trip generation data (i.e., α and E_i) should not have major adverse impacts on our analysis.

Table 6.16 Trip Generation Data

Zone	G_i^o	S_i^o	E_i	α_i
CAIR	125,540.	9.363	112,986.	1340
BNHA	81,240.	9.9286	73,116.	818
ZGZG	20,178.	9.9134	18,160.	204
ABKB	6,803.	9.9134	6,123.	69
MNSR	21,004.	9.6107	18,904.	212
SHRB	9,700.	9.6107	8,730.	101
DMIT	6,494.	8.894	5,845.	73
PRTS	2,323.	8.3537	2,091.	28
ISML	7,846.	9.1587	7,061.	86
SWES	2,580.	8.5713	2,322.	30
SHKM	33,200.	10.0362	29,880.	331
TANT	38,677.	9.3537	34,809.	414
MHLK	9,781.	9.3537	8,803.	105
FKRS	11,706.	9.538	10,535.	123
ETYB	6.000.	9.334	5,400.	64
DMHR	13,682.	9.334	12,314	147
ALEX	26,615.	8.5737	23,954	310.
FYUM	11,226.	8.9846	10,103.	125
BSWF	13,751.	8.7727	12,376.	157
MNIA	6,237.	7.3347	5,613.	85
ASYT	9,867.	6.31	8,880.	156
SHAG	6,934.	5.948	6,241	117
QENA	6,062.	4.9553	5,456.	122
ASWN	2,834.	2.4167	2,550.	118

VII. ANALYSIS AND RESULTS

As indicated earlier, the objective of our application is to assess the applicability of the STEM methodoloy, both from the computational as well as the behavioral points of view. In this chapter we actually perform the analysis and evaluate the results.

7.1 PERFORMING THE ANALYSIS

In order to perform the analysis we need to specifically define the set of issues to be addressed and then design the analysis to address these issues.

From the computational point of view, the major issues are related to convergence and efficiency. Specifically, we are interested in answering the following two questions:

(1) What is the "best" convergence criterion to be used as a stopping rule for the iterative prediction process?

(2) How much computer time is required to arrive at an equilibrium that is "sufficiently" close to the exact solution?

From the behavioral point of view, we are assessing the ability of the STEM model to represent actual behavior and to predict behavioral responses to changes in the system. Specifically, we would like to answer the following two questions:

(3) How do our predictions compare with observed data? Suppose that there are considerable differences between predicted and observed values, what are the reasons?

(4) Suppose that the fleet capacity of express train is doubled

everywhere in the system, how would low income passengers respond to that change?

To address the first issue we suggest several convergence criteria, analyze the performance of each and recommend the "best" one, if any.

As far as the second issue is concerned, there are several factors that would affect computational efficiency such as network size, fleet capacity constraints, initialization, steepness of link cost functions, parameters (α and θ) of demand functions, etc. The network size may be expressed in terms of the number of nodes, links, O-D pairs, origins and destinations. Computer time required to find the shortest tree from a given node (i.e., a given origin) to all other nodes, depends upon the number of nodes and links in the network (i.e., in the multimodal composed network). At a given interation we need to calculate the shortest tree as many times as the number of origins in the network. The number of iterations required to equilibrate trip distribution depends upon the number of O-D pairs and origins since at each iteration we find a direction for improvement by selecting the most "needy" destination for each origin. That is, the number of O-D pairs to be equilibrated at a given iteration equals the number of origins in the network. In our analysis we fix the number of origins and O-D pairs, and vary the number of nodes and links. Specifically, we create three multimodal composed networks: the first includes express and local trains only, the second includes normal bus in addition, and the third includes all four modes: express, local, bus and taxi. We assume that trips may originate from each of the 24-zones and terminate at any of the other 23-zones on the system. That is, each network has 24 origins and 552 O-D pairs. The number of nodes and links on each composed network is as indicated earlier in section 6.2 of Chapter VI.

The existence of fleet capacity constraints in the system has direct and indirect implications on computational efficiency. As indicated in subsection 6.3.5 of Chapter VI, there is a strong correlation between the accurate representation of fleet capacity constraints at the link level and the steepness of cost functions; in our case study we have chosen to have very steep cost functions in order to obtain a "sufficiently" accurate representation of such constraints, and hence we expect that more iterations would be required to achieve a given level of accuracy of predictions at equilibrium.

Also the existence of fleet capacity constraints have implications on the initialization of the prediction process as well as the final predictions at equilibrium. Neglecting such constraints in the initialization would result in an "infeasible" and unrealistic initial solution, and hence we would expect that more iterations would be required to arrive at an equilibrium solution that would be "reasonably feasible". In fact, if we continue neglecting such constraints in subsequent iterations there is no guarantee that our equilibrium solution would be "feasible" after a "reasonable" number of iterations. As a matter of fact, in our initial computer runs we did ignore fleet capacities; our initial modal split and traffic assignment were very unrealistic and after 250 iterations we were still not "reasonably feasible" on a good number of modal links on the network (see Appendix D). In the initial solution, no one single passenger used local train, less than 0.1% used taxi, and the rest used express train (which was reasonably loaded) and normal bus. The four intercity bus companies were, unrealistically, carrying about ten times their existing fleet capacities. The most unrealistic flow was found on the East Delta bus from Banha to Shebin El-Kom where there is only one bus per day with overcrowding capacity of 87 passengers; the flow assigned to that modal link was 12,844 trips, which is about 148 times its existing fleet capacity. After 250 iterations, of course there has been a lot of improvement but we still observe that flow is over "fleet" capacity on 96 out of 534 modal links in the network; the flow/capacity ratio is about 1.5 or more on about one-third of the 96 links. Thus, neglecting fleet capacity constraints particularly in the initial solution will have computational as well as behavioral implications. Computationally, we will need a considerable number of iterations to arrive at a "reasonably feasible" solution. Behaviorally, if we stop at a "practically infeasible" solution, it will not reflect a meaningful behavior of users in the system and hence would bias our behavioral and policy analysis.

Therefore, the existence of fleet capacity constraints should be taken into account in the initialization of the prediction process and in subsequent iterations as well. That is, we need to start with an initial solution that is "reasonably feasible" and to maintain "feasibility" as we proceed in subsequent iterations. This requires two modifications in our SPND algorithm. The first modification is in the initialization step and the second is in the one-dimensional search. As far as the initialization is concerned, we essentially assume, as before, that trip generation is given by its minimum value and trip distribution is given by a logit model calculated using the minimum perceived costs in the system (see Chapter IV). Traffic assignment on the multimodal composed network is performed incrementally where the increments are defined based on the available fleet capacities. Formally, the modified initialization procedure may be described as follows:

Step 0 (Initialization)

Step 0.1 Assume that the network is empty and calculate minimum link perceived costs, i.e., set $F^{o} = 0$ and calculate $C^{o} = C_a(0)$, for all $a \varepsilon A$. Set $i = 1$ in an ordered set of origins I.

Step 0.2 Find the shortest tree from i to all other destinations. That is, U^{o}_{ij} for all $j \varepsilon D_i$. Set $j = 1$ in an ordered set of O-D pairs D_i.

Step 0.3 Calculate initial trip generation and trip distribution as follows:

$$G^{o}_i = E_i \ ;$$

$$T^{o}_{ij} = G^{o}_i \frac{\exp(-\theta u^{o}_{ij} + A_j)}{\sum\limits_{k \varepsilon D_i} \exp(-\theta u^{o}_{ik} + A_k)} \quad \text{for all } j \varepsilon D_i \ ;$$

if $i < I$, then $i \leftarrow i + 1$ and go to step 0.2 ;

otherwise, set $i = 1$ and $j = 1$, and continue .

Step 0.4 Determine the increment, ΔT^{o}_{ij} , to be assigned to the shortest path, p^{o}, from i to j such that the fleet capacity on any link on P^{o} may not be exceeded by more than 20%. That is,

$$(\text{CAPACITY})_a \leftarrow 1.2 * (\text{CAPACITY})_a \quad \text{for all } a \varepsilon p^{o}$$

$$(\text{CAPACITY})_{p^{o}} = \min_{a \varepsilon p^{o}} (\text{CAPACITY})_a$$

$$\Delta T^{o}_{ij} = \min\{T^{o}_{ij} \ , \ (\text{CAPACITY})_{p^{o}}\}$$

Step 0.5 Assign the increment ΔT^{o}_{ij} and update link fleet capacities and flows. That is,

$$F_a^o = \begin{cases} F_a^o + \Delta T_{ij}^o & \text{if } a \varepsilon p^o \\ F_a^o & \text{otherwise} \end{cases} ;$$

$(\text{CAPACITY})_a \leftarrow (\text{CAPACITY})_a - \Delta T_{ij}^o$ for all $a \varepsilon p^o$;

$T_{ij}^o \leftarrow T_{ij}^o - \Delta T_{ij}^o$;

If $j < D_i$, then $j \leftarrow j + 1$ and go to step 0.4;
otherwise, continue.

Step 0.6 Update link costs and shortest trees. That is,

$C_a^o = C_a(F_a^o)$ for all $a \varepsilon A$;

If $i < I$, then $i \leftarrow i + 1$, find the shortest tree and go to step 0.4.

Otherwise, continue.

Step 0.7 Check for termination. That is,

if $T_{ij}^o = 0$ for all ij, then stop; an initial "feasible" solution is obtained.

If $T_{ij}^o \neq 0$ for some O-D pairs but has been constant for the last two iterations, then stop; an initial "feasible" solution could not be obtained.

Otherwise, set $i = 1$ and $j = 1$, and go to step 0.4.

As far as the one-dimensional search is concerned, we essentially restrict the step size in such a way to maintain "reasonable feasibility" of the solution as we proceed. The idea has been suggested before by Daganzo (1977). Formally, we introduce the following modifications:

Step 2 (One-Dimensional Search)

Step 2.1 Calculate maximum step size, λ_{max}, as follows:

$$\lambda_{max} = \min\{1, \min_{d_a > 0} \frac{(\text{CAPACITY})_a - F_a}{d_a}\}$$

where

d_a is the descent direction on link a.

$(\text{CAPACITY})_a \leftarrow 1.3 * (\text{CAPACITY})_a$

Step 2.2 Minimize $Z(\lambda)$

subject to $0 \leq \lambda \leq \lambda_{max}$

The above modifications have been incorporated in the computer code presented in Appendix A.

In order for the above modified procedure to converge, Daganzo [1977] invokes a strong assumption that is not satisfied in our case, namely he requires the link cost to approach infinity as the link flow approaches its "capacity". Hearn and Ribera [1981] proved convergence of this modified procedure under a weaker and more natural assumption. They require that whenever the flow approaches capacity, the link cost should be "sufficiently" large such that the integral $\phi(H^o)$ in the objective function, at the initial solution is strictly less than that $\phi(H^c)$ where the flows are at their capacities. This assumption is satisfied in our modified procedure since the flows in any initial solution cannot exceed more than 20% of "capacities" while in subsequent iterations the flows can reach up to 30% more than "capacities". The corresponding costs are magnified with a power of 20, implying that the value of $\phi(H^c)$ where the flows are at their "relaxed capacities" should always be strictly greater than that $\phi(H^o)$ at the initial solution.

The other factors which would affect computational efficiency (e.g., parameters d of demand functions) are assumed to be fixed constants obtained as described in Chapter VI.

To address the third issue we simply compare our predictions on NET3 (which represent the existing situation) and "observed" behavior, and interpret the results. To answer the fourth question we double the fleet capacity of express train on each link and predict equilibrium on the multimodal composed network of all four modes before and after the change in fleet capacities.

In the following sections we present and discuss our findings in relation to each of these four issues.

7.2. CONVERGENCE CRITERION

We know from Chapter IV that the SPND algorithm does converge to the exact equilibrium asymptotically. We also know from the preceding section that the modified algorithm is convergent as well. Practically, however, we would be willing to accept a solution that is "sufficiently" close to the exact one. The "best" criterion to use as a stopping rule for the procedure is a one that monotonically approaches a given value which is known prior to beginning the process; the stopping rule would be simply to stop whenever this measurement is within a prespecified tolerance limit from that given value. This "best" criterion may not always be available. For example, we know that the value of the objective function Z is monotonically decreasing but we do not know its optimum value apriori. Alternatively, we know that at optimality the difference between the last two iterations is zero, but there is no guarantee that this difference is monotonically decreasing along the process. Therefore, in our search for the "best" convergence criterion we will be looking for the measure which possess the above desireable features.

In our search we have investigated the following converence criteria:

Stop whenever,

CC1: $100*(Z^{r-1} - Z^{r})/|Z^{r}| < \varepsilon\%$

CC2: $100*|G_i^r - G_i^{r-1}|/G_i^r < \varepsilon\%$ for K% of origins

CC3: $\mathrm{TGRMSE} = \sqrt{\sum_i \frac{G_i^r}{\mathrm{TTG}} (G_i^r - G_i^{r-1})^2} < \varepsilon$

CC4: $100*|T_{ij}^r - T_{ij}^{r-1}|/T_{ij}^r < \varepsilon\%$ for K% of O-D pairs

CC5: $\mathrm{TDRMSE} = \sqrt{\sum_{ij} \frac{T_{ij}^r}{\mathrm{TTG}} (T_{ij}^r - T_{ij}^{r-1})^2} < \varepsilon$

CC6: $100*|F_a^r - F_a^{r-1}|/F_a^r < \varepsilon$ for K% of links

CC7: $\mathrm{LFRMSE} = \sqrt{\sum_a \frac{F_a^r}{\mathrm{TLF}} (F^r - F^{r-1})^2} < \varepsilon$

CC8: step size $\lambda^r < \varepsilon$

CC9: $100*|T_{ij}^r - (T_{ij}^r)_{\mathrm{logit}}|/(T_{ij}^r)_{\mathrm{logit}} < \varepsilon\%$ for K% O-D pairs

CC10: $\mathrm{LRMSE} = \sqrt{\sum_{ij} \frac{T_{ij}^r}{\mathrm{TTG}} (T_{ij}^r - (T_{ij}^r)_{\mathrm{logit}})^2} < \varepsilon$

CC11: $\text{ERMSE} \equiv \sqrt{\sum_i (u_i^r)^2} < \varepsilon$

where

r = current iteration

TGRMSE, TDRMSE and LFRMSE are the weighted average of the root mean square errors of trip generation, trip distribution and link flows respectively.

LRMSE is the weighted average of the root mean square error between predicted trip distribution and logit calculations.

ERMSE is the total root mean square error of equilibrium.

TTG = total number of trips generated in the system

TLF = total link flows

ε = a predetermined tolerance limit

K = a predetermined confidence limit

The convergence criteria CC1 through CC7, are essentially measuring the difference between the last two iterations. It should be obvious that there is a strong positive correlation between any of these measures and the step size (i.e., the criterion CC8). Whenever λ^r is relatively small, we expect that the values of CC1 through CC7 are also relatively small, and vice versa. The correlation is not perfect, however, because the curvature of the objective function Z may not be identical in different directions. That is, if the step size is the same at two different iterations, the difference in Z at these iterations may not be identical. Nevertheless, the strong correlation, does exist as may be observed from Figure 7.1**. Notice that the absolute value of Z is monotonically decreasing

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**The figure 7.1 depicts the results of initial computer runs where we have neglected the existence of fleet capacities in the initial solution.

(see figure 7-6) in spite of the fact that the percent change in Z is not, as shown in figure 7-1. Therefore, to evaluate the performance of CC1 through CC7, it suffices to consider CC8 only.

The convergence criteria CC9 and CC10 are essentially comparing the predicted trip distribution matrix with the corresponding logit distribution model.

The logit test can be constructed at any given iteration in the process as follows:

(1) Given the predicted trip distribution matrix, find the minimum perceived cost matrix on the network (i.e., find the costs on the shortest paths between all O-D pairs in the network).

(2) Given the cost matrix calculated in (1), calculate a trip distribution matrix according to the logit model postulated and calibrated earlier.

(3) Compare the predicted trip distribution matrix with the "logit" by calculating CC9 and/or CC10.

At equilibrium the predicted and the logit values should coincide and thus, the value of CC10 should asymptotically approach zero.

The convergence criterion CC11 is based on the calculations of direction finding for trip generation at each iteration of the algorithm. Recall from Chapter IV that,

$$U_i^r = \frac{1}{\theta}\left[S_i^r - \ell n(\alpha S_i^r + E_i)\right] + \frac{1}{\theta}\left[\ell n\ T_{ij*}^r - A_{j*}\right] + U_{ij*}^r$$

where j* is the most "needy" destination in the set D_i as determined in the direction finding step at iteration r. That is, j* is a destination that is relatively "near" and/or "attractive" compared to other destinations in

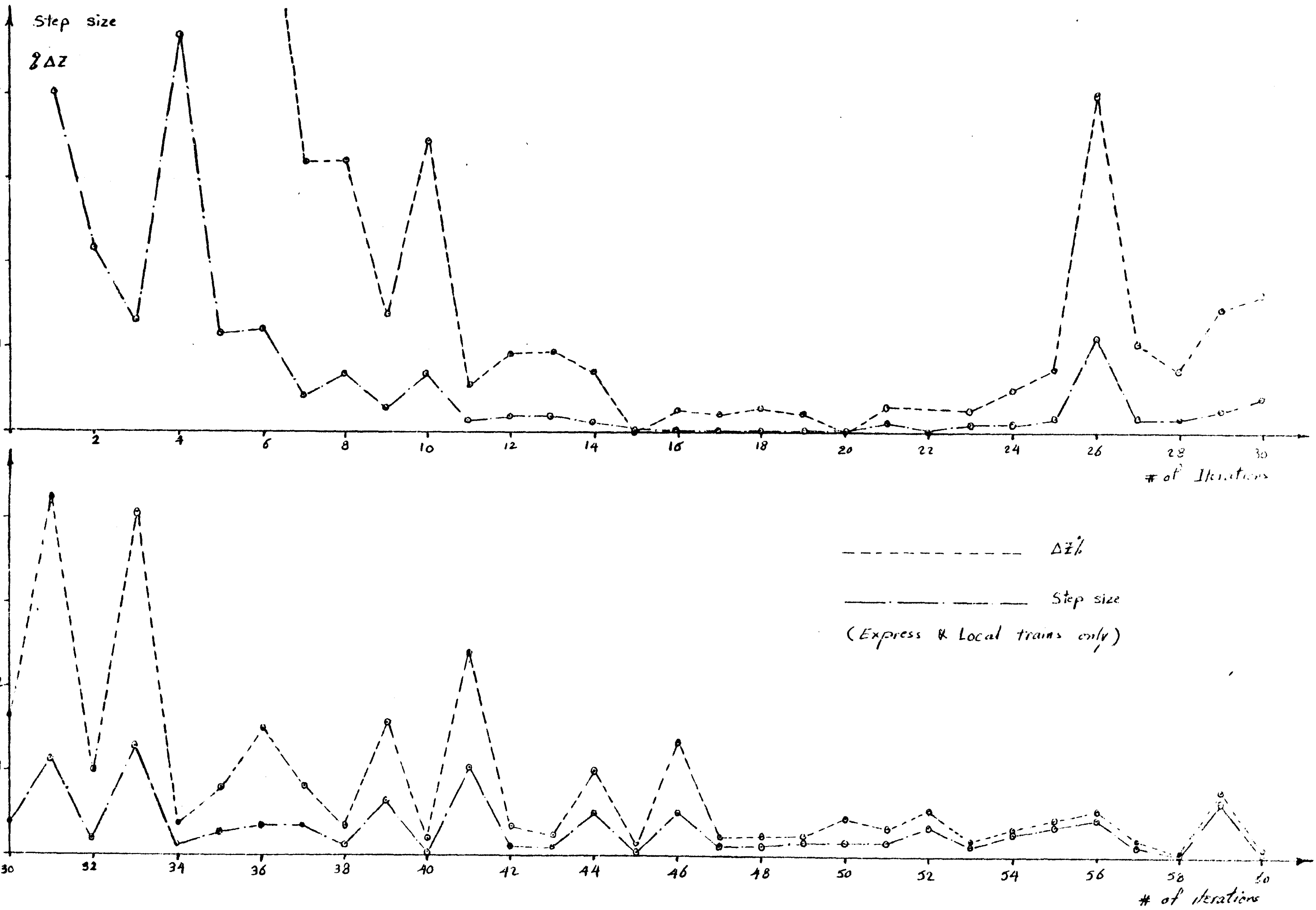

Figure 7.1 Percent change in Z and Stepsize vs. # of iterations
(initial computer runs where we neglected "feasibility")

the set D_i but is still not getting its "fair" distribution of trips generated from i. U_i^r may be looked upon as the marginal cost of generating an additional trip from origin i going through the shortest path to the most needy destination. If U_i^r is negative then we are willing to increase the current level of demand generated at i, and vise versa. Therefore, at equilibrium U_i^* should satisfy the following conditions:

(1) $U_i^* = 0 \quad \text{if } E_i < G_i^* < M_i$

(2) $U_i^* > 0 \quad \text{if } E_i = G_i^*$

(3) $U_i^* < 0 \quad \text{if } G_i^* = M_i.$

In most practical situations we expect G_i^* to be strictly within its lower and upper bounds, and hence U_i^* to equal zero; consequently we expect ERMSE to approach zero at equilibrium. Notice that our choice of M_i may always be such that G_i^* will never approach it. As for the lower bound (i.e., E_i), we know from our definition of the accessibility variable, S_i, that as long as there is at least one "attractive" destination in the system (for each origin), the value of S_i will always be strictly positive and hence G_i^* will be strictly greater than E_i. If, however, there is some $G_i = E_i$ we might as well neglect that origin in calculating ERMSE. Thus, we can always be sure that the value of ERMSE at equilibrium is indeed zero. In fact if it turns out that ERMSE is monotonically approaching zero, we would be more inclined to recommend it as the "real best" convergence criterion.

Calculations of the above convergence criteria have been incorporated into our computer code and their results were produced at each iteration; the computer output at a typical iteration is shown in Table 7.1. In addition to calculating the above eleven measures at each iteration, the computer output includes the current value of the objective function, the CPU time consumed in different steps of the procedure at that iteration, number of inner iterations of the one-dimensional search, total travel cost, total passenger-kms produced in the system and additional information for the logit convergence test (i.e., CC9).

To evaluate the performance of the measures CC1 through CC8, we focus on CC8 as a "representative" of the "group". Figures 7.2 and 7.3 depict the relationship between the optimum step size (λ) and the number of iterations (ITER) for NET3 (i.e., the network which includes express train, local train, normal bus and taxi) and NET2 (i.e., the network which includes express train, local train and normal bus), respectively. The figures show the results of each iteration uptil ITER = 192. The randomness of the step size is quite apparent in both figures; we can hardly observe any systematic variation in its value. In fact we notice that very early in the procedure (e.g., ITER = 13 in Figure 7.2 and ITER = 14 in Figure 7.3) the step size is very small indicating very small values for any of the measures CC1 through CC7 as well. So if we were to stop based on any of these criteria, it is obvious that we would stop prematurely. This simple fact leads us to exclude CC1-CC8 from consideration. Also notice that the variation in Figure 7.3 is relatively smaller than that in Figure 7.2; this is due to the existence of fleet capacity constraints on NET2 while NET3 is less constrained. In fact, this additional observation should strengthen our decision to exclude CC1-CC8 from further consideration.

To evaluate the performance of the logit convergence test (i.e., CC9 and CC10) we choose CC10 to be its "representative". Figure 7.4 depicts

Table 7.1 Computer output of the 52nd iteraton of the overall network
(i.e. Express, Local, Bus and Taxi)

```
ITERATION NUMBER  52     :
-------------------------

THE OBJECTIVE VALUE IS                        -5508965.500
PREVIOUS VALUE IS WITHIN                              0.013%   OF THE CURRENT ONE

THE %DIFFERENCE IN FLOW BETWEEN LAST TWO ITERATIONS:
FOR    24    OUT OF    24     ORIGINS,
AND  543    OUT OF   552     O-D PAIRS,
AND  532    OUT OF   534     LINKS.
IS WITHIN     5.00   PERCENT


NUMBER OF INNER ITERATIONS=     1
OPTIMUM STEP SIZE=        0.00186


TOTAL TRAVEL COST =                         532408.938
TOTAL TRAVEL DISTANCE =                   52141640.00


ROOTE MEAN SQUARE ERRORS OF:
EQUILIBRIUM=                  27.169
TRIP GENERATION=               3.258
TRIP DISTRIBUTION=            41.727
MODAL LINK FLOWS=             59.266


CPU TIME FOR DIRECTION FINDING=              2.53    SECONDS
CPU TIME FOR ONE DIMENSIONAL SEARCH=         0.38    SECONDS
CPU TIME FOR CONVERGENCE TEST=               0.18    SECONDS
CPU TIME FOR OUTPUT CALCULATIONS=            0.16    SECONDS

LOGIT CONVERGENCE TEST:
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IT CALCULATES THE %DIFFERENCE BETWEEN PREDICTED O-D DEMAND AND THAT CALCULATED BY A LOGIT MODEL.


PREDICTIONS OF     82 OUT OF    552 O-D PAIRS ARE WITHIN      5% OF THE LOGIT MODEL
PREDICTIONS OF    162 OUT OF    552 O-D PAIRS ARE WITHIN     10% OF THE LOGIT MODEL
PREDICTIONS OF    289 OUT OF    552 O-D PAIRS ARE WITHIN     20% OF THE LOGIT MODEL
PREDICTIONS OF    331 OUT OF    552 O-D PAIRS ARE WITHIN     30% OF THE LOGIT MODEL
PREDICTIONS OF    353 OUT OF    552 O-D PAIRS ARE WITHIN     40% OF THE LOGIT MODEL
PREDICTIONS OF    379 OUT OF    552 O-D PAIRS ARE WITHIN     60% OF THE LOGIT MODEL
PREDICTIONS OF    405 OUT OF    552 O-D PAIRS ARE WITHIN     80% OF THE LOGIT MODEL
PREDICTIONS OF    412 OUT OF    552 O-D PAIRS ARE WITHIN    100% OF THE LOGIT MODEL


THERE ARE   225 O-D PAIRS WHICH HAVE LESS THAN 100 TRIPS


AMONG THE REMAINING    140 O-D PAIRS,     77 HAVE PREDICTIONS LESS THAN 100 TRIPS


ROOT MEAN SQUARE ERROR BETWEEN MODEL PREDICTIONS AND LOGIT:
TOTAL RMSE=         9665.302
```

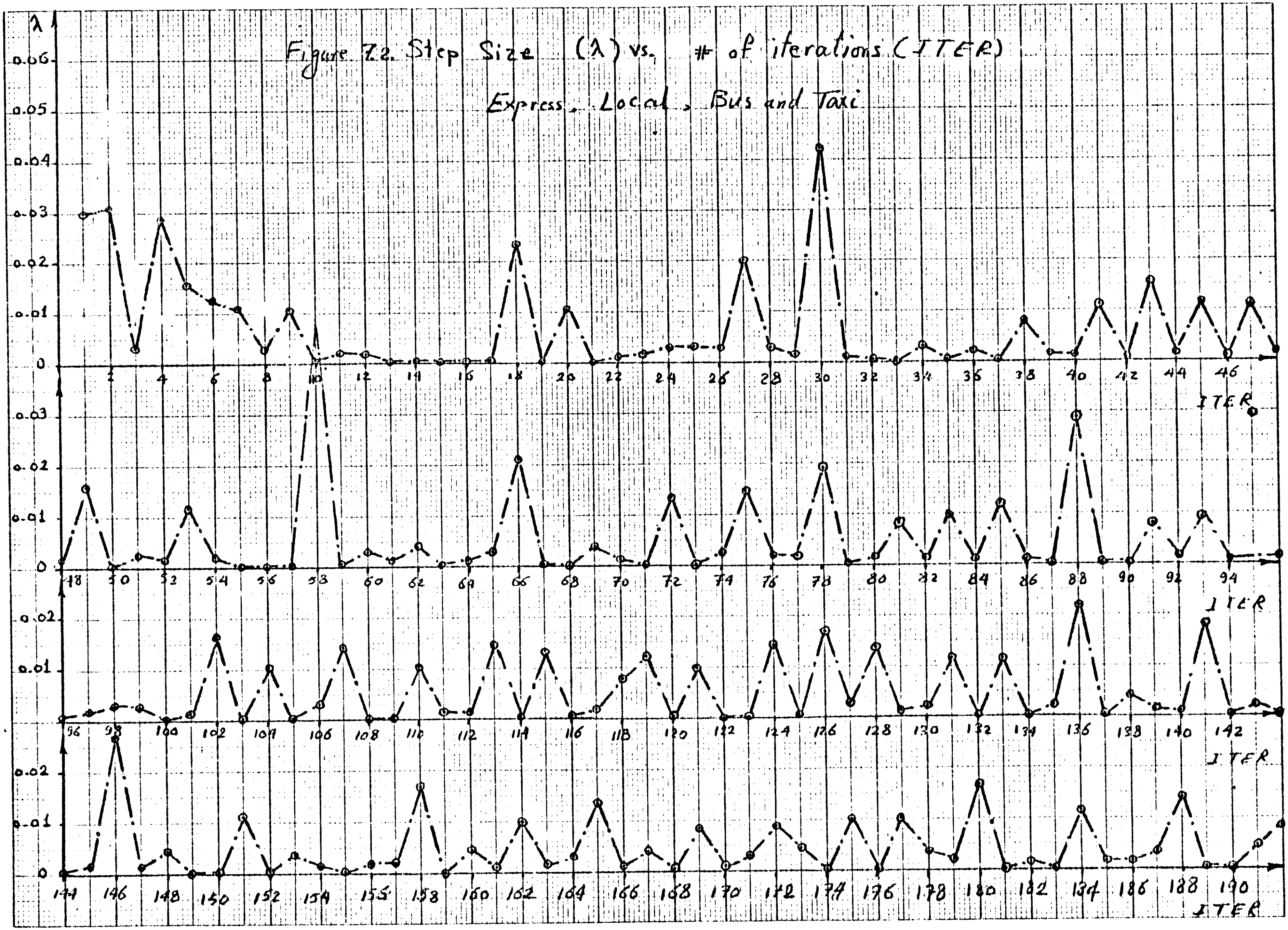
Figure 72. Step Size (λ) vs. # of iterations (ITER)
Express, Local, Bus and Taxi

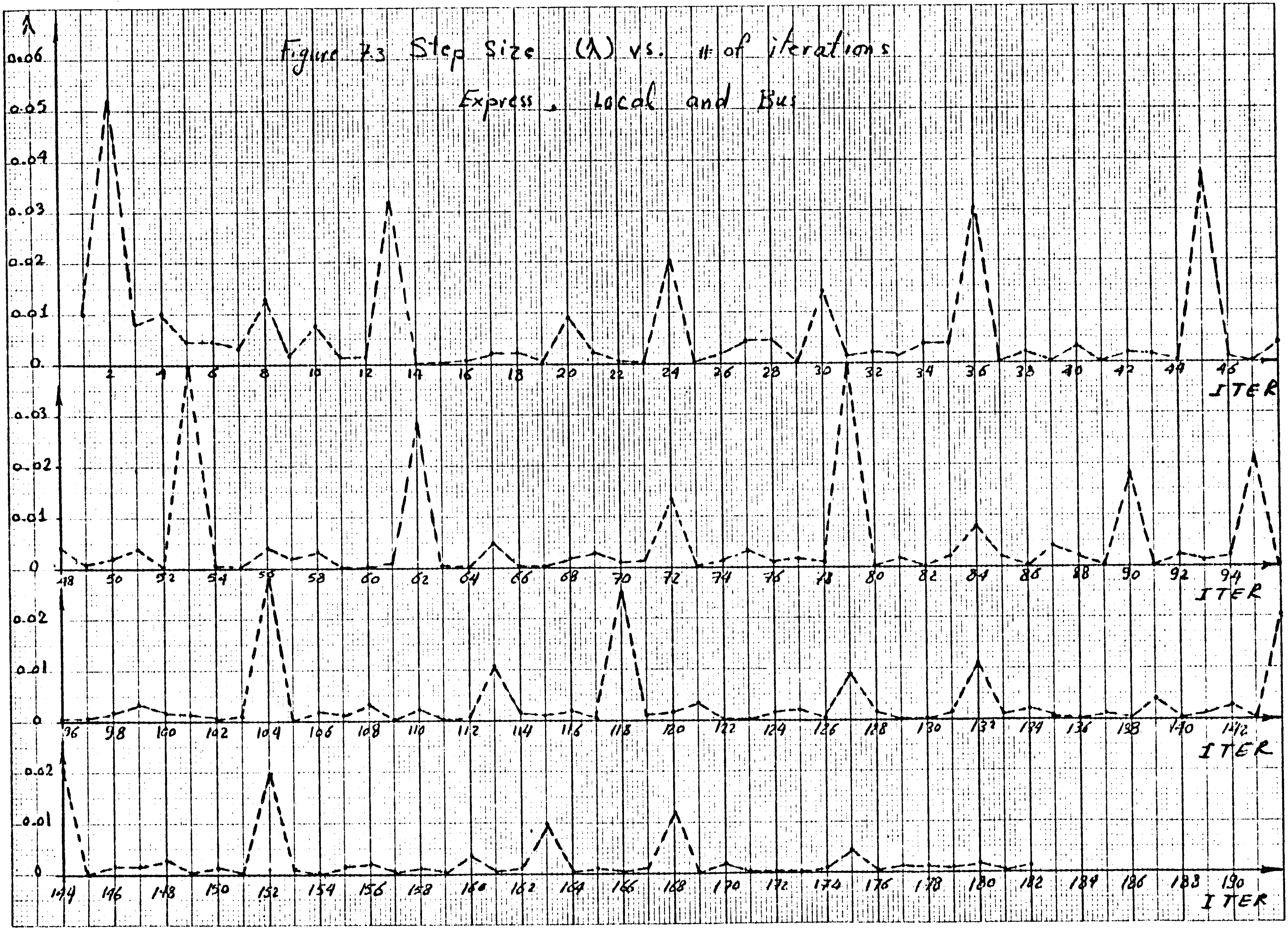

Figure 7.3 Step Size (λ) vs. # of iterations

Express, Local and Bus

the LRMSE versus ITER for both NET2 and NET3. Recall that at equilibrium we expect LRMSE to equal zero; it would be interesting if LRMSE is monotonically decreasing. Unfortunately, this is not the case; one can easily see from Figure 7.4 that LRMSE is fluctuating up and down. However, taking a more closer look at Figure 7.4 and imagining a "moving average" of LRMSE, we could observe that such an average is decreasing, more or less, monotonically. In fact we can easily observe that the fluctuations in the first 100 iterations or so are mostly between 3,000 ~ 2,000, while from ITER = 100 ~ 150 the fluctuations are mostly between 2,500 ~ 1,500 and from ITER = 150 ~ 200 the fluctuations are mostly between 2,000 ~ 1,000. This indicates that such an average value of LRMSE would be a reasonable measure to consider. For reasons which should be obvious shortly, we did not proceed in that direction. A last comment on Figure 7.4 is related to the comparison between the LRMSE for NET2 and NET3. We can easily see that LRMSE is in general much higher for NET2 than it is for NET3; the reasons are again related to the existence of more "capacity" constraints on the former network compared to the later one.

It remains to evaluate the performance of the "equilibrium test", that is CC11. Recall that ERMSE should equal zero at equilibrium provided that trip generation values are strictly within their bounds. Figure 7.5 depicts the relationship between ERMSE and ITER for all four networks in our analysis, that is NET1 (i.e., express and local trains only), NET2, NET3 and NET4 (i.e., NET3 with the fleet capacity doubled on express train) networks.

The first glance at Figure 7.5 reveals the desirable property which we are looking for in all convergence criteria, that is monotonicity.

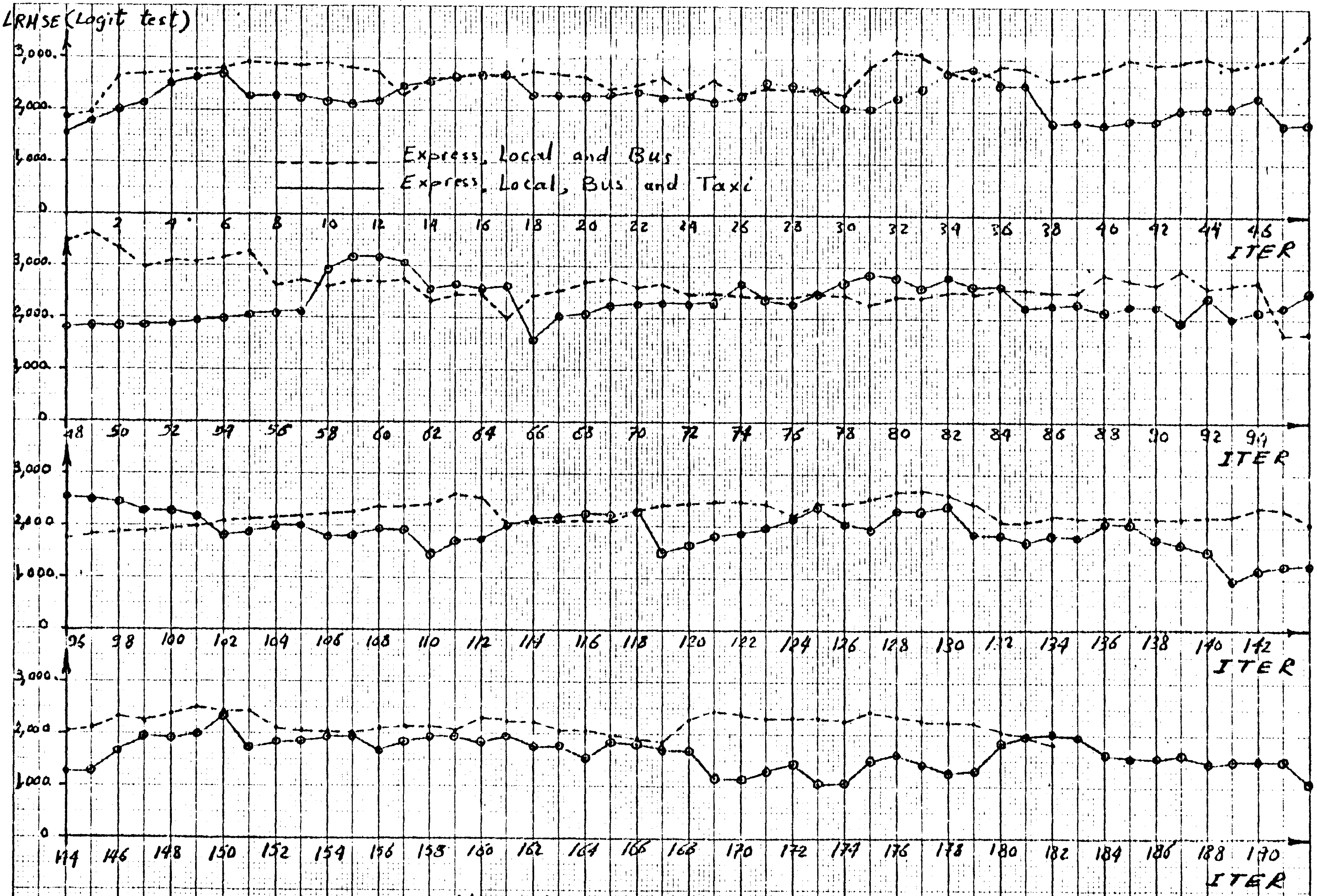

Figure 7.4 Logit test (LRMSE) vs. # of iterations (ITER)

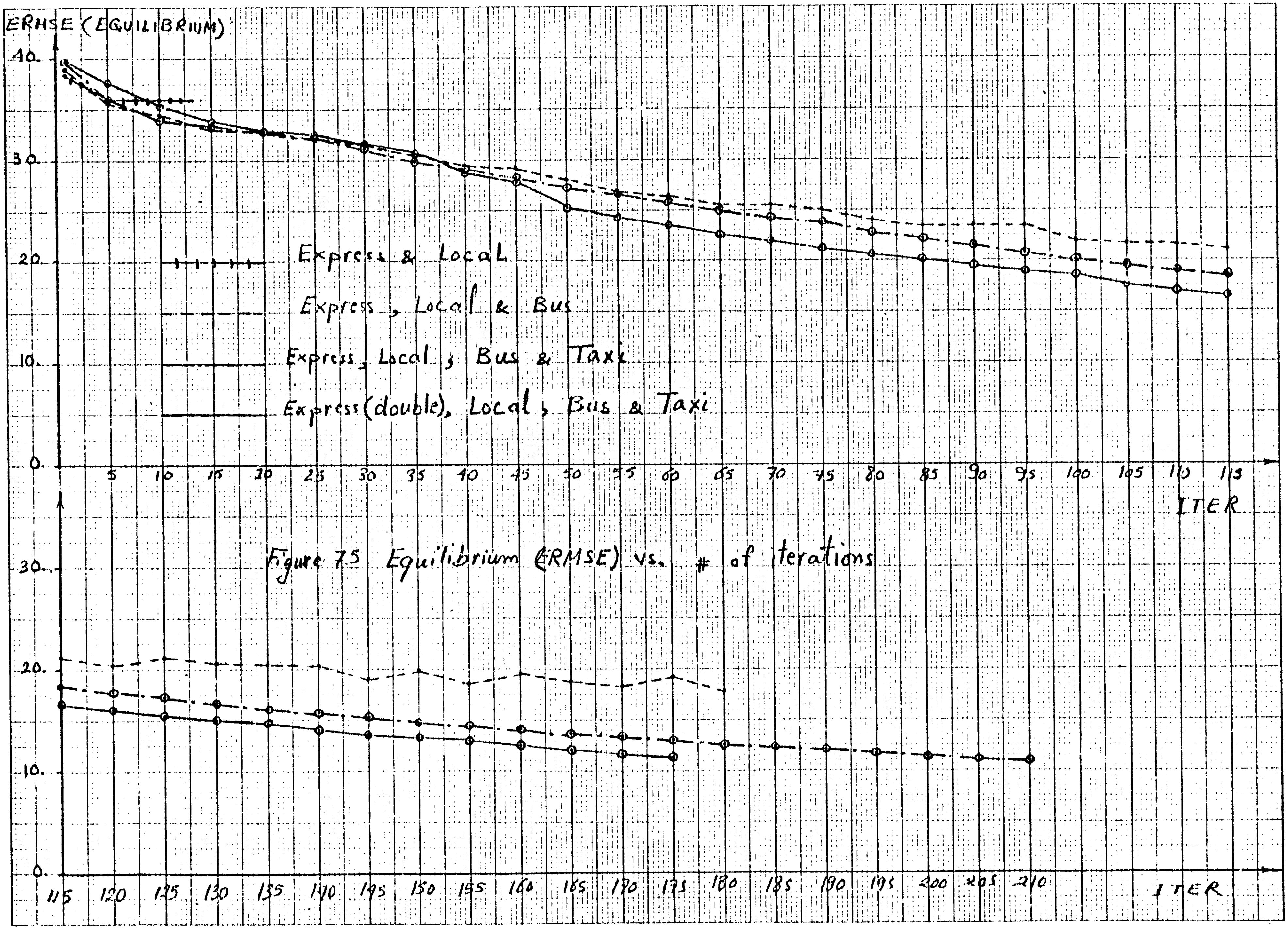

Figure 7.5 Equilibrium (ERMSE) vs. # of Iterations

Particularly for the largest two "unconstrained" networks, ERMSE is indeed monotonically decreasing. The relationship between ERMSE and the level of fleet capacity constraints in the system is evident; the rate of decrease of ERMSE is the highest for NET4 and decreases as the network becomes more constrained. In fact for NET1, which is severely constrained, ERMSE stabilized at the value of about 36; for NET2 the ERMSE value was monotonically decreasing (with a rate less than larger networks) until the total demand in the network reached its "constrained" level, it began to exhibit slight fluctuations (when ERMSE was about 20) while it was still, on the average, decreasing but with a lesser rate than before. These results are very interesting because we have found a criterion that monotonically approaches its optimum value that is known as apriori. Therefore, we can safely conclude that the "best" convergence criterion is, undoubtedly, the ERMSE value (or any other measure based on the value of U_i for all i). However, in applying the test we have to be more careful in terms of detecting whether the system is severely constrained or not. That is, we may decide to stop whenever ERMSE comes within a predetermined tolerance limit or whenever its value stays almost constant over a given number of successive iterations. That is, a suggested convergence criterion may be as follows:

CC11: IF ERMSE , stop we are at equilibrium
Otherwise,
IF $_1$, STOP the system
is severely constrained (or congested).
where , $_1$ are prespecified tolerance
limits and n is a prespecified number of iterations.

7.3. COMPUTATIONAL EFFICIENCY

As mentioned earlier, computational efficiency depends upon many factors such as network size, fleet capacity constraints, initialization, steepness of cost functions, parameters of demand functions, and the nature of the algorithm itself. In our analysis we are investigating the effect of two major factors, these are network size and fleet capacity constraints. The implications of the fleet capacity constraints on the steepness of cost functions, initialization and the one-dimensional search have been taken into account as explained earlier in section 7.1 of this chapter.

Recall that in our analysis we have four different problems. For the purpose of investigating computational efficiency we may distinguish among these problems based on their network sizes and fleet capacities, as shown in Table 7.2. All four problems have 24 origins and 552 O-D pairs. The first three networks are different in their sizes (i.e., number of nodes and links) and fleet capacities. The third and the fourth networks have the same size but the later has more relaxed fleet capacity (i.e., because the express train fleet capacity is doubled).

The CPU time required for the simultaneous prediction of equilibrium on any network using the SPND algorithm may be decomposed into a number of components based on the task performed by the algorithm. At a given iteration in the process, CPU time is mainly consumed in direction finding and one-dimensional search in addition to the calculations of convergence test, intermediate output, updating, etc. At the beginning of the process, CPU time is consumed in predicting the initial solution and at the end in producing the final output. In general, the CPU time consumed in any typical iteration (including initialization and final

Table 7.2 Major Characteristics of the Four Problems in the Analysis

Name	Description	Network Size				Fleet Capacity
		# Origin	#O-D Pair	# Nodes	# Links	
NET1	Express and Local	24	552	90	224	Severly Constrained
NET2	Express, Local and Normal Bus	24	552	125	394	Less Constrained
NET3	Express, Local, Normal Bus and Taxi	24	552	152	534	Not Constrained
NET4	Express(doubled), Local, Normal Bus and Taxi	24	552	152	534	More Relaxed than NET3

output calculations) depends mainly upon the network size, while the number of iterations required to achieve equilibrium would be more influenced by the nature of the algorithm itself as well as the problem at hand. In our case study, however, the network size and the fleet capacity constraints do interact in determining the CPU time for initilization, and one-dimensional search at different iterations.

Table 7.3 displays the different components of the CPU time for all four problems. The CPU time for initialization was the highest for the second problem (NET2), that is about 3.5 times the value for the larger problems NET3 and NET4. This may be explained if we know that NET2 is constrained by fleet capacity while NET3 and NET4 are not (after 5 iterations, we still could not assign 928 trips to NET2 while we were able to assign all the demand to NET3 and NET4 in 3 iterations). Strangely enough, the existence of severe fleet capacity constraints on the first problem (NET1) did not result in an increase in its CPU time for initialization similar to that for NET2. This may also be explained by noticing that after 4 iterations we could not assign 3537 trips to NET1 which implies more saving in terms of assignment efforts compared to NET2, NET3 and NET4; in addition, NET1 is the smallest.

The CPU time for one-dimensional search varies depending on the number of inner iterations required to arrive at the optimum step size. Again, because of the existence of fleet capacity constraints the step size is constrained (according to the modifications introduced in section 7.1) and thus, less inner iterations would be required to reach the optimum value. In fact, before introducing these modifications the number of inner iterations was 8; the modified procedure requires 3 inner iterations only.

Table 7.3 Computer CPU Time (in seconds) on VAX-11/VMS

CPU Time Components		Problem Name			
		NET1	NET2	NET3	NET4
Initialization		11.5	68	20.2	19.4
A Typical Iteration	Direction Finding	1.37	1.95	2.57	2.57
	One-Dimensional Search	0.2~0.5	0.3~0.5	0.38~0.75	0.38~0.75
	Convergence Test Intermediate Output	0.26	0.35	0.38	0.38
	Total/Iteration	1.98	2.7	3.5	3.5
Final Output		6.13	8.	8.85	8.85
Total CPU Time (for 100 Iterations)		215.63	346.	379.	378.2

The CPU time for convergence test and intermediate output (in Table 7.3) is "relatively" high because we are testing several criteria and producing "relatively" more intermediate output than would be required in practice. Based on our conclusions in the preceding section, this component of CPU time should be neglegible.

The CPU time for producing the final output is dependent on the problem size and the specific needs of the application at hand. For example, in other applications there might not be a need to print out a detailed information for each modal link, this would save considerable amount of effort.

To complete the discussion we need to know how many iterations would be required to arrive at a "sufficiently" good solution. To answer this question we plot the value of the objective function Z against the number of iterations for all four problems (see Figure 7.6). Looking at the figure, the performance of the SPND algorithm is as expected; the rate of decrease of Z decreases as the number of iterations increase exhibiting the well-known "tailing-off" phenomenon of the Frank-Wolf procedure. Notice That we gained in the first 100 about 5 to 6 times what we gained in the remaining 100 iterations. Also notice that Z improves more rapidly in a "relative" sense, for problems that are more relaxed in terms of fleet capacities. This is consistent with our earlier results in Figures 7.2, 7.3 and 7.5. It should be mentioned at this point that the rate of convergence (of all four problems) is constrained by the modification introduced in the one-dimensional search and we would expect the algorithm to perform relatively better in other applications.

The rate of convergence for different types of variables in the system may not be identical. In fact, we observe (e.g., see Figure 7.4)

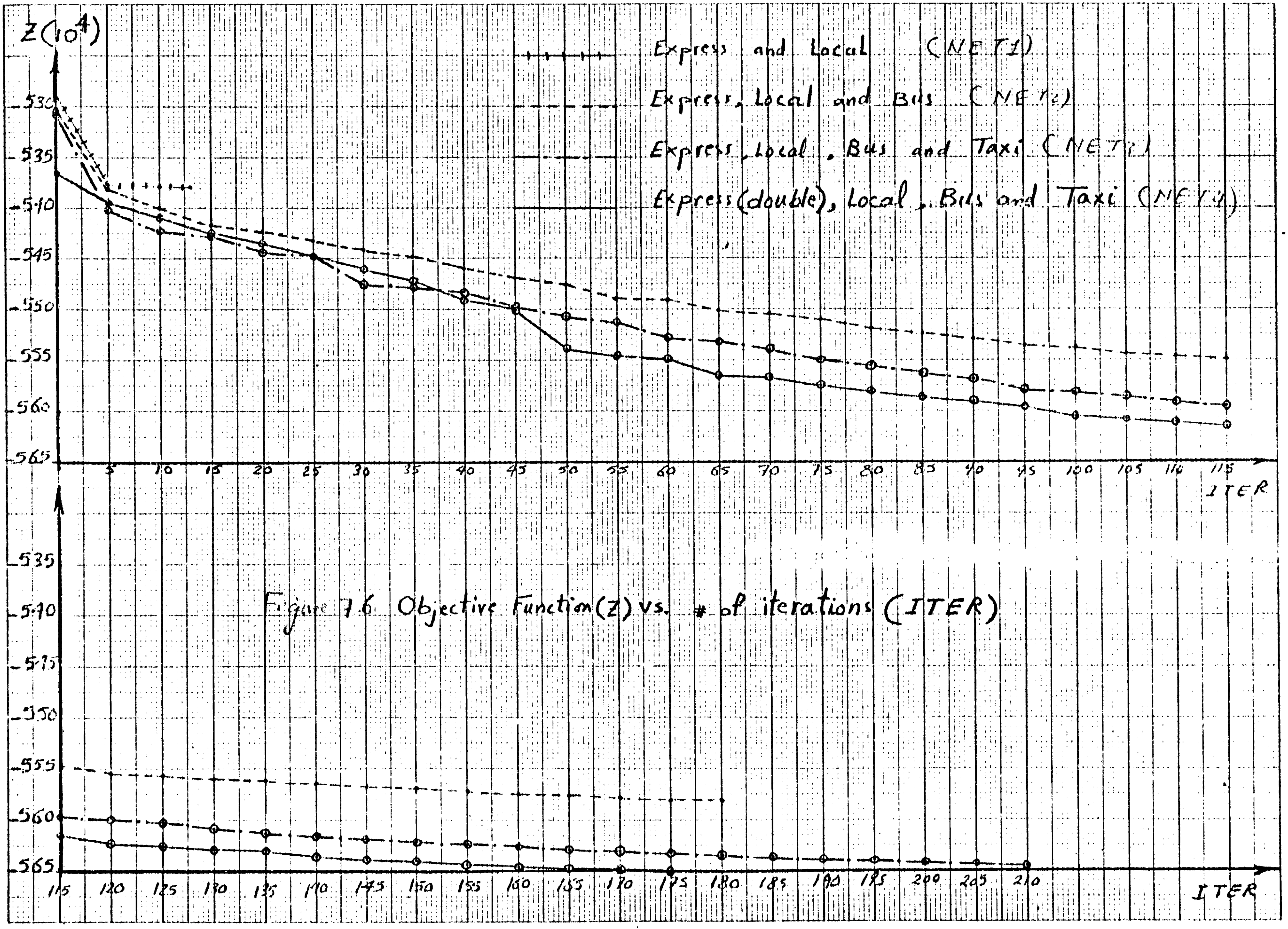

Figure 7.6 Objective Function (Z) vs. # of iterations (ITER)

that trip distribution variables have the slowest rate of convergence while trip generation variables are the fastest. This is so because on one hand we have 552 trip distribution variables and at each iteration we equilibrate only 24 of these large number, on the other hand we only have 24 trip generation variables and all are equilibrated at each iteration. The rate of convergence of modal link flows would be somewhere in the middle between trip generation and trip distribution variables, since we have 244-534 links and at each iteration we equilibrate the flows on the 24 shortest paths determined in the direction finding step.

At any rate, suppose that a "sufficiently" good solution may be obtained after 100 iterations, then the total CPU time required would be 3.6 ~ 6.3 minutes; this cost is almost negligible when compared with the anticipated benefit of such an analysis. In fact, if we are talking about making decisions to invest millions of dollars on transport projects, even if the analysis would require hours of computer time the cost would still be negligible. As indicated earlier, there is no clear cut definition of what is an efficient procedure. Nevertheless, based on our computational results so far, we may say that the SPND algorithm appears to be "reasonably" efficient for analyzing large-scale systems. In fact we believe that there is still more room for improvement in the computational efficiency of our procedure.

7.4 ABILITY TO REPRESENT ACTUAL BEHAVIOR

In the preceding two sections we have analyzed the results from the computational point of view. In this section we would like to assess the ability of our STEM model to represent actual behavior on transport systems, in general, and on the Egyptian intercity system in particular. In the next section we would like to focus on the ability to predict behavioral responses to changes in the system.

As indicated earlier, the ability of the STEM methodology to represent actual behavior on transport systems depends upon the state-of-the-art of modelling travel behavior and the behavioral assumptions of the STEM model itself. The ability to represent behavior on a given system is constrained by the above factors and the ability of modelling travel behavior on that particular system which may, in turn, be constrained by the lack of appropriate and reliable data and the existence of some special peculiar features on that system. The major limitation in relation to the state-of-the-art is the lack of a well defined theory of trip generation and trip distribution behavior. The STEM model itself stands somewhere in the middle of the range of behaviorally "acceptable" transport planning models. The behavioral modelling of the Egyptian intercity system (see chapter VI) appears to be reasonable in some, but not all, of its components. The main areas of limitation seems to be the calibration of demand models (because of the lack of theory and supportive data), the estimation of loading and unloading delays (because of the considerable amount of research and data collection efforts required to obtain better estimates), and the modelling of fleet capacity constraints (because of the limitation of the state-of-the-art). These limitations, particularly those related to the Egyptian system, are expected to constrain the ability of our methodology to represent behavior on that system. The major special features of the Egyptian intercity transport system are the non-existence of the usual traffic congestion, the existence of fleet capacity constraints on major modes and the topology of the network (i.e., a very dense network in Lower Egypt and one corridor in Upper Egypt). The existence of these special features is expected to limit the generality of our results. We do belive, however, that learning about the behavioral implications of these special and limiting aspects of the application is as useful as learning about the general behavioral acceptability of the STEM methodology.

To assess the behavioral ability of the STEM model we compare our predictions with "observed" data. The "observed" data used in the comparison is partially estimated and synthesized as explained in chapter VI, and hence may not be as reliable as desired. For the purposes of comparison, however, we assume that this "observed" data is representing the actual behavior on the Egyptian transport system. This assumption, though may not be true, is reasonable since it has already been implied in our design of the case study. That is, we have actually used these "observed" data to calibrate our demand models. The trip generation model, in particular, may be considered as a function of "observed" data. In fact, our assumption that the minimum trip generation is 90% of the "observed" value would imply that our predictions of trip generation may be reasonably close to "observed" data; of course we still expect some differences due to the averaging of the parameter α. Nevertheless apart from that, we expect the comparison between predicted and "observed" values to be very fruitful in terms of identifying the different capacities and limitations of the approach in the particular application at hand.

Table 7.4 compares the "observed" trip generation and trip attraction data with those predicted on the network representing the existing situation (i.e., NET3). Looking at the last row in table 7.4, we notice that the total demand predicted on NET3 is within 1.5% from the corresponding observed value; this indicates that our results on the aggregate level are quite satisfactory. Looking at the trip generation data, we can see that the percent difference between predicted and observed values is less than 10% for all origins with more than 10,000 trips and is less than 20% for almost all origins with less than 10,000 trips; again this is very reasonable. The highest differences, percentage wise, are observed for PRTS and SWES (i.e., +63.8% and +57.8% respectively). In absolute terms, however, these differences are 1,482 and 1,490 trips, respectively, and should not be overemphasized. The largest differences, in absolute terms, are those of CAIR and BNHA; again this should not be overemphasized since their percent differences are reasonably low (i.e., -8.6% and -7.7%, respectively). The main reason for these discrepancies between predicted and observed trip generation demands is related to our choice of the parameter "α". Recall that, in chapter VI, we have calculated α_i for each origin then selected some "average" value (i.e., $\alpha = 200$). If we compare the differences in table 7.4 and those between α_i and α in tables 6.16, we can clearly see that the correlation is almost perfect; whenever α_i is greater than α, we tend to underestimate G_i and vice versa; the difference between predicted and observed values is positively correlated with the difference between α_i and α. This suggests that trip generation predictions, in general, may be improved by defining an α_i for each origin rather than an average value for all origins; notice that the STEM methodology allows this modification to be incorporated in the model very easily.

Table 7.4 Comparison between Predicted and Observed Trip Generation and Attraction

ZONE	Trip Generation			Trip Attraction		
	NET3	Observed	%Diff.	NET3	Observed	%Diff.
ALEX	25,688	26,615	-3.5	14,125	26,150	-46
DMHR	14,093	13,682	+3	13,898	13,824	+0.5
ETYB	7,187	6,000	+19.8	7,953	6,224	+27.8
KFRS	12,331	11,706	+5.3	9,820	11,196	-12.3
MHLK	10,644	9,781	+8.8	12,776	9,924	+28.7
TANT	36,644	38,677	-5.2	48,555	38,452	+26.3
SHKM	31,719	33,200	-4.5	44,208	33,628	+31.5
BNHA	74,949	81,240	-7.7	88,104	66,383	+32.7
CAIR	114,739	125,540	-8.6	110,823	139,565	-20.6
ZGZG	19,992	20,178	-0.9	29,205	21,768	+34.2
ABKB	7,939	6,803	+16.7	8,385	5,716	+46.7
MNSR	20,708	21,004	-1.4	18,178	19,692	-7.7
SHRB	10,519	9,700	+8.4	9,765	11,447	-14.7

Table 7.4 (continued)

ZONE	Trip Generation			Trip Attraction		
	NET3	Observed	%Diff.	NET3	Observed	%Diff.
DMIT	7,605	6,494	+17.1	4,024	6,209	-35.2
PRTS	3,805	2,323	+63.8	2,018	2,975	-32.2
ISML	8,827	7,846	+12.5	6,476	7,524	-13.9
SWES	4,070	2,580	+57.8	2,550	2,903	-12.1
FYUM	11,826	11,226	+5.3	8,156	12,156	-32.9
BSWF	14,102	13,751	+2.6	11,571	12,206	-5.2
MNIA	7,211	6,237	+15.6	4,607	6,777	-32
ASYT	10,368	9,867	+5.1	6,871	9,432	-2.7
SHAG	7,662	6,934	+10.5	5,702	7,294	-21.8
QENA	6,754	6,062	+11.4	4,115	6,025	-55.7
ASWN	3,664	2,834	+29.3	1,162	2,624	-55.7
TOTAL	473,045	480,280	-1.5	473,045	480,280	-1.5

Looking at the trip attraction data in table 7.4, we find that the discrepancies between predicted and observed values are in general higher compared to trip generation; however, for the majority of destinations, these differences may still be considered relatively reasonable. Unfortunately, the highest differences, in absolute terms, are observed for the most important destinations in the system (i.e., CAIR, BNHA, TANTA, SHKM and ALEX). Recall that our model predicts trip attraction indirectly through trip distribution, and hence our trip attraction results are mainly influenced by the parameters and the specification of the trip distribution logit model, as well as the O-D perceived costs in the system. The O-D perceived costs, in turn, are influenced to a great extent by the existence of fleet capacity constraints in the system as reflected through the link cost functions. Therefore, it seems that the reasons for these relatively high discrepancies in trip attraction results (particularly of the above five mentioned destinations) are related to the trip distribution model itself and/or to the existence of fleet capacity constraints in the system.

As far as the trip distribution model is concerned, it seems that the attractiveness measure, A_j, is misspecified. It is true that a measure based on the "number of trips attracted" should be quite reasonable (given the lack of socio-economic data), but it appears that the "total number of trips attracted", D_j, is "too aggregate" to capture the variability in destination choice behavior of users at different origins. To see this, let us suggest an alternative measure of attractiveness and compare it with the current one in terms of their implications on trip distribution predictions. We simply suggest the use of T_{ij} instead of D_j to represent the attractiveness of destination j. That is we define $A_{ij} = \ell n\ T_{ij}$, instead of $A_j = \theta_1 \ell n\ D_j$, as our alternative attractiveness variable. This implies that the attractiveness of a given destination j would, in general, vary according to the origin i from which a given user is travelling; this measure should be able to capture the variability in behavior at different origins which the current measure failed to reflect. To see how the current misspecification affected our trip distribution (and consequently trip attraction) results, let us assume that the effect of perceived cost on trip distribution is negligible (i.e., the value of θ is very close to zero), and that $\theta_1 = 1.0$. Then, a simple transformation shows us that trip distribution will be given by either one of the following models according to the attractiveness measure we use, that is,

$$\text{A1:}\quad \hat{T}_{ij} = \hat{G}_i \cdot \frac{T_{ij}}{\sum\limits_j T_{ij}} \qquad (\text{if } A_{ij} = \ell n\ T_{ij}),\ \text{for all } ij$$

$$\text{A2:}\quad \hat{T}_{ij} = \hat{G}_i \cdot \frac{D_j}{\sum\limits_j D_j} \qquad (\text{if } A_j = \ell n\ D_j),\ \text{for all } ij$$

where $\hat{}$ indicates that the value is predicted.

Now let us analyze the movement between CAIR and BNHA since, as we will see shortly, it represents, more or less, the "worst case" in our demand predictions; table 7.5 (including tables 7.5.1 through 7.5.4) shows the results of this analysis. From the information on observed trips (table 7.5.1.) we can see the great importance of BNHA to CAIR and vice versa. About 87% of total trips generated from Banha goes to Cairo representing more than 50% of the total trips attracted to Cairo. On the other hand, more than 45% of the trips generated from Cairo is attracted to Banha representing more than 85% of its total trip attraction. Also notice that the volume of demand between Cairo and Banha represents more than one fourth of the total demand in the system (recall that we are dealing with low income passengers only).

Invoking the above hypothetical assumptions and calculating trip distribution by A2, our predictions would be as shown in table 7.5.2. The values in table 7.5.2 are very low compared to the observed data indicating that we have greatly underestimated the importance of each one of these zones with respect to the passengers travelling from the other. Specifically we have assumed that the relative importance of Cairo is 29% (as suggested by observed values on the national level) while for travellers from Banha, Cairo is in fact relatively 87% important compared with other destinations (as suggested by observed values at Banha); similar assumptions affected the movement in the other direction. To correct for this bias, we again invoked the same hypothetical assumptions and calculated trip distribution by A1; the results are shown in table 7.5.3. It is clear that our predictions in table 7.5.3 are far better than those in table 7.5.2. In fact our new predictions are very close to the observed values; the remaining differences between predicted and observed values are due to the differences in our trip generation predictions. Comparing these results (particularly those of table 7.5.2) with our actual predictions on NET3 (shown in table 7.5.4) reveals to us a number of interesting points. First, we notice that our trip distribution predictions on NET3 are far better than those of table 7.5.2; they are still, however, considerably less than observed values. The difference between the results of table 7.5.2 and on NET3 is attributable to introducing the effect of the perceived cost on trip distribution on NET3. It seems that the effect of cost, in this particular situation, was in the positive direction because Cairo and Banha are very near to each other and the perceived cost

Table 7.5 Analysis of Deman Between Cairo & Banha

Table 7.5.1 Observed Trips

To From	CAIR	BNHA	G_i
CAIR	-	56,886	125,540
BNHA	70,729	-	81,240
D_j	139,565.	66,383	480,280

Table 7.5.2 Predicted Trips (A2)

To From	CAIR	BNHA	G_i
CAIR	-	15,834	114,739
BNHA	21,735	-	74,949
D_j	-	-	473,045

Table 7.5 (continued)

Table 7.5.3 Predicted trips (A1)

To From	CAIR	BNHA	G_i
CAIR	-	51,977	114,739
BNHA	65,206	-	74,949
D_j	-	-	473,045

Table 7.5.4 Predicted Trips (NET3)

To From	CAIR	BNHA	G_i
CAIR	-	38,549	114,739
BAHA	32,080	-	74,949
D_j	110,823	88,104	473,045

between them would be relatively low encouraging more trips to travel between them; of course, in general, this may not be the case. Second, we notice that the resultant error, of the biases in trip distribution values, on the predictions of total trip attraction is unpredictable; for Banha the error is +32.7% (i.e., an overestimation of 21,721 trips) and for Cairo it is -20.6% (i.e., an underestimation of 28,742 trips). The reasons are obvious. The magnitude and direction of prediction errors due to the above effects are, in general, different from one O-D pair to another. In addition, there are other factors that affect trip distribution predictions and we have yet to take their effects into account.

It seems that the second major factor (beside the misspecification of attractiveness) is the existence of fleet capacity constraints in the system. This factor will be discussed in detail from all its aspects in the following section. Here we only mention one example which should be sufficient to prove our point. Comparison between NET3 and NET4 (see section 7.5) revealed that there is about 5,563 trips diverted to SHKM (Shebin El-Kom) because of the fleet capacity constraints on the Cairo-Banha-Tanta corridor. That is, more than half the difference between predicted total trip attraction at SHKM on NET3 and observed value (i.e., 5,563 out of 10,580 trips or about 53%) is due to such constraints.

A third factor which would introduce biases in trip distribution behavior is the parameter θ. Recall that θ has been calculated as an "average" value based on a selected number of O-D pairs having Cairo as their common origin (see chapter VI). Therefore, depending upon the variability of users' behavior at different origins (as far as their sensitivity to travel cost is concerned), this "averaging" would bias trip distribution predictions. Behaviorally, we expect users' sensitivity to travel cost to depend upon their socio-economic characteristics which may be captured through the definition of user types; in our case categorization is based on income. One might argue that for a given income level, social life would vary from one zone to another such that their sensitivity to travel cost would be significantly different. Or, in general, there might be some other socio-economic factors which are not captured in our categorization of passengers, but are specific for each zone. In such a case it would be preferable to specify a parameter θ_i for each origin i instead of an "average" θ; our methodology does allow such modifications. Nevertheless, in our case study, it seems that the errors due to an average θ are not significant enough to suggest such a change.

The Comparison between modal split predictions on NET3 and observed values is shown in table 7.6. The observed values are calculated from table 5.2 (see chapter V) assuming, as before, that low income passengers constitute 80% of rail movement and 75% of intercity bus traffic. Looking at table 7.6, we can clearly see that our predictions imply more longer trips than observed; that is, the average distance is 56% more on NET3 than it is observed. This is one of the implications of the misspecification of attractiveness in the trip distribution model. That is, we have overestimated the relative importance of destinations in Upper Egypt (Lower Egypt) to users originating from Lower Egypt (Upper Egypt) and underestimated the relative importance of destinations in the same region, particularly those of Upper Egypt. For example, on the aggregate level, BNHA is the second attractive destination in the system (after CAIR). For users in ASWN, BNHA is among the least attractive destinations (see appendix C). This would result in overestimating trips from ASWN to BNHA and underestimating trips to other zones in Upper Egypt which became relatively less important. The

Table 7.6 Comparison of Modal split Predictions on NET3 and Observed Values

MODE	Passenger			Passenger-kms (1000)			Average distance (km)		
	Observed	Predicted	%Δ	Observed	Predicted	%Δ	Observed	Predicted	%Δ
Rail	381,808	348,861	-8.6	30,247	43,268	+43	79	124	+57
Bus	300,616	75,707	-7.5	13,151	5,035	-62	44	66.5	+51
Taxi	-	59,097	-	-	3,903	-	52	66	+27
TOTAL	682,424	519,615	-24	43,398	52,206	+20.3	64	100	+56

reader can verify that the same argument is true for almost all O-D pairs with one end in Upper Egypt and the other in Lower Egypt (see appendix C). This will lead us to predict more longer trips since the distances between zones in Upper Egypt and those in Lower Egypt are relatively long. Keeping this in mind, we can see that the railway results in table 7.6 are quite consistent and reasonable. As for the results of normal bus travel, our predictions are far below the observed values both for passengers and passenger-kms travelled. Recall that our assumption on the observed low income passengers on bus (i.e., 75%) is based on the modal split survey conducted by NEDECO (1981) on the Cairo-Alexandria corridor. It seems that low income bus ridership along this corridor is relatively above national average, and hence the average percentage of low income travellers on bus may actually be far below 75%. Unfortunately, the available data could not provide us with a better estimate. In addition, notice that in our analysis we have assumed that low income passengers would choose normal buses only and under no circumstances would they travel by Lux bus. It seems that this assumption is too restrictive. Recall from table 6.10 that "Lux" bus is an aggregation of "five" types of bus service, these are: First class bus, Arrow, Flight Pullmann, Lux Pullmann and Super Lux Pullmann. The quality index in table 6.10, indicates that First class and Arrow services are considered "sufficient" similar to the taxi. Therefore, it seems more appropriate to include these types of bus service in the choice set as we did for the taxi.

At the aggregate level, comparison between predicted total passengers and passenger-kms produced on all modes and observed values, indicates that the results are in general comparable, except for the fact that our predictions implies more longer trips than observed, as explained earlier.

As far as traffic assignment is concerned, it is greatly influenced by fleet capacity constraints on the system, as expected.

To conclude this section, we note that the major differences between predicted and "observed" behavior are related to the misspecification of the trip distribution model and the approximation of modelling fleet capacity constraints. We have suggested an alternative, more disaggregate, specification for the trip distribution model and have demonstrated its capability to produce better predictions. We do believe, however, that our demand models still have a lot of potentialities which we could not demonstrate; the major limitations are the lack of theory and supportive socio-economic data, particularly on the Egyptian intercity transport system. The approximate approach of modelling fleet capacity constraints introduces fictitious cost on the system which influences travel behavior. This fictitious cost should be negligible at equilibrium provided that the system is not globally or regionally constrained. Our results indicate that after about 200 iterations the system appears to be constrained in the Middle Delta region and hence the fictitious cost still has a relatively significant influence on travel behavior, particularly on that of trip distribution. The problem may be considered as a special one since in general we would expect the effect of the usual congestion to be predominant. On the other hand, the inability of the state-of-the-art to provide a practically accurate solution for this problem is a general concern. In fact, regardless of how you look at it, the existence of fleet capacity constraints on the Egyptian system did not allow us to demonstrate one of the expected major potentialities of our STEM methodology, that is the ability to represent the usual congestion effects.

7.5 ABILITY TO PREDICT BEHAVIORAL CHANGES

An important issue in assessing the applicability of the STEM methodology is its ability to predict changes of users' behavior in response to changes of the system. In this section we investigate this issue.

Let us first assume that our predictions on NET3 represent the actual behavior in the system. Of course, in view of the comparison between NET3 and observed values in section 7.4, this assumption is not valid but is necessary for the purpose of analysis in this section.

Now suppose that express train schedules are doubled everywhere in the system; what are the implications of this change on the user's behavior. To answer this question we compare our predictions before (i.e., NET3) and after the change (i.e., NET4). The final results of both problems are included in Appendix E. For the sake of analysis, we have extracted some results as shown in tables 7.7 to 7.9.

Table 7.7 compares trip generation and trip attraction results of NET3 and NET4. Our first observation is related to the total demand, there is almost no difference between NET3 and NET4 in this regard (results show a 0.1% increase in total demand). This indicates that on the aggregate level the system was essentially unconstrained. Looking at the trip generation results in table 7.7, we notice that the predictions of NET4 are consistently exhibiting a very slight increase over those of NET3; in absolute terms, the difference is surprisingly constant at about 27 trips for each origin. It seems that the incremental change in the accessibility variable was the same for each origin due to the "uniformity" of the change in the system.

Table 7.7 Comparison Between Predicted Trip Generation and Attraction of problems NET3 and NET4

ZONE	Trip Generation			Trip Attraction		
	NET3	NET4	%Δ	NET3	NET4	%Δ
ALEX	25,688	25,714	+0.1	14,125	14,501	+2.7
DMHR	14,093	14,120	+0.2	13,898	12,930	-7
ETYB	7,187	7,214	+0.4	7,953	6,586	-17
KFRS	12,311	12,358	+0.2	9,820	8,634	-12
MHLK	10,644	10,671	+0.25	12,776	13,804	+8
TANT	36,644	36,672	+0.07	48,555	51,090	+5.2
SHKM	31,719	31,746	+0.08	44,208	38,645	-12.6
BNHA	74,949	74,976	+0.04	88,104	89,832	+2
CAIR	114,739	114,765	+0.02	110,823	116,133	+5
ZGZG	19,992	20,019	+0.1	29,205	28,098	-3.8
ABKB	7,939	7,966	+0.3	8,385	7,157	-14.6
MNSR	20,708	20,735	+0.1	18,178	17,370	-4.4
SHRB	10,519	10,546	+0.2	9,765	9,020	-7.6

Table 7.7 (continued)

ZONE	Trip Generation			Trip Attraction		
	NET3	NET4	%Δ	NET3	NET4	%Δ
DMIT	7,605	7,631	+0.3	4,024	4,362	+8.4
PRTS	3,805	3,830	+0.6	2,018	2,470	+22.4
ISML	8,827	8,853	+0.3	6,476	7,121	+10.
SWES	4,070	4,096	+0.6	2,550	2,633	+3.3
FYUM	11,826	11,852	+0.2	8,156	7,555	-7.4
BSWF	14,102	14,128	+0.2	11,571	12,074	+4.3
MNIA	7,211	7,234	+0.4	4,607	4,245	-7.9
ASYT	10,368	10,390	+0.2	6,871	6,753	-1.7
SHAG	7,662	7,683	+0.3	5,702	6,005	+5.3
QENA	6,754	6,773	+0.4	4,115	4,927	+20
ASWN	3,664	3,681	+0.6	1,162	1,708	+47
TOTAL	473,045	473,654	+0.1	473,045	473,654	+0.1

Trip attraction results exhibit variable differences (in terms of their magnitudes and signs) which are in general relatively greater than those of trip generation results. This indicates that the system was constrained by its fleet capacity at various locations. The "apparently" random discrepancies between trip attraction predictions of NET3 and NET4 are, in fact, not random at all and may be explained and fully understood if we analyze trip distribution results. Table 7.8 compares trip distribution predictions from/to Cairo for NET3 and NET4. Focusing on the Middle Delta region we notice that trips from Cairo to Banha and Tanta increased while those going to Shebin El-Kom (SHKM) decreased; in fact the decrease of trips to SHKM is almost identical with the increase to Tanta. This indicates that because of the fleet capacity constraint, on the Cairo - Banha - Tanta corridor, about 3,000 trips diverted to SHKM instead of Tanta. The trips that were supposed to go to Banha (i.e., about 2,300 trips) diverted to ZGZG and ABKB (this explains the results of ZGZG and ABKB in table 7.8). The results of Upper Egypt show a decrease to all zones in the area, this indicates that again because of the constraints in the Middle Delta region trips were diverted to Upper Egypt instead of going to their preferred destinations in Lower Egypt, this explains the increase in the results of ALEX, DMHR, MNSR, SHRB, DMIT and ISML. Referring to the results of trips attracted to Cairo (see table 7.8), we find an increase in trips coming from all zones in Lower Egypt (except SHKM, ZGZG and ABKB; the reasons pertaining to these zones have been already explained). This again indicates the tremendous effect of the constraints which existed on the Cairo-Banha-Tanta corridor; it prevented about 8,500 trips coming from different zones in Lower Egypt to terminate at Cairo, they were diverted to other zones "around" the constrained region or to Upper Egypt. This type

Table 7.8 Trip Distribution Predictions From/To Cairo

ZONE	FROM CAIRO			TO CAIRO		
	NET3	NET4	Diff.	NET3	NET4	Diff.
ALEX	3710	4063	+354	5,484	6398	+914
DMHR	2644	3058	+414	2,629	3,402	+773
ETYB	1666	1626	-40	13771	1,759	+388
KFRS	1773	1624	-149	2,118	2,311	+193
MHLK	2286	3936	+1650	1995	2392	+397
TANT	12659	15,710	+3051	9,174	11,396	+2322
SHKM	15792	12,686	-3106	10,092	8,907	-1135
BNHA	38,549	40,869	+2320	32,080	33,967	+1887
CAIR	-	-	-	-	-	-
ZGZG	10,627	9,857	-770	7,053	6,688	-365
ABKB	3,460	1,718	-1742	2,418	2,211	-207
MNSR	3,427	4,017	+590	2,834	4,609	+775
SHRB	1,679	1,708	+29	1,762	2209	+447

Table 7.8 (continued)

ZONE	FROM CAIRO			TO CAIRO		
	NET3	NET4	Diff.	NET3	NET4	Diff.
DMIT	586	599	+13	1,240	1,531	+291
PRTS	430	393	-37	880	985	+105
ISML	2,049	3079	+1030	2,740	2,759	+19
SWES	1,129	1049	-80	2,184	2,042	+19
FYUM	3,740	2656	-1084	5,968	5,850	-118
BSWF	4,706	3771	-935	7,647	7,040	-607
MNIA	1,275	642	-633	3,043	2,911	-132
ASYT	1,253	810	-443	3,581	3,261	-320
SHAG	545	189	-356	2,102	1,911	-191
QENA	622	614	-8	1,161	1,215	+54
ASWN	132	91	-41	417	379	-38
TOTAL	114,739	114,765	+26	110,823	16,133	+5310

of analysis when applied to different zones, should clearly indicate the existence of fleet capacity constraints (particularly in the Middle Delta region) and the effect of such constraints on trip distribution behavior. It should be obvious at this point that users' responses are quite rational and justified (assuming of course that our inputs represent their actual behavior as mentoned earlier).

As far as modal split behavior is concerned, results are quite consistent with the above observations. Table 7.9 shows modal passsenger-kms produced on NET3 and NET4. Modal split results show an increase of about 8% in total passenger-kms on NET4 compared to NET3. They may be explained by the fact that the constraints on NET3 prevented many trips from going to their preferred destinations and, as a consequence, they diverted to other "nearer" destinations, so to speak. As expected, the results indicate decreases in modal shares of all modes but the express train. The increase in passenger-kms on express train is not 100% (as would be expected if the existing constraints were uniformly spread all over the network) because the existing constraints were, more or less, limited in terms of location; the increase is about 37% only. The greatest decrease in absolute terms and percentage wise may be observed on local train (and not the taxi). At the first glance, this is a surprising result. However, if we recall that users on NET3 are more inclined towards longer trips compared to the actual system (see secton 7.4), we can understand why local train is perceived (on NET3 and NET4) to be relatively "expensive"! Recall that local trains stop at every city and village and are expected, by definition, to be used by low income people for "local" travel. For longer trips, the delay on local trains becomes enormous discouraging their use. Therefore, we have to be very cautious to draw conclusions concerning the usefulness of local train

Table 7.9 Modal passenger-kms produced per day (in 1979), on NET3 and NET4

Mode	NET3		NET4	
Express	31,248,279	60	42,714,006	76
Local	12,020,035	23	6,203,618	11
Bus	5,034,687	9.6	4,570,475	8
Taxi	3,903,161	7.4	2,757,805	5
Total	52,206,162	100%	56,245,904	100%

service on the actual Egyptian system based on this analysis. In fact, our assumption that trips may originate or terminate at the 24-zone centroids only (as assumed in the intercity project [1982]) is not "fair" to evaluate local train service, because such an assumption does not reflect the real benefit of using local trains while, on the other hand, travel cost on local train is fully taken into account.

As far as traffic assignment is concerned, we notice that the results on NET4 represent the "net" effect of the above mentioned factors on the modal link flows. Hence analyzing such results would involve unnecessary repetitions.

To conclude this section we note that the ability to predict behavioral changes is obviously dependent upon the ability to represent behavior, in the first place. Therefore, because our results on the ability to represent behavior were, in a sense, inconclusive, we tend to think of the results on the ability to predict behavioral changes as being also inconclusive. However, in view of the above analysis, there are strong indications that the STEM model would be capable of predicting rational behavioral responses of users to policy changes in the system.

VIII SUMMARY AND CONCLUSIONS

Existing transport planning methodologies, which have been applied to hundreds of transport studies throughout the world for the past 30 years, involve a "σεγξεντιαω ρθοψεσσ" for predicting short-run transport equilibria often with four stages: trip generation, trip distribution, modal split and traffic assignment. Unfortunately, the sequential approach (whether using aggregate or disaggregate models) has an inherent weakness; its predictions need not be internally consistent. That is, because user decisions concerning trip frequency, destination, mode and route choices are inherently interrelated, the performance or demand levels that one needs to assume as given inputs at any one stage in the process need not agree with those that one determines as outputs from the other stages.

This deficiency has precipitated attempts to predict all four stages simultaneously. Research intended to meet this objective of the simultaneous prediction of equilibrium has proceeded in three directions. One of these lines of investigation has significant computational advantages (Beckman et al [1956], Bruynooghe et al [1968], Leblanc [1973], Nguyen [1974], Golden [1975], Evans [1976], Florian and Nguyen [1978]); the others permit richer modelling of user behavior (Asmuth [1978], Smith [1979], Aashtiani [1979], Dafermos [1980, 1981], Sheffi and Daganzo [1980]. Aashtiani and Magnanti [1981], Pang and Chan [1981], Friesz et al [1982]). Regrettably, to date none of these studies has generated models that are both behaviorally acceptable and computationally tractable for large-scale applications. Review of these, and other related studies illustrates the tradeoffs between the behavioral and computational aspects of the equilibrium problem.

Therefore, our objective in this thesis has been to strike a balance between the behavioral and practical considerations of the problem. That is, to develop a unified consistent methodology for transportation planning within which trip generation, trip distribution, modal split, traffic assignment and the corresponding performance levels can be predicted simultaneously for a set of behaviorally acceptable demand and performance models, with an algorithm that is convergent and computationally efficient for large-scale applications.

Towards the achievement of that objective, we have specified a family of Simultaneous Transportation Equilibrium Models (STEM's). In any STEM model, trip generation is given by a general linear model which can depend upon the system's performance through an accessibility measure that is based on the random utility theory of users' behavior. Trip distribution is given by the well known logit model. Alternative assumptions on modal split and traffic assignment can be considered within our framework. Modal split can be user optimized, system optimized or a logit model. Traffic assignment can be user or system optimized.

In order to prove existence and uniqueness of equilibrium on any STEM model, and more importantly, to develop a convergent and efficient algorithm for predicting that equilibrium, we have formulated a family of optimization problems. Considering one of these optimization problems, we have proven that it has a solution (i.e., theorem 3.1) and under mild assumptions on demand and performance models it is a convex program that is equivalent to a given STEM model (i.e., theorem 3.2). Based on these results we have proved existence and uniqueness of equilibrium on that STEM model (i.e., theorem 3.3). The results can easily be extended to other STEM's in the family. In any of these Equivalent Convex programs (ECP's), we are minimizing a convex objective function subject to a set of linear constraints. The constraints in any ECP problem represent the flow conservation equations on any given transportation network in addition to the non-negativity constraints. The objective function is composed of three sets of terms; two of them may be familiar to the reader while the third set, J(S), is new. In fact, any ECP problem can be distinguished from other formulations if we recognize the definition of the accessibility measure S_i and its introduction as a decision variable in the problem, and the specificaion of the set of terms J(S) in its objective function.

In our methodology we predict equilibrium on any STEM model by solving the corresponding ECP problem. In this respect, we have developed a convergent and computationally "efficient" algorithm (SPND) for the simultaneous prediction of equilibrium on our STEM models. The SPND algorithm belongs essentially to the class of feasible direction methods for solving nonlinear optimization problems. At any given iteration in the process, the algorithm performs two basic steps; in the first step it determines a direction for improvement and in the second, it performs a one-dimensional search for a better solution in that direction. The direction finding in the first step is performed according to the Frank-Wolf [1956] procedure of solving quadratic optimization problems (i.e., we solve a linearized ECP problem). The efficient solution of this linearized ECP problem is indeed the most distinguishable feature of the SPND algorithm. Essentially the direction for improvement is found by assigning total demand from a given origin on the shortest path going to the most "needy" destination, and that is precisely why we call it the SPND algorithm. The second step is performed using the bisection method (i.e., a standard procedure). The procedure has been programmed on a computer and tested on a small hypothetical example for validation. This completes the development of the methodology.

In order to assess the applicability of the STEM methodology we have actually applied it to a real large-scale system, namely the Egyptian intercity transport multimodal network. The main features of the Egyptian transport system have been described with more emphasis placed on issues related to passenger transport. Specifically, we have described the existing issues and policies related to the infrastructure, transport movements, transport fleet, tariffs and costs, and management.

To address the major computational and behavioral issues of the analysis, we have designed a case study on the Egyptian intercity system. Modelling the system (or designing the case study) involved four major tasks. In the first task (i.e., passenger types-choice sets mapping), we have categorized passengers into three income groups: high, middle and low, and existing transport services into eleven types: auto, taxi, intercity bus (lux and normal), diesel units (I-AC and II-AC classes), express trains (I-AC, II-AC, II and III classes) and local trains (III-class). Then, we defined a "mapping" between these passenger types and available transport services. In the second task, (i.e., multimodal composed networks), we have modelled mode and route choice behavior of users on the system. We have assumed that modal split and traffic assignment are both given in accordance with the user optimization travel behavior. The technical representation of this behavioral assumption required creating a copy of the network for each service type and connecting these copies through loading and unloading links; that is, we have constructed a set of multimodal composed networks. In the third task, we have modelled the system's performance as perceived by users by specifying a set of link user perceived cost functions consistent with our postulated assumption that these are monotonically increasing functions of link flows. The user cost components taken into consideration are those of travel time, tariff, delay at intermadiate nodes, loading and unloading. Fleet capacity constraints--considered to be a major problem on the Egyptian intercity system--have been approximated by an additional term in the link user cost functions. In the fourth task, we modelled trip generation and trip distribution behavior in the system. We have identified the data required for calibration of demand models, commented on data availability and calibration results, and invoked the necessary assumptions to, hopefully, produce reasonable representation of actual user behavior in the system.

In the analysis we focused on one passenger type, the low income group since they represent the majority of users in the system. We have also defined a set of issues to be addressed. From the computational point of view, we have focused on two major issues: convergence criterion and efficiency. From the behavioral point of view, we have concentrated on assessing the ability of the STEM methodology to represent actual behaviour and its ability to predict behavioral responses to changes in the system. In order to address these issues we have analyzed four problems: NET1 (includes express and local trains only), NET2 (includes express, local and normal bus), NET3 (includes express, local, normal bus and taxi), and NET4 (the same as NET3 except that the fleet capacity of express train is doubled). Before presenting our conclusions pertaining to each of these issues, we would like to indicate that the existence of fleet capacity constraints as a major problem in the system, necessitated two modifications in the procedure (one in the initial solution and the other in the one-dimensional search) to assure "feasibility".

Below is a brief definition of each of these four issues, description of the analysis involved and summary of conclusions.

(1) Convergence Criterion:

The issue here is to find the "best" convergence criterion to be used as a stopping rule for the iterative prediction process. We have investigated eleven criteria; of them seven are based on measuring the difference between the last two iterations, two is based on comparison between trip distribution predictions and logit calculations, one is simply the step size of the one-dimensional search and one is based on an internal calculation in the direction finding step of the procedure. We found that there is a strong positive correlation between the first seven criteria and the step size. The step size was found to be, more or less, "random". Therfore, it was concluded that, in general, the criteria based on the difference between the last two iterations are not appropriate since they exhibit a random pattern of behavior which would cause the procedure to stop prematurely. The logit criterion was found to be fluctuating around some "moving" average which appears to be slowly decreasing; it was concluded that although this criterion is better than the previous eight, it is still not desirable because of these fluctuations. The last criterion was found to monotonically approach its optimum value as long as there is a feasible solution to the problems. The basis of the measure may be interpreted as the marginal cost of assigning one additional trip from a given origin on the shortest path to the "needy" destination. At equilibrium this cost should be zero as long as trip generation is strictly within its bounds as would be expected whenever the system is unconstrained. Therefore we refer to this measure as the "equilibrium criterion". We have concluded that this criterion is indeed the best since it is monotonically approaching an optimum value that is known apriori.

(2) Computational Efficiency:

The question addressed here was: how much computer time is required to arrive at an equilibrium that is "sufficiently" close to the exact solution? While computational efficiency may be influenced by many factors, in our analysis we have considered the effect of what appears to be the most two important factors; these are network size and fleet capacity constraints. As far as the network size is concerned, we have considered three networks all having 24 origins and 552 O-D pairs. The smallest network had 90 nodes and 244 links, and the largest had 152 nodes and 534 links. Fleet capacity constraints were accounted for in the initialization process and by modifying the one dimensional search at each iteration. We found that the average CPU time per iteration varies between 2 seconds on the smallest network and 3.5 on the largest one. As expected, fleet capacity constraint was found to reduce the step size in the one-dimensional search, and hence to increase the number of iterations required to arrive at a given level of accuracy. The initial solution was found to consume more CPU time when fleet capacity constraints were "moderate" compared to either severe constraints or relatively unconstrained situations. As far as the general performance of the algorithm is concerned, we found that, again as expected, the rate of convergence decreases as the solution approached equilibrium; that is, the algorithm exhibits the tailing-off phenomenon of the Frank-Wolf approach. The gain in the first 100 iterations was found to be about 5 times the gain in the later 100 iterations. Assuming that a "sufficiently" good solution may be obtained after 100 iterations, the total CPU time required would be 3.6 to 6.3 minutes. Based on these results and the fact that there is no clear cut definition of computational efficiency we have concluded that our approach appears to be reasonably efficient for large-scale applications. In fact, if we are talking about making decisions to invest millions of dollars, even if the analysis required hours of computer time the cost would still be acceptable. We have also noted that in our case the step size was constrained and the cost functions were very steep. In general, however, the step size is not constrained and the cost functions are expected to be mild and hence, the algorithm is expected to perform relatively better.

(3) Ability to represent actual behavior:

The objective here was to assess the ability of the STEM model to represent actual behavior on transport systems in gerneral, and on the Egyptian intercity system in particular. We have addressed this issue by comparing predicted and "observed" behavior. We have found that major differences exist between predicted and "observed" data and that the main reasons are the misspecification of the trip distribution model and the approximation of modelling fleet capacity constraints. We have suggested an alternative, more disaggregate, specification for the logit distribution model and have demonstrated its capability to produce better predictions. We have noted, however, that our demand models still have a lot of potentialities which could not be demonstrated because of the lack of theory and supportive socio-economic data, particularly on the Egyptian intercity system. The approximate approach of modelling fleet capacity constraints resulted in very steep cost functions with fictitious costs that had a significant influence on travel behavior, particularly on that of trip distribution. We have noted that the existence of fleet capacity constraints may be considered as a special feature of the Egyptian intercity system and that the state-of-the-art has yet to provide us with a satisfactory solution to the problem. We have concluded that the existence of such constraints on the Egyptian system did not allow us to demonstrate one of the expected major potentialities of our STEM methodology, that is the ability to represent the usual congestion effects.

(4) Ability to predict behavioral changes:

The objective in this issue was to assess the ability of the STEM methodology to predict behavioral responses of users to policy changes in the system. We have noted that this issue is obviously dependent upon the previous one and therefore, because our results on the ability to represent behavior were, in a sense, inconclusive we tend to think of the results on the ability to predict behavioral changes as being also inconclusive. We have concluded, however, that in view of our analysis there are clear indications that the STEM model would be capable of predicting rational behavioral responses of users to policy changes in the system provided that it can represent existing behavior in an acceptable fashion.

At the conclusion, we may summarize the main contributions of this thesis in the following points:

[1] We have included a general trip generation model, which can depend upon the system's performance through an accessibility variable based on the random utility theory of users' behavior, and a logit trip distribution model, in an equilibrium (STEM) framework. In other words, we have specified a family of STEM models which include the above behaviorally acceptable features in an internally consistent manner.

[2] We have formulated a family of optimization problems which have desirable qualitative characteristics (i.e., a given optimization problem in the family has a solution that is unique and that can be obtained by minimizing a convex function subject to a set of linear constraints), and at the same time equivalent to the above behaviorally acceptable and internally consistent STEM models.

[3] We have developed a convergent algorithm for the simultaneous prediction of equilibrium on any of the STEM models. The algorithm is "reasonably" efficient for large-scale applications.

[4] The contributions in [1], [2], and [3] all together implies the development of a unified consistent methodology for transportation planning, within which, trip generation, trip distribution, modal split, traffic assignment and the corresponding performance levels for realistic systems can be predicted simultaneously and efficiently with a convergent algorithm.

[5] We have actually applied the STEM methodology to a real large-scale system, namely the intercity multimodal transport system of EGYPT.

We have assessed the applicability of the approach computationally and behaviorally.

[6] We have suggested a new convergence criterion for our STEM model, which out performs traditional criteria used in other equilibrium models.

As far as future research is concerned, there are several directions for investigations of topics generated by the developments in this thesis.

One natural direction is to apply the STEM methodology to other large-scale systems elsewhere. Notice that the Egyptian intercity system exhibits some special features, such as the non-existence of the usual congestion of urban travel, the existence of fleet capacity constraints, and the very fact that it is an intercity system instead of urban system. Therefore, applying the methodology to other, particularly urban, systems may prove to be very fruitful.

Another direction of research would be to further improve the computational efficiency of the approach. Notice that our algorithm utilizes only first order information. It would be interesting to investigate ways of incorporating second order information into the algorithmic procedure.

A third direction would be to investigate the practical implications of including more general nonseparable cost functions into the approach. In fact, as indicated earlier, an extended version of the STEM methodology which includes this general feature is currently being applied to the same Egyptian system.

A fourth direction would be to focus on the development of a well defined theory of trip generation and trip distribution behavior in intercity as well as urban contexts.

A fifth direction is to view the STEM model as a component of the more general equilibrium problem of economic spatially separated markets. Hence, we would proceed to develop a more general equilibrium model.

A sixth direction would be to extend the basic notion of the STEM methodology to predict equilibrium simultaneously on other non-transport large-sclae systems.

As a final comment, this thesis is not by any means the end of the road in the field of transport equilibrium modelling. To the contrary, it may be more properly viewed as a starting point on the road to the "wilderness" of application of general transport equilibrium models after years of living in the "luxury" of pure academic research.

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APPENDIX A

LIST OF THE COMPUTER PROGRAM FOR THE SIMULTANEOUS PREDICTION OF EQUILIBRIUM (THE SPND ALGORITHM)

```
C
C     A PROGRAM FOR THE SIMULTANEOUS PREDICTION OF EQUILIBRIUM
C     ON TRANSPORTATION NETWORKS.
C
C     DEVELOPED BY K. NABIL ALI SAFWAT, JUNE 1982.
C
C
      REAL X(2048),Y(2048),COST(2048),SPC(512),T(2048),L(2048),          00000020
     1 COEF(5,2048),LASTF,NAME(512),NM1,NM2,NN/'N'/,CLDX(2048),
     2 EPS,EPS1,MAXVCL(2048),ARG1(26),C1(5),M1,L1,A/'A'/,YES/'YES'/      00000040
      REAL TG(512),TGP(512),S(512),SP(512),TD(2048),TDP(2048),BS,
     1 TA(512),E(512),M(512),ATR(512),ALPHA,THETA,MINZ,MAXS(512),
     2 PCZ,PCTG(512),PCTD(2048),PCX(2048),CPU14,CPU12,CPU23,CPU34,
     3 OLDTG(512),OLDTD(2048),OLDZ,CPUC1,SPC1(2048),TA1(512),
     4 PTDL(2048),TDL(2048),TT1
      REAL TTG,TX,TGSQ,TDSQ,XSQ,TGRMS,GRMS,TDRMS,XRMS
      INTEGER*4 CODE,HANDLE,CPU1,CPU2,CPU3,CPU4,CPUC,CPU5
      INTEGER*2 NARC3,NORIG,NDEST,ODP,ODPR,R
      INTEGER*2 NARC,NEWSR,NT,ORIG(2048),N,DEST(2048),BACK,ISPC(512),    00000050
     1 FROM(2048),TO(2048),I,J,FWD(512),NEXT(2048),ITER,MITER,IACT,T1,P,00000060
     2 P1,ONE/1/,NARC1,NARC2,O,D,K,NT1,MID,SHP(2048),ITER1,F1,ISN/0/,    00000070
     3 ITMAX,NT2,NORIG1
      INTEGER FILE                                                       00000090
      LOGICAL*1 FLAG,FL1/.FALSE./                                        00000100
      DATA ORIG,DEST/4096*10000/,T/2048*0.0/                             00000110
      DATA ARG1/'ASSI','SAVE','EXIT','ADDA','ADDO','DELA','DELO','UPDA',00000120
     1 'UPDO','DISP','RERE','HELP','CTOL','ADDP','GENE','ATTR',
     2 'CONT','ARCS','OD-P','PATH','ORGN','DSTN','AON','CR','USER',
     3 'SYST'/
      HANDLE=0
      CALL LIB$INIT_TIMER(HANDLE)
C     CALL ERRSET(215,0,200,1)                                           00000150
      NAME(1)=YES                                                        00000160
      WRITE (6,13)                                                       00000170
   13 FORMAT('1',78('*')/' * A PROGRAM FOR PREDICTING TRIP GENERATION',     18
     1',TRIP DISTRIBUTION,',T79,'*'/
     2' * MODAL SPLIT AND TRIP ASSIGNMENT SIMULTANIOUSLY',T79,'*'/
     3' *',T79,'*'/' * BY K. NABIL ALI SAFWAT,IN MAY 1981',T79,'*'/
     4' *',T79,'*'/
     5' * THE PROGRAM IS AN EXTENSION OF A TRAFFIC ASSIGNMENT CODE',
     6 T79,'*'/' * DEVELOPED EARLIER BY SHLOMIT AND ZVI TAREM, IN ',
     7'JANUARY 1980.',T79,'*'/' ',78('*'))
      WRITE (6,5)
  490 CALL INPUT(NARC,T,NT,ORIG,DEST,L,MAXVCL,FROM,TO,FWD,NEXT,N,EPS,
     1 EPS1,COEF,NARC2,X,FL1,NAME,ISN,ITMAX,E,ATR,ALPHA,THETA)
  130 WRITE (6,49)                                                       00000290
   49 FORMAT(' ENTER NEXT ACTION:')                                      00000300
      CALL ACTION(IACT,ARG1,1,16,ISN)
  530 GO TO (170,140,120,210,220,230,240,250,260,270,490,510,640,1100,
     1 1200,1300),IACT
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00000330
C                 HELP                                                C 00000340
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00000350
  510 WRITE (6,5)                                                        00000360
    5 FORMAT(/' A LEGAL ACTION IS ONE OF THE FOLLOWING:'/'.''ASSIGN''', 00000370
     1 ', ''SAVE'', ''EXIT'', ''ADDARCS'',''ADDODPAIRS'', ''DELARC''',  00000380
     2 ', ''DELODPAIR'','/' ''UPDARC'', ''UPDODPAIR'', ''DISPLAY'',',    00000390
     3 ' ''TOLERANCE'', ''REREAD'' , ''HELP'','/' ''ADDPARAMETERS''',
     4 ' ''GENERATION'',''ATTRACTION''.')
      GO TO 130                                                          00000410
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00000420
```

```
                  ADDING AN ARC TO THE NETWORK                     C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
 210 WRITE(6,28)
  28 FORMAT(' ENTER ARC DATA:')
 441 NARC1=NARC+1
 440 CALL GETARC(F1,T1,L1,C1,M1,NARC1,NAME,NM1,NM2,N,FL1)
     IF (FL1) GO TO 130
     CALL SEARCH(P,P1,F1,T1,FWD,NEXT,TO)
     IF (P.NE.0) GO TO 420
     IF (F1.NE.0) GO TO 253
     N=N+1
     F1=N
     NAME(N)=NM1
 253 IF (T1.NE.0) GO TO 254
     N=N+1
     T1=N
     NAME(N)=NM2
 254 NARC=NARC1
     NARC2=NARC2+1
     DO 252 KK=1,5
 252 COEF(KK,NARC)=C1(KK)
     FROM(NARC)=F1
     TO(NARC)=T1
     L(NARC)=L1
     MAXVOL(NARC)=M1
     NEXT(NARC)=0
     IF (P1.NE.0) GO TO 430
     FWD(F1)=NARC
     GO TO 441
 430 NEXT(P1)=NARC
     GO TO 441
 420 WRITE (6,29)
  29 FORMAT(' THIS ARC ALREADY EXISTS. REENTER:')
     GO TO 440
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
                 ADDING AN O-D PAIR TO THE NETWORK                 C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
 220 WRITE (6,37)
  37 FORMAT(' ENTER O-D PAIR DATA:')
 461 NT1=NT+1
 460 CALL GETOD(NT1,O,D,T2,NAME,N,FL1)
     IF (FL1) GO TO 130
     CALL SRCHOD(O,D,ORIG,DEST,K,MID,NT)
     IF (K.NE.0) GO TO 450
     IF (O.EQ.0.OR.D.EQ.0) GO TO 451
     CALL INSOD(O,D,T2,ORIG,DEST,T,NT,MID)
     NT=NT1
     GO TO 461
 450 WRITE (6,38)
  38 FORMAT(' THIS PAIR ALREADY EXISTS. REENTER:')
     GO TO 460
 451 WRITE (6,62)
  62 FORMAT(' JOINT NAME INCORRECT. REENTER:')
     GO TO 460
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
                 DELETING AN ARC FROM THE NETWORK                  C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
 230 WRITE (6,36)
  36 FORMAT(' ENTER FROM AND TO OF ARC TO BE DELETED:'/'  XXXX XXXX')
     READ (1,45) RL,NM1,NM2
     IF (RL.NE.NN) GO TO 600
```

```
      WRITE (6,43)
   43 FORMAT(' ENTER ARC NUMBER:'/'  XXXX')
      READ (1,63) I
   63 FORMAT(1X,I4)
      IF (I.GT.NARC) GO TO 570
      F1=FROM(I)
      T1=TO(I)
      GO TO 610
  600 CALL CONV(NM1,NM2,F1,T1,NAME,N)
      IF (F1.EQ.0.OR.T1.EQ.0) GO TO 570
  610 CALL SEARCH(P,P1,F1,T1,FWD,NEXT,TO)
      IF (P.EQ.0) GO TO 570
      IF (P1.EQ.0) FWD(FROM(P))=0
      IF (P1.NE.0) NEXT(P1)=NEXT(P)
      FROM(P)=0
      NARC2=NARC2-1
      GO TO 130
  570 WRITE (6,27)
      GO TO 230
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                 DELETING AN O-D PAIR FROM THE NETWORK                 C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  240 WRITE (6,42)
   42 FORMAT(' ENTER ORIG AND DEST OF PAIR TO BE DELETED:'/
     1 '  XXXX XXXX')
      READ (1,45) RL,NM1,NM2
      IF (RL.NE.NN) GO TO 620
      WRITE (6,64)
   64 FORMAT(' ENTER OD PAIR NUMBER:'/'  XXXX')
      READ (1,63) K
      IF (K.GT.NT) GO TO 500
      GO TO 630
  620 CALL CONV(NM1,NM2,O,D,NAME,N)
      IF (O.EQ.0.OR.D.EQ.0) GO TO 500
      CALL SRCHOD(O,D,ORIG,DEST,K,MID,NT)
      IF (K.EQ.0) GO TO 500
  630 NT=NT-1
      CALL DELOD(ORIG,DEST,T,NT,K)
      GO TO 130
  500 WRITE (6,41)
      GO TO 240
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                    UPDATING AN O-D PAIR                               C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  260 WRITE (6,39)
   39 FORMAT(' ENTER PAIR TO BE CHANGED:')
  480 CALL GETOD(ONE,O,D,T2,NAME,N,FL1)
      IF (O.EQ.0.OR.D.EQ.0) GO TO 470
      CALL SRCHOD(O,D,ORIG,DEST,K,MID,NT)
      IF (K.EQ.0) GO TO 470
      T(K)=T2
      GO TO 130
  470 WRITE (6,41)
   41 FORMAT(' THIS PAIR DOES NOT EXIST. REENTER:')
      GO TO 480
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                    UPDATING AN ARC                                    C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  250 WRITE (6,28)
  410 CALL GETARC(F1,T1,L1,C1,M1,ONE,NAME,NM1,NM2,N,FL1)
      IF (F1.EQ.0.OR.T1.EQ.0) GO TO 400
```

```
      CALL SEARCH(P,P1,F1,T1,FWD,NEXT,TO)
      IF (P.EQ.0) GO TO 400
      MAXVOL(P)=M1
      DO 251 KK=1,5
  251 COEF(KK,P)=C1(KK)
      GO TO 130
  400 WRITE (6,27)
   27 FORMAT(' THIS ARC DOES NOT EXIST. REENTER:')
      GO TO 410
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                 DISPLAYING DESIRED DATA                              C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  270 WRITE (6,21)
   21 FORMAT(' ENTER DESIRED QUANTITY (ARCS, OD-PAIRS , PATH , ORGNS',
     1 ' OR DSTNS:')
      CALL ACTION(IACT,ARG1,18,22,ISN)
      GO TO (280,290,580,1400,1500),IACT
  280 WRITE (6,44)
   44 FORMAT(' ENTER FROM AND TO OF ARC OR ENTER ''A'' (FOR ''ALL'')',
     1 ' IN COLUMN 1:'/'  XXXX XXXX')
  283 READ (1,45) BL,NM1,NM2
   45 FORMAT(A1,A4,1X,A4)
      IF (BL.EQ.A) GO TO 281
      CALL CONV(NM1,NM2,F1,T1,NAME,N)
      IF (F1.EQ.0.OR.T1.EQ.0) GO TO 282
      CALL SEARCH(P,P1,F1,T1,FWD,NEXT,TO)
      IF (P.EQ.0) GO TO 282
      WRITE (6,24)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C DISPLAYING ARC DATA                                                  C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
   24 FORMAT(' NO.  FROM  TO    LEN  MAXVOL    C(1)      C(2)      ',
     1 ' C(3)      C(4)      C(5)'/'+___  ____  __    ___  ______    ',
     2 '    ____      ____      ____      ____      ____')
      WRITE (6,34) P,NAME(FROM(P)),NAME(TO(P)),L(P),MAXVOL(P),
     1 (COEF(J,P),J=1,5)
   34 FORMAT(1X,I4,2(1X,A4),1X,F6.2,1X,F9.2,5(1X,F9.5))
      GO TO 130
  282 WRITE (6,27)
      GO TO 283
  281 IF (NARC.EQ.0) GO TO 130
      WRITE (6,24)
      DO 310 I=1,NARC
      IF (FROM(I).EQ.0) GO TO 310
      WRITE (6,34) I,NAME(FROM(I)),NAME(TO(I)),L(I),MAXVOL(I),
     1 (COEF(J,I),J=1,5)
  310 CONTINUE
      GO TO 130
  290 WRITE (6,47)
   47 FORMAT(' ENTER ORIG AND DEST OF PAIR OR ENTER ''A'' (FOR ''ALL''',
     1 ') IN COLUMN 1:'/'  XXXX XXXX')
  293 READ (1,45) BL,NM1,NM2
      IF (BL.EQ.A) GO TO 291
      CALL CONV(NM1,NM2,O,D,NAME,N)
      IF (O.EQ.0.OR.D.EQ.0) GO TO 292
      CALL SRCHOD(O,D,ORIG,DEST,K,MID,NT)
      IF (K.EQ.0) GO TO 292
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C DISPLAYING OD PAIRS DATA.                                            C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      WRITE (6,25)
```

```
   25 FORMAT('   NO.  ORIG DEST DEMAND'/'+___  ____ ____ ______')
      WRITE (6,35) K,NAME(ORIG(K)),NAME(DEST(K)),T(K)
   35 FORMAT(1X,I4,2(1X,A4),1X,F8.2)
      GO TO 130
  292 WRITE (6,41)
      GO TO 293
  291 IF (NT.EQ.0) GO TO 130
      WRITE (6,25)
      DO 320 I=1,NT
      IF (ORIG(I).EQ.0) GO TO 320
      WRITE (6,35) I,NAME(ORIG(I)),NAME(DEST(I)),T(I)
  320 CONTINUE
      GO TO 130
  580 WRITE (6,56)
   56 FORMAT(' ENTER ORIG AND DEST:'/'  XXXX XXXX')
  581 READ (1,45) B,NM1,NM2
      CALL CONV(NM1,NM2,O,D,NAME,N)
      IF (O.EQ.0.OR.D.EQ.0) GO TO 582
      CALL SHPATH(COST,O,ISPC,SPC,TC,FWD,NEXT,N)
      J=NARC
      SHP(NARC)=D
      I=ISPC(D)
  550 IF (I.EQ.0) GO TO 540
      J=J-1
      SHP(J)=FROM(I)
      I=ISPC(FROM(I))
      GO TO 550
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C DISPLAYING A SUBSIDERY SHORTEST PATH.                             C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  540 WRITE (6,57) NAME(O),NAME(D),SPC(D),(NAME(SHP(I)),I=J,NARC)
   57 FORMAT(' THE ROUT FROM ',A4,' TO ',A4,' COSTS',F8.3,', AND IS:'/
     1 10(15(1X,A4)/))
      GO TO 130
  582 WRITE (6,61)
   61 FORMAT(' WRONG JUNCTION NAME. REENTER:')
      GO TO 581
 1400 WRITE(6,970)
      NORIG=1
      ODPR=1
 1403 IF(ODPR.GT.NT) GO TO 1408
      R=ORIG(ODPR)
      WRITE(6,1402) NORIG,NAME(R),E(R)
 1402 FORMAT(1X,I4,4X,A4,4X,F10.3)
      DO 1406 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 1407
 1406 CONTINUE
 1407 ODPR=I
      NORIG=NORIG+1
      GO TO 1403
 1408 GO TO 130
 1500 WRITE(6,980)
      NDEST=1
      ODPR=1
 1503 R=DEST(ODPR)
      WRITE(6,1501) NDEST,NAME(R),ATR(R)
 1501 FORMAT(1X,I4,4X,A4,4X,F10.3)
 1502 ODPR=ODPR+1
      ODI=ODPR-1
      IF(ODPR.GT.NT) GO TO 130
      DO 1505 I=1,ODI
```

```
      IF(DEST(I).EQ.DEST(ODPR)) GO TO 1502
 1505 CONTINUE
      NDEST=NDEST+1
      GO TO 1503
 1100 WRITE(6,1101)
 1101 FORMAT(//' ENTER PARAMETERS:'/
     1         ' -----------------'//' ALPHA        THETA'/
     2         ' ----------   ----------'/
     3         ' XXXXX.XXXX   XXX.XXXXXX')
      READ(1,1110) ALPHA,THETA
 1110 FORMAT(1X,F10.4,4X,F10.6)
      WRITE(6,1120) ALPHA,THETA
 1120 FORMAT(' ALPHA=',2X,F10.4,'  AND THETA=',2X,F10.6)
      GO TO 130
 1200 CALL GENERATION(NORIG,NT,ORIG,DEST,NAME,E)
      GO TO 130
 1300 CALL ATTRACTION(NDEST,NT,ORIG,DEST,NAME,ATR)
      GO TO 130
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00002610
C                  PERFORMING THE ANALYSIS                            C 00002620
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00002630
  170 FL1=.FALSE.                                                       00002640
      WRITE (6,58)                                                      00002650
   58 FORMAT(' ENTER DESIRED OPTIMIZATION MODE (''USER'' OR ''SYSTEM''',00002660
     1 '):')                                                            00002670
      CALL ACTION(IACT,ARG1,25,26,ISN)                                  00002680
      IF (IACT.EQ.2) FL1=.TRUE.                                         00002690
      WRITE (6,65)                                                      00002740
   65 FORMAT(' ENTER OUTPUT FILE NUMBER (DEFAULT IS 6):'/' XX')         00002750
      READ (1,66) FILE                                                  00002760
   66 FORMAT(3I)                                                        00002770
      IF (FILE.EQ.0) FILE=6                                             00002780
      WRITE(FILE,930)
  930 FORMAT('1 PROBLEM DEFINITION:'/'  ==================='///)
      WRITE(FILE,932)
  932 FORMAT( ' LINK DATA:',
     1 '   COST=C1*LENGTH+(C2*(FLOW/CAPACITY)**C3)+C4*',
     2 'LENGTH+C5'/' ---------'//
     3 ' LINK FROM  TO  LENGTH     C1        C2        C3        C4',
     4 '         C5     CAPACITY'/
     5 ' ---- ---- ---- ------- --------- --------- --------- -----',
     6 '---- --------  ----------')
      DO 945 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 945
      WRITE(FILE,940) I,NAME(FROM(I)),NAME(TO(I)),L(I),
     1 (COEF(J,I),J=1,5),MAXVOL(I)
  940 FORMAT(1X,I4,2(1X,A4),1X,F7.2,5(1X,F9.5),1X,F9.2)
  945 CONTINUE
      GO TO 8000
      WRITE(FILE,950)
  950 FORMAT(//' ORIGIN-DESTINATION PAIRS:'/
     1         ' -------------------------')
      ODPR=1
  951 IF(ODPR.GT.NT) GO TO 957
      R=ORIG(ODPR)
      DO 955 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 956
      WRITE(FILE,952) I,NAME(R),NAME(DEST(I))
  952 FORMAT(1X,I4,2(4X,A4))
  955 CONTINUE
  956 ODPR=I
```

```
      GO TO 951
  957 WRITE(FILE,960) ALPHA,THETA
  960 FORMAT(//' ALPHA=    ',F10.3,4X,'AND THETA=    ',F7.5)
 8000 DO 40 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 40
      Y(I)=0.
      X(I)=0.0
      OLDX(I)=0.0
      COST(I)=C(I,X,COEF,L,MAXVOL)
   40 CONTINUE
      NEWSR=1
  700 IF(NEWSR.GT.NT) GO TO 986
      R=ORIG(NEWSR)
      TA(R)=0.
      TG(R)=E(R)
      S(R)=0.
      OLDTG(R)=TG(R)
      CALL SPPATH(COST,R,ISPC,SPC,TC,FWD,NEXT,N)
      DO 710 J=NEWSR,NT
      IF(ORIG(J).NE.R) GO TO 720
      TA(R)=TA(R)+EXP(-THETA*SPC(DEST(J))+ATR(DEST(J)))
      TD(J)=TG(R)*EXP(-THETA*SPC(DEST(J))+ATR(DEST(J)))
  710 CONTINUE
  720 NEWSR=J
      GO TO 700
  986 NEWSR=1
  988 IF(NEWSR.GT.NT) GO TO 974
      R=ORIG(NEWSR)
      MAXS(R)=ALOG(TA(R))
      M(R)=ALPHA*MAXS(R)+E(R)
      DO 987 I=NEWSR,NT
      IF(ORIG(I).NE.R) GO TO 989
      TD(I)=TD(I)/TA(R)
      OLDTD(I)=TD(I)
  987 CONTINUE
  989 NEWSR=I
      GO TO 988
  974 WRITE(FILE,970)
  970 FORMAT('1TRIP GENERATION DATA:'/
     1          ' --------------------'//
     2 '  NO.  ORIGIN  MIN. GENERATION  MAX. GENERATION',
     3 '  MAX. ACCESSIBILITY'/
     4 ' ----  ------  ---------------  ---------------  ',
     5 '------------------')
      NORIG=1
      ODPR=1
  972 IF(ODPR.GT.NT) GO TO 977
      R=ORIG(ODPR)
      WRITE(FILE,973) NORIG,NAME(R),E(R),M(R),MAXS(R)
  973 FORMAT(1X,I4,4X,A4,4X,F10.3,6X,F10.3,8X,F10.5)
      DO 975 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 976
  975 CONTINUE
  976 ODPR=I
      NORIG=NORIG+1
      GO TO 972
  977 WRITE(FILE,980)
  980 FORMAT('1TRIP ATTRACTION DATA:'/
     1          ' ---------------------'//
     2 '  NO. DESTINATION  ATTRACTION'/
     3 ' ---- -----------  ----------')
```

```
      NDEST=1
      ODPR=1
  981 R=DEST(ODPR)
      WRITE(FILE,982) NDEST,NAME(R),ATR(R)
  982 FORMAT(1X,I4,4X,A4,6X,F10.5)
  983 ODPR=ODPR+1
      ODP=ODPR-1
      IF (ODPR.GT.NT) GO TO 730
      DO 985 I=1,ODP
      IF(DEST(I).EQ.DEST(ODPR)) GO TO 983
  985 CONTINUE
      NDEST=NDEST+1
      GO TO 981
  730 NORIG=NORIG-1
      WRITE(FILE,6000) N,NARC2,NT,NORIG,NDEST
 6000 FORMAT(///' THE NETWORK HAS:',1X,I6,2X,'NODES'/
     1 '                    ',1X,I6,2X,'LINKS'/
     2 '                    ',1X,I6,2X,'O-D PAIRS'/
     3 '                    ',1X,I6,2X,'ORIGINS'/
     4 '                    ',1X,I6,2X,'DESTINATIONS')
      WRITE(FILE,3000)
 3000 FORMAT('1INITIAL SOLUTION:'/' -----------------'//
     1 ' TRIP GENERATION= MINIMUM TRIP GENERATION'/
     2 ' ACCESSIBILITY  = ZERO'/' TRIP DISTRIBUTION IS GIVEN BY ',
     3 'A LOGIT MODEL'/' O-D TRAVEL COST= MINIMUM O-D COST'/
     4 ' MODAL SPLIT & TRAFFIC ASSIGNMENT IS CONSTRAINED BY FLEET',
     5 ' CAPACITIES'//)
      CALL INITIAL(ORIG,N,SPC,NT,DEST,X,TD,ISPC,FROM,COST,TO,FWD,NEXT,
     1 FILE,TG,NAME,L,MAXVOL,NARC,COEF)
      WRITE(FILE,3500)
 3500 FORMAT('1INITIAL MODAL SPLIT AND TRAFFIC ASSIGNMENT:'/
     1      ' ========================================='//
     2 ' LINK FROM  TO  LENGTH  CAPACITY     FLOW    INITIAL',
     3 ' COST'/' ---- ---- ---- ------- --------- ---------- -------',
     4 '-----')
      DO 745 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 745
      WRITE(FILE,3200) I,NAME(FROM(I)),NAME(TO(I)),L(I),MAXVOL(I),
     1 X(I),COST(I)
 3200 FORMAT(1X,I4,T7,A4,T12,A4,T17,F7.2,T25,F9.2,T35,F10.3,T46,
     1 F12.5)
      IF(X(I).EQ.0.0) GO TO 745
      OLDX(I)=X(I)
      COST(I)=C(I,X,COEF,L,MAXVOL)
  745 CONTINUE
      ITER=0                                                            00002840
      MITER=0
      OLDZ=Z(NARC,NT,ORIG,DEST,ALPHA,THETA,S,E,TD,ATR,COEF,X,L,MAXVOL,
     1 FROM)
      WRITE(6,5100) OLDZ
 5100 FORMAT(' INITIAL VALUE OF Z = ',F30.2)
      CODE=2
      CALL LIB$STAT_TIMER(CODE,CPUO,HANDLE)
      CPU4=CPUO
      CPUO1=CPUO*0.01
      WRITE(FILE,3600) OLDZ,CPUO1
 3600 FORMAT(//' INITIAL VALUE OF OBJECTIVE FUNCTION=',F30.2//
     1 ' CPU TIME FOR INITIALIZATION=    ',F10.2,2X,' SECONDS')
      NORIG1=0
  520 ITER=ITER+1
      CALL SOLVE(ORIG,N,SPC,NT,DIST,Y,TD,ISPC,FROM,COST,TO,FWD,NEXT,
```

```
     . E,M,ATR,ALPHA,THETA,S,SP,TGP,TDP,SPC1,TA1,NORIG,NORIG1,GRMS)
      CALL LIB$STAT_TIMER(CODE,CPU1,HANDLE)
      CPU14=(CPU1-CPU4)*0.01
      CALL LOGIT(TG,TA1,TD,SPC1,ATR,ORIG,DEST,NT,PTDL,TDL,FILE,
     1 THETA)
      CALL ITEROUT(ITER,FILE,TD,TDL,PTDL,SPC1,NAME,NT,ORIG,DEST,
     1 TT1)
      CALL LIB$STAT_TIMER(CODE,CPU5,HANDLE)
      CALL BSZMIN(NARC,NT,ORIG,DEST,TG,TGP,S,SP,TD,TDP,X,Y,E,ATR,
     1 ALPHA,THETA,ITER,ITER1,COEF,FLAG,FI1,EPS,EPS1,MINZ,BS,
     2 COST,I,MAXVOL,FROM)
      CALL LIB$STAT_TIMER(CODE,CPU2,HANDLE)
      WRITE(6,5200) MINZ
 5200 FORMAT(' CURRENT VALUE OF Z =  ',F30.2)
      NARC3=0
      NORIG1=0
      NT2=0
      TTG=0.
      TX=0.
      TGSQ=0.
      TDSQ=0.
      XSQ=0.
      ODPR=1
 2000 IF(ODPR.GT.NT) GO TO 2220
      R=ORIG(ODPR)
      PCTG(R)=100.0*(TG(R)-OLDTG(R))/TG(R)
      TGSQ=TGSQ+(TG(R)*(TG(R)-OLDTG(R))*(TG(R)-OLDTG(R)))
      TTG=TTG+TG(R)
      OLDTG(R)=TG(R)
      IF(ABS(PCTG(R)).GT.EPS1) GO TO 2100
      NORIG1=NORIG1+1
 2100 DO 2200 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 2210
      PCTD(I)=100.0*(TD(I)-OLDTD(I))/TD(I)
      TDSQ=TDSQ+(TD(I)*(TD(I)-OLDTD(I))*(TD(I)-OLDTD(I)))
      OLDTD(I)=TD(I)
      IF(ABS(PCTD(I)).GT.EPS1) GO TO 2200
      NT2=NT2+1
 2200 CONTINUE
 2210 ODPR=I
      GO TO 2000
 2220 DO 2230 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 2230
      IF(X(I).NE.0.0) GO TO 2225
      PCX(I)=0.
      GO TO 2226
 2225 PCX(I)=100.0*(X(I)-OLDX(I))/X(I)
      XSQ=XSQ+(X(I)*(X(I)-OLDX(I))*(X(I)-OLDX(I)))
      TX=TX+X(I)
 2226 OLDX(I)=X(I)
      Y(I)=0.
      COST(I)=C(I,X,COEF,L,MAXVOL)
      IF(ABS(PCX(I)).GT.EPS1) GO TO 2230
      NARC3=NARC3+1
 2230 CONTINUE
      TGRMS=SQRT(TGSQ/TTG)
      TDRMS=SQRT(TDSQ/TTG)
      XRMS=SQRT(XSQ/TX)
 2240 PCZ=100.0*(OLDZ-MINZ)/ABS(MINZ)
      CALL ZCONV(PCZ,OLDZ,MINZ,EPS,FLAG)
      OLDZ=MINZ
```

```
      CALL LIB$STAT_TIMER(CODE,CPU3,HANDLE)
      WRITE(6,5000) ITER,PCZ,BS
 5000 FORMAT(1X,I4,2X,F30.2,2X,F7.5)
      CALL OUTPUT(NARC,X,COST,L,MAXVOL,FROM,TC,ITER,ITER1,NAME,FILE,
     1 COEF,S,TG,SPC,TD,ORIG,DEST,FWD,NEXT,NT,N,ISPC,MINZ,NARC2,NARC3,
     2 EPS1,ALPHA,THETA,NORIG,NORIG1,NT2,PCTG,PCTD,PCX,PCZ,FLAG,BS,
     3 ITMAX,ATR,TGRMS,GRMS,TDRMS,XRMS)
      CALL LIB$STAT_TIMER(CODE,CPU4,HANDLE)
      CPU12=(CPU2-CPU5)*0.01
      CPU23=(CPU3-CPU2)*0.01
      CPU34=(CPU4-CPU3)*0.01+(CPU5-CPU1)*0.01
      WRITE(FILE,2250) CPU14,CPU12,CPU23,CPU34
 2250 FORMAT(//' CPU TIME FOR DIRECTION FINDING=      ',F10.2,2X,' SECO',
     1'NDS'/' CPU TIME FOR ONE DIMENSIONAL SEARCH=',F10.2,2X,' SECONDS'/
     2       ' CPU TIME FOR CONVERGENCE TEST=       ',F10.2,2X,' SECONDS'/
     3       ' CPU TIME FOR OUTPUT CALCULATIONS=    ',F10.2,2X,' SECONDS')
      IF(FLAG.AND.(ITER.LT.ITMAX)) GO TO 520
      WRITE(FILE,2260) ITER,CPU4
 2260 FORMAT(//' THE FINAL EQUILIBRIUM IS OBTAINED AT THE',2X,I4,2X,
     1 'TH  ITERATION.'/' TOTAL CPU TIME=',2X,I15,'X0.01 SECONDS')
      GO TO 130

C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                  SAVING DATA ON AN EXTERNAL FILE                    C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  140 CALL SAVE(NARC,T,NT,ORIG,DEST,L,MAXVOL,FROM,TC,FWD,NEXT,N,EPS,
     1 EPS1,COEF,NARC2,COST,X,NAME,ITMAX,ALPHA,THETA,E,ATR)
      GO TO 130
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                  CHANGING TOLERANCES AND ITMAX                      C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  640 WRITE (6,67)
   67 FORMAT( ' ENTER TOLERANCE LIMITS AND',
     1 'MAX NUMBER OF ITERATIONS.'/
     2 ' USE THE FOLLOWING FORMAT:'/
     3 '  Z %TOL      FLOW%TOL ITMAX'/
     4 ' XXXX.XXXXX XXXX.XXXXX XXX')
      READ (1,68) EPS,EPS1,ITMAX
      IF (ITMAX.EQ.0) ITMAX=200
      IF (EPS.EQ.0.) EPS=.01
      IF (EPS1.EQ.0.) EPS1=5.
   68 FORMAT(2(1X,F10.5),1X,I3)
      WRITE (6,69) EPS,EPS1,ITMAX
   69 FORMAT( ' %TOLERANCE OF Z=              ',F8.5/
     1        ' %TOLERANCE OF DEMANDS=        ',F8.5/
     2        ' MAXIMUM NUMBER OF ITERATIONS=',I4)
      GO TO 130
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C                  EXITING FROM PROGRAM, WITH SAVE OPTION             C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  120 WRITE (6,51)
   51 FORMAT(' DO YOU WANT TO SAVE? ENTER''YES'' OR ''NO'':')
      READ (1,52) RL
   52 FORMAT(A3)
      WRITE (6,53) RL
   53 FORMAT(' ',A3)
      IF (RL.EQ.YES) CALL SAVE(NARC,T,NT,ORIG,DEST,L,MAXVOL,FROM,TC,FWD,
     1 NEXT,N,EPS,EPS1,COEF,NARC2,COST,X,NAME,ITMAX,ALPHA,THETA,E,ATR)
      STOP
      END
```

```
      SUBROUTINE INITIAL(ORIG,N,SPC,NT,DEST,Y,TD,ISPC,FROM,COST,TC,
     1 FWD,NEXT,FILE,TG,NAME,L,MAXVOL,NARC,COEF)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE INITIAL PERFORMS AN INITIAL ALL-OR-NOTHING ASSIGNMENT    C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL SPC(1),Y(1),TD(1),COST(1),TG(1),NAME(1),SPC1(2048),TT1,
     1 L(1),MAXVOL(1),CAP(2048),TG1(512),TTG,TD1(2048),TD2(2048),
     2 COEF(5,2048),TTG1
      INTEGER FILE
      INTEGER*2 N,NT,DEST(1),ISPC(1),TC(1),FWD(1),NEXT(1),FROM(1),
     1 NEWSR,R,I,J,BACK,ORIG(1),ITER,NARC
      TTG=0.0
      TTG1=0.0
      ITER=0
      NEWSR=1
    5 IF(NEWSR.GT.NT) GO TO 12
      R=ORIG(NEWSR)
      TG1(R)=1.
      DO 10 J=NEWSR,NT
      IF(ORIG(J).NE.R) GO TO 11
      TD1(J)=TD(J)
      TD2(J)=TD(J)
   10 CONTINUE
   11 NEWSR=J
      GO TO 5
   12 DO 20 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 20
      Y(I)=0.0
      IF(MAXVOL(I).EQ.1.) GO TO 20
      CAP(I)=MAXVOL(I)
   20 CONTINUE
   30 ITER=ITER+1
      IF(ITER.GT.10) GO TO 130
      NEWSR=1
   40 IF(NEWSR.GT. NT) GO TO 120
      R=ORIG(NEWSR)
      IF(TG1(R).EQ.0.0) GO TO 50
      TG1(R)=0.0
      CALL SEPATH(COST,R,ISPC,SPC,TC,FWD,NEXT,N)
   50 DO 100 J=NEWSR,NT
      IF(ORIG(J).NE.R) GO TO 110
      IF(TD2(J).EQ.0.0) GO TO 100
      SPC1(J)=SPC(DEST(J))
      BACK=ISPC(DEST(J))
   60 IF(BACK.EQ.0) GO TO 80
      IF(MAXVOL(BACK).EQ.1.) GO TO 70
      IF(CAP(BACK).GT.TD1(J)) GO TO 70
      TD1(J)=CAP(BACK)
   70 BACK=ISPC(FROM(BACK))
      GO TO 60
   80 IF(TD1(J).EQ.0.0) GO TO 95
      BACK=ISPC(DEST(J))
   90 IF(BACK.EQ.0) GO TO 95
      Y(BACK)=Y(BACK)+TD1(J)
      IF(MAXVOL(BACK).EQ.1.) GO TO 92
      CAP(BACK)=CAP(BACK)-TD1(J)
      COST(BACK)=C(BACK,Y,COEF,L,MAXVOL)
   92 BACK=ISPC(FROM(BACK))
      GO TO 90
   95 TD2(J)=TD2(J)-TD1(J)
      TD1(J)=TD2(J)
```

```
      TG1(R)=TG1(R)+TD2(J)
  100 CONTINUE
  110 NEWSR=J
      TTG=TTG+TG1(R)
      GO TO 40
  120 WRITE(6,125) ITER,TTG
  125 FORMAT(I6,' TRIPS REMAINING=',F10.0)
      WRITE(FILE,125) ITER,TTG
      IF(TTG.EQ.0.0) GO TO 130
      IF(TTG.EQ.TTG1) GO TO 150
      TTG1=TTG
      TTG=0.0
      GO TO 30
  130 IF(TTG.NE.0.0) GO TO 150
      WRITE(FILE,140) ITER
  140 FORMAT(//' INITIAL FEASIBLE SOLUTION OBTAINED AFTER',I6,
     1 ' ITERATIONS')
      WRITE(6,140) ITER
      GO TO 210
  150 WRITE(FILE,160) ITER,TTG
  160 FORMAT(//' AFTER',I6,' ITERATIONS,WE STILL CANNOT ASSIGN',
     1 F10.0,' TRIPS TO THE SYSTEM')
      WRITE(6,160) ITER,TTG
  210 WRITE(FILE,200)
  200 FORMAT(//' ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX')
      CALL DMATRIX(TD,NAME,NT,ORIG,DEST,FILE,TT1)
      WRITE(FILE,320)
  320 FORMAT(//'1ORIGIN-DESTINATION MINIMUM PERCEIVED COST',
     1 ' MATRIX:'//)
      CALL CMATRIX(SPC1,NAME,NT,ORIG,DEST,FILE)
      RETURN
      END
```

```
      SUBROUTINE SOLVE(ORIG,N,SPC,NT,DEST,Y,TD,ISPC,FROM,COST,TO,FWD,
     1 NEXT,E,M,ATR,ALPHA,THETA,S,SP,TGP,TDP,SPC1,TA1,NORIG,NORIG1,GRMS)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE SOLVE FINDS A DECENT DIRECTION  GIVEN THE CURRENT        C
C SOLUTION . IT RETURNS THE TRIAL SOLUTION IN VECTORS Y,TDP,TGP.      C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL SPC(1),Y(1),COST(1),TD(1),E(1),M(1),ATR(1),ALPHA,THETA,WMIN,
     1 W(2048),CR,S(1),SP(1),TGP(1),TDP(1),SPC1(1),TA1(1),GRMS,CRSQ
      INTEGER*2 N,NT,DEST(1),ISPC(1),TO(1),FWD(1),NEXT(1),FROM(1),NEWSR,
     1 R,I,J,ND,BACK,ORIG(1),NORIG,NORIG1
      CRSQ=0.
      NEWSR=1
   90 IF (NEWSR.GT.NT) GO TO 200
      R=ORIG(NEWSR)
      TA1(R)=0.0
      CALL SHPATH(COST,R,ISPC,SPC,TO,FWD,NEXT,N)
      WMIN=0.01E+30
      DO 60 J=NEWSR,NT
      IF (ORIG(J).NE.R) GO TO 40
      SPC1(J)=SPC(DEST(J))
      TA1(R)=TA1(R)+EXP(-THETA*SPC1(J)+ATR(DEST(J)))
      TDP(J)=0.
      W(J)=(1./THETA)*(ALOG(TD(J))-ATR(DEST(J)))+SPC(DEST(J))
      IF(WMIN.LT.W(J)) GO TO 60
      WMIN=W(J)
      ND=J
   60 CONTINUE
   40 NEWSR=J
      CR=(1./THETA)*(S(ORIG(ND))-ALOG(ALPHA*S(ORIG(ND))+E(ORIG(ND))))
     1  +WMIN
      CRSQ=CRSQ+CR*CR
      IF(CR.LE.0.) GO TO 130
      SP(ORIG(ND))=0.
      TGP(ORIG(ND))=E(ORIG(ND))
      GO TO 140
  130 SP(ORIG(ND))=(M(ORIG(ND))-E(ORIG(ND)))/ALPHA
      TGP(ORIG(ND))=M(ORIG(ND))
  140 TDP(ND)=TGP(ORIG(ND))
      BACK=ISPC(DEST(ND))
   80 IF (BACK.EQ.0) GO TO 90
      Y(BACK)=Y(BACK)+TDP(ND)
      BACK=ISPC(FROM(BACK))
      GO TO 80
  200 GRMS=SQRT(CRSQ)
      RETURN
      END
```

```
      SUBROUTINE BSZMIN(NARC,NT,ORIG,DEST,TG,TGP,S,SP,TD,TDP,X,Y,
     1 E,ATR,ALPHA,THETA,ITER,ITER1,COEF,FLAG,FL1,EPS,EPS1,MINZ,BS,COST,
     2 L,MAXVOL,FROM)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE BSZMIN MINIMIZES THE OBJECTIVE FUNCTION ALONGE THE         C
C DECENT DIRECTION USING THE BISECTING METHOD                           C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL B1,B2,BS,TG(1),TGP(1),S(1),SP(1),TD(1),TDP(1),X(1),Y(1),
     1 E(1),ATR(1),ALPHA,THETA,COEF(5,1),EPS,EPS1,MINZ,COST(1),
     2 GZ1,GZ2,GZ3,GZ,SB(512),TDB(2048),XB(2048),L(1),MAXVOL(1),
     3 CAP(2048),BMAX
      INTEGER*2 I,J,NARC,NT,ORIG(1),DEST(1),ITER,ITER1,R,ODPR,
     1 FROM(1)
      LOGICAL*1 FLAG,FL1
      ITER1=0
      FLAG=.FALSE.
      B1=0.
      B2=1.
      DO 6 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 6
      IF(MAXVOL(I).EQ.1.) GO TO 6
      IF(Y(I).LE.X(I)) GO TO 6
      CAP(I)=1.1*MAXVOL(I)
      BMAX=(CAP(I)-X(I))/(Y(I)-X(I))
      IF(BMAX.LT.B2) B2=BMAX
    6 CONTINUE
      BS=(B1+B2)/2.
    5 ITER1=ITER1+1
      GZ1=0.
      GZ2=0.
      GZ3=0.
      ODPR=1
    8 IF(ODPR.GT.NT) GO TO 14
      R=ORIG(ODPR)
      SB(R)=S(R)+BS*(SP(R)-S(R))
      GZ1=GZ1+(SB(R)-ALOG(ALPHA*SB(R)+E(R)))*(SP(R)-S(R))
      DO 10 J=ODPR,NT
      IF(ORIG(J).NE.R) GO TO 12
      TDB(J)=TD(J)+BS*(TDP(J)-TD(J))
      GZ2=GZ2+(ALOG(TDB(J))-ATR(DEST(J)))*(TDP(J)-TD(J))
   10 CONTINUE
   12 ODPR=J
      GO TO 8
   14 DO 16 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 16
      XB(I)=X(I)+BS*(Y(I)-X(I))
      COST(I)=C(I,XB,COEF,L,MAXVOL)
      GZ3=GZ3+COST(I)*(Y(I)-X(I))
   16 CONTINUE
      GZ=(ALPHA/THETA)*GZ1+(1./THETA)*GZ2+GZ3
      IF(ABS(GZ).LE.0.01) GO TO 30
      IF((B2-B1).LE.0.01) GO TO 30
      IF(GZ.GT.0.) GO TO 20
      B1=BS
      GO TO 25
   20 B2=BS
   25 BS=(B1+B2)/2.
      GO TO 5
   30 BS=(B1+B2)/2.
      ODPR=1
   31 IF(ODPR.GT.NT) GO TO 34
```

```
      R=ORIG(ODPR)
      S(R)=S(R)+BS*(SP(R)-S(R))
      TG(R)=TG(R)+BS*(TGP(R)-TG(R))
      DO 32 J=ODPR,NT
      IF(ORIG(J).NE.R) GO TO 33
      TD(J)=TD(J)+BS*(TDP(J)-TD(J))
   32 CONTINUE
   33 ODPR=J
      GO TO 31
   34 DO 35 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 35
      X(I)=X(I)+BS*(Y(I)-X(I))
   35 CONTINUE
   40 MINZ=Z(NARC,NT,ORIG,DEST,ALPHA,THETA,S,E,TD,ATR,COEF,
     1 X,L,MAXVOL,FROM)
      RETURN
      END
```

```
      SUBROUTINE LOGIT(TG,TA1,TD,SPC1,ATR,CRIG,DEST,NT,PTCL,TDL,
     1 FILE,THETA)
C
C     THIS PROGRAM APPLIES A CONVERGENCE TEST ON THE PREDICTED
C     TRIP DISTRIBUTICN BY COMPARING IT WITH LOGIT CALCULATIONS.
C
      REAL TG(1),TA1(1),TD(1),SPC1(1),ATR(1),PTDL(1),TDL(1),THETA,
     1 TTD,TDLSQ,WTDLSQ,TDLRMS,WTDLRMS
      INTEGEE FILE
      INTEGER*2 NT,I,J,N(10),TOL(8),ORIG(1),DEST(1),N1
      DATA TCL/5,10,20,30,40,60,80,100/
      TTD=0.
      TDLSQ=0.
      WTDLSQ=0.
      DO 2 I=1,10
      N(I)=0
    2 CONTINUE
      DO 80 I=1,NT
      TDL(I)=TG(ORIG(I))*EXP(-THETA*SPC1(I)+ATR(DEST(I)))/TA1(ORIG(I))
      TDLSQ=TDLSQ+(TD(I)-TDL(I))*(TD(I)-TDL(I))
      WTDLSQ=WTDLSQ+TD(I)*(TD(I)-TDL(I))*(TD(I)-TDL(I))
      TTD=TTD+TD(I)
      IF(TDL(I).LT.1.0) TDL(I)=1.0
      PTDL(I)=100.0*(TD(I)-TDL(I))/TDL(I)
      IF(ABS(PTDL(I)).GT.TOL(1)) GO TO 5
      N(1)=N(1)+1
    5 IF(ABS(PTDL(I)).GT.TOL(2)) GO TO 10
      N(2)=N(2)+1
   10 IF(ABS(PTDL(I)).GT.TOL(3)) GO TO 20
      N(3)=N(3)+1
   20 IF(ABS(PTDL(I)).GT.TOL(4)) GO TO 30
      N(4)=N(4)+1
   30 IF(ABS(PTDL(I)).GT.TOL(5)) GO TO 40
      N(5)=N(5)+1
   40 IF(ABS(PTDL(I)).GT.TOL(6)) GO TO 50
      N(6)=N(6)+1
   50 IF(ABS(PTDL(I)).GT.TOL(7)) GO TO 60
      N(7)=N(7)+1
   60 IF(ABS(PTDL(I)).GT.TOL(8)) GO TO 70
      N(8)=N(8)+1
   70 IF(TD(I).GT.100.) GO TO 80
      N(9)=N(9)+1
      IF(PTDL(I).LT.TOL(8)) GO TO 80
      N(10)=N(10)+1
   80 CONTINUE
      WRITE(FILE,100)
  100 FORMAT(//'1LOGIT CONVERGENCE TEST:'/23('-')//
     1 ' IT CALCULATES THE %DIFFERENCE BETWEEN PREDICTED O-D DEMAND',
     2 ' AND THAT CALCULATED BY A LOGIT MODEL.'//)
      WRITE(FILE,200) (N(I),NT,TOL(I),I=1,8)
  200 FORMAT(' PREDICTIONS OF',I6,' OUT OF',I6,' O-D PAIRS ARE ',
     1 'WITHIN',I6,'% OF THE LOGIT MODEL')
      N1=NT-N(8)
      WRITE(FILE,250) N(9)
  250 FORMAT(//' THERE ARE',I6,' O-D PAIRS WHICH HAVE LESS THAN 100',
     1 ' TRIPS')
      WRITE(FILE,300) N1,N(10)
  300 FORMAT(//' AMONG THE REMAINING',I6,' O-D PAIRS,',I6,
     1 ' HAVE PREDICTIONS LESS THAN 100 TRIPS')
      TDLRMS=SQRT(TDLSQ)
      WTDLRMS=SQRT(WTDLSQ/TTD)
```

```
      WRITE(FILE,400) TDLRMS,WTDLRMS
  400 FORMAT(//' ROOT MEAN SQUARE ERROR BETWEEN MODEL PREDICTIONS',
     1 ' AND LOGIT:'/' TOTAL RMSE=       ',F10.3/
     2                 ' WEIGHTED AVERAGE=',F10.3)
      RETURN
      END
      SUBROUTINE ZCONV(PCZ,OLDZ,MINZ,EPS,FLAG)
C
C     THIS IS A CONVERGENCE TEST ON THE OBJECTIVE FUNCTION
C
      REAL PCZ,OLDZ,MINZ,EPS
      LOGICAL*1 FLAG
      IF(ABS(PCZ).GT.EPS) FLAG=.TRUE.
      RETURN
      END
```

```
      SUBROUTINE OUTPUT(NARC,X,COST,L,MAXVOL,FROM,TC,ITER,ITER1,
     1 NAME,FILE,COEF,S,TG,SPC,TD,ORIG,DEST,FWD,NEXT,NT,N,ISPC,MINZ,
     2 NARC2,NARC3,EPS1,ALPHA,THETA,NORIG,NORIG1,NT2,PCTG,PCTD,PCX,PCZ,
     3 FLAG,BS,ITMAX,ATR,TGRMS,GRMS,TDRMS,XRMS)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00006090
C SUBROUTINE OUTPUT WRITES THE RESULTS OF THE ASSIGNMENT ON AN       C 00006100
C ARBITRARY OUTPUT FILE. THE DEFAULT IS FILE 6 (THE TERMINAL).       C 00006110
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00006120
      REAL X(1),COST(1),L(1),MAXVOL(1),NAME(1),COEF(5,1),S(1),
     1 TG(1),SPC(1),TD(1),ALPHA,THETA,MINZ,EPS1,PCTG(1),PCTD(1),PCX(1),
     2 PCZ,BS,TTG(30),TTA(30),TT1,SPC1(2048),TD1(2048),TA1(512),
     3 PTDL(2048),ATR(1),RATIO(2048),TGRMS,GRMS,TDRMS,XRMS,RL
      INTEGER*2 NARC,I,FROM(1),TC(1),ITER,ITER1,N,NT,ORIG(1),NORIG,NT2
     1,DEST(1),FWD(1),NEXT(1),R,ODPR,ISPC(1),NARC2,NARC3,J,NORIG1,
     2 ITMAX,NARC4,ITER2(16)
      DATA ITER2/5,10,20,30,40,50,60,70,80,90,100,120,140,160,180,200/
      INTEGER FILE                                                     00006150
      LOGICAL*1 FL1,FLAG
      FL1=.FALSE.                                                      00006210
      TOTT=0.0                                                         00006220
      TOTL=0.0                                                         00006230
      DO 100 I=1,NARC                                                  00006240
      IF(FROM(I).EQ.0) GO TO 100
      TOTT=TOTT+X(I)*COST(I)                                           00006320
      TOTL=TOTL+X(I)*L(I)                                              0000633
  100 CONTINUE
      WRITE(FILE,70)
   70 FORMAT('1 OUTPUT OF THE MODEL:'/
     1         '  ===================')
      WRITE(FILE,80) ITER,MINZ,PCZ
   80 FORMAT(///' ITERATION NUMBER',I4,4X,':'/
     1            ' -------------------------'/
     2 ' THE OBJECTIVE VALUE IS',F30.3/' PREVIOUS VALUE IS WITHIN',
     3 F28.3,'%   OF THE CURRENT ONE'//
     4 ' THE %DIFFERENCE IN FLOW BETWEEN LAST TWO ITERATIONS:')
      WRITE(FILE,90) NORIG1,NORIG,NT2,NT,NARC3,NARC2,EPS1
   90 FORMAT(' FOR',I5,3X,'OUT OF',I5,
     1 3X,' ORIGINS,'/' AND',I5,3X,'OUT OF',I5,3X,' O-D PAIRS,'/
     2 ' AND',I5,3X,'OUT OF',I5,3X,' LINKS.'/
     3 ' IS WITHIN',3X,F5.2,'  PERCENT')
      WRITE(FILE,60) ITER1,BS
   60 FORMAT(//' NUMBER OF INNER ITERATIONS=',1X,I4/
     1 ' OPTIMUM STEP SIZE=',7X,F7.5/)
      WRITE(FILE,3) TOTT,TOTL
    3 FORMAT(/' TOTAL TRAVEL COST =',F30.3/' TOTAL TRAVEL DISTANCE =',  00006360
     1 F26.2)
      WRITE(FILE,640) GRMS,TGRMS,TDRMS,XRMS
  640 FORMAT(//' ROOTE MEAN SQUARE ERRORS OF:'/
     1 ' EQUILIBRIUM=                ',F10.3/
     2 ' TRIP GENERATION=            ',F10.3/
     3 ' TRIP DISTRIBUTION=          ',F10.3/
     4 ' MODAL LINK FLOWS=           ',F10.3)
      DO 600 I=1,16
      IF(ITER2(I).NE.ITER) GO TO 600
      WRITE(6,610) ITER
  610 FORMAT(' DO YOU WANT TO SEE MODAL SPLITE TRAFFIC ASSIGNMENT',
     1 ' OF',I6,' TH ITERATION?'/' TYPE''YES''OR''NO'':')
      READ(1,620) RL
  620 FORMAT(A3)
      WRITE(6,630) RL
  630 FORMAT(' ',A3)
```

```
      IF(RL.NE.'YES') RETURN
      GO TO 26
  600 CONTINUE
      IF(FLAG.AND.(ITER.LT.ITMAX)) RETURN
      ODPR=1
   11 IF(ODPR.GT.NT) GO TO 20
      R=ORIG(ODPR)
      TA1(R)=0.0
      CALL SHPATH(COST,R,ISPC,SPC,TC,FWD,NEXT,N)
      DO 15 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 16
      SPC1(I)=SPC(DEST(I))
      TA1(R)=TA1(R)+EXP(-THETA*SPC1(I)+ATR(DEST(I)))
   15 CONTINUE
   16 ODPR=I
      GO TO 11
   20 CALL LOGIT(TG,TA1,TD,SPC1,ATR,ORIG,DEST,NT,PTDL,TDL,FILE,
     1 THETA)
      WRITE(FILE,1)
    1 FORMAT(//'1TRIP GENERATION:'/' ================')
      WRITE(FILE,4)
    4 FORMAT(/' NO. ',1X,'ORIGIN ',1X,'TRIP GENERATION',1X,
     1'ACCESSIBILITY',1X,'%CHANGE OF DEMAND'/
     2 ' ---- ------ ---------------',
     2 ' ------------- -----------------')
      NORIG=1
      ODPR=1
    8 IF(ODPR.GT.NT) GO TO 9
      R=ORIG(ODPR)
      WRITE(FILE,5) NORIG,NAME(R),TG(R),S(R),PCTG(R)
    5 FORMAT(1X,I4,1X,A4,3X,F12.3,4X,F10.5,5X,F10.3)
      DO 6 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 7
    6 CONTINUE
    7 ODPR=I
      NORIG=NORIG+1
      GO TO 8
    9 WRITE(FILE,300)
  300 FORMAT('1ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AT',
     1 ' EQUILIBRIUM:'/' ======================================',
     2 '=================='/' IT INCLUDES TRIPS PREDICTED,',
     3 ' CALCULATED BY LOGIT AND %DIFFERENCE BETWEEN BOTH.'/
     4 ' IT ALSO INCLUDES TOTAL EMISSIONS AND ATTRACTIONS AT EACH',
     5 ' ZONE, AS WELL AS TOTAL TRIPS IN THE SYSTEM (PER DAY).'//)
      CALL CDMATRIX(TD,TDL,PTDL,NAME,NT,ORIG,DEST,FILE,TT1)
      WRITE(FILE,660)
  660 FORMAT('1ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AT',
     1 ' EQUILIBRIUM (PREDICTED)')
      CALL DMATRIX(TD,NAME,NT,ORIG,DEST,FILE,TT1)
      WRITE(FILE,500)
  500 FORMAT('1ORIGIN-DESTINATION PERCEIVED COST MATRIX AT',
     1 ' EQUILIBRIUM:'/54('=')//)
      CALL CMATRIX(SPC1,NAME,NT,ORIG,DEST,FILE)
   26 WRITE(FILE,21)
   21 FORMAT(//'1MODAL SPLIT AND TRIP ASSIGNMENT:'/
     1          ' ================================')
      WRITE(FILE,22)
   22 FORMAT(/' LINK FROM  TO  LENGTH  FLOW/CAP     FLOW      COST',
     1'    %CHANGE OF FLOW'/ ' ---- ---- ---- ------ ---------',
     2' --------- ----------- --------------')
      NARC4=0
```

```
      DO 25 I=1,NARC
      IF(FROM(I).EQ.0) GO TO 25
      RATIO(I)=X(I)/MAXVOL(I)
      IF(MAXVOL(I).EQ.1.0) GO TO 24
      IF(RATIO(I).LE. 1.0) GO TO 24
      NARC4=NARC4+1
   24 WRITE(FILE,23) I,NAME(FROM(I)),NAME(TO(I)),L(I),RATIO(I),
     1 X(I),COST(I),PCX(I)
   23 FORMAT(1X,I4,1X,A4,1X,A4,1X,F6.2,1X,F9.2,1X,F9.3,1X,F12.5,1X,
     1 F7.2)
   25 CONTINUE
      WRITE(FILE,200) NARC4,NARC2
  200 FORMAT(//' FLOW IS OVER CAPACITY ON',I6,' OUT OF',I6,
     1 ' MODAL LINKS IN THE NETWORK.')
      RETURN
      END
```

```
      SUBROUTINE INPUT(NARC,T,NT,ORIG,DEST,L,MAXVOL,FROM,TO,FWD,NEXT,N,
     1 EPS,EPS1,COEF,NARC2,X,FL1,NAME,ISN,ITMAX,E,ATR,ALPHA,THETA)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE INPUT READS IN THE NETWORK DATA FROM AN EXTERNAL FILE OF C
C FROM THE TERMINAL.                                                  C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL COEF(5,1),MAXVOL(1),T(1),MED(2)/'TERM','EXTE'/,C1(5),L1,M1,
     1 L(1),X(1),NAME(1),NM1,NM2,E(1),ATR(1),ALPHA,THETA
      INTEGER*2 N,NARC,NT,I,FROM(1),TO(1),FWD(1),NEXT(1),K,IACT,P,P1,
     1 ORIG(1),DEST(1),NT1,T1,T2,T5,F1,NARC2,O,D,MID,NARC1,ISN,ITMAX
      INTEGER FILE,N1
      LOGICAL*1 FL,FL1
      WRITE (6,14)
   14 FORMAT(' ENTER NETWORK INPUT MEDIUM (''TERMINAL'' OR ''EXTERNA',
     1 'L''):')
      CALL ACTION(IACT,MED,1,2,ISN)
      GO TO (190,200),IACT
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C READING NETWORK FROM AN EXTERNAL FILE.                              C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  200 FL1=.TRUE.
      WRITE (6,21)
   21 FORMAT(' ENTER INPUT FILE NUMBER:'/' XX')
      READ (1,22) FILE
   22 FORMAT(I3)
      WRITE (6,17) FILE
   17 FORMAT(' THE NETWORK WILL BE READ FROM FILE ',I2,'.')
      READ (FILE,15) N,NARC2,NT,EPS,EPS1,NARC,ITMAX,ALPHA,THETA
   15 FORMAT(20A4)
      WRITE (6,9) N,NARC2,NT
    9 FORMAT(' ',I4,' NODES, ',I4,' ARCS, ',I4,' O-D PAIRS,')
      WRITE (6,62) EPS,EPS1,ITMAX
   62 FORMAT( ' TOLERANCE FOR MINIMUM F =',F7.4,' , TOLERANCE FOR',
     1 ' FINAL CONVERGANCE =',F7.4/' MAX NUMBER OF ITERATIONS =',I3)
      WRITE(6,63) ALPHA,THETA
   63 FORMAT(' ALPHA=',2X,F10.4,' AND THETA=',2X,F10.6)
      IF (N.EQ.0) GO TO 240
      READ (FILE,15) (NAME(I),FWD(I),I=1,N)
  240 IF (NARC.EQ.0) GO TO 250
      READ (FILE,15) (FROM(I),TO(I),L(I),(COEF(J,I),J=1,5),MAXVOL(I),
     1 NEXT(I),X(I),I=1,NARC)
  250 IF (NT.EQ.0) GO TO 260
      READ (FILE,15) (ORIG(I),DEST(I),T(I),E(ORIG(I)),ATR(DEST(I)),
     1 I=1,NT)
  260 REWIND FILE
      WRITE (6,19)
   19 FORMAT(' DATA WAS READ.')
      RETURN
  190 FL1=.FALSE.
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C READING THE NETWORK FROM THE TERMINAL.                              C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      WRITE (6,1)
    1 FORMAT( ' ENTER MINIMUM F TOLERANCE CONVERGANCE TOLERANCE AND ',
     1 'MAX NUMBER OF ITERATIONS.'/
     2 ' USE THE FOLLOWING FORMAT:'/' MIN F TOL  CONV TOL ITMAX'/
     3 ' XXXX.XXXXX XXXX.XXXXX XXX')
      READ (1,2) EPS,EPS1,ITMAX
    2 FORMAT(2(1X,F10.5),1X,I3)
      IF (ITMAX.EQ.0) ITMAX=20
      IF (EPS.EQ.0.0) EPS=0.01
```

```
      IF (EPS1.EQ.0.0) EPS1=0.1
      WRITE (6,62) EPS,EPS1,ITMAX
      N=0
      NARC=0
      NT=0
      DO 180 I=1,512
  180 FWD(I)=0
      WRITE (6,3)
    3 FORMAT(' ENTER DATA FOR EACH ARC. USE THE FOLLOWING FORMAT:'/
     1 ' FROM  TO  LENGTH  COEF(1)   COEF(2)   COEF(3)   COEF(4)',
     2 '   COEF(5) MAX VOLUME'/'  XXXX XXXX XXX.XX XXX.XXXXX X',
     3 'XX.XXXXX XXX.XXXXX XXX.XXXXX XXX.XXXXX XXXXXX.XX')
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C READIND ARC DATA.                                                    C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  123 NARC1=NARC+1
  120 CALL GETARC(F1,T5,L1,C1,M1,NARC1,NAME,NM1,NM2,N,FL)
      IF (FL) GO TO 100
      CALL SEARCH(P,P1,F1,T5,FWD,NEXT,TO)
      IF (P.NE.0) GO TO 140
      NARC=NARC1
      IF (F1.NE.0) GO TO 121
      N=N+1
      F1=N
      NAME(N)=NM1
  121 IF (T5.NE.0) GO TO 122
      N=N+1
      T5=N
      NAME(N)=NM2
  122 DO 99 KK=1,5
   99 COEF(KK,NARC)=C1(KK)
      FROM(NARC)=F1
      TO(NARC)=T5
      L(NARC)=L1
      MAXVOL(NARC)=M1
      NEXT(NARC)=0
      IF (F1.NE.0) GO TO 110
      FWD(FROM(NARC))=NARC
      GO TO 123
  140 WRITE (6,8)
    8 FORMAT(' THIS ARC ALREADY EXISTS. REENTER:')
      GO TO 120
  110 NEXT(P1)=NARC
      GO TO 123
  100 WRITE (6,6)
    6 FORMAT(' ENTER DATA FOR EACH O-D PAIR. USE THE FOLLOWING FORMAT:'/
     1 ' ORIG DEST   DEMAND'/' XXXX XXXX XXXX.XXXXX')
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C READING OD PAIR DATA.                                                 C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
  231 NT1=NT+1
  230 CALL GETOD(NT1,O,D,T3,NAME,N,FL)
      IF (FL) GO TO 150
      CALL SRCHOD(O,D,ORIG,DEST,K,MID,NT)
      IF (K.NE.0) GO TO 220
      IF (O.EQ.0.OR.D.EQ.0) GO TO 221
      CALL INSOD(O,D,T3,ORIG,DEST,T,NT,MID)
      NT=NT1
      GO TO 231
  220 WRITE (6,24)
   24 FORMAT(' THIS PAIR ALREADY EXISTS. REENTER:')
```

```
      GO TO 230                                                         00006000
  221 WRITE (6,61)                                                      00006010
   61 FORMAT(' JUNCION NAMES INVALID. REENTER:')                        00006020
      GO TO 230                                                         00006030
  150 NARC2=NARC                                                        00006040
      RETURN                                                            00006050
      END                                                               00006060
       SUBROUTINE GENERATION(NORIG,NT,ORIG,DEST,NAME,E)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      REAL BI/' '/,F/'F'/,EX/'E'/,NAME(1),E(1),E1,K
      INTEGER*2 I,NORIG,ODPR,R,ORIG(1),DEST(1),NT
      WRITE(6,1)
    1 FORMAT(' ENTER GENERATION DATA:')
      NORIG=1
      ODPR=1
    7 IF(ODPR.GT.NT) GO TO 8
      R=ORIG(ODPR)
   22 WRITE(6,2) NORIG,NAME(R)
    2 FORMAT(1X,I4,4X,A4,':')
   33 READ(1,3) K,E1
    3 FORMAT(A1,16X,F10.3)
      IF(K.EQ.BI) GO TO 10
      IF(K.EQ.F) GO TO 20
      IF(K.NE.EX) GO TO 30
      RETURN
   10 WRITE(6,4) K,NORIG,NAME(R),E1
    4 FORMAT(A1,I4,4X,A4,4X,F10.3)
      E(R)=E1
      DO 5 I=ODPR,NT
      IF(ORIG(I).NE.R) GO TO 6
    5 CONTINUE
    6 ODPR=I
      NORIG=NORIG+1
      GO TO 7
    8 WRITE(6,9)
    9 FORMAT(' END OF ORIGINS')
      RETURN
   20 WRITE(6,21)
   21 FORMAT(' NO.   ORIGIN  MIN. GENERATION'/
     1        ' ----    ----     ----------'/
     2        ' XXXX    XXXX     XXXXXX.XXX')
      GO TO 22
   30 WRITE(6,31)
   31 FORMAT(' INVALID CONTROL CHARACTER. REENTER:')
      GO TO 33
      END
       SUBROUTINE ATTRACTION(NDEST,NT,ORIG,DEST,NAME,ATR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      REAL BI/' '/,F/'F'/,EX/'E'/,NAME(1),ATR(1),ATR1,K
      INTEGER*2 I,NDEST,NT,ORIG(1),DEST(1),R,ODPR,ODP
      WRITE(6,1)
    1 FORMAT(' ENTER ATTRACTION DATA:')
      NDEST=1
      ODPR=1
    7 R=DEST(ODPR)
   22 WRITE(6,2) NDEST,NAME(R)
    2 FORMAT (1X,I4,4X,A4,':')
   33 READ(1,3) K,ATR1
    3 FORMAT(A1,19X,F10.3)
      IF(K.EQ.BI) GO TO 10
      IF(K.EQ.F)  GO TO 20
```

```
     F(K.NE.EX) GO TO 30
      RETURN
   10 WRITE(6,4) K,NDEST,NAME(R),ATR1
    4 FORMAT(A1,I4,4X,A4,7X,F10.3)
      ATR(R)=ATR1
   11 ODPR=ODPR+1
      ODP=ODPR-1
      IF(ODPR.GT.NT) GO TO 18
      DO 15 I=1,ODP
      IF(DEST(I).EQ.DEST(ODPR)) GO TO 11
   15 CONTINUE
      NDEST=NDEST+1
      GO TO 7
   18 WRITE(6,19)
   19 FORMAT(' END OF DESTINATIONS')
      RETURN
   20 WRITE(6,21)
   21 FORMAT('  NO.  DESTINATION  ATTRACTION'/
     1         ' ----    ----        ----------'/
     2         ' XXXX    XXXX        XXXXXX.XXX')
      GO TO 22
   30 WRITE(6,31)
   31 FORMAT(' INVALID CONTROL CHARACTER. REENTER:')
      GO TO 33
      END
```

```
      SUBROUTINE SHPATH(COST,R,ISPC,SPC,TO,FWD,NEXT,N)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE SHPATH FINDS THE SHORTEST PATH FROM NODE R TO ANY OTHER  C
C NODE IN THE NETWORK. IT USES DIJKSTRA'S IMPROVED ALGORITHM.         C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL COST(1),SPC(1),TREE(512)
      INTEGER*2 R,ISPC(1),TO(1),FWD(1),NEXT(1),N1,IMIN,K,I,N,I1,NN,JJ
      LOGICAL*1 FINAL(2048)
      DO 10 I=1,N
      SPC(I)=1.E30
   10 FINAL(I)=.FALSE.
      FINAL(N+1)=.TRUE.
      SPC(R)=0.0
      FINAL(R)=.TRUE.
      ISPC(R)=0
      XN=N
      I1=ALOG(XN)/ALOG(2.)+0.999
      N1=2**I1
      DO 15 I=1,N1
   15 TREE(I)=1.E30
      I=R
   20 NN=FWD(I)
   30 IF (NN.EQ.0) GO TO 40
      K=TO(NN)
      IF (FINAL(K)) GO TO 50
   70 IF (SPC(K).LE.SPC(I)+COST(NN)) GO TO 50
      SPC(K)=SPC(I)+COST(NN)
      ISPC(K)=NN
      CALL UPDTRE(SPC,N1,IMIN,TREE,K)
   50 NN=NEXT(NN)
      GO TO 30
   40 FINAL(IMIN)=.TRUE.
      I=IMIN
      CALL KILL(SPC,FINAL,N1,IMIN,TREE)
      IF (.NOT.FINAL(IMIN)) GO TO 20
      J=FWD(I)
   60 IF (J.EQ.0) RETURN
      IF (.NOT.FINAL(TO(J))) GO TO 20
      J=NEXT(J)
      GO TO 60
C     RETURN
      END
      SUBROUTINE UPDTRE(SPC,N1,IMIN,TREE,K)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE UPDTRE PERFORMS THE UPDATING OF THE SORTING TREE WHEN A  C
C SPC VALUE CHANGES.                                                  C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL TREE(1),SPC(1)
      INTEGER*2 P,K,N1,IMIN
      P=(K+N1-1)/2
   10 IF (P.EQ.0) GO TO 20
      IF (TREE(P).LE.SPC(K)) RETURN
      TREE(P)=SPC(K)
      P=P/2
      GO TO 10
   20 IMIN=K
      RETURN
      END
      SUBROUTINE KILL(SPC,FINAL,N1,IMIN,TREE)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE KILL DELETES THE PREVIOUSE MINIMUM VALUE FROM THE SORTINGC
```

```
C TREE AND UPDATES IT.                                                 C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL TREE(1),SPC(1)
      INTEGER*2 P1,IMIN,N1,P,P2
      LOGICAL*1 FINAL(1)
      P1=IMIN
      P=(P1+N1-1)/2
      P2=P1+1
      IF (P1/2*2.EQ.P1) P2=P1-1
      TREE(P)=1.E30
      IF (.NOT.FINAL(P2)) TREE(P)=SPC(P2)
   30 P1=P
      P=P/2
      IF (P.EQ.0) GO TO 40
      P2=P1+1
      IF (P1/2*2.NE.P1) P2=P1-1
      TREE(P)=TREE(P1)
      IF (TREE(P1).GT.TREE(P2)) TREE(P)=TREE(P2)
      GO TO 30
   40 IMIN=1
   70 IMIN=IMIN*2
      IF (IMIN.GT.N1-1) GO TO 80
      IF (TREE(IMIN).GT.TREE(IMIN+1)) IMIN=IMIN+1
      GO TO 70
   80 IMIN=IMIN-N1+1
      IF (FINAL(IMIN+1)) RETURN
      IF (FINAL(IMIN).OR.(SPC(IMIN).GT.SPC(IMIN+1)))  IMIN=IMIN+1
      RETURN
      END
```

```
      SUBROUTINE SAVE(NARC,T,NT,ORIG,DEST,L,MAXVOL,FROM,TO,FWD,NEXT,N,
     1 EPS,EPS1,COEF,NARC2,COST,X,NAME,ITMAX,ALPHA,THETA,E,ATR)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE SAVE SAVES THE NETWORK ON AN ARBITRARY EXTERNAL FILE.    C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL T(1),L(1),MAXVOL(1),COEF(5,1),COST(1),X(1),NAME(1),ALPHA,
     1 THETA,E(1),ATR(1)
      INTEGER*2 NARC,NT,ORIG(1),DEST(1),FROM(1),TO(1),FWD(1),NEXT(1),
     1 N,I,NARC2,ITMAX
      INTEGER FILE
      WRITE (6,21)
   21 FORMAT(' ENTER SAVE FILE NUMBER:'/' XX')
      READ (1,22) FILE
   22 FORMAT(I3)
      WRITE (6,17) FILE
   17 FORMAT(' THE NETWORK WILL BE SAVED ON FILE ',I2,'.')
      WRITE (FILE,15) N,NARC2,NT,EPS,EPS1,NARC,ITMAX,ALPHA,THETA
   15 FORMAT(20A4)
      IF (N.EQ.0) GO TO 10
      WRITE (FILE,15) (NAME(I),FWD(I),I=1,N)
   10 IF (NARC.EQ.0) GO TO 20
      WRITE (FILE,15) (FROM(I),TO(I),L(I),(COEF(J,I),J=1,5),MAXVOL(I),
     1 NEXT(I),X(I),I=1,NARC)
   20 IF (NT.EQ.0) GO TO 30
      WRITE (FILE,15) (ORIG(I),DEST(I),T(I),E(ORIG(I)),ATR(DEST(I)),
     1 I=1,NT)
   30 REWIND FILE
      WRITE (6,19)
   19 FORMAT(' DATA WAS SAVED.')
      RETURN
      END
```

```
      SUBROUTINE GETARC(F1,T1,L1,C1,M1,I,NAME,NM1,NM2,N,FL,
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE GETARC READS THE DATA OF AN ARC.                         C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL L1,M1,C1(1),BL/' '/,NAME(1),NM1,NM2,F/'F'/,E/'E'/,NN/'N'/
      INTEGER*2 I,J,F1,T1,N
      INTEGER N1
      LOGICAL*1 FL
   60 WRITE (6,4) I
    4 FORMAT(' ',I4,':')
   30 READ (1,5) R,NM1,NM2,L1,(C1(J),J=1,5),M1
    5 FORMAT(A1,A4,1X,A4,1X,F6.2,5(1X,F9.5),1X,F9.2)
      IF (R.EQ.BL) GO TO 50
      IF (R.EQ.F) GO TO 10
      IF (R.NE.E.AND.R.NE.NN) GO TO 20
      FL=.TRUE.
      RETURN
   10 WRITE (6,16)
   16 FORMAT(
     1 ' FROM  TO  LENGTH  COEF(1)   COEF(2)   COEF(3)   COEF(4)',
     2 '   COEF(5)  MAX VOLUME'/'  XXXX XXXX XXX.XX XXX.XXXXX X',
     3 'XX.XXXXX XXX.XXXXX XXX.XXXXX XXX.XXXXX XXXXXX.XX')
      GO TO 60
   50 WRITE (6,6) NM1,NM2,L1,(C1(J),J=1,5),M1
    6 FORMAT(2(1X,A4),1X,F6.2,5(1X,F9.5),1X,F9.2)
      CALL CONV(NM1,NM2,F1,T1,NAME,N)
      FL=.FALSE.
      RETURN
   20 WRITE (6,1)
    1 FORMAT(' INVALID CONTROL CHARACTER. REENTER:')
      GO TO 30
      END
      SUBROUTINE SEARCH(P,P1,F,T,FWD,NEXT,TO)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE SEARCH LOOKS FOR THE DESIRED ARC AND RETURNS A POINTER TOC
C THAT ARC AND TO THE ONE PRECEEDING IT.                               C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      INTEGER*2 P,F,T,FWD(1),NEXT(1),TO(1),P1
      P1=0
      P=0
      IF (F.EQ.0) RETURN
      IF (FWD(F).EQ.0) RETURN
      P=FWD(F)
  140 IF (TO(P).EQ.T) RETURN
      P1=P
      P=NEXT(P)
      IF (P.NE.0) GO TO 140
      RETURN
      END
      SUBROUTINE INSOD(O,D,T1,ORIG,DEST,T,NT,PLACE)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE INSOD INSERTS AN OD PAIR INTO THE LIST.                   C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      INTEGER*2 O,D,ORIG(1),DEST(1),NT,PLACE,K
      REAL T(1)
      IF (NT.GT.PLACE) GO TO 20
      ORIG(NT+1)=O
      DEST(NT+1)=D
      T(NT+1)=T1
      RETURN
   20 K=NT
```

```
      ORIG(K+1)=ORIG(K)
      DEST(K+1)=DEST(K)
      T(K+1)=T(K)
      K=K-1
      IF (K.GT.PLACE) GO TO 10
      ORIG(PLACE+1)=O
      DEST(PLACE+1)=D
      T(PLACE+1)=T1
      RETURN
      END
       SUBROUTINE DELOD(ORIG,DEST,T,NT,PLACE)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE DELOD DELETES AN OD PAIR FROM THE LIST.                   C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      INTEGER*2 ORIG(1),DEST(1),PLACE,NT,K
      REAL T(1)
      DO 10 K=PLACE,NT
      ORIG(K)=ORIG(K+1)
      DEST(K)=DEST(K+1)
   10 T(K)=T(K+1)
      RETURN
      END
       SUBROUTINE SRCHOD(O,D,ORIG,DEST,K,MID,NT)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE SRCHOD LOOKS FOR THE DESIRED OD PAIR AND RETURNS A POINTER
C TO IT OR A POINTER TO THE PALCE AFTER WICH IT SHOULD BE INSERTED.   C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      INTEGER*2 O,D,ORIG(1),DEST(1),K,MID,NT,I,J,ONE
      K=0
      MID=0
      IF (NT.EQ.0) RETURN
      ONE=1
      I=1
      J=NT
   40 MID=(I+J)/2
      IF (O-ORIG(MID)) 10,20,30
   10 IF (MID.EQ.I) GO TO 100
      J=MID
      GO TO 40
   30 IF (MID.EQ.I) GO TO 100
      I=MID
      GO TO 40
   20 I=MID
   21 IF (ORIG(I).NE.O) GO TO 60
      IF (DEST(I).EQ.D) GO TO 70
      I=I-1
      IF (I.GE.ONE) GO TO 21
   60 DO 80 I=MID,NT
      IF (ORIG(I).NE.O) RETURN
      IF (DEST(I).EQ.D) GO TO 70
   80 CONTINUE
      MID=NT
      RETURN
   70 K=I
      RETURN
  100 IF (O.GT.ORIG(MID+1)) MID=MID+1
      RETURN
      END
       SUBROUTINE GETOD(I,O,D,T,NAME,N,FL)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE GETOD READS THE TRAVEL DEMAND OF AN OD PAIR.              C
```

```
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00008490
      REAL BL/' '/,NAME(1),NM1,NM2,F/'F'/,E/'E'/,NN/'N'/                00008500
      INTEGER*2 I,C,D,N                                                 00008510
      LOGICAL*1 FL                                                      00008520
   20 WRITE (6,2) I                                                     00008530
    2 FORMAT(' ',I4,':')                                                00008540
   50 READ (1,3) R,NM1,NM2,T                                            00008550
    3 FORMAT(A1,A4,1X,A4,1X,F10.5)                                      00008560
      IF (R.EQ.BL) GO TO 10                                             00008570
      IF (R.EQ.F) GO TO 30                                              00008580
      IF (R.NE.E.AND.R.NE.NN) GO TO 40                                  00008590
      FL=.TRUE.                                                         00008600
      RETURN                                                            00008610
   30 WRITE (6,1)                                                       00008620
    1 FORMAT(' ORIG DEST   DEMAND'/'+____ ____   ______'/'  XXXX XXXX', 00008630
     1 ' XXXX.XXXXX')                                                   00008640
      GO TO 20                                                          00008650
   10 WRITE (6,3) R,NM1,NM2,T                                           00008660
      CALL CONV(NM1,NM2,C,D,NAME,N)                                     00008670
      FL=.FALSE.                                                        00008680
      RETURN                                                            00008690
   40 WRITE (6,4)                                                       00008700
    4 FORMAT(' INVALID CONTROL CHARACTER. REENTER:')                    00008710
      GO TO 50                                                          00008720
      END                                                               00008730
       SUBROUTINE CONV(IN1,IN2,OUT1,OUT2,NAME,N)                         00009030
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00009040
C SUBROUTINE CONV CONVERTS NODE NAMES TO INTERNAL NODE NUMBERS AND    C 00009050
C RETURNS 0'S IF THEY DO NOT EXIST.                                   C 00009060
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C 00009070
      REAL IN1,IN2,NAME(1)                                              00009080
      INTEGER*2 OUT1,OUT2,N,I                                           00009090
      LOGICAL*1 F1,F2                                                   00009100
      F1=.FALSE.                                                        00009110
      F2=.FALSE.                                                        00009120
      OUT1=0                                                            00009130
      OUT2=0                                                            00009140
      IF (N.EQ.0) RETURN                                                00009150
      DO 10 I=1,N                                                       00009160
      IF (IN1.NE.NAME(I)) GO TO 20                                      00009170
      OUT1=I                                                            00009180
      IF (F2) RETURN                                                    00009190
      F1=.TRUE.                                                         00009200
   20 IF (IN2.NE.NAME(I)) GO TO 10                                      00009210
      OUT2=I                                                            00009220
      IF (F1) RETURN                                                    00009230
      F2=.TRUE.                                                         00009240
   10 CONTINUE                                                          00009250
      RETURN                                                            00009260
      END                                                               00009270
```

```
      FUNCTION Z(NARC,NT,ORIG,DEST,ALPHA,THETA,S,E,TD,ATR,COEF,X,
     1 L,MAXVOL,FROM)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C FUNCTION Z EVALUATES THE OBJECTIVE FUNCTION AT A GIVEN POINT        C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL S(1),E(1),TD(1),ATR(1),ALPHA,THETA,Z1,Z2,Z3
     1 ,X(1),COEF(5,1),L(1),MAXVOL(1)
      INTEGER*2 I,J,NARC,NT,ORIG(1),DEST(1),ODPR,R,FROM(1)
      Z1=0.
      Z2=0.
      ODPR=1
   32 IF(ODPR.GT.NT) GO TO 38
      R=ORIG(ODPR)
      Z1=Z1+(ALPHA/2.)*S(R)*S(R)+ALPHA*S(R)-(ALPHA*S(R)+E(R))*
     1 ALOG(ALPHA*S(R)+E(R))
      DO 35 J=ODPR,NT
      IF(ORIG(J).NE.R) GO TO 37
      Z2=Z2+TD(J)*ALOG(TD(J))-TD(J)*ATR(DEST(J))-TD(J)
   35 CONTINUE
   37 ODPR=J
      GO TO 32
   38 Z3=F(X,NARC,COEF,L,MAXVOL,FROM)
      Z=Z1+(1./THETA)*Z2+Z3
      RETURN
      END
```

```
       FUNCTION C(I,X,COEF,L,MAXVOL)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C FUNCTICN C CALCULATES THE ARC COSTS TC BE USED BY THE SHORTEST PATH C
C ALGORITHM.                                                          C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL X(1),COEF(5,1),L(1),MAXVCL(1)
      INTEGER*2 I
      C=COEF(1,I)*L(I)+COEF(2,I)*(X(I)/MAXVCI(I))**CCEF(3,I)+
     1 COEF(4,I)*L(I)+COEF(5,I)
      RETURN
      END
       FUNCTICN F(X,NARC,COEF,L,MAXVOL,FROM)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C FUNCTION F CAICUIATES THE INTEGPAI OF THE CCST FUNCTION FOR A       C
C GIVEN LINK                                                          C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL X(1),COEF(5,1),L(1),MAXVCL(1)
      INTEGEF*2 I,NARC,FROM(1)
      F=0.0
      DO 10 I=1,NARC
      IF(FRCM(I).EQ.0) GC TC 10
      F=F+CCEF(1,I)*L(I)*X(I)+(CCEF(2,I)*MAXVOL(I)/(COEF(3,I)+1))*
     1 (X(I)/MAXVOL(I))**(CCEF(3,I)+1.0)+COEF(4,I)*L(I)*
     2 X(I)+COEF(5,I)*X(I)
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ACTION(IACT,ACT,N1,N2,ISN)
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
C SUBROUTINE ACTION READS THE NEXT ACTION TO BE TAKEN AND RETURNS A   C
C CODE WHICH IDENTIFIES THE ACTION.                                   C
C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C C
      REAL ACT(1),ARG(10)
      INTEGER*2 IACT,ISN
10    READ (1,2) ARG
    2 FORMAT(10A4)
   40 DO 20 I=N1,N2
      IF (ARG(1).EQ.ACT(I)) GO TO 30
   20 CONTINUE
      WRITE (6,1) ARG
    1 FORMAT(' ',10A4/' THIS IS NOT A VALID RESPONSE. REENTER:')
      GO TO 10
   30 ISN=ISN+1
      WRITE(6,3) ISN,ARG
    3 FORMAT(10X,I4,3X,10A4)
      IACT=I-N1+1
      RETURN
      END
```

```
      SUBROUTINE ITEROUT(ITER,FILE,TD,TDL,PTDL,SPC1,NAME,NT,ORIG,DEST,
     1 TT1)
C
C     THIS PROGRAM WRITES O-D MATRICES FOR A GIVEN SET OF ITERATIONS.
C
      REAL TD(1),TDL(1),PTDL(1),SPC1(1),NAME(1),TT1,RL
      INTEGER FILE
      INTEGER*2 NT,ORIG(1),DEST(1),ITER,ITER3,ITER2(25),I
      DATA ITER2/5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150,
     1 160,170,180,190,200,210,220,230,240/
      ITER3=ITER-1
      DO 10 I=1,25
      IF(ITER2(I).NE.ITER3) GO TO 10
      WRITE(6,20) ITER3
   20 FORMAT(' DO YOU WANT TO SEE O-D MATRICES OF',I6,'TH ITERATION?'/
     1 ' TYPE''YES''OR''NO'':')
      READ(1,30) RL
   30 FORMAT(A3)
      WRITE(6,40) RL
   40 FORMAT(' ',A3)
      IF(RL.NE.'YES') RETURN
      WRITE(FILE,50) ITER3
   50 FORMAT('1ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AFTER THE',
     1 I6,'TH ITERATION:'/71('=')/' IT INCLUDES TRIPS PREDICTED,',
     2 ' TRIPS CALCULATED BY LOGIT AND %DIFFERENCE BETWEEN BOTH.'//)
      CALL ODMATRIX(TD,TDL,PTDL,NAME,NT,ORIG,DEST,FILE,TT1)
      WRITE(FILE,60) ITER3
   60 FORMAT('1ORIGIN-DESTINATION PERCEIVED COST MATRIX AFTER THE',
     1 I6,'TH ITERATION:'/65('='))
      CALL CMATRIX(SPC1,NAME,NT,ORIG,DEST,FILE)
      WRITE(6,70) ITER3
   70 FORMAT(' MATRICES OF',I6,'TH ITERATION ARE STORED IN YOUR',
     1 ' OUTPUT FILE')
      RETURN
   10 CONTINUE
      END
```

```
      SUBROUTINE DMATRIX(TD,NAME,NT,ORIG,DEST,FILE,TT1)
C
C     IT CREATES AN O-D MATRIX OF EGYPT'S 24 ZONES
C
      REAL NM(24),NAME1,NAME2,TD(1),NAME(1),
     1 OD(30,30),TTG(30),TTA(30),TT1
      INTEGER FILE
      INTEGER*2 NT,ORIG(1),DEST(1),I,J,IO,ID,N,N1
      DATA NM/'ALEX','DMHR','ETYB','KFRS','MHLK','TANT','SHKM',
     1 'BNHA','CAIR','ZGZG','ABKB','MNSR','SHRB','DMIT','PRTS',
     2 'ISML','SWES','FYUM','BSWF','MNIA','ASYT','SHAG','QENA',
     3 'ASWN'/
      N=24
      DO 40 J=1,NT
      NAME1=NAME(ORIG(J))
      NAME2=NAME(DEST(J))
      IO=0
      ID=0
      DO 30 I=1,N
      IF(NM(I).NE.NAME1) GO TO 20
      IO=I
      GO TO 30
   20 IF(NM(I).NE.NAME2) GO TO 30
      ID=I
   30 CONTINUE
      OD(IO,ID)=TD(J)
   40 CONTINUE
      DO 60 I=1,N
      TTG(I)=0.
      TTA(I)=0.
   60 CONTINUE
      DO 80 J=1,N
      DO 70 I=1,N
      TTA(J)=TTA(J)+OD(I,J)
   70 CONTINUE
   80 CONTINUE
      DO 100 I=1,N
      DO 90 J=1,N
      TTG(I)=TTG(I)+OD(I,J)
   90 CONTINUE
  100 CONTINUE
      TT1=0.0
      DO 110 I=1,N
      TT1=TT1+TTG(I)
  110 CONTINUE
C
C     WRITE THE O-D MATRIX CREATED ABOVE
C
      WRITE(FILE,120) (NM(I),I=1,13)
  120 FORMAT(1X,4X,'TO',2X,13(A4,4X)/' FROM',104('-'))
      DO 140 I=1,N
      WRITE(FILE,130) NM(I),(OD(I,J),J=1,13)
  130 FORMAT(1X,A4,13F8.0)
  140 CONTINUE
      WRITE(FILE,150) (TTA(J),J=1,13)
  150 FORMAT(1X,108('-')/1X,'ATTR',13F8.0/1X,108('-'))
      N1=N+1-14
      WRITE(FILE,160) (NM(I),I=14,N)
  160 FORMAT('1O-D MATRIX (CONTINUED)'//
     1 5X,<N1>(4X,A4),'  GENERATN'/1X,102('-'))
      DO 170 I=1,N
```

```
      WRITE(FILE,180) NM(I),(OD(I,J),J=14,N),TTG(I)
  180 FORMAT(1X,A4,<N1>F8.0,F10.0)
  170 CONTINUE
      WRITE(FILE,190) (TTA(J),J=14,N),TT1
  190 FORMAT(1X,102('-')/1X,'ATTR',<N1>F8.0,F10.0/1X,102('-'))
      RETURN
      END
      SUBROUTINE ODMATRIX(TD,TDL,PTDL,NAME,NT,ORIG,DEST,FILE,TT1)
C
C     IT CREATES AN O-D MATRIX OF EGYPT'S 24 ZONES
C
      REAL NM(24),NAME1,NAME2,TD(1),NAME(1),
     1 POD(30,30),LOD(30,30),OD(30,30),TTG(30),TTA(30),TT1,
     2 TTAL(30),PTTA(30),PTDL(1),TDL(1)
      INTEGER FILE
      INTEGER*2 NT,ORIG(1),DEST(1),I,J,IO,ID,N,N1
      DATA NM/'ALEX','DMHR','ETYB','KFRS','MHLK','TANT','SHKM',
     1 'BNHA','CAIR','ZGZG','ABKB','MNSF','SHRB','DMIT','PRTS',
     2 'ISML','SWES','FYUM','BSWF','MNIA','ASYT','SHAG','QENA',
     3 'ASWN'/
      N=24
      DO 40 J=1,NT
      NAME1=NAME(ORIG(J))
      NAME2=NAME(DEST(J))
      IO=0
      ID=0
      DO 30 I=1,N
      IF(NM(I).NE.NAME1) GO TO 20
      IO=I
      GO TO 30
   20 IF(NM(I).NE.NAME2) GO TO 30
      ID=I
   30 CONTINUE
      OD(IO,ID)=TD(J)
      LOD(IO,ID)=TDL(J)
      POD(IO,ID)=PTDL(J)
   40 CONTINUE
      DO 60 I=1,N
      TTG(I)=0.
      TTA(I)=0.
      TTAL(I)=0.
   60 CONTINUE
      DO 80 J=1,N
      DO 70 I=1,N
      TTA(J)=TTA(J)+OD(I,J)
      TTAL(J)=TTAL(J)+LOD(I,J)
   70 CONTINUE
   80 CONTINUE
      DO 100 I=1,N
      DO 90 J=1,N
      TTG(I)=TTG(I)+OD(I,J)
   90 CONTINUE
  100 CONTINUE
      TT1=0.0
      DO 110 I=1,N
      TT1=TT1+TTG(I)
  110 CONTINUE
      DO 200 I=1,N
      IF(TTAL(I).EQ.0.0) GO TO 200
      PTTA(I)=100.0*(TTA(I)-TTAL(I))/TTAL(I)
  200 CONTINUE
```

```
C
C     WRITE THE O-D MATRIX CREATED ABOVE
C
      WRITE(FILE,120) (NM(I),I=1,13)
  120 FORMAT(1X,4X,'TO',2X,13(A4,4X)/' FROM',104('-'))
      DO 140 I=1,N
      WRITE(FILE,130) NM(I),(OD(I,J),J=1,13)
  130 FORMAT(/1X,A4,13F8.0)
      WRITE(FILE,135) (LOD(I,J),J=1,13)
      WRITE(FILE,136) (PCD(I,J),J=1,13)
  135 FORMAT(5X,13F8.0)
  136 FORMAT(5X,13(1X,F6.0,'%'))
  140 CONTINUE
      WRITE(FILE,150) (TTA(J),J=1,13),(TTAL(J),J=1,13),
     1 (PTTA(J),J=1,13)
  150 FORMAT(1X,108('-')/1X,'ATTR',13F8.0/5X,13F8.0/
     1 5X,13(1X,F6.0,'%')/1X,108('-'))
      N1=N+1-14
      WRITE(FILE,160) (NM(I),I=14,N)
  160 FORMAT('1O-D MATRIX (CONTINUED)'//
     1 5X,<N1>(4X,A4),'  GENERATN'/1X,102('-'))
      DO 170 I=1,N
      WRITE(FILE,180) NM(I),(OD(I,J),J=14,N),TTG(I)
  180 FORMAT(/1X,A4,<N1>F8.0,F10.0)
      WRITE(FILE,185) (LOD(I,J),J=14,N)
      WRITE(FILE,186) (PCD(I,J),J=14,N)
  185 FORMAT(5X,<N1>F8.0)
  186 FORMAT(5X,<N1>(1X,F6.0,'%'))
  170 CONTINUE
      WRITE(FILE,190) (TTA(J),J=14,N),TT1,(TTAL(J),J=14,N),
     1 (PTTA(J),J=14,N)
  190 FORMAT(1X,102('-')/1X,'ATTR',<N1>F8.0,F10.0/
     1 5X,<N1>F8.0/5X,<N1>(1X,F6.0,'%')/1X,102('-'))
      RETURN
      END
      SUBROUTINE CMATRIX(SPC1,NAME,NT,ORIG,DEST,FILE)
C
C     IT CREATES AN O-D MATRIX OF EGYPT'S 24 ZONES
C
      REAL NM(24),NAME1,NAME2,NAME(1),SPC1(1),COD(30,30)
      INTEGER FILE
      INTEGER*2 NT,ORIG(1),DEST(1),I,J,IO,ID,N,N1
      DATA NM/'ALEX','DMHR','ETYR','KFRS','MHLK','TANT','SHKM',
     1 'BNHA','CAIR','ZGZG','ABKR','MNSR','SHRB','DMIT','PRTS',
     2 'ISML','SWES','FYUM','BSWF','MNIA','ASYT','SHAG','QENA',
     3 'ASWN'/
      N=24
      DO 40 J=1,NT
      NAME1=NAME(ORIG(J))
      NAME2=NAME(DEST(J))
      IO=0
      ID=0
      DO 30 I=1,N
      IF(NM(I).NE.NAME1) GO TO 20
      IO=I
      GO TO 30
   20 IF(NM(I).NE.NAME2) GO TO 30
      ID=I
   30 CONTINUE
      COD(IO,ID)=SPC1(J)
   40 CONTINUE
```

```
C
C     WRITE THE O-D MATRIX CREATED ABOVE
C
      WRITE(FILE,120) (NM(I),I=1,13)
  120 FORMAT(1X,4X,'TO',2X,13(A4,4X)/' FROM',104('-'))
      DO 140 I=1,N
      WRITE(FILE,130) NM(I),(COD(I,J),J=1,13)
  130 FORMAT(1X,A4,13F8.3)
  140 CONTINUE
      N1=N+1-14
      WRITE(FILE,160) (NM(I),I=14,N)
  160 FORMAT('1O-D MATRIX (CONTINUED)'//
     1 5X,<N1>(4X,A4)/1X,102('-'))
      DO 170 I=1,N
      WRITE(FILE,180) NM(I),(COD(I,J),J=14,N)
  180 FORMAT(1X,A4,<N1>F8.3)
  170 CONTINUE
      RETURN
      END
```

APPENDIX B

THE MULTIMODAL COMPOSED NETWORK OF EXPRESS, LOCAL, BUS AND TAXI; AND INPUTS TO LINK USER COST FUNCTIONS

* COEFFICIENT OF LINK COST FUNCTIONS:

C_1 = value of time x average travel time per km.

C_2 and C_3 are constants.

C_4 = Per km tariff.

C_5 =
value of time x loading delay + entry charge
value of time x unloading delay

* IDENTIFICATION OF MODAL NODES:

Each node has a 4-character name, the last two indicates the mode as follows;

LT = Local train
ET = Express train
EB = East Delta Bus Co.
WB = West Delta Bus Co.
MB = Middle Delta Bus Co.
UB = Upper Egypt Bus Co.
TX = Taxi

```
PROBLEM DEFINITION:
==================


LINK DATA:   COST=C1*LENGTH+(C2*(FLOW/CAPACITY)**C3)+C4*LENGTH+C5
---------

LINK FROM  TO  LENGTH     C1        C2        C3         C4         C5     CAPACITY
---- ---- ---- ------- --------- --------- --------- --------- -------- ---------
   1 AXLT QNLT  121.68   0.00431   0.10000  20.00000   0.00190   0.33226   8208.00
   2 QNLT AXIT  121.68   0.00431   0.10000  20.00000   0.00190   0.33226   8208.00
   3 AXLT DRIT   60.69   0.00215   0.10000  20.00000   0.00190   0.15389   8208.00
   4 DRLT AXIT   60.69   0.00215   0.10000  20.00000   0.00190   0.15389   8208.00
   5 DRLT QNIT   42.60   0.00538   0.10000  20.00000   0.00190   0.08744  27360.00
   6 QNLT DRIT   42.60   0.00538   0.10000  20.00000   0.00190   0.08744  27360.00
   7 QNLT KSIT   17.96   0.00538   0.10000  20.00000   0.00190   0.04575  27360.00
   8 KSLT QNIT   17.96   0.00538   0.10000  20.00000   0.00190   0.04575  27360.00
   9 KSLT SNIT   63.05   0.00538   0.10000  20.00000   0.00190   0.12591  21888.00
  10 SNLT KSIT   63.05   0.00538   0.10000  20.00000   0.00190   0.12591  21888.00
  11 SNLT DTIT   40.77   0.00355   0.10000  20.00000   0.00190   0.11892  16416.00
  12 DTIT SNIT   40.77   0.00355   0.10000  20.00000   0.00190   0.11892  16416.00
  13 SNLT MRIT   23.82   0.00355   0.10000  20.00000   0.00190   0.13291  19152.00
  14 MRLT SNIT   23.82   0.00355   0.10000  20.00000   0.00190   0.13291  19152.00
  15 MKLT MRIT   25.36   0.00215   0.10000  20.00000   0.00190   0.09793  35568.00
  16 MRLT MKIT   25.36   0.00215   0.10000  20.00000   0.00190   0.09793  35568.00
  17 MKLT MHIT   13.23   0.00215   0.10000  20.00000   0.00190   0.02099  41040.00
  18 MHLT MKIT   13.23   0.00215   0.10000  20.00000   0.00190   0.02099  41040.00
  19 QNLT MHIT   30.58   0.00538   0.10000  20.00000   0.00190   0.06645  32832.00
  20 MHLT QNIT   30.58   0.00538   0.10000  20.00000   0.00190   0.06645  32832.00
  21 DRLT EBIT   25.20   0.00215   0.10000  20.00000   0.00190   0.05596  13680.00
  22 EBLT DRIT   25.20   0.00215   0.10000  20.00000   0.00190   0.05596  13680.00
  23 EBIT KZIT   17.84   0.00215   0.10000  20.00000   0.00190   0.03847  13680.00
  24 KZLT EBIT   17.84   0.00215   0.10000  20.00000   0.00190   0.03847  13680.00
  25 KZLT TTIT   17.76   0.00215   0.10000  20.00000   0.00190   0.03847  13680.00
  26 TTLT KZIT   17.76   0.00215   0.10000  20.00000   0.00190   0.03847  13680.00
  27 TTLT MHIT   14.42   0.00215   0.10000  20.00000   0.00190   0.02099  68400.00
  28 MHLT TTIT   14.42   0.00215   0.10000  20.00000   0.00190   0.02099  68400.00
  29 MHLT ZTIT   30.49   0.00323   0.10000  20.00000   0.00190   0.06645   2736.00
  30 ZTLT MHIT   30.49   0.00323   0.10000  20.00000   0.00190   0.06645   2736.00
  31 MRLT AKIT   47.54   0.00538   0.10000  20.00000   0.00190   0.13990  32832.00
  32 AKLT MRIT   47.54   0.00538   0.10000  20.00000   0.00190   0.13990  32832.00
  33 AKLT ZGIT   23.00   0.00538   0.10000  20.00000   0.00190   0.04897  38304.00
  34 ZGLT AKIT   23.00   0.00538   0.10000  20.00000   0.00190   0.04897  38304.00
  35 ZTLT ZGIT   29.92   0.00355   0.10000  20.00000   0.00190   0.08744  27360.00
  36 ZGLT ZTIT   29.92   0.00355   0.10000  20.00000   0.00190   0.08744  27360.00
  37 ILLT ZGIT   78.32   0.00215   0.10000  20.00000   0.00190   0.19586  19152.00
  38 ZGLT ILIT   78.32   0.00215   0.10000  20.00000   0.00190   0.19586  19152.00
  39 BHLT ZGLT   35.00   0.00215   0.10000  20.00000   0.00190   0.09094  24624.00
  40 ZGLT BHIT   35.00   0.00215   0.10000  20.00000   0.00190   0.09094  24624.00
  41 BHLT ZTLT   33.76   0.00538   0.10000  20.00000   0.00190   0.05246  24624.00
  42 ZTIT BHIT   33.76   0.00538   0.10000  20.00000   0.00190   0.05246  24624.00
  43 TTLT ZTIT   26.29   0.00355   0.10000  20.00000   0.00190   0.05946  27360.00
  44 ZTLT TTIT   26.29   0.00355   0.10000  20.00000   0.00190   0.05946  27360.00
  45 TTLT BHIT   41.40   0.00215   0.10000  20.00000   0.00190   0.05394  13680.00
  46 BHLT TTIT   41.40   0.00215   0.10000  20.00000   0.00190   0.05394  13680.00
  47 TTLT SKIT   28.13   0.00355   0.10000  20.00000   0.00190   0.06296  38304.00
  48 SKLT TTIT   28.13   0.00355   0.10000  20.00000   0.00190   0.06296  38304.00
  49 KZLT MFIT   49.87   0.00538   0.10000  20.00000   0.00190   0.09793  21888.00
  50 MFLT KZIT   49.87   0.00538   0.10000  20.00000   0.00190   0.09793  21888.00
  51 EBLT IBIT  119.57   0.00355   0.10000  20.00000   0.00190   0.32527  13680.00
```

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 52 IBLT EBIT  119.57   0.00355   0.10000  20.00000   0.00190   0.32527  13680.00
 53 SKLT MFIT   13.56   0.00355   0.10000  20.00000   0.00190   0.05246  38304.00
 54 MFLT SKIT   13.56   0.00355   0.10000  20.00000   0.00190   0.05246  38304.00
 55 MFLT BHIT   26.85   0.00538   0.10000  20.00000   0.00190   0.05946  27360.00
 56 BHLT MFIT   26.85   0.00538   0.10000  20.00000   0.00190   0.05946  27360.00
 57 BHLT QBIT   30.87   0.00215   0.10000  20.00000   0.00190   0.07345  16416.00
 58 QBLT BHIT   30.87   0.00215   0.10000  20.00000   0.00190   0.07345  16416.00
 59 MFIT QBIT   51.38   0.00355   0.10000  20.00000   0.00190   0.14690  30096.00
 60 QBLT MFIT   51.38   0.00355   0.10000  20.00000   0.00190   0.14690  30096.00
 61 QBLT CRIT   14.14   0.00215   0.10000  20.00000   0.00190   0.03847  98496.00
 62 CRLT QBIT   14.14   0.00215   0.10000  20.00000   0.00190   0.03847  98496.00
 63 IBLT CRIT    3.28   0.00215   0.10000  20.00000   0.00190   0.02448  30096.00
 64 CRLT IBIT    3.28   0.00215   0.10000  20.00000   0.00190   0.02448  30096.00
 65 IBIT GZIT    9.67   0.00215   0.10000  20.00000   0.00190   0.03847  21888.00
 66 GZLT IBIT    9.67   0.00215   0.10000  20.00000   0.00190   0.03847  21888.00
 67 GZLT WTIT   79.03   0.00215   0.10000  20.00000   0.00190   0.19936  10944.00
 68 WTLT GZIT   79.03   0.00215   0.10000  20.00000   0.00190   0.19936  10944.00
 69 WTLT BSIT   31.95   0.00215   0.10000  20.00000   0.00190   0.07345  16416.00
 70 BSIT WTIT   31.95   0.00215   0.10000  20.00000   0.00190   0.07345  16416.00
 71 WTIT FMIT   37.74   0.00355   0.10000  20.00000   0.00190   0.08044   5472.00
 72 FMLT WTIT   37.74   0.00355   0.10000  20.00000   0.00190   0.08044   5472.00
 73 BSIT MNIT  122.73   0.00215   0.10000  20.00000   0.00190   0.27980  10944.00
 74 MNLT BSIT  122.73   0.00215   0.10000  20.00000   0.00190   0.27980  10944.00
 75 MNLT ATIT  128.37   0.00215   0.10000  20.00000   0.00190   0.26581  13680.00
 76 ATLT MNIT  128.37   0.00215   0.10000  20.00000   0.00190   0.26581  13680.00
 77 ATLT SGIT   91.95   0.00215   0.10000  20.00000   0.00190   0.30079  19152.00
 78 SGLT ATIT   91.95   0.00215   0.10000  20.00000   0.00190   0.30079  19152.00
 79 SGLT QEIT  141.59   0.00215   0.10000  20.00000   0.00190   0.46167  13680.00
 80 QEIT SGIT  141.59   0.00215   0.10000  20.00000   0.00190   0.46167  13680.00
 81 QELT ANIT  270.22   0.00215   0.10000  20.00000   0.00190   0.62955   8208.00
 82 ANLT QEIT  270.22   0.00215   0.10000  20.00000   0.00190   0.62955   8208.00
 83 QBLT ZGIT   26.94   0.00538   0.10000  20.00000   0.00190   0.15039  21888.00
 84 ZGIT QBIT   26.94   0.00538   0.10000  20.00000   0.00190   0.15039  21888.00
 87 ALEX AXIT    0.00   0.00000   0.00000   1.00000   0.00000   0.26483      1.00
 88 AXLT ALEX    0.00   0.00000   0.00000   1.00000   0.00000   0.09793      1.00
 89 DMHR DRIT    0.00   0.00000   0.00000   1.00000   0.00000   0.26483      1.00
 90 DRIT DMHR    0.00   0.00000   0.00000   1.00000   0.00000   0.09793      1.00
 91 ETYB EBIT    0.00   0.00000   0.00000   1.00000   0.00000   0.33478      1.00
 92 EBLT ETYB    0.00   0.00000   0.00000   1.00000   0.00000   0.16786      1.00
 93 KFRS KSIT    0.00   0.00000   0.00000   1.00000   0.00000   0.27882      1.00
 94 KSLT KFRS    0.00   0.00000   0.00000   1.00000   0.00000   0.11192      1.00
 95 MHIK MKIT    0.00   0.00000   0.00000   1.00000   0.00000   0.16690      1.00
 96 MKLT MHIK    0.00   0.00000   0.00000   1.00000   0.00000   0.01400      1.00
 97 TANT TTIT    0.00   0.00000   0.00000   1.00000   0.00000   0.19498      1.00
 98 TTLT TANT    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
 99 SHKM SKIT    0.00   0.00000   0.00000   1.00000   0.00000   0.22266      1.00
100 SKIT SHKM    0.00   0.00000   0.00000   1.00000   0.00000   0.05596      1.00
101 BNHA BHIT    0.00   0.00000   0.00000   1.00000   0.00000   0.19488      1.00
102 BHLI BNHA    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
103 CAIR CRIT    0.00   0.00000   0.00000   1.00000   0.00000   0.29867      1.00
104 CRLT CAIR    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
105 ZGZG ZGIT    0.00   0.00000   0.00000   1.00000   0.00000   0.22286      1.00
106 ZGIT ZGZG    0.00   0.00000   0.00000   1.00000   0.00000   0.05596      1.00
107 ABKB AKIT    0.00   0.00000   0.00000   1.00000   0.00000   0.29867      1.00
108 AKLT ABKB    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
109 MNSR MRIT    0.00   0.00000   0.00000   1.00000   0.00000   0.26483      1.00
110 MRLT MNSR    0.00   0.00000   0.00000   1.00000   0.00000   0.09793      1.00
111 SHRF SNIT    0.00   0.00000   0.00000   1.00000   0.00000   0.22266      1.00
112 SNLT SHRF    0.00   0.00000   0.00000   1.00000   0.00000   0.05596      1.00
113 DMIT DTIT    0.00   0.00000   0.00000   1.00000   0.00000   0.16089      1.00
114 DTLT DMIT    0.00   0.00000   0.00000   1.00000   0.00000   0.01400      1.00
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115 PRTS PSIT    0.00    0.00000    0.00000    1.00000    0.00000    0.19488       1.00
116 PSLT PRIS    0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
117 ISML ILIT    0.00    0.00000    0.00000    1.00000    0.00000    0.16089       1.00
118 ILLT ISML    0.00    0.00000    0.00000    1.00000    0.00000    0.01400       1.00
119 FYUM FMIT    0.00    0.00000    0.00000    1.00000    0.00000    0.19488       1.00
120 FMLT FYUM    0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
121 BSWF BSIT    0.00    0.00000    0.00000    1.00000    0.00000    0.19488       1.00
122 BSIT BSWF    0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
123 MNIA MNIT    0.00    0.00000    0.00000    1.00000    0.00000    0.22286       1.00
124 MNIT MNIA    0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
125 ASYT ATIT    0.00    0.00000    0.00000    1.00000    0.00000    0.25084       1.00
126 ATLT ASYT    0.00    0.00000    0.00000    1.00000    0.00000    0.08394       1.00
127 SHAG SGIT    0.00    0.00000    0.00000    1.00000    0.00000    0.25084       1.00
128 SGLT SHAG    0.00    0.00000    0.00000    1.00000    0.00000    0.08394       1.00
129 QENA QEIT    0.00    0.00000    0.00000    1.00000    0.00000    0.36276       1.00
130 QELT QENA    0.00    0.00000    0.00000    1.00000    0.00000    0.19586       1.00
131 ASWN ANIT    0.00    0.00000    0.00000    1.00000    0.00000    0.27882       1.00
132 ANIT ASWN    0.00    0.00000    0.00000    1.00000    0.00000    0.11192       1.00
133 AXET DRET   60.69    0.00200    0.10000   20.00000    0.00210    0.06995   31920.00
134 DRET AXET   60.69    0.00200    0.10000   20.00000    0.00210    0.06995   31920.00
135 DRET QNET   42.60    0.00502    0.10000   20.00000    0.00210    0.04547    6080.00
136 QNET DRET   42.60    0.00502    0.10000   20.00000    0.00210    0.04547    6080.00
137 DRET EBET   25.20    0.00200    0.10000   20.00000    0.00210    0.02798   24320.00
138 EBET DRET   25.20    0.00200    0.10000   20.00000    0.00210    0.02798   24320.00
139 EBET KZET   17.84    0.00200    0.10000   20.00000    0.00210    0.02448   24320.00
140 KZET EBET   17.84    0.00200    0.10000   20.00000    0.00210    0.02448   24320.00
141 KZET TTET   17.76    0.00200    0.10000   20.00000    0.00210    0.02448   24320.00
142 TTET KZET   17.76    0.00200    0.10000   20.00000    0.00210    0.02448   24320.00
143 TTET MHET   14.42    0.00200    0.10000   20.00000    0.00210    0.01399   12160.00
144 MHET TTET   14.42    0.00200    0.10000   20.00000    0.00210    0.01399   12160.00
145 MHET QNET   30.58    0.00502    0.10000   20.00000    0.00210    0.03148    3040.00
146 QNET MHET   30.58    0.00502    0.10000   20.00000    0.00210    0.03148    3040.00
147 QNET KSET   42.60    0.00502    0.10000   20.00000    0.00210    0.02448    9120.00
148 KSET QNET   42.60    0.00502    0.10000   20.00000    0.00210    0.02448    9120.00
149 KSET SNET   63.05    0.00502    0.10000   20.00000    0.00210    0.06995    4560.00
150 SNET KSET   63.05    0.00502    0.10000   20.00000    0.00210    0.06995    4560.00
151 SNET DTET   40.77    0.00334    0.10000   20.00000    0.00210    0.04897    9120.00
152 DTET SNET   40.77    0.00334    0.10000   20.00000    0.00210    0.04897    9120.00
153 SNET MRET   23.82    0.00334    0.10000   20.00000    0.00210    0.04897    9120.00
154 MRET SNET   23.82    0.00334    0.10000   20.00000    0.00210    0.04897    9120.00
155 MKET MRET   25.36    0.00200    0.10000   20.00000    0.00210    0.06995    9120.00
156 MRET MKET   25.36    0.00200    0.10000   20.00000    0.00210    0.06995    9120.00
157 MHET MKET   13.23    0.00200    0.10000   20.00000    0.00210    0.01399    9120.00
158 MKET MHET   13.23    0.00200    0.10000   20.00000    0.00210    0.01399    9120.00
159 MRET AKET   47.54    0.00502    0.10000   20.00000    0.00210    0.06995    4560.00
160 AKET MRET   47.54    0.00502    0.10000   20.00000    0.00210    0.06995    4560.00
161 PSET ILET   77.94    0.00200    0.10000   20.00000    0.00210    0.04897    4560.00
162 ILET PSET   77.94    0.00200    0.10000   20.00000    0.00210    0.04897    4560.00
163 ZGET AKET   23.00    0.00502    0.10000   20.00000    0.00210    0.04897    4560.00
164 AKET ZGET   23.00    0.00502    0.10000   20.00000    0.00210    0.04897    4560.00
165 ZGET ILET   78.32    0.00200    0.10000   20.00000    0.00210    0.06995    7600.00
166 ILET ZGET   78.32    0.00200    0.10000   20.00000    0.00210    0.06995    7600.00
167 ZGET BHET   35.00    0.00200    0.10000   20.00000    0.00210    0.04897   16720.00
168 BHET ZGET   35.00    0.00200    0.10000   20.00000    0.00210    0.04897   16720.00
169 TTET BHET   41.40    0.00200    0.10000   20.00000    0.00210    0.06995   27360.00
170 BHET TTET   41.40    0.00200    0.10000   20.00000    0.00210    0.06995   27360.00
171 TTET SKET   28.13    0.00334    0.10000   20.00000    0.00210    0.04897    1520.00
172 SKET TTET   28.13    0.00334    0.10000   20.00000    0.00210    0.04897    1520.00
173 SKET MFET   13.56    0.00334    0.10000   20.00000    0.00210    0.02448    1520.00
174 MFET SKET   13.56    0.00334    0.10000   20.00000    0.00210    0.02448    1520.00
175 MFET QRET   51.38    0.00334    0.10000   20.00000    0.00210    0.06296    1520.00
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176 QBET MFET    51.38    0.00334    0.10000   20.00000    0.00210    0.06296   1520.00
177 BHET QBET    30.87    0.00200    0.10000   20.00000    0.00210    0.05946  44080.00
178 QBET BHET    30.87    0.00200    0.10000   20.00000    0.00210    0.05946  44080.00
179 QBET CRET    14.14    0.00200    0.10000   20.00000    0.00210    0.02448  47120.00
180 CRET QBET    14.14    0.00200    0.10000   20.00000    0.00210    0.02448  47120.00
181 CRET SSET   144.56    0.00334    0.10000   20.00000    0.00210    0.02798   6080.00
182 SSET CRET   144.56    0.00334    0.10000   20.00000    0.00210    0.02798   6080.00
183 CRET IBET     3.28    0.00200    0.10000   20.00000    0.00210    0.02448  31920.00
184 IBET CRET     3.28    0.00200    0.10000   20.00000    0.00210    0.02448  31920.00
185 IBET GZET     9.67    0.00200    0.10000   20.00000    0.00210    0.02448  31920.00
186 GZET IBET     9.67    0.00200    0.10000   20.00000    0.00210    0.02448  31920.00
187 GZET BSET   110.98    0.00200    0.10000   20.00000    0.00210    0.10840  30400.00
188 BSET GZET   110.98    0.00200    0.10000   20.00000    0.00210    0.10840  30400.00
189 BSET MNET   122.73    0.00200    0.10000   20.00000    0.00210    0.15389  22800.00
190 MNET BSET   122.73    0.00200    0.10000   20.00000    0.00210    0.15389  22800.00
191 MNET ATET   128.37    0.00200    0.10000   20.00000    0.00210    0.15389  22800.00
192 ATET MNET   128.37    0.00200    0.10000   20.00000    0.00210    0.15389  22800.00
193 ATET SGET    91.95    0.00200    0.10000   20.00000    0.00210    0.13291  18240.00
194 SGET ATET    91.95    0.00200    0.10000   20.00000    0.00210    0.13291  18240.00
195 SGET QEET   141.59    0.00200    0.10000   20.00000    0.00210    0.15389  13680.00
196 QEET SGET   141.59    0.00200    0.10000   20.00000    0.00210    0.15389  13680.00
197 QEET ANET   270.22    0.00200    0.10000   20.00000    0.00210    0.15389   6080.00
198 ANET QEET   270.22    0.00200    0.10000   20.00000    0.00210    0.15389   6080.00
199 ALEX AXET     0.00    0.00000    0.00000    1.00000    0.00000    0.26753      1.00
200 AXET ALEX     0.00    0.00000    0.00000    1.00000    0.00000    0.09793      1.00
201 DMHR DRET     0.00    0.00000    0.00000    1.00000    0.00000    0.23955      1.00
202 DRET DMHR     0.00    0.00000    0.00000    1.00000    0.00000    0.06995      1.00
203 ETYB EBET     0.00    0.00000    0.00000    1.00000    0.00000    0.29551      1.00
204 EBET ETYB     0.00    0.00000    0.00000    1.00000    0.00000    0.12591      1.00
205 KFRS KSET     0.00    0.00000    0.00000    1.00000    0.00000    0.25354      1.00
206 KSET KFRS     0.00    0.00000    0.00000    1.00000    0.00000    0.08394      1.00
207 MHLK MKET     0.00    0.00000    0.00000    1.00000    0.00000    0.16960      1.00
208 MKET MHLK     0.00    0.00000    0.00000    1.00000    0.00000    0.01400      1.00
209 TANT TTET     0.00    0.00000    0.00000    1.00000    0.00000    0.19758      1.00
211 TTET TANT     0.00    0.00000    0.00000    1.00000    0.00000    0.02798      1.00
212 SHKM SKET     0.00    0.00000    0.00000    1.00000    0.00000    0.21157      1.00
213 SKET SHKM     0.00    0.00000    0.00000    1.00000    0.00000    0.04197      1.00
214 BNHA BHET     0.00    0.00000    0.00000    1.00000    0.00000    0.19758      1.00
215 BHET BNHA     0.00    0.00000    0.00000    1.00000    0.00000    0.02798      1.00
217 CAIR CRET     0.00    0.00000    0.00000    1.00000    0.00000    0.21157      1.00
218 CRET CAIR     0.00    0.00000    0.00000    1.00000    0.00000    0.04197      1.00
219 ZGZG ZGET     0.00    0.00000    0.00000    1.00000    0.00000    0.21157      1.00
220 ZGET ZGZG     0.00    0.00000    0.00000    1.00000    0.00000    0.04197      1.00
221 ABKB AKET     0.00    0.00000    0.00000    1.00000    0.00000    0.19758      1.00
222 AKET ABKB     0.00    0.00000    0.00000    1.00000    0.00000    0.02798      1.00
223 MNSR MRET     0.00    0.00000    0.00000    1.00000    0.00000    0.23955      1.00
224 MRET MNSR     0.00    0.00000    0.00000    1.00000    0.00000    0.06995      1.00
225 SHRB SNET     0.00    0.00000    0.00000    1.00000    0.00000    0.21157      1.00
226 SNET SHRB     0.00    0.00000    0.00000    1.00000    0.00000    0.04197      1.00
227 DMIT DTET     0.00    0.00000    0.00000    1.00000    0.00000    0.16359      1.00
228 DTET DMIT     0.00    0.00000    0.00000    1.00000    0.00000    0.01400      1.00
229 PRTS PSET     0.00    0.00000    0.00000    1.00000    0.00000    0.19758      1.00
230 PSET PRTS     0.00    0.00000    0.00000    1.00000    0.00000    0.02798      1.00
231 ISML ILET     0.00    0.00000    0.00000    1.00000    0.00000    0.16359      1.00
232 ILET ISML     0.00    0.00000    0.00000    1.00000    0.00000    0.01400      1.00
233 SWES SSET     0.00    0.00000    0.00000    1.00000    0.00000    0.19758      1.00
234 SSET SWES     0.00    0.00000    0.00000    1.00000    0.00000    0.02798      1.00
235 FYUM FMET     0.00    0.00000    0.00000    1.00000    0.00000    0.16359      1.00
236 FMET FYUM     0.00    0.00000    0.00000    1.00000    0.00000    0.01400      1.00
237 BSWF BSET     0.00    0.00000    0.00000    1.00000    0.00000    0.21157      1.00
238 BSET BSWF     0.00    0.00000    0.00000    1.00000    0.00000    0.04197      1.00
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239 MNIA MNET    0.00    0.00000    0.00000    1.00000    0.00000    0.26753       1.00
240 MNET MNIA    0.00    0.00000    0.00000    1.00000    0.00000    0.09793       1.00
241 ASYT ATET    0.00    0.00000    0.00000    1.00000    0.00000    0.22556       1.00
242 ATET ASYT    0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
243 SHAG SGET    0.00    0.00000    0.00000    1.00000    0.00000    0.23955       1.00
244 SGET SHAG    0.00    0.00000    0.00000    1.00000    0.00000    0.06700       1.00
245 QENA QEET    0.00    0.00000    0.00000    1.00000    0.00000    0.30950       1.00
246 QEET QENA    0.00    0.00000    0.00000    1.00000    0.00000    0.13990       1.00
247 ASWN ANET    0.00    0.00000    0.00000    1.00000    0.00000    0.25354       1.00
248 ANET ASWN    0.00    0.00000    0.00000    1.00000    0.00000    0.06394       1.00
249 DTEB PSEB   63.00    0.00237    0.10000   20.00000    0.00220    0.00000     696.00
250 PSEB DTEB   63.00    0.00237    0.10000   20.00000    0.00220    0.00000     696.00
251 DTEB SNEB   42.00    0.00237    0.10000   20.00000    0.00220    0.00000    1565.00
252 SNEB DTEB   42.00    0.00237    0.10000   20.00000    0.00220    0.00000    1565.00
253 SNEB MREB   24.10    0.00237    0.10000   20.00000    0.00220    0.00000    2869.00
254 MREB SNEB   24.10    0.00237    0.10000   20.00000    0.00220    0.00000    2869.00
255 MREB SLEB   20.20    0.00237    0.10000   20.00000    0.00220    0.00000    1304.00
256 SLEB MREB   20.20    0.00237    0.10000   20.00000    0.00220    0.00000    1304.00
257 SLEB ZGEB   30.70    0.00226    0.10000   20.00000    0.00220    0.00000     782.00
258 ZGEB SLEB   30.70    0.00226    0.10000   20.00000    0.00220    0.00000     782.00
259 SLEB AKEB   30.00    0.00237    0.10000   20.00000    0.00220    0.00000     522.00
260 AKEB SLEB   30.00    0.00237    0.10000   20.00000    0.00220    0.00000     522.00
261 MREB BHEB   75.20    0.00226    0.10000   20.00000    0.00220    0.00000     174.00
262 BHEB MREB   75.20    0.00226    0.10000   20.00000    0.00220    0.00000     174.00
263 SKEB BHEB   26.00    0.00227    0.10000   20.00000    0.00220    0.00000      87.00
264 BHEB SKEB   26.00    0.00227    0.10000   20.00000    0.00220    0.00000      87.00
265 BHEB ZGEB   35.00    0.00237    0.10000   20.00000    0.00220    0.00000    1652.00
266 ZGEB BHEB   35.00    0.00237    0.10000   20.00000    0.00220    0.00000    1652.00
267 ZGEB AKEB   25.50    0.00237    0.10000   20.00000    0.00220    0.00000    3086.00
268 AKEB ZGEB   25.50    0.00237    0.10000   20.00000    0.00220    0.00000    3086.00
269 AKEB ILEB   70.50    0.00237    0.10000   20.00000    0.00220    0.00000     348.00
270 ILEB AKEB   70.50    0.00237    0.10000   20.00000    0.00220    0.00000     348.00
271 ILEB PSEB   76.00    0.00226    0.10000   20.00000    0.00220    0.00000     609.00
272 PSEB ILEB   76.00    0.00226    0.10000   20.00000    0.00220    0.00000     609.00
273 ILEB ZGEB   81.00    0.00215    0.10000   20.00000    0.00220    0.04082    2217.00
274 ZGEB ILEB   81.00    0.00215    0.10000   20.00000    0.00220    0.04082    2217.00
275 ILEB SSEB   89.00    0.00237    0.10000   20.00000    0.00220    0.00000     522.00
276 SSEB ILEB   89.00    0.00237    0.10000   20.00000    0.00220    0.00000     522.00
277 SSEB CREB  133.50    0.00226    0.10000   20.00000    0.00220    0.03500    1044.00
278 CREB SSEB  133.50    0.00226    0.10000   20.00000    0.00220    0.03500    1044.00
279 CREB ZGEB   77.20    0.00237    0.10000   20.00000    0.00220    0.11904    1608.00
280 ZGEB CREB   77.20    0.00237    0.10000   20.00000    0.00220    0.11904    1608.00
281 CREB BHEB   47.20    0.00215    0.10000   20.00000    0.00220    0.31400    2608.00
282 BHEB CREB   47.20    0.00215    0.10000   20.00000    0.00220    0.31400    2608.00
283 SHKM SKEB    0.00    0.00000    0.00000    1.00000    0.00000    0.17883       1.00
284 SKEB SHKM    0.00    0.00000    0.00000    1.00000    0.00000    0.06995       1.00
285 BNHA BHEB    0.00    0.00000    0.00000    1.00000    0.00000    0.15085       1.00
286 BHEB BNHA    0.00    0.00000    0.00000    1.00000    0.00000    0.04197       1.00
287 CAIR CREB    0.00    0.00000    0.00000    1.00000    0.00000    0.15085       1.00
288 CREB CAIR    0.00    0.00000    0.00000    1.00000    0.00000    0.04197       1.00
289 ZGZG ZGEB    0.00    0.00000    0.00000    1.00000    0.00000    0.19282       1.00
290 ZGEB ZGZG    0.00    0.00000    0.00000    1.00000    0.00000    0.06394       1.00
291 ABKB AKEB    0.00    0.00000    0.00000    1.00000    0.00000    0.16484       1.00
292 AKEB ABKB    0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
293 MNSR MREB    0.00    0.00000    0.00000    1.00000    0.00000    0.24878       1.00
294 MREB MNSR    0.00    0.00000    0.00000    1.00000    0.00000    0.13990       1.00
295 SHRB SNEB    0.00    0.00000    0.00000    1.00000    0.00000    0.19282       1.00
296 SNEB SHRB    0.00    0.00000    0.00000    1.00000    0.00000    0.06394       1.00
297 DMIT DTEB    0.00    0.00000    0.00000    1.00000    0.00000    0.13686       1.00
298 DTEB DMIT    0.00    0.00000    0.00000    1.00000    0.00000    0.07798       1.00
299 PRTS PSEB    0.00    0.00000    0.00000    1.00000    0.00000    0.13686       1.00
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300 PSEB PRTS    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
301 ISML ILEB    0.00   0.00000   0.00000   1.00000   0.00000   0.13686      1.00
302 ILEB ISML    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
303 SWES SSEB    0.00   0.00000   0.00000   1.00000   0.00000   0.13686      1.00
304 SSEB SWES    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
305 AXMB DRMB   56.50   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
306 DRMB AXMB   56.50   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
307 DRMB EBMB   25.70   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
308 EBMB DRMB   25.70   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
309 EBMB TTMB   39.00   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
310 TTMB EBMB   39.00   0.00215   0.10000  20.00000   0.00220   0.00000    217.00
311 TTMB KSMB   39.00   0.00237   0.10000  20.00000   0.00220   0.00000   2130.00
312 KSMB TTMB   39.00   0.00237   0.10000  20.00000   0.00220   0.00000   2130.00
313 KSMB SNMB   63.30   0.00237   0.10000  20.00000   0.00220   0.00000    522.00
314 SNMB KSMB   63.30   0.00237   0.10000  20.00000   0.00220   0.00000    522.00
315 MKMB MRMB   19.50   0.00237   0.10000  20.00000   0.00220   0.00000   1652.00
316 MRMB MKMB   19.50   0.00237   0.10000  20.00000   0.00220   0.00000   1652.00
317 TTMB MKMB   26.50   0.00215   0.10000  20.00000   0.00220   0.00000   3043.00
318 MKMB TTMB   26.50   0.00215   0.10000  20.00000   0.00220   0.00000   3043.00
319 TTMB ZGMB   55.00   0.00237   0.10000  20.00000   0.00220   0.00000    652.00
320 ZGMB TTMB   55.00   0.00237   0.10000  20.00000   0.00220   0.00000    652.00
321 BHMB MRMB   75.20   0.00226   0.10000  20.00000   0.00220   0.00000    348.00
322 MRMB BHMB   75.20   0.00226   0.10000  20.00000   0.00220   0.00000    348.00
323 TTMB BHMB   43.00   0.00215   0.10000  20.00000   0.00220   0.02041   3434.00
324 BHMB TTMB   43.00   0.00215   0.10000  20.00000   0.00220   0.02041   3434.00
325 TTMB SKMB   26.00   0.00215   0.10000  20.00000   0.00220   0.00000   4043.00
326 SKMB TTMB   26.00   0.00215   0.10000  20.00000   0.00220   0.00000   4043.00
327 SKMB BHMB   26.00   0.00227   0.10000  20.00000   0.00220   0.00000   1565.00
328 BHMB SKMB   26.00   0.00227   0.10000  20.00000   0.00220   0.00000   1565.00
329 SKMB CRMB   65.50   0.00237   0.10000  20.00000   0.00220   0.11904   2695.00
330 CRMB SKMB   65.50   0.00237   0.10000  20.00000   0.00220   0.11904   2695.00
331 CRMB BHMB   47.20   0.00215   0.10000  20.00000   0.00220   0.30400   5825.00
332 BHMB CRMB   47.20   0.00215   0.10000  20.00000   0.00220   0.30400   5825.00
333 KSMB MKMB   26.00   0.00237   0.10000  20.00000   0.00220   0.00000   1913.00
334 MKMB KSMB   26.00   0.00237   0.10000  20.00000   0.00220   0.00000   1913.00
335 ALEX AXMB    0.00   0.00000   0.00000   1.00000   0.00000   0.20681      1.00
336 AXMB ALEX    0.00   0.00000   0.00000   1.00000   0.00000   0.09793      1.00
337 DMHR DRMB    0.00   0.00000   0.00000   1.00000   0.00000   0.26277      1.00
338 DRMB DMHR    0.00   0.00000   0.00000   1.00000   0.00000   0.15389      1.00
339 ETYB EBMB    0.00   0.00000   0.00000   1.00000   0.00000   0.36070      1.00
340 EBMB ETYB    0.00   0.00000   0.00000   1.00000   0.00000   0.25182      1.00
341 KFRS KSMB    0.00   0.00000   0.00000   1.00000   0.00000   0.27676      1.00
342 KSMB KFRS    0.00   0.00000   0.00000   1.00000   0.00000   0.16786      1.00
343 MHLK MKMB    0.00   0.00000   0.00000   1.00000   0.00000   0.10883      1.00
344 MKMB MHLK    0.00   0.00000   0.00000   1.00000   0.00000   0.01399      1.00
345 TANT TTMB    0.00   0.00000   0.00000   1.00000   0.00000   0.13686      1.00
346 TTMB TANT    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
347 SHKM SKMB    0.00   0.00000   0.00000   1.00000   0.00000   0.17583      1.00
348 SKMB SHKM    0.00   0.00000   0.00000   1.00000   0.00000   0.06995      1.00
349 BNHA BHMB    0.00   0.00000   0.00000   1.00000   0.00000   0.15085      1.00
350 BHMB BNHA    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
351 CAIR CRMB    0.00   0.00000   0.00000   1.00000   0.00000   0.15085      1.00
352 CRMB CAIR    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
353 ZGZG ZGMB    0.00   0.00000   0.00000   1.00000   0.00000   0.10282      1.00
354 ZGMB ZGZG    0.00   0.00000   0.00000   1.00000   0.00000   0.08394      1.00
355 MNSR MRMB    0.00   0.00000   0.00000   1.00000   0.00000   0.24878      1.00
356 MRMB MNSR    0.00   0.00000   0.00000   1.00000   0.00000   0.14990      1.00
357 SHRB SNMB    0.00   0.00000   0.00000   1.00000   0.00000   0.10282      1.00
358 SNMB SHRB    0.00   0.00000   0.00000   1.00000   0.00000   0.08394      1.00
359 AXWB DRWB   56.50   0.00215   0.10000  20.00000   0.00220   0.00000   2608.00
360 DRWB AXWB   56.50   0.00215   0.10000  20.00000   0.00220   0.00000   2608.00
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361 DRWB KSWB   57.40   0.00237   0.10000  20.00000   0.00220   0.00000    348.00
362 KSWB DRWB   57.40   0.00237   0.10000  20.00000   0.00220   0.00000    348.00
363 DRWB EBWB   25.70   0.00215   0.10000  20.00000   0.00220   0.00000   2260.00
364 EBWB DRWB   25.70   0.00215   0.10000  20.00000   0.00220   0.00000   2260.00
365 EBWB CRWB  126.70   0.00226   0.10000  20.00000   0.00220   0.12430    348.00
366 CRWB EBWB  126.70   0.00226   0.10000  20.00000   0.00220   0.12430    348.00
367 ALEX AXWB    0.00   0.00000   0.00000   1.00000   0.00000   0.20681      1.00
368 AXWB ALEX    0.00   0.00000   0.00000   1.00000   0.00000   0.09793      1.00
369 DMHR DRWB    0.00   0.00000   0.00000   1.00000   0.00000   0.26277      1.00
370 DRWB DMHR    0.00   0.00000   0.00000   1.00000   0.00000   0.15389      1.00
371 ETYB EBWB    0.00   0.00000   0.00000   1.00000   0.00000   0.36070      1.00
372 EBWB ETYB    0.00   0.00000   0.00000   1.00000   0.00000   0.25182      1.00
373 KFBS KSWB    0.00   0.00000   0.00000   1.00000   0.00000   0.27676      1.00
374 KSWB KFBS    0.00   0.00000   0.00000   1.00000   0.00000   0.16788      1.00
375 CAIR CRWB    0.00   0.00000   0.00000   1.00000   0.00000   0.15085      1.00
376 CRWB CAIR    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
377 CRUB SSUB  133.50   0.00226   0.10000  20.00000   0.00220   0.00000    261.00
378 SSUB CRUB  133.50   0.00226   0.10000  20.00000   0.00220   0.00000    261.00
379 CRUB GZUB   10.00   0.00538   0.10000  20.00000   0.00220   0.00000   1304.00
380 GZUB CRUB   10.00   0.00538   0.10000  20.00000   0.00220   0.00000   1304.00
381 GZUB FMUB   97.50   0.00226   0.10000  20.00000   0.00220   0.14500    739.00
382 FMUB GZUB   97.50   0.00226   0.10000  20.00000   0.00220   0.14500    739.00
383 GZUB BSUB  118.50   0.00226   0.10000  20.00000   0.00220   0.31000    782.00
384 BSUB GZUB  118.50   0.00226   0.10000  20.00000   0.00220   0.31000    782.00
385 FMUB BSUB   43.00   0.00226   0.10000  20.00000   0.00220   0.00000   1435.00
386 BSUB FMUB   43.00   0.00226   0.10000  20.00000   0.00220   0.00000   1435.00
387 BSUB MNUB  130.00   0.00226   0.10000  20.00000   0.00220   0.00000   1087.00
388 MNUB BSUB  130.00   0.00226   0.10000  20.00000   0.00220   0.00000   1087.00
389 SWES SSUB    0.00   0.00000   0.00000   1.00000   0.00000   0.13686      1.00
390 SSUB SWES    0.00   0.00000   0.00000   1.00000   0.00000   0.02798      1.00
391 CAIR CRUB    0.00   0.00000   0.00000   1.00000   0.00000   0.15085      1.00
392 CRUB CAIR    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
393 FYUM FMUB    0.00   0.00000   0.00000   1.00000   0.00000   0.15085      1.00
394 FMUB FYUM    0.00   0.00000   0.00000   1.00000   0.00000   0.04197      1.00
395 BSWF BSUB    0.00   0.00000   0.00000   1.00000   0.00000   0.19282      1.00
396 BSUB BSWF    0.00   0.00000   0.00000   1.00000   0.00000   0.08394      1.00
397 MNIA MNUB    0.00   0.00000   0.00000   1.00000   0.00000   0.29075      1.00
398 MNUB MNIA    0.00   0.00000   0.00000   1.00000   0.00000   0.16187      1.00
399 AXTX DRTX   56.50   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
400 DRTX AXTX   56.50   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
401 DRTX EBTX   25.70   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
402 EBTX DRTX   25.70   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
403 DRTX KSTX   57.40   0.00185   0.10000  20.00000   0.00675   0.00000   5000.00
404 KSTX DRTX   57.40   0.00185   0.10000  20.00000   0.00675   0.00000   5000.00
405 KSTX TTTX   39.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
406 TTTX KSTX   39.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
407 KSTX MKTX   26.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
408 MKTX KSTX   26.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
409 TTTX MKTX   26.50   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
410 MKTX TTTX   26.50   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
411 KSTX SNTX   63.30   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
412 SNTX KSTX   63.30   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
413 SNTX DTTX   42.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
414 DTTX SNTX   42.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
415 MKTX SNTX   48.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
416 SNTX MKTX   48.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
417 MRTX SNTX   24.10   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
418 SNTX MRTX   24.10   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
419 MKTX MRTX   19.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
420 MRTX MKTX   19.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
421 MRTX SLTX   20.20   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
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422 SLTX MRTX    20.20   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
423 MKTX SLTX    32.00   0.00185   0.10000  20.00000   0.00675   0.00000   5000.00
424 SLTX MKTX    32.00   0.00185   0.10000  20.00000   0.00675   0.00000   5000.00
425 SLTX AKTX    30.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
426 AKTX SLTX    30.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
427 SLTX ZGTX    30.70   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
428 ZGTX SLTX    30.70   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
429 EBTX TTTX    39.00   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
430 TTTX EBTX    39.00   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
431 TTTX ZGTX    55.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
432 ZGTX TTTX    55.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
433 TTTX BHTX    43.00   0.00168   0.10000  20.00000   0.00675   0.04290  31683.00
434 BHTX TTTX    43.00   0.00168   0.10000  20.00000   0.00675   0.04290  31683.00
435 TTTX SKTX    26.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
436 SKTX TTTX    26.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
437 SKTX BHTX    26.00   0.00195   0.10000  20.00000   0.00675   0.00000  18000.00
438 BHTX SKTX    26.00   0.00195   0.10000  20.00000   0.00675   0.00000  18000.00
439 SKTX DHTX    39.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
440 DHTX SKTX    39.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
441 EBTX DHTX   100.70   0.00176   0.10000  20.00000   0.00675   0.00000   5172.00
442 DHTX EBTX   100.70   0.00176   0.10000  20.00000   0.00675   0.00000   5172.00
443 DHTX GZTX    29.00   0.00224   0.10000  20.00000   0.00675   0.08200   4892.00
444 GZTX DHTX    29.00   0.00224   0.10000  20.00000   0.00675   0.08200   4892.00
445 DHTX CRTX    26.00   0.00224   0.10000  20.00000   0.00675   0.07000   4892.00
446 CRTX DHTX    26.00   0.00224   0.10000  20.00000   0.00675   0.07000   4892.00
447 GZTX AXTX   173.50   0.00185   0.10000  20.00000   0.00675   0.37500   5000.00
448 AXTX GZTX   173.50   0.00185   0.10000  20.00000   0.00675   0.37500   5000.00
449 CRTX BHTX    47.20   0.00168   0.10000  20.00000   0.00675   0.21300  31683.00
450 BHTX CRTX    47.20   0.00168   0.10000  20.00000   0.00675   0.21300  31683.00
451 BHTX ZGTX    35.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
452 ZGTX BHTX    35.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
453 ZGTX CRTX    77.20   0.00224   0.10000  20.00000   0.00675   0.07000   4892.00
454 CRTX ZGTX    77.20   0.00224   0.10000  20.00000   0.00675   0.07000   4892.00
455 ZGTX AKTX    25.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
456 AKTX ZGTX    25.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
457 DTTX PSTX    63.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
458 PSTX DTTX    63.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
459 PSTX ILTX    76.00   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
460 ILTX PSTX    76.00   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
461 ILTX AKTX    70.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
462 AKTX ILTX    70.50   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
463 ILTX ZGTX    81.00   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
464 ZGTX ILTX    81.00   0.00168   0.10000  20.00000   0.00675   0.00000  31683.00
465 ILTX CRTX   123.50   0.00176   0.10000  20.00000   0.00675   0.26800   7688.00
466 CRTX ILTX   123.50   0.00176   0.10000  20.00000   0.00675   0.26800   7688.00
467 ILTX SSTX    89.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
468 SSTX ILTX    89.00   0.00224   0.10000  20.00000   0.00675   0.00000   4892.00
469 SSTX CRTX   133.50   0.00176   0.10000  20.00000   0.00675   0.05100   7688.00
470 CRTX SSTX   133.50   0.00176   0.10000  20.00000   0.00675   0.05100   7688.00
471 CRTX GZTX    10.00   0.00419   0.10000  20.00000   0.00675   0.00000  13978.00
472 GZTX CRTX    10.00   0.00419   0.10000  20.00000   0.00675   0.00000  13978.00
473 GZTX FMTX    97.50   0.00176   0.10000  20.00000   0.00675   0.10150   7688.00
474 FMTX GZTX    97.50   0.00176   0.10000  20.00000   0.00675   0.10150   7688.00
475 GZTX BSTX   118.50   0.00176   0.10000  20.00000   0.00675   0.21750   7688.00
476 BSTX GZTX   118.50   0.00176   0.10000  20.00000   0.00675   0.21750   7688.00
477 FMTX BSTX    43.00   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
478 BSTX FMTX    43.00   0.00176   0.10000  20.00000   0.00675   0.00000   7688.00
479 BSTX MNTX   130.00   0.00176   0.10000  20.00000   0.00675   0.00000   6430.00
480 MNTX BSTX   130.00   0.00176   0.10000  20.00000   0.00675   0.00000   6430.00
481 MNTX ATTX   135.50   0.00176   0.10000  20.00000   0.00675   0.00000   5172.00
482 ATTX MNTX   135.50   0.00176   0.10000  20.00000   0.00675   0.00000   5172.00
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483 ATTX SGTX    95.00    0.00176    0.10000   20.00000    0.00675    0.00000    6430.00
484 SGTX ATTX    95.00    0.00176    0.10000   20.00000    0.00675    0.00000    6430.00
485 SGTX QNTX   141.50    0.00176    0.10000   20.00000    0.00675    0.00000    7688.00
486 QNTX SGTX   141.50    0.00176    0.10000   20.00000    0.00675    0.00000    7688.00
487 QNTX ANTX   271.00    0.00185    0.10000   20.00000    0.00675    0.00000    5000.00
488 ANTX QNTX   271.00    0.00185    0.10000   20.00000    0.00675    0.00000    5000.00
489 BHTX MRTX    75.20    0.00176    0.10000   20.00000    0.00675    0.00000    5172.00
490 MRTX BHTX    75.20    0.00176    0.10000   20.00000    0.00675    0.00000    5172.00
491 ALEX AXTX     0.00    0.00000    0.00000    1.00000    0.00000    0.24793       1.00
492 AXTX ALEX     0.00    0.00000    0.00000    1.00000    0.00000    0.09793       1.00
493 DMHR DRTX     0.00    0.00000    0.00000    1.00000    0.00000    0.24793       1.00
494 DRTX DMHR     0.00    0.00000    0.00000    1.00000    0.00000    0.09793       1.00
495 ETYB EBTX     0.00    0.00000    0.00000    1.00000    0.00000    0.31788       1.00
496 EBTX ETYB     0.00    0.00000    0.00000    1.00000    0.00000    0.16788       1.00
497 KFRS KSTX     0.00    0.00000    0.00000    1.00000    0.00000    0.26192       1.00
498 KSTX KFRS     0.00    0.00000    0.00000    1.00000    0.00000    0.11192       1.00
499 MHLK MKTX     0.00    0.00000    0.00000    1.00000    0.00000    0.16399       1.00
500 MKTX MHLK     0.00    0.00000    0.00000    1.00000    0.00000    0.01399       1.00
501 TANT TTTX     0.00    0.00000    0.00000    1.00000    0.00000    0.17798       1.00
502 TTTX TANT     0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
503 SHKM SKTX     0.00    0.00000    0.00000    1.00000    0.00000    0.20596       1.00
504 SKTX SHKM     0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
505 BNHA BHTX     0.00    0.00000    0.00000    1.00000    0.00000    0.17798       1.00
506 BHTX BNHA     0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
507 CAIR CRTX     0.00    0.00000    0.00000    1.00000    0.00000    0.19197       1.00
508 CRTX CAIR     0.00    0.00000    0.00000    1.00000    0.00000    0.04197       1.00
509 ZGZG ZGTX     0.00    0.00000    0.00000    1.00000    0.00000    0.20596       1.00
510 ZGTX ZGZG     0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
511 ABKB AKTX     0.00    0.00000    0.00000    1.00000    0.00000    0.19197       1.00
512 AKTX ABKB     0.00    0.00000    0.00000    1.00000    0.00000    0.04197       1.00
513 MNSR MRTX     0.00    0.00000    0.00000    1.00000    0.00000    0.24793       1.00
514 MRTX MNSR     0.00    0.00000    0.00000    1.00000    0.00000    0.09793       1.00
515 SHRB SNTX     0.00    0.00000    0.00000    1.00000    0.00000    0.20596       1.00
516 SNTX SHRB     0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
517 DMIT DTTX     0.00    0.00000    0.00000    1.00000    0.00000    0.16399       1.00
518 DTTX DMIT     0.00    0.00000    0.00000    1.00000    0.00000    0.01399       1.00
519 PRTS PSTX     0.00    0.00000    0.00000    1.00000    0.00000    0.17798       1.00
520 PSTX PRTS     0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
521 ISML ILTX     0.00    0.00000    0.00000    1.00000    0.00000    0.16399       1.00
522 ILTX ISML     0.00    0.00000    0.00000    1.00000    0.00000    0.01399       1.00
523 SWES SSTX     0.00    0.00000    0.00000    1.00000    0.00000    0.17798       1.00
524 SSTX SWES     0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
525 FYUM FMTX     0.00    0.00000    0.00000    1.00000    0.00000    0.17798       1.00
526 FMTX FYUM     0.00    0.00000    0.00000    1.00000    0.00000    0.02798       1.00
527 BSWF BSTX     0.00    0.00000    0.00000    1.00000    0.00000    0.20596       1.00
528 BSTX BSWF     0.00    0.00000    0.00000    1.00000    0.00000    0.05596       1.00
529 MNIA MNTX     0.00    0.00000    0.00000    1.00000    0.00000    0.27591       1.00
530 MNTX MNIA     0.00    0.00000    0.00000    1.00000    0.00000    0.12591       1.00
531 ASYT ATTX     0.00    0.00000    0.00000    1.00000    0.00000    0.23394       1.00
532 ATTX ASYT     0.00    0.00000    0.00000    1.00000    0.00000    0.08394       1.00
533 SHAG SGTX     0.00    0.00000    0.00000    1.00000    0.00000    0.23394       1.00
534 SGTX SHAG     0.00    0.00000    0.00000    1.00000    0.00000    0.08394       1.00
535 QENA QNTX     0.00    0.00000    0.00000    1.00000    0.00000    0.34586       1.00
536 QNTX QENA     0.00    0.00000    0.00000    1.00000    0.00000    0.19586       1.00
537 ASWN ANTX     0.00    0.00000    0.00000    1.00000    0.00000    0.26192       1.00
538 ANTX ASWN     0.00    0.00000    0.00000    1.00000    0.00000    0.11192       1.00
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APPENDIX C

DATA FOR CALIBRATING DEMAND FUNCTIONS

BASE YEAR RAIL PASSENGER (÷10) O-D MATRIX

SEMI-GOVERNORATE ZONES

ZONE	CAI 1	GIZ 2	QAL 3	SKS 4	SKN 5	DKE 6	DKW 7	DAM 8	PTS 9	ISM 10	SUZ 11	MIF 12	GHS 13	GHN 14	KAF 15
1	8	136	2402	662	95	186	104	88	7	212	50	1011	813	120	[illegible]
2	136	36	144	25	4	8	5	4	0	10	2	36	34	5	[illegible]
3	2402	144	107	172	11	25	9	7	0	20	2	285	147	13	14
4	662	25	172	889	109	85	25	16	1	175	3	92	177	23	25
5	95	4	11	109	74	67	18	8	0	14	1	14	27	11	7
6	186	8	25	85	67	167	242	50	1	22	2	48	246	278	42
7	104	5	9	25	18	242	269	117	0	13	1	25	83	108	71
8	87	4	7	16	8	50	117	245	0	11	1	17	42	19	27
9	7	0	0	1	0	1	0	0	0	6	0	1	1	0	1
10	212	10	20	175	14	22	13	11	6	82	13	29	52	10	14
11	50	2	2	3	1	2	1	1	0	13	0	3	4	1	2
12	1011	36	285	92	14	48	25	17	1	29	3	1431	1628	48	42
13	813	34	147	177	27	246	83	42	1	52	4	1628	1240	379	220
14	120	5	13	23	11	278	108	19	0	10	1	48	379	0	40
15	158	8	14	25	7	42	71	27	1	14	2	42	220	40	435
16	114	6	8	12	3	12	7	5	0	6	1	32	138	11	25
17	122	6	11	17	4	17	15	10	0	11	1	34	104	14	218
18	783	39	40	64	16	58	51	42	2	48	7	114	248	43	191
19	9	0	1	1	0	1	1	1	0	1	0	1	2	1	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	133	11	6	7	2	4	3	3	0	5	1	9	11	2	4
22	246	31	9	10	2	5	4	4	0	7	2	13	16	3	5
23	108	8	5	7	2	5	4	4	0	6	1	9	13	3	5
24	130	8	7	10	3	7	6	6	1	10	2	13	18	4	8
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	50	3	3	4	1	3	2	3	0	4	1	5	7	2	3
27	55	3	3	5	1	3	3	3	0	5	1	6	9	2	4
28	29	2	2	3	1	2	2	2	0	3	1	3	5	1	2
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]
ATTR	7823	578	3452	2619	495	1585	1188	737	25	790	105	5001	5664	1142	1626

ZONE	BHS 16	BHN 17	ALX 18	WDS 19	SIN 20	FAY 21	BES 22	MYA 23	ASY 24	NEW 25	SOH 26	QEN 27	ASW 28	RED 29	ZONAL PRODUCT.
1	114	122	783	9	0	133	246	108	130	0	50	55	29	0	7823
2	6	6	39	0	0	11	31	8	8	0	3	3	2	0	578
3	8	11	40	1	0	6	9	5	7	0	3	3	2	0	3452
4	12	17	64	1	0	7	10	7	10	0	4	5	3	0	2619
5	3	4	16	0	0	2	2	2	3	0	1	1	1	0	495
6	12	17	58	1	0	4	5	5	7	0	3	3	2	0	1585
7	7	15	51	1	0	3	4	4	6	0	2	3	2	0	1187
8	5	10	42	1	0	3	4	4	6	0	3	3	2	0	737
9	0	0	2	0	0	0	0	0	1	0	0	0	0	0	25
10	6	11	48	1	0	5	7	6	10	0	4	5	3	0	790
11	1	1	7	0	0	1	2	1	2	0	1	1	1	0	105
12	32	34	114	1	0	9	13	9	13	0	5	6	3	0	5001
13	138	104	248	2	0	11	16	13	18	0	7	9	5	0	5664
14	11	14	43	1	0	2	3	3	4	0	2	2	1	0	1142
15	25	218	191	1	0	4	5	5	8	0	3	4	2	0	1626
16	124	74	82	1	0	2	3	3	4	0	2	2	1	0	677
17	74	124	678	2	1	3	5	4	7	0	3	4	2	0	1492
18	82	678	0	29	1	18	23	24	40	0	17	21	12	0	2694
19	1	2	29	0	0	0	1	1	1	0	1	1	1	0	57
20	0	1	1	0	0	0	0	0	0	0	0	0	0	0	4
21	2	3	18	0	0	444	67	12	12	0	4	5	2	0	770
22	3	5	23	1	0	67	168	42	19	0	6	6	3	0	700
23	3	4	24	1	0	12	42	987	233	0	25	17	7	0	1536
24	4	7	40	1	0	12	19	233	992	0	321	77	22	0	1961
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	2	3	17	1	0	4	6	25	321	0	2078	209	17	0	2776
27	2	4	21	1	0	5	6	17	77	0	209	1148	97	0	1692
28	1	2	12	1	0	2	3	7	22	0	17	97	341	0	564
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

BASE YEAR PUBLIC BUS PASSENGERS 1979 (*10)

SEMI-GOVERNORATE ZONES

ZONE	CAI 1	GIZ 2	QAL 3	SKS 4	SKN 5	DKE 6	DKN 7	DAM 8	FTS 9	ISM 10	SUZ 11	MIF 12	GHS 13	GHN 14	KAF 15
1	0	161	2811	401	54	153	15	30	68	65	144	293	62	7	29
2	191	81	2058	57	9	25	3	5	12	11	24	61	10	1	5
3	4032	2821	674	103	7	64	3	4	5	5	7	141	24	1	4
4	286	42	87	816	130	169	8	7	8	18	5	19	29	3	6
5	73	12	10	192	279	89	7	8	8	24	6	4	5	2	4
6	162	27	79	154	56	806	411	118	30	13	8	27	50	51	41
7	12	2	2	6	3	235	58	23	4	1	1	1	3	5	11
8	34	6	4	8	6	106	52	1305	83	5	3	3	4	2	7
9	53	10	4	7	5	18	4	67	8	69	14	2	2	1	3
10	73	12	5	24	18	12	1	5	92	59	26	2	2	0	2
11	122	21	5	5	3	6	1	3	15	19	8	2	1	0	1
12	260	54	144	22	3	28	2	3	3	2	2	520	118	2	6
13	67	11	28	31	3	54	4	3	3	2	1	128	74	12	19
14	6	1	1	2	1	44	5	1	1	0	0	2	9	9	9
15	37	7	5	8	4	53	16	8	5	2	2	7	19	12	79
16	33	7	4	4	1	9	1	2	2	1	1	10	48	1	19
17	24	5	3	3	1	9	1	2	2	1	1	4	7	1	81
18	231	40	9	11	4	23	4	8	11	4	6	10	11	2	23
19	12	3	1	1	0	2	0	1	2	1	1	1	0	0	1
20	7	1	0	1	0	1	0	1	3	1	4	0	0	0	0
21	309	75	12	7	2	6	1	2	5	3	7	5	2	0	2
22	216	52	9	6	2	5	1	2	4	2	6	4	1	0	1
23	32	7	2	1	0	2	0	1	2	1	2	1	0	0	0
24	14	3	1	1	0	1	0	0	1	0	1	0	0	0	0
25	5	1	0	0	0	0	0	0	1	0	1	0	0	3	0
26	3	1	0	0	6	0	0	0	0	0	0	3	0	0	0
27	5	1	0	0	0	0	0	0	1	0	1	0	0	0	0
28	4	1	0	0	0	0	0	0	1	0	1	0	0	0	0
29	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ATTR	6304	3463	5957	1873	592	1919	597	1608	370	307	275	1249	482	105	353

BHS 16	BHN 17	ALX 18	WDS 19	SIN 20	FAY 21	BES 22	MYA 23	ASY 24	NEW 25	SOH 26	QEN 27	ASW 28	RED 29	ZONAL PRODUCTION
40	21	223	8	7	294	205	39	13	3	4	5	4	1	5161
8	4	39	2	1	69	47	8	3	1	1	1	1	0	2738
5	3	9	1	0	13	10	2	1	0	0	0	0	0	7938
3	2	9	0	1	5	4	1	1	0	0	0	0	0	1661
1	1	5	0	0	3	2	1	0	0	0	0	0	0	737
9	8	24	1	1	6	5	2	1	0	0	1	0	0	2094
1	1	3	0	0	1	0	0	0	0	0	0	0	0	372
2	2	9	1	1	2	2	1	0	0	0	0	0	0	1646
1	2	6	1	2	4	3	2	1	0	0	1	0	0	293
1	1	4	0	1	3	3	1	0	0	0	0	0	0	350
1	1	5	1	5	6	5	2	1	0	0	1	1	0	232
10	3	10	0	0	4	3	1	0	0	0	0	0	0	1200
48	7	12	0	0	2	2	1	0	0	0	0	0	0	512
1	1	2	0	0	0	0	0	0	0	0	0	0	0	86
29	91	36	1	0	2	2	1	0	0	0	0	0	0	427
98	41	23	0	0	1	1	0	0	0	0	0	0	0	308
52	144	161	1	0	1	1	1	0	0	0	0	0	0	509
25	193	8	40	1	9	8	3	2	1	1	1	1	0	688
1	2	44	5	0	2	2	1	1	0	0	0	0	0	93
0	0	1	0	0	1	1	0	0	0	0	0	0	0	24
2	1	9	1	1	5543	673	24	4	1	1	1	1	0	6697
1	1	8	1	1	822	2419	108	7	1	2	2	1	0	3685
0	0	3	0	0	18	72	1194	88	2	5	3	2	0	1440
0	0	2	0	0	5	8	112	1226	6	109	10	3	0	1506
0	0	1	0	0	1	2	3	10	8	2	2	1	0	32
0	0	1	0	0	1	1	3	89	1	297	76	2	0	477
0	0	1	0	0	1	2	3	10	1	102	1910	95	2	2138
0	0	1	0	0	1	1	2	3	1	3	119	240	1	380
0	0	0	0	0	0	0	0	0	0	0	2	1	1	10

APPENDIX [illegible]

BASE YEAR CAR PASSENGER (*10) 1979 O-D MATRIX [SFDCOX]

SEMI-GOVERNORATE ZONES

ZONE	CAI 1	GIZ 2	QAL 3	SKS 4	SKN 5	DKE 6	DKW 7	DAM 8	PTS 9	ISM 10	SUZ 11	MIF 12	GHS 13	GHN 14	KAF 15
1	0	88	381	174	34	55	10	12	96	89	92	216	74	18	21
2	128	186	117	33	9	14	3	4	28	21	21	62	17	4	6
3	613	144	328	25	4	12	1	1	4	3	2	236	23	3	2
4	92	17	17	183	35	36	3	2	7	15	2	12	11	2	2
5	27	6	2	46	87	13	2	2	8	13	2	3	2	1	1
6	83	18	19	76	21	229	108	24	18	5	2	15	28	36	20
7	8	2	1	3	2	75	46	12	5	1	0	2	3	6	35
8	13	3	1	3	2	21	12	226	62	3	1	2	2	2	3
9	51	12	1	6	5	8	3	36	8	56	5	2	2	1	2
10	123	25	3	26	19	6	1	6	335	128	14	3	2	1	1
11	86	17	2	2	2	1	0	1	9	10	0	2	1	0	0
12	164	39	319	13	3	8	1	1	3	2	1	354	73	5	3
13	123	24	31	21	4	32	6	3	5	2	2	180	595	109	16
14	45	10	6	6	3	77	20	4	5	1	1	16	166	0	30
15	23	5	2	3	2	19	48	4	5	1	1	4	11	17	52
16	52	18	5	4	1	6	1	1	3	1	1	13	124	6	12
17	24	7	2	2	1	3	1	1	2	1	1	4	13	2	27
18	94	34	7	8	4	12	3	4	11	3	3	15	22	6	23
19	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
20	3	1	0	0	0	0	0	0	2	1	0	0	0	0	0
21	53	28	1	1	1	1	0	0	2	1	1	1	1	0	0
22	23	11	1	1	0	0	0	0	1	0	0	1	0	0	0
23	11	4	0	0	0	0	0	0	1	0	0	1	0	0	0
24	4	2	0	0	0	0	0	0	1	0	0	0	0	0	0
25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27	3	1	0	0	0	0	0	0	1	0	0	0	0	0	0
28	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
29	6	2	0	0	0	0	0	0	1	0	1	0	0	0	0
ATTR	1860	764	1246	637	241	631	269	348	615	358	153	1146	1171	219	259

BHS 16	BHN 17	ALX 18	WDS 19	SIN 20	FAY 21	BES 22	MYA 23	ASY 24	NEW 25	SOH 26	QEN 27	ASW 28	RED 29	ZONAL PRODUCTN
85	32	100	7	5	33	18	8	4	2	2	1	0	3	1659
47	10	42	3	2	21	12	4	2	1	1	1	0	1	798
7	3	9	0	0	1	1	0	0	0	0	0	0	0	1423
3	2	7	0	0	0	0	0	0	0	0	0	0	0	449
1	1	3	0	0	0	0	0	0	0	0	0	0	0	221
7	6	18	1	0	1	0	0	0	0	0	0	0	0	739
1	1	3	0	0	0	0	0	0	0	0	0	0	0	207
1	2	5	0	0	0	0	0	0	0	0	0	0	0	366
2	2	6	1	2	1	0	0	0	0	0	0	0	0	205
2	1	5	0	2	1	1	1	0	0	0	0	0	0	707
1	1	3	0	1	1	0	0	0	0	0	0	0	0	141
11	4	12	0	0	1	0	0	0	0	0	0	0	0	1021
213	26	40	1	0	1	0	0	0	0	0	0	0	0	1437
12	6	15	0	0	0	0	0	0	0	0	0	0	0	424
8	27	23	0	0	0	0	0	0	0	0	0	0	0	254
165	43	43	1	0	0	0	0	0	0	0	0	0	0	502
54	69	228	1	0	0	0	0	0	0	0	0	0	0	444
46	396	0	17	1	2	1	1	1	1	1	0	0	1	716
1	1	16	1	0	0	0	0	0	0	0	0	0	0	26
0	0	1	0	0	0	0	0	0	0	0	0	0	0	11
1	1	3	0	0	59	17	1	0	0	0	0	0	0	175
1	0	2	0	0	14	56	5	1	0	0	0	0	0	118
0	0	2	0	0	1	9	140	10	1	1	0	0	0	186
0	0	1	0	0	0	0	17	115	2	10	1	0	0	156
0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
0	0	0	0	0	0	0	1	10	1	190	41	0	1	248
0	0	1	0	0	0	0	1	2	1	48	172	2	4	236
0	0	0	0	0	0	0	0	1	0	1	7	4	1	19
0	0	1	0	0	0	0	0	1	0	1	2	0	36	56

BASE YEAR TAXI PASSENGER O-D MATRIX 1979 (*10)

SEMI-GOVERNORATE ZONES

ZONE	CAI 1	GIZ 2	QAL 3	SKS 4	SKN 5	DKE 6	DKW 7	DAM 8	PTS 9	ISM 10	SUZ 11	MIF 12	GHS 13	GHN 14	15	BHS 16	BHN 17	ALX 18	WDS 19	SIN 20	FAY 21	BES 22	MYA 23	ASY 24	NEW 25	SOH 26	QEN 27	ASW 28	RED 29	ZONAL PRODUCT
1	0	679	1640	362	70	327	20	36	186	228	349	575	314	32	[illegible]	40	95	227	28	13	155	70	26	20	1	8	8	4	19	5612
2	1256	1722	494	65	16	71	5	10	46	44	67	142	58	7	[illegible]	12	24	84	11	4	89	72	13	8	0	3	3	2	6	4351
3	1829	526	888	82	8	72	2	3	6	6	7	985	89	4	[illegible]	4	8	18	1	0	3	2	1	1	0	0	0	0	1	4545
4	383	76	88	784	154	288	9	7	16	46	6	45	51	4	9	3	7	17	2	1	2	1	1	1	0	0	0	0	1	2002
5	82	20	9	161	314	88	5	5	12	26	4	7	7	2	4	1	2	6	1	1	1	0	0	0	0	0	0	0	1	762
6	339	77	71	287	80	1745	259	128	51	18	7	52	147	105	75	9	22	49	4	2	3	2	1	2	0	1	1	1	2	3540
7	34	8	3	12	6	356	150	41	10	2	1	5	18	28	79	1	4	8	1	0	0	0	0	0	0	0	0	0	0	769
8	48	13	3	8	6	211	27	834	182	10	3	5	10	4	13	1	5	12	1	1	1	0	0	1	0	0	0	0	1	1402
9	156	40	5	11	9	42	5	130	0	276	15	4	5	2	6	1	4	11	2	4	2	1	1	1	0	1	1	1	2	738
10	359	73	10	72	40	28	2	12	438	288	41	6	5	1	3	1	3	8	1	3	2	1	1	1	0	0	1	0	2	1401
11	245	49	5	4	3	5	0	2	13	18	0	3	2	0	1	0	1	4	1	1	2	1	1	1	0	0	0	0	2	365
12	590	157	903	39	6	54	3	4	5	4	4	2019	516	11	14	11	15	30	2	1	3	1	1	1	0	0	0	0	1	4396
13	248	49	65	45	5	111	8	6	5	3	2	280	767	106	45	107	49	51	2	0	1	1	0	1	0	0	0	0	1	1959
14	51	11	7	5	2	147	26	5	3	1	1	15	247	0	43	5	7	11	1	0	0	0	0	0	0	0	0	0	0	594
15	118	30	10	10	5	97	69	13	11	3	3	18	75	46	454	46	201	100	3	1	2	1	1	1	0	0	0	0	1	1320
16	77	20	9	5	1	18	2	2	2	1	1	20	231	6	73	144	241	76	1	0	1	0	0	0	0	0	0	0	0	932
17	122	34	10	8	2	26	3	5	6	2	3	18	68	5	232	85	719	1493	7	1	2	1	1	1	0	0	1	0	1	2855
18	290	112	22	19	7	58	6	11	16	6	7	36	80	9	99	39	1617	0	65	2	6	3	3	3	0	1	2	1	3	2525
19	17	7	1	1	0	2	0	1	1	0	1	1	1	0	1	0	4	57	6	0	1	0	0	0	0	0	0	0	0	107
20	28	8	1	2	1	3	0	2	10	4	6	1	1	0	1	0	1	3	1	0	1	0	0	1	0	0	0	0	1	77
21	226	131	5	3	1	4	0	1	4	2	3	4	2	0	1	1	2	6	1	0	759	61	6	3	0	1	1	0	1	1229
22	101	72	2	1	1	2	0	1	2	1	2	2	1	0	1	0	1	3	1	0	70	429	50	3	0	1	1	0	1	749
23	51	23	2	1	1	3	0	1	3	1	2	2	1	0	1	0	1	4	1	0	9	64	1203	114	0	6	3	1	1	1499
24	31	12	1	1	1	2	0	1	2	1	1	1	1	0	1	0	1	4	1	0	3	3	173	4589	2	194	19	4	5	5056
25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	2	0	0	0	0	0	4
26	10	4	0	0	0	1	0	0	1	0	1	0	0	0	[illegible]	0	0	2	1	0	1	1	4	196	0	1651	148	5	6	2034
27	11	4	0	1	0	1	0	0	1	1	1	1	0	0	[illegible]	0	1	2	1	0	1	1	3	19	0	138	7319	53	38	7598
28	4	2	0	0	0	1	0	0	1	0	0	0	0	0	[illegible]	0	0	1	0	0	0	0	1	3	0	4	63	258	5	346
29	20	6	1	1	1	2	0	1	3	1	3	1	1	0		0	1	3	1	1	1	0	1	4	0	5	27	6	261	351
ATTR	6728	3967	4247	1990	739	3767	603	1259	1035	995	541	4249	2700	372	12	513	3037	2282	147	37	1121	718	1492	4975	4	2018	7601	339	364	59117

Table A5:

INTER-GOVERNORATE DISTANCE KMS MATRIX(GOV CAPITALS) BASIC BUS NET 1979 31/9

SEMI-GOVERNORATE ZONES

ZONE	CAI 1	GIZ 2	QAL 3	SKS 4	SKN 5	DKE 6	DKW 7	DAM 8	PTS 9	ISM 10	SUZ 11	MIF 12	GHS 13	GHN 14	KAF 15
1	0	7	49	76	76	125	125	191	200	120	134	75	95	95	145
2	7	0	56	83	83	132	132	198	207	127	141	74	101	101	151
3	49	56	0	38	38	76	76	142	200	120	183	26	46	46	96
4	76	83	38	0	0	58	58	124	162	82	171	64	60	60	97
5	76	83	38	0	0	58	58	124	162	82	171	64	60	60	97
6	125	132	76	58	58	0	0	66	136	117	206	80	54	54	58
7	125	132	76	58	58	0	0	66	136	117	206	80	54	54	58
8	191	198	142	124	124	66	66	0	70	144	233	143	116	116	110
9	200	207	200	162	162	136	136	70	0	80	169	213	186	186	180
10	120	127	120	82	82	117	117	144	80	0	89	146	142	142	159
11	134	141	183	171	171	206	206	233	169	89	0	209	229	229	248
12	75	74	26	64	64	80	80	143	213	146	209	0	27	27	77
13	95	101	46	60	60	54	54	116	186	142	229	27	0	0	50
14	95	101	46	60	60	54	54	116	186	142	229	27	0	0	50
15	145	151	96	97	97	58	58	110	180	159	248	77	50	50	0
16	160	162	111	125	125	103	103	161	231	204	293	92	65	65	51
17	160	162	111	125	125	103	103	161	231	204	293	92	65	65	51
18	210	203	173	187	187	165	165	223	293	266	344	154	127	127	113
19	471	464	463	477	477	455	455	513	583	556	605	444	417	417	403
20	354	361	354	316	316	351	351	316	246	234	323	380	376	376	393
21	106	99	155	182	182	231	231	297	306	226	240	173	200	200	250
22	123	120	172	199	199	248	248	314	323	243	257	194	218	218	268
23	251	248	300	327	327	376	376	442	451	371	385	322	346	346	396
24	390	387	439	466	466	515	515	581	590	510	524	461	485	485	535
25	613	615	667	694	694	743	743	809	818	738	752	689	713	713	763
26	493	490	542	569	569	618	618	684	693	613	627	564	588	588	638
27	637	634	686	713	713	762	762	828	789	709	620	708	732	732	782
28	939	936	988	1015	1015	1064	1064	1130	1091	1011	922	1010	1034	1034	1084
29	540	547	589	577	577	612	612	639	575	495	406	615	635	635	654
ATTR	6965	7021	6942	7105	7105	7566	7566	8941	9507	8047	9209	7203	7221	7221	7957

	BHS 16	BHN 17	ALX 18	WDS 19	SIN 20	FAY 21	BES 22	MYA 23	ASY 24	NEW 25	SOH 26	QEN 27	ASW 28	RED 29	ZONAL PRODUCTN	
1	160	160	210	471	354	106	123	251	390	613	493	637	939	540	6965	1
2	162	162	203	464	361	99	120	248	387	615	490	634	936	547	7021	2
3	111	111	173	463	354	155	172	300	439	667	542	686	988	589	6942	3
4	125	125	187	477	316	182	199	327	466	694	569	713	1015	577	7105	4
5	125	125	187	477	316	182	199	327	466	694	569	713	1015	577	7105	5
6	103	103	165	455	351	231	248	376	515	743	618	762	1064	612	7566	6
7	103	103	165	455	351	231	248	376	515	743	618	762	1064	612	7566	7
8	161	161	223	513	316	297	314	442	581	809	684	828	1130	639	8941	8
9	231	231	293	583	246	306	323	451	590	818	693	789	1091	575	9507	9
10	204	204	266	556	234	226	243	371	510	738	613	709	1011	495	8047	10
11	293	293	344	605	323	240	257	385	524	752	627	620	922	406	9209	11
12	92	92	154	444	380	173	194	322	461	689	564	708	1010	615	7203	12
13	65	65	127	417	376	200	218	346	485	713	588	732	1034	635	7221	13
14	65	65	127	417	376	200	218	346	485	713	588	732	1034	635	7221	14
15	51	51	113	403	393	250	268	396	535	763	638	782	1084	654	7957	15
16	0	0	62	352	438	261	282	410	549	777	652	796	1098	699	8427	16
17	0	0	62	352	438	261	282	410	549	777	652	796	1098	699	8427	17
18	62	62	0	290	500	302	323	451	590	818	693	837	1139	750	9754	18
19	352	352	290	0	790	563	584	712	851	1079	954	1098	1400	1011	17236	19
20	438	438	500	790	0	460	477	605	744	972	847	943	1245	729	14235	20
21	261	261	302	563	460	0	37	165	304	532	407	551	853	646	8420	21
22	282	282	323	584	477	37	0	128	267	495	370	514	816	663	8582	22
23	410	410	451	712	605	165	128	0	139	367	242	386	688	600	10567	23
24	549	549	590	851	744	304	267	139	0	228	103	247	549	461	12930	24
25	777	777	818	1079	972	532	495	367	228	0	331	475	777	689	19086	25
26	652	652	693	954	847	407	370	242	103	331	0	144	446	358	15093	26
27	796	796	837	1098	943	551	514	386	247	475	144	0	302	214	18110	27
28	1098	1098	1139	1400	1245	853	816	688	549	777	446	302	0	516	26264	28
29	699	699	750	1011	729	646	663	600	461	689	358	214	516	0	16743	29
	8427	8427	9754	17236	14235	8420	8582	10567	12930	19086	15093	18110	26264	16743	309450	

Table (A-2) : Urban and Rural Population by Traffic Zone (in 1,000)

Zone	1976*			1979**			1983**		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Cairo	5084	-	5084	5687	-	5687	6267	-	6267
Giza	1379	1039	2418	1583	1070	2653	1790	1143	2933
Qalyubia	685	989	1674	753	1018	1771	836	1090	1926
Sharkia N	408	1323	1731	489	1363	1852	203	1457	1660
Sharkia E	122	768	890	140	791	931	114	845	959
Dakahlia E	536	1515	2051	630	1560	2190	727	1667	2394
Dakahlia W	119	563	682	122	580	702	123	621	744
Damietta	143	414	557	164	426	590	186	455	641
Port Said	263	-	263	327	-	327	418	-	418
Ismaillia	174	178	352	228	183	411	313	197	510
Suez	194	-	194	263	388	651	376	-	376
Minufia	337	1374	1711	387	1415	1802	437	1512	1949
Gharbia S	438	1097	1535	503	1130	1633	568	1207	1775
Gharbia N	328	431	759	377	444	821	426	474	900
Kafer El - Shiekh	291	1112	1403	334	1145	1479	378	1224	1602
Beheira S	83	768	851	116	791	907	146	846	992
Beheira W	570	1096	1666	655	1129	1783	702	1207	1909
Alexandria	2319	-	2319	2685	-	2695	3112	-	3112
Western desert	51	62	113	59	64	123	67	68	135
Sinia	10	-	10	-	-	-	-	-	-
Fayoum	276	864	1140	317	890	1207	359	950	1309
Beni Suef	276	833	1109	317	858	1175	359	919	1278
Minya	431	1525	2056	495	1674	2169	560	1790	2350
Asyut	470	1225	1695	540	1262	1802	610	1347	1957
New Valley	34	50	84	39	51	90	44	54	98
Sohag	405	1520	1925	465	1565	2030	526	1672	2198
Qena	392	1314	1706	450	1353	1803	510	1446	1956
Aswan	230	390	620	264	402	666	299	430	729
Red Sea	48	8	56	55	8	63	63	9	72
Total	16096	20555	36654	18454	21560	40013	20889	22630	43519

* Source : NTS, phase II, 1981

** Obtained by adjustment and interpolation of the NTS, phase II governorate Figures.

able (A-1) : 1979 Base Year Passenger Trips Per Day (x10)**

Zone	P.C.	Taxi	Bus	Rail	Total
1	1659	5612	5161	7823	20255
2	612	2629	2655	542	6438
3	1095	3665	7264	3345	15369
4	260	1218	845	1730	4053
5	134	448	458	421	1461
6	510	1795	1288	1418	5011
7	161	611	314	918	2004
8	140	568	341	492	1541
9	205	738	283	25	1251
10	579	1113	291	708	2691
11	141	365	232	105	843
12	667	2377	672	3520	7236
13	842	1192	438	4424	6896
14	424	594	86	1142	2246
15	202	874	348	1137	2561
16	337	788	210	553	1888
17	375	2136	365	1368	4244
18	716	2525	675	2694	6610
19	25	101	78	57	261
20	11	77	24	4	116
21	116	470	1149	326	2061
22	62	320	1266	532	2180
23	38	296	246	549	1129
24	41	467	282	969	1759
25	2	4	32	0	38
26	50	383	180	698	1311
27	64	279	228	544	1115
28	15	88	140	223	466
29	20	90	9	0	119
Total	9503	31823	25560	36267	103153

* Source : NTS, phase II, 1981.

** Intrazonal trips are excluded.

APPENDIX D

INITIAL AND FINAL SOLUTIONS WITH NO ACCOUNT FOR THE EXISTENCE OF FLEET CAPACITY CONSTRAINTS

(NET3)

INITIAL SOLUTION[*]

(NET3)

[Express train, Local train, Normal Bus and Taxi]

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[*] No account for fleet capacity constraints
in the SPND algorithm

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TIAL MODAL SPLIT AND TRAFFIC ASSIGNMENT:
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LINK FROM  TO   LENGTH  CAPACITY      FLOW     INITIAL COST
---- ---- ---- ------- --------- ---------- ------------
   1 AXLT QNLT  121.68   8208.00      0.000      1.05017
   2 QNLT AXLT  121.68   8208.00      0.000      1.05017
   3 AXLT DRLT   60.69   8208.00      0.000      0.39058
   4 DRLT AXLT   60.69   8208.00      0.000      0.39058
   5 DRLT QNLT   42.60  27360.00      0.000      0.38138
   6 QNLT DRLT   42.60  27360.00      0.000      0.38138
   7 QNLT KSLT   17.96  27360.00      0.000      0.16967
   8 KSLT QNLT   17.96  27360.00      0.000      0.16967
   9 KSLT SNLT   63.05  21888.00      0.000      0.56095
  10 SNLT KSLT   63.05  21888.00      0.000      0.56095
  11 SNLT DTLT   40.77  16416.00      0.000      0.33092
  12 DTLT SNLT   40.77  16416.00      0.000      0.33092
  13 SNLT MRLT   23.82  19152.00      0.000      0.25677
  14 MRLT SNLT   23.82  19152.00      0.000      0.25677
  15 MKLT MRLT   25.36  35568.00      0.000      0.19683
  16 MRLT MKLT   25.36  35568.00      0.000      0.19683
  17 MKLT MHLT   13.23  41040.00      0.000      0.07259
  18 MHLT MKLT   13.23  41040.00      0.000      0.07259
  19 QNLT MHLT   30.58  32832.00      0.000      0.27745
  20 MHLT QNLT   30.58  32832.00      0.000      0.27745
  21 DRLT EBLT   25.20  13680.00      0.000      0.15424
  22 EBLT DRLT   25.20  13680.00      0.000      0.15424
  23 EBLT KZLT   17.84  13680.00      0.000      0.10805
  24 KZLT EBLT   17.84  13680.00      0.000      0.10805
  25 KZLT TTLT   17.76  13680.00      0.000      0.10773
  26 TTLT KZLT   17.76  13680.00      0.000      0.10773
  27 TTLT MHLT   14.42  68400.00      0.000      0.07723
  28 MHLT TTLT   14.42  68400.00      0.000      0.07723
  29 MHLT ZTLT   30.49   2736.00      0.000      0.21585
  30 ZTLT MHLT   30.49   2736.00      0.000      0.21585
  31 MRLT AKLT   47.54  32832.00      0.000      0.46793
  32 AKLT MRLT   47.54  32832.00      0.000      0.46793
  33 AKLT ZGLT   23.00  38304.00      0.000      0.20767
  34 ZGLT AKLT   23.00  38304.00      0.000      0.20767
  35 ZTLT ZGLT   29.92  27360.00      0.000      0.24302
  36 ZGLT ZTLT   29.92  27360.00      0.000      0.24302
  37 ILLT ZGLT   78.32  19152.00      0.000      0.50131
  38 ZGLT ILLT   78.32  19152.00      0.000      0.50131
  39 BHLT ZGLT   35.00  24624.00      0.000      0.22744
  40 ZGLT BHLT   35.00  24624.00      0.000      0.22744
  41 BHLT ZTLT   33.76  24624.00      0.000      0.28540
  42 ZTLT BHLT   33.76  24624.00      0.000      0.28540
  43 TTLT ZTLT   26.29  27360.00      0.000      0.19617
  44 ZTLT TTLT   26.29  27360.00      0.000      0.19617
  45 TTLT BHLT   41.49  13680.00      0.000      0.24540
  46 BHLT TTLT   41.49  13680.00      0.000      0.24540
  47 TTLT SKLT   28.13  38304.00      0.000      0.20924
  48 SKLT TTLT   28.13  38304.00      0.000      0.20924
  49 KZLT MFLT   49.67  21888.00      0.000      0.44203
  50 MFLT KZLT   49.67  21888.00      0.000      0.44203
  51 EBLT IBLT  119.57  13680.00      0.000      0.94703
  52 IBLT EBLT  119.57  13680.00      0.000      0.94703
  53 SKLT MFLT   13.56  38304.00      0.000      0.12297
  54 MFLT SKLT   13.56  38304.00      0.000      0.12297
  55 MFLT BHLT   26.85  27360.00      0.000      0.24473
  56 BHLT MFLT   26.85  27360.00      0.000      0.24473
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    BHLT QBLT    30.87  16416.00        0.000        0.19364
 58 QBLT BHLT    30.87  16416.00        0.000        0.19364
 59 MFLT QBLT    51.38  30096.00        0.000        0.41408
 60 QBLT MFLT    51.38  30096.00        0.000        0.41408
 61 QBLT CRLT    14.14  98496.00        0.000        0.09362
 62 CRLT QBLT    14.14  98496.00        0.000        0.09362
 63 IBLT CRLT     3.28  30096.00        0.000        0.03727
 64 CRLT IBLT     3.28  30096.00        0.000        0.03727
 65 IBLT GZLT     9.67  21888.00        0.000        0.07618
 66 GZLT IBLT     9.67  21888.00        0.000        0.07618
 67 GZLT WTLT    79.03  10944.00        0.000        0.59758
 68 WTLT GZLT    79.03  10944.00        0.000        0.59758
 69 WTLT BSLT    31.95  16416.00        0.000        0.19606
 70 BSLT WTLT    31.95  16416.00        0.000        0.19606
 71 WTLT FMLT    37.74   5472.00        0.000        0.27669
 72 FMLT WTLT    37.74   5472.00        0.000        0.27669
 73 BSLT MNLT   122.73  10944.00        0.000        0.75845
 74 MNLT BSLT   122.73  10944.00        0.000        0.75845
 75 MNLT ATLT   128.37  13680.00        0.000        0.76645
 76 ATLT MNLT   128.37  13680.00        0.000        0.76645
 77 ATLT SGLT    91.95  19152.00        0.000        0.65940
 78 SGLT ATLT    91.95  19152.00        0.000        0.65940
 79 SGLT QELT   141.59  13680.00        0.000        1.01387
 80 QELT SGLT   141.59  13680.00        0.000        1.01387
 81 QELT ANLT   270.22   8208.00        0.000        1.68341
 82 ANLT QELT   270.22   8208.00        0.000        1.68341
 83 QBLT ZGLT    26.94  21888.00        0.000        0.33628
 84 ZGLT QBLT    26.94  21888.00        0.000        0.33628
 87 ALEX AXLT     0.00      1.00        0.000        0.26483
 88 AXLT ALEX     0.00      1.00        0.000        0.09793
 89 DMHR DRLT     0.00      1.00        0.000        0.26483
 90 DRLT DMHR     0.00      1.00        0.000        0.09793
 91 ETYB EBLT     0.00      1.00        0.000        0.33478
 92 EBLT ETYB     0.00      1.00        0.000        0.16788
 93 KFRS KSLT     0.00      1.00        0.000        0.27882
 94 KSLT KFRS     0.00      1.00        0.000        0.11192
 95 MHLK MKLT     0.00      1.00        0.000        0.16690
 96 MKLT MHLK     0.00      1.00        0.000        0.01400
 97 TANT TTLT     0.00      1.00        0.000        0.19498
 98 TTLT TANT     0.00      1.00        0.000        0.02798
 99 SHKM SKLT     0.00      1.00        0.000        0.22286
100 SKLT SHKM     0.00      1.00        0.000        0.05596
101 BNE4 BHLT     0.00      1.00        0.000        0.19488
102 BHLT BNE4     0.00      1.00        0.000        0.02799
103 CAIR CRLT     0.00      1.00        0.000        0.20867
104 CRLT CAIR     0.00      1.00        0.000        0.04197
105 ZGZG ZGLT     0.00      1.00        0.000        0.22286
106 ZGLT ZGZG     0.00      1.00        0.000        0.05596
107 ABKB AKLT     0.00      1.00        0.000        0.20867
108 AKLT ABKB     0.00      1.00        0.000        0.04197
109 MNSP MRLT     0.00      1.00        0.000        0.26483
110 MRLT MNSP     0.00      1.00        0.000        0.09793
111 SHRB SKLT     0.00      1.00        0.000        0.22286
112 SKLT SHRB     0.00      1.00        0.000        0.05596
113 DKIT DTLT     0.00      1.00        0.000        0.19988
114 DTLT DKIT     0.00      1.00        0.000        0.01400
115 PRTS FSLT     0.00      1.00        0.000        0.19488
116 FSLT PRTS     0.00      1.00        0.000        0.02799
117 ISML ILLT     0.00      1.00        0.000        0.19488
118 ILLT ISML     0.00      1.00        0.000        0.01400
119 FYUS FMLT     0.00      1.00        0.000        0.19988
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120 FMLT FYUM    0.00      1.00       0.000      0.2279
121 BSWF BSIT    0.00      1.00       0.000      0.19465
122 BSLT BSWF    0.00      1.00       0.000      0.02798
123 MNIA MNLT    0.00      1.00       0.000      0.22266
124 MNLT MNIA    0.00      1.00       0.000      0.05596
125 ASYT ATLT    0.00      1.00       0.000      0.25084
126 ATLT ASYT    0.00      1.00       0.000      0.05394
127 SHAG SGLT    0.00      1.00       0.000      0.25264
128 SGLT SHAG    0.00      1.00       0.000      0.04394
129 QENA QELT    0.00      1.00       0.000      0.36276
130 QELT QENA    0.00      1.00       0.000      0.14586
131 ASWN ANLT    0.00      1.00       0.000      0.27882
132 ANLT ASWN    0.00      1.00       0.000      0.11192
133 AXET DRET   60.69  31920.00     175.230      0.31028
134 DRET AXET   60.69  31920.00     405.270      0.31028
135 DRET QNET   42.60   6080.00       0.000      0.33345
136 QNET DRET   42.60   6080.00       0.000      0.33345
137 DRET EBET   25.20  24320.00     781.182      0.12777
138 EBET DRET   25.20  24320.00    1280.003      0.12777
139 EBET KZET   17.84  24320.00    4245.525      0.09513
140 KZET EBET   17.84  24320.00    4028.682      0.09513
141 KZET TTET   17.76  24320.00    4245.525      0.09481
142 TTET KZET   17.76  24320.00    4028.682      0.09481
143 TTET MHET   14.42  12160.00    1529.606      0.07109
144 MHET TTET   14.42  12160.00    1115.121      0.07109
145 MHET QNET   30.58   3040.00       0.000      0.23820
146 QNET MHET   30.58   3040.00       0.000      0.23820
147 QNET KSET   42.60   9120.00       0.000      0.31246
148 KSET QNET   42.60   9120.00       0.000      0.31246
149 KSET SNET   63.05   4560.00      38.021      0.49617
150 SNET KSET   63.05   4560.00     119.616      0.49617
151 SNET DTET   40.77   9120.00     519.510      0.26097
152 DTET SNET   40.77   9120.00     928.927      0.26097
153 SNET MRET   23.82   9120.00    1141.077      0.17283
154 MRET SNET   23.82   9120.00     741.960      0.17283
155 MKET MRET   25.36   9120.00    1242.456      0.17038
156 MRET MKET   25.36   9120.00    1285.456      0.17038
157 MHET MKET   13.23   9120.00    1529.606      0.06638
158 MKET MHET   13.23   9120.00    1115.121      0.06638
159 MRET AKET   47.54   4560.00       0.000      0.39132
160 AKET MRET   47.54   4560.00       0.000      0.39132
161 PSET ILET   77.94   4560.00      29.351      0.35761
162 ILET PSET   77.94   4560.00      45.144      0.35761
163 ZGET AKET   23.00   4560.00     285.464      0.20445
164 AKET ZGET   23.00   4560.00     174.996      0.20445
165 ZGET ILET   78.32   7600.00     654.247      0.38010
166 ILET ZGET   78.32   7600.00     405.[illegible]      0.38010
167 ZGET BHET   35.00  16720.00    1282.396      0.18757
168 BHET ZGET   35.00  16720.00    1966.047      0.18757
169 TTET BHET   41.40  27360.00    4[illegible]30.549      0.23389
170 BHET TTET   41.40  27360.00    6490.758      0.23389
171 TTET SKET   26.13   1520.00       0.000      0.19525
172 SKET TTET   26.13   1520.00       0.000      0.19525
173 SKET MFET   13.56   1520.00     291.545      0.09499
174 MFET SKET   13.56   1520.00    1470.982      0.09499
175 MFET QBET   51.35   1520.00     291.545      0.35014
176 QBET MFET   51.35   1520.00    1470.982      0.35014
177 BHET QBET   30.87  44080.00   37113.441      0.10171
178 QBET BHET   30.87  44080.00   51219.564      0.10171
179 QBET CRET   14.14  47120.00   37404.4[illegible]      0.08047
180 CRET QBET   14.14  47120.00   52097.742      0.08047
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[illegible]1 CRET SSET 144.56   6080.00   [illegible]    0.77969
182 SSET CRET 144.56   6080.00   [illegible]    0.77969
183 CRET IBET   3.28  31920.00   7159.961    0.03747
184 IBET CRET   3.28  31920.00  26633.556    0.03747
185 IBET GZET   9.67  31920.00   7159.961    0.06277
186 GZET IBET   9.67  31920.00  26633.556    0.06277
187 GZET BSET 110.98  30400.00   7159.961    0.54788
188 BSET GZET 110.98  30400.00  26633.556    0.54788
189 BSET MNET 122.73  22800.00   2037.737    0.63990
190 MNET BSET 122.73  22800.00  17535.523    0.63990
191 MNET ATET 128.37  22800.00   1537.558    0.66224
192 ATET MNET 128.37  22800.00  14679.163    0.66224
193 ATET SGET  91.95  18240.00   1845.386    0.49703
194 SGET ATET  91.95  18240.00  10177.304    0.49703
195 SGET QEET 141.59  13680.00   1062.609    0.71459
196 QEET SGET 141.59  13680.00   6740.682    0.71459
197 QEET ANET 270.22   6080.00    368.460    1.22396
198 ANET QEET 270.22   6080.00   2550.000    1.22396
199 ALEX AXET   0.00      1.00    175.200    0.26753
200 AXET ALEX   0.00      1.00    425.270    0.05793
201 DMHP DRET   0.00      1.00    605.981    0.23955
202 DRET DMHP   0.00      1.00    874.823    0.06995
203 ETYR ERET   0.00      1.00   3391.146    0.29551
204 ERET ETYR   0.00      1.00   3265.392    0.12591
205 KFRS KSET   0.00      1.00     98.021    0.25354
206 KSET KFRS   0.00      1.00    119.616    0.05394
207 MHLK MKET   0.00      1.00    519.716    0.16960
208 MKET MHLK   0.00      1.00    977.223    0.01400
209 TANT TTET   0.00      1.00   1361.299    0.19758
211 TTET TANT   0.00      1.00   3623.907    0.02798
212 SHKM SKET   0.00      1.00    291.545    0.21157
213 SKET SHKM   0.00      1.00   1478.082    0.04197
214 BNHA BHET   0.00      1.00  35036.227    0.19758
215 BHET BNHA   0.00      1.00  45099.137    0.02798
217 CAIR CRET   0.00      1.00  45496.063    0.21157
218 CRET CAIR   0.00      1.00  49846.820    0.04197
219 ZGZG ZGET   0.00      1.00    201.942    0.21157
220 ZGET ZGZG   0.00      1.00    394.356    0.04197
221 ARKS AKET   0.00      1.00    174.996    0.19758
222 AKET ARKS   0.00      1.00    256.264    0.02798
223 MNSR MRET   0.00      1.00    144.379    0.23955
224 MRET MNSR   0.00      1.00   [illegible]    0.06995
225 SHRR SNET   0.00      1.00    331.766    0.21157
226 SNET SHRR   0.00      1.00    310.391    0.04197
227 DMIT DTET   0.00      1.00    428.927    0.14359
228 DTET DMIT   0.00      1.00    619.51[illegible]    0.01400
229 PRTS PSET   0.00      1.00     29.351    0.19758
230 PSET PRTS   0.00      1.00     48.144    0.02798
231 ISMI ILET   0.00      1.00    [illegible]76.558    0.14359
232 ILET ISMI   0.00      1.00    659.133    0.01400
233 SWES SSET   0.00      1.00      0.000    0.19758
234 SSET SWES   0.00      1.00      0.000    0.02798
235 FYUM FMET   0.00      1.00      0.000    0.14359
236 FMET FYUM   0.00      1.00   [illegible]    0.01400
237 BSWI BSET   0.00      1.00  11327.[illegible]    0.21157
238 BSET BSWI   0.00      1.00   7173.[illegible]    0.04197
239 MNIA ANET   0.00      1.00   47[illegible]2.176    0.26753
240 ANET MNIA   0.00      1.00   2455.[illegible]72    0.05793
241 ASYT ATET   0.00      1.00   [illegible]    0.22556
242 ATET ASYT   0.00      1.00   [illegible]    0.05596
243 [illegible] [illegible]   0.00      1.00   [illegible]241.[illegible]    0.2[illegible]
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    SGET SPAC    0.00       1.00   3536.[illegible]      0.16700
245 QENA QEET    0.00       1.00   5456.[illegible]      0.[illegible]
246 QEET QENA    0.00       1.00   2012.1[illegible]      0.15090
247 ASWN ANET    0.00       1.00   2550.000      0.25354
248 ANET ASWN    0.00       1.00    318.960      0.06394
249 DTEB PSEB   63.00     696.00    526.517      0.27720
250 PSEB DTEB   63.00     696.00    739.492      0.27720
251 DTEB SNEB   42.00    1565.00   5231.713      0.11482
252 SNEB DTEB   42.00    1565.00   3256.742      0.11482
253 SNEB MREB   24.10    2869.00  11281.252      0.13604
254 MREB SNEB   24.10    2869.00   9455.569      0.13604
255 MREB SLEB   20.20    1304.00  12355.085      0.08488
256 SLEB MREB   20.20    1304.00  11546.171      0.08488
257 SLEB ZGEB   30.70     782.00  11387.262      0.13201
258 ZGEB SLEB   30.70     782.00  10318.938      0.13201
259 SLEB AKEB   30.00     522.00    968.4[illegible]2      0.13200
260 AKEB SLEB   30.00     522.00   1229.233      0.13200
261 MREB BHEB   75.20     174.00   8657.903      0.32336
262 BHEB MREB   75.20     174.00   6482.741      0.32336
263 SKEB BHEB   26.00      87.00  10176.315      0.11206
264 BHEB SKEB   26.00      87.00  12543.854      0.11206
265 BHEB ZGEB   35.00    1652.00   9535.597      0.15400
266 ZGEB BHEB   35.00    1652.00  10918.758      0.15400
267 ZGEB AKEB   25.50    3086.00   3779.289      0.11220
268 AKEB ZGEB   25.50    3086.00   5203.659      0.11220
269 AKEB ILEB   70.50     348.00    619.674      0.31020
270 ILEB AKEB   70.50     348.00    865.390      0.31020
271 ILEB PSEB   76.00     609.00    932.659      0.32680
272 PSEB ILEB   76.00     609.00   1585.434      0.32680
273 ILEB ZGEB   81.00    2217.00   7129.991      0.38102
274 ZGEB ILEB   81.00    2217.00   4352.775      0.38102
275 ILEB SSEB   89.00     522.00    489.204      0.39160
276 SSEB ILEB   89.00     522.00    804.467      0.39160
277 SSEB CREB  133.50    1044.00      0.000      0.60905
278 CREB SSEB  133.50    1044.00      0.000      0.60905
279 CREB ZGEB   77.20    1608.00  21314.131      0.45872
280 ZGEB CREB   77.20    1608.00  20299.656      0.45872
281 CREB BHEB   47.20    2608.00      0.000      0.50224
282 BHEB CREB   47.20    2608.00      0.000      0.50224
283 SHKM SKEB    0.00       1.00  10176.315      0.17853
284 SKEB SHKM    0.00       1.00  12543.854      0.06995
285 BNHA BHEB    0.00       1.00  21693.174      0.15085
286 BHEB BNHA    0.00       1.00  219[illegible].633      0.04197
287 CAIR CREB    0.00       1.00  21314.131      0.15085
288 CREB CAIR    0.00       1.00  20299.656      0.04197
289 ZGZG ZGEB    0.00       1.00  14742.440      0.10282
290 ZGEB ZGZG    0.00       1.00  14447.148      0.06394
291 ABKR AKEB    0.00       1.00   5751.[illegible]7      0.16484
292 AKEB ABKR    0.00       1.00   45[illegible].422      0.05596
293 MNSR MREB    0.00       1.00  12113.725      0.24876
294 MREB MNSR    0.00       1.00  11526.325      0.13900
295 SHEB SNEB    0.00       1.00   6754.[illegible]      0.1[illegible]282
296 SNEB SHEB    0.00       1.00   6454.277      0.06394
297 DMIT DTEB    0.00       1.00   4516.072      0.17666
298 DTEB DMIT    [illegible]       1.00   3154.[illegible]76      0.[illegible]79[illegible]
299 PRTS PSEB    0.00       1.00   [illegible]61.649      0.15666
300 PSEB PRTS    0.00       1.00   1175.[illegible]      0.02796
301 ISKL ILEB    0.00       1.00   [illegible]184.441      0.15666
302 ILEB ISKL    [illegible]       1.00   [illegible]      [illegible]
303 SWKS SSEB    0.00       1.00    [illegible]04.467      0.15666
304 SSEB SWKS    0.00       1.00    489.204      0.02799
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305 AXMB DRMB    56.50     217.00  16212.221          0.23[illegible]
306 DRMB AXMB    56.50     217.00   9014.214          0.23739
307 DRMB EBMB    25.70     217.00  21632.565          0.10794
308 EBMB DRMB    25.70     217.00  12637.851          0.10794
309 EBMB TTMB    39.00     217.00  22754.654          0.16380
310 TTMB EBMB    39.00     217.00  13067.466          0.16380
311 TTMB KSMB    39.00    2130.00   7371.961          0.17160
312 KSMB TTMB    39.00    2130.00   9591.141          0.17160
313 KSMB SNMB    63.30     522.00   1713.810          0.27852
314 SNMB KSMB    63.30     522.00   1796.273          0.27852
315 MKMB MRMB    19.50    1652.00   6190.968          0.06560
316 MRMB MKMB    19.50    1652.00   7285.816          0.06560
317 TTMB MKMB    26.50    3043.00  13587.628          0.11130
318 MKMB TTMB    26.50    3043.00  13490.171          0.11130
319 TTMB ZGMB    55.00     652.00   5686.934          0.24200
320 ZGMB TTMB    55.00     652.00   4650.317          0.24200
321 BHMB MRMB    75.20     348.00      0.000          0.32336
322 MRMB BHMB    75.20     348.00      0.000          0.32336
323 TTMB BHMB    43.00    3434.00  16673.869          0.20101
324 BHMB TTMB    43.00    3434.00  17141.742          0.20101
325 TTMB SKMB    26.00    4043.00  23819.443          0.10920
326 SKMB TTMB    26.00    4043.00  30935.295          0.10920
327 SKMB BHMB    26.00    1565.00      0.000          0.11206
328 BHMB SKMB    26.00    1565.00      0.000          0.11206
329 SKMB CRMB    65.50    2695.00  27533.143          0.40724
330 CRMB SKMB    65.50    2695.00  37698.109          0.40724
331 CRMB BHMB    47.20    5825.00      0.000          0.50224
332 BHMB CRMB    47.20    5825.00      0.000          0.50224
333 KSMB MKMB    26.00    1913.00    957.755          0.11440
334 MKMB KSMB    26.00    1913.00    797.193          0.11440
335 ALEX AXMB     0.00       1.00  16212.221          0.29681
336 AXMB ALEX     0.00       1.00   9014.214          0.09793
337 DMHR DRMB     0.00       1.00   7966.542          0.26277
338 DRMB DMHR     0.00       1.00   6109.532          0.15369
339 ETYB EBMB     0.00       1.00   1418.654          0.36070
340 EBMB ETYB     0.00       1.00   1186.484          0.25182
341 KFRS KSMB     0.00       1.00   9465.212          0.27676
342 KSMB KFRS     0.00       1.00   7587.925          0.16768
343 MHLK MKMB     0.00       1.00   4207.140          0.10988
344 MKMB MHLK     0.00       1.00   9449.947          0.01599
345 TANT TTMB     0.00       1.00  35447.713          0.13686
346 TTMB TANT     0.00       1.00  44093.930          0.02798
347 SHKM SKMB     0.00       1.00  19412.145          0.17853
348 SKMB SHKM     0.00       1.00  27461.262          0.06995
349 BNHA BHMB     0.00       1.00  17141.742          0.15985
350 BHMB BNHA     0.00       1.00  16673.869          0.04197
351 CAIR CRMB     0.00       1.00  37698.109          0.15185
352 CRMB CAIR     0.00       1.00  27533.143          0.04197
353 ZGZG ZGMB     0.00       1.00   4650.317          0.19262
354 ZGMB ZGZG     0.00       1.00   5686.934          0.08394
355 MNSR MRMB     0.00       1.00   7285.816          0.24876
356 MKMB MNSR     0.00       1.00   6190.968          0.13992
357 SHMB SNMB     0.00       1.00   1796.273          0.14282
358 SNMB SHMB     0.00       1.00   1713.810          0.0[illegible]364
359 AXWB DRWB    56.50    26[illegible].00   7366.575          0.23730
360 DRWB AXWB    56.50    26[illegible].00   [illegible].643          0.23731
361 DRWB KSWB    57.40     346.00   1110.361          0.25256
362 KSWB DRWB    57.40     346.00    994.724          0.25256
363 DRWB EBWB    25.70    2260.00  10188.993          0.10794
364 EBWB DRWB    25.70    2260.00   7563.377          0.10794
365 EPWB CRWB   126.70    34[illegible].00  1[illegible]          0.66011
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66 CRWB EBWB 126.7    348.00    7503.377      0.6651
367 ALEX AXWB   0.00     1.00    7566.578      0.29681
368 AXWB ALEX   0.00     1.00    5195.643      0.09743
369 DMHF DRWB   0.00     1.00    3741.476      0.26277
370 DRWB DMHF   0.00     1.00    3312.459      0.15389
371 ETYP EBWB   0.00     1.00       0.000      0.36070
372 EBWB ETYP   0.00     1.00       0.000      0.25162
373 KFES KSWB   0.00     1.00     904.724      0.27676
374 KSWB KFES   0.00     1.00    1119.061      0.16788
375 CAIP CRWB   0.00     1.00    7503.377      0.15085
376 CRWB CAIP   0.00     1.00   10188.993      0.04197
377 CRUB SSUB 133.50   261.00    1064.758      0.57405
378 SSUB CRUB 133.50   261.00    1517.533      0.57405
379 CRUB GZUB  10.00  1304.00    5431.497      0.07200
380 GZUB CRUB  10.00  1304.00    9192.066      0.07200
381 GZUB FMUB  97.50   739.00    5431.497      0.56425
382 FMUB GZUB  97.50   739.00    9192.966      0.56425
383 GZUB BSUB 118.50   782.00       0.000      0.81955
384 BSUB GZUB 118.50   782.00       0.000      0.81955
385 FMUB BSUB  43.00  1435.00     930.742      0.18490
386 BSUB FMUB  43.00  1435.00    1904.534      0.18490
387 BSUB MNUB 130.00  1087.00     359.971      0.55900
388 MNUB BSUB 130.00  1087.00     630.824      0.55900
389 SWES SSUB   0.00     1.00    1517.533      0.13686
390 SSUB SWES   0.00     1.00    1064.758      0.02798
391 CAIR CRUB   0.00     1.00    6359.065      0.15085
392 CRUB CAIR   0.00     1.00   10572.423      0.04197
393 FYUM FMUB   0.00     1.00   10102.999      0.15085
394 FMUB FYUM   0.00     1.00    7266.209      0.04197
395 BSWF BSUB   0.00     1.00    1740.560      0.19282
396 BSUB BSWF   0.00     1.00    1287.620      0.08394
397 MNIA MNUB   0.00     1.00     830.824      0.29075
398 MNUB MNIA   0.00     1.00     359.971      0.18187
399 AXTX DRTX  56.50 31683.00       0.000      0.46048
400 DRTX AXTX  56.50 31683.00       0.000      0.46048
401 DRTX EBTX  25.70 31683.00       0.000      0.20946
402 EBTX DRTX  25.70 31683.00       0.000      0.20946
403 DRTX KSTX  57.40  5000.00       0.000      0.47642
404 KSTX DRTX  57.40  5000.00       0.000      0.47642
405 KSTX TTTX  39.00  4892.00       0.000      0.33618
406 TTTX KSTX  39.00  4892.00       0.000      0.33618
407 KSTX MKTX  26.00  4892.00      77.053      0.22412
408 MKTX KSTX  26.00  4892.00      81.332      0.22412
409 TTTX MKTX  26.50 31683.00       0.000      0.21598
410 MKTX TTTX  26.50 31683.00       0.000      0.21598
411 KSTX SNTX  63.30  4892.00       0.000      0.54565
412 SNTX KSTX  63.30  4892.00       0.000      0.54565
413 SNTX DTTX  42.00  4892.00       0.000      0.36294
414 DTTX SNTX  42.00  4892.00       0.000      0.36294
415 MKTX SNTX  48.00  4892.00       0.000      0.41376
416 SNTX MKTX  48.00  4892.00       0.000      0.41376
417 MRTX SNTX  24.10  4892.00       0.000      0.20774
418 SNTX MRTX  24.10  4892.00       0.000      0.20774
419 MKTX MRTX  19.50  4892.00       0.000      0.16609
420 MRTX MKTX  19.50  4892.00       0.000      0.16609
421 MRTX SLTX  20.20  4892.00       0.000      0.17412
422 SLTX MRTX  20.20  4892.00       0.000      0.17412
423 MKTX SLTX  32.00  5000.00     153.193      0.26560
424 SLTX MKTX  32.00  5000.00     196.917      0.26560
425 SLTX AKTX  30.00  4892.00     153.193      0.25860
426 AKTX SLTX  30.00  4892.00     196.917      0.25860
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427 SLTX ZGTX    30.70    7688.00        0.000        0.252
428 ZGTX SLTX    30.70    7688.00        0.000        0.25235
429 EBTX TTTX    39.00   31683.00        0.000        0.31785
430 TTTX EBTX    39.00   31683.00        0.000        0.31785
431 TTTX ZGTX    55.00    4892.00        0.000        0.47410
432 ZGTX TTTX    55.00    4892.00        0.000        0.47410
433 TTTX BHTX    43.00   31683.00        0.000        0.39335
434 BHTX TTTX    43.00   31683.00        0.000        0.39335
435 TTTX SKTX    26.00    4892.00        0.000        0.22412
436 SKTX TTTX    26.00    4892.00        0.000        0.22412
437 SKTX BHTX    26.00   18000.00        0.000        0.21788
438 BHTX SKTX    26.00   18000.00        0.000        0.21788
439 SKTX DHTX    39.50    4892.00        0.000        0.34049
440 DHTX SKTX    39.50    4892.00        0.000        0.34049
441 EBTX DHTX   100.70    5172.00        0.000        0.82775
442 DHTX EBTX   100.70    5172.00        0.000        0.82775
443 DHTX GZTX    29.00    4892.00        0.000        0.33198
444 GZTX DHTX    29.00    4892.00        0.000        0.33198
445 DHTX CRTX    26.00    4892.00        0.000        0.29412
446 CRTX DHTX    26.00    4892.00        0.000        0.29412
447 GZTX AXTX   173.50    5000.00        0.000        1.81505
448 AXTX GZTX   173.50    5000.00        0.000        1.81505
449 CRTX BHTX    47.20   31683.00        0.000        0.59768
450 BHTX CRTX    47.20   31683.00        0.000        0.59768
451 BHTX ZGTX    35.00    4892.00        0.000        0.30170
452 ZGTX BHTX    35.00    4892.00        0.000        0.30170
453 ZGTX CRTX    77.20    4892.00        0.000        0.73546
454 CRTX ZGTX    77.20    4892.00        0.000        0.73546
455 ZGTX AKTX    25.50    4892.00        0.000        0.21981
456 AKTX ZGTX    25.50    4892.00        0.000        0.21981
457 DTTX PSTX    63.00    4892.00        0.000        0.54306
458 PSTX DTTX    63.00    4892.00        0.000        0.54306
459 PSTX ILTX    76.00    7688.00        0.000        0.62472
460 ILTX PSTX    76.00    7688.00        0.000        0.62472
461 ILTX AKTX    70.50    4892.00        0.000        0.60771
462 AKTX ILTX    70.50    4892.00        0.000        0.60771
463 ILTX ZGTX    81.00   31683.00        0.000        0.66015
464 ZGTX ILTX    81.00   31683.00        0.000        0.66015
465 ILTX CRTX   123.50    7688.00        0.000        1.28317
466 CRTX ILTX   123.50    7688.00        0.000        1.28317
467 ILTX SSTX    89.00    4892.00        0.000        0.76718
468 SSTX ILTX    89.00    4892.00        0.000        0.76718
469 SSTX CRTX   135.50    7688.00        0.000        1.14637
470 CRTX SSTX   135.50    7688.00        0.000        1.14637
471 CRTX GZTX    10.00   13976.00        0.000        0.10250
472 GZTX CRTX    10.00   13976.00        0.000        0.10250
473 GZTX FMTX    97.50    7688.00        0.000        0.92295
474 FMTX GZTX    97.50    7688.00        0.000        0.92295
475 GZTX BSTX   118.50    7688.00        0.000        1.15157
476 BSTX GZTX   118.50    7688.00        0.000        1.15157
477 FMTX BSTX    43.00    7688.00        0.000        0.35346
478 BSTX FMTX    43.00    7688.00        0.000        0.35346
479 BSTX MNTX   130.00    6430.00        0.000        1.06863
480 MNTX BSTX   130.00    6430.00        0.000        1.06863
481 MNTX ATTX   135.50    5172.00        0.000        1.11391
482 ATTX MNTX   135.50    5172.00        0.000        1.11391
483 ATTX SGTX    95.00    6430.00        0.000        0.78090
484 SGTX ATTX    95.00    6430.00        0.000        0.78090
485 SGTX QNTX   141.50    7688.00        0.000        1.16313
486 QNTX SGTX   141.50    7688.00        0.000        1.16313
487 QNTX ANTX   271.00    5000.00        0.000        2.24950
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488 ANTX QNTX  271.00   5000.00        0.000       2.2449
489 BHTX MRTX   75.20   5172.00        0.000       0.61814
490 MRTX BHTX   75.20   5172.00        0.000       0.61814
491 ALEX AXTX    0.00      1.00        0.000       0.24793
492 AXTX ALEX    0.00      1.00        0.000       0.04793
493 DMHR DRTX    0.00      1.00        0.000       0.24793
494 DRTX DMHR    0.00      1.00        0.000       0.09793
495 ETYB EBTX    0.00      1.00        0.000       0.31788
496 EBTX ETYB    0.00      1.00        0.000       0.16788
497 KFRS KSTX    0.00      1.00       77.053       0.26192
498 KSTX KFRS    0.00      1.00       91.332       0.11192
499 MHLK MKTX    0.00      1.00       76.140       0.16399
500 MKTX MHLK    0.00      1.00      115.575       0.01399
501 TANT TTTX    0.00      1.00        0.000       0.17798
502 TTTX TANT    0.00      1.00        0.000       0.02798
503 SHKM SKTX    0.00      1.00        0.000       0.20596
504 SKTX SHKM    0.00      1.00        0.000       0.05596
505 BNHA BHTX    0.00      1.00        0.000       0.17798
506 BHTX BNHA    0.00      1.00        0.000       0.02798
507 CAIR CRTX    0.00      1.00        0.000       0.19197
508 CRTX CAIR    0.00      1.00        0.000       0.04197
509 ZGZG ZGTX    0.00      1.00        0.000       0.20596
510 ZGTX ZGZG    0.00      1.00        0.000       0.05596
511 ABKB AKTX    0.00      1.00      196.907       0.19197
512 AKTX ABKB    0.00      1.00      153.193       0.04197
513 MNSR MRTX    0.00      1.00        0.000       0.24793
514 MRTX MNSR    0.00      1.00        0.000       0.09793
515 SHRB SNTX    0.00      1.00        0.000       0.20596
516 SNTX SHRB    0.00      1.00        0.000       0.05596
517 DMIT DTTX    0.00      1.00        0.000       0.16399
518 DTTX DMIT    0.00      1.00        0.000       0.01399
519 PRTS PSTX    0.00      1.00        0.000       0.17798
520 PSTX PRTS    0.00      1.00        0.000       0.02798
521 ISML ILTX    0.00      1.00        0.000       0.16399
522 ILTX ISML    0.00      1.00        0.000       0.01399
523 SWES SSTX    0.00      1.00        0.000       0.17798
524 SSTX SWES    0.00      1.00        0.000       0.02798
525 FYUM FMTX    0.00      1.00        0.000       0.17798
526 FMTX FYUM    0.00      1.00        0.000       0.02798
527 BSWF BSTX    0.00      1.00        0.000       0.20596
528 BSTX BSWF    0.00      1.00        0.000       0.05596
529 MNIA MNTX    0.00      1.00        0.000       0.27591
530 MNTX MNIA    0.00      1.00        0.000       0.12591
531 ASYT ATTX    0.00      1.00        0.000       0.23394
532 ATTX ASYT    0.00      1.00        0.000       0.08394
533 SHAG SGTX    0.00      1.00        0.000       0.23394
534 SGTX SHAG    0.00      1.00        0.000       0.08394
535 QENA QNTX    0.00      1.00        0.000       0.34586
536 QNTX QENA    0.00      1.00        0.000       0.19586
537 ASWN ANTX    0.00      1.00        0.000       0.26192
538 ANTX ASWN    0.00      1.00        0.000       0.11192


INITIAL VALUE OF OBJECTIVE FUNCTION=                  515653024584.0

CPU TIME FOR INITIALIZATION=        15.[illegible]   [illegible]


LOGIT CONVERGENCE TEST:
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FINAL SOLUTION[*]

(NET3)

[Express train, Local train, Normal bus and Taxi]

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[*] This is the solution after 250 iterations assuming no account for fleet capacity constraints in the SPND algorithm

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AL SPLIT AND TRIP ASSIGNMENT:
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LINK FROM  TO  LENGTH  FLOW/CAP     FLOW        COST     %CHANGE OF FLOW
---- ---- ---- ------ --------- --------- ------------ -------------
   1 AXLT QNLT 121.68      0.00     0.000      1.05017      0.00
   2 QNLT AXLT 121.68      0.00     0.000      1.05017      0.00
   3 AXLT DRLT  60.69      0.08   676.404      0.39058     -0.39
   4 DRLT AXLT  60.69      0.09   722.887      0.39058     -0.39
   5 DRLT QNLT  42.60      0.00     0.000      0.38138      0.00
   6 QNLT DRLT  42.60      0.00     0.000      0.38138      0.00
   7 QNLT KSLT  17.96      0.00     0.000      0.16967      0.00
   8 KSLT QNLT  17.96      0.04  1131.890      0.16967     -0.39
   9 KSLT SNLT  63.05      0.00     0.000      0.56095      0.00
  10 SNLT KSLT  63.05      0.00     0.000      0.56095      0.00
  11 SNLT DTLT  40.77      0.01   100.069      0.33092     -0.39
  12 DTLT SNLT  40.77      0.00    60.131      0.33092     -0.39
  13 SNLT MRLT  23.82      0.01   211.536      0.25677     -0.39
  14 MRLT SNLT  23.82      0.01   233.280      0.25677     -0.39
  15 MKLT MRLT  25.36      0.07  2456.304      0.19683     -0.39
  16 MRLT MKLT  25.36      0.18  6428.261      0.19683     -0.39
  17 MKLT MHLT  13.23      0.31 12792.613      0.07259      0.01
  18 MHLT MKLT  13.23      0.21  8720.312      0.07259     -0.39
  19 QNLT MHLT  30.58      0.03  1131.890      0.27745     -0.39
  20 MHLT QNLT  30.58      0.00     0.000      0.27745      0.00
  21 DRLT EBLT  25.20      0.21  2834.876      0.15424     -0.39
  22 EBLT DRLT  25.20      0.10  1412.523      0.15424     -0.39
  23 EBLT KZLT  17.84      0.31  4253.201      0.10805      0.34
  24 KZLT EBLT  17.84      0.14  1929.355      0.10805     -0.39
  25 KZLT TTLT  17.76      0.31  4253.201      0.10773      0.34
  26 TTLT KZLT  17.76      0.14  1929.355      0.10773     -0.39
  27 TTLT MHLT  14.42      0.13  8617.706      0.07723     -0.39
  28 MHLT TTLT  14.42      0.20 13937.926      0.07723     -0.02
  29 MHLT ZTLT  30.49      0.03    86.581      0.21585     -0.39
  30 ZTLT MHLT  30.49      0.04   102.603      0.21585     -0.39
  31 MRLT AKLT  47.54      0.00     0.000      0.46793      0.00
  32 AKLT MRLT  47.54      0.00    79.080      0.46793     -0.39
  33 AKLT ZGLT  23.00      0.08  2666.018      0.20767     -0.39
  34 ZGLT AKLT  23.00      0.06  2192.931      0.20767     -0.39
  35 ZTLT ZGLT  29.92      0.09  2358.740      0.24302     -0.39
  36 ZGLT ZTLT  29.92      0.06  1676.861      0.24302      4.47
  37 ILLT ZGLT  78.32      0.01   206.919      0.50131     -0.39
  38 ZGLT ILLT  78.32      0.04   743.720      0.50131     -0.39
  39 BHLT ZGLT  35.00      0.01   316.325      0.22744     -0.39
  40 ZGLT BHLT  35.00      0.00     0.000      0.22744      0.00
  41 BHLT ZTLT  33.76      0.00     0.000      0.26540      0.00
  42 ZTLT BHLT  33.76      0.00     0.000      0.26540      0.00
  43 TTLT ZTLT  26.29      0.08  2272.150      0.19617     -0.39
  44 ZTLT TTLT  26.29      0.06  1574.258      0.19617      4.79
  45 TTLT BHLT  41.49      1.41 19227.736      0.29523     -0.12
  46 BHLT TTLT  41.49      1.32 18024.484      0.27151      1.26
  47 TTLT SKLT  28.13      0.11  4198.005      0.20924      0.35
  48 SKLT TTLT  28.13      0.06  2138.781      0.20924     -0.39
  49 KZLT MFLT  49.07      0.00     0.000      0.44203      0.00
  50 MFLT KZLT  49.07      0.00     0.000      0.44203      0.00
  51 EBLT IBLT 119.57      0.00     0.000      0.94703      0.00
  52 IBLT EBLT 119.57      0.00     0.827      0.94703     -0.39
  53 SKLT MFLT  13.56      0.06  2135.548      0.12297     -0.39
  54 MFLT SKLT  13.56      0.15  5610.611      0.12297     -0.39
  55 MFLT BHLT  26.85      0.01   150.167      0.24473     -0.39
  56 BHLT MFLT  26.85      0.00     0.000      0.24473      0.00
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 57 BHLT QBLT  30.67       1.23 22264.154        0.20393    [illegible].14
 58 QBLT BHLT  30.67       1.47 24156.908        0.25264   -0.39
 59 MFLT QBLT  51.38       0.07  2007.381        0.41408   -0.39
 60 QBLT MFLT  51.38       0.19  5618.611        0.41408   -0.39
 61 QBLT CRLT  14.14       0.33 32481.035        0.09362   -0.23
 62 CRLT QBLT  14.14       0.43 42664.242        0.09362   -0.39
 63 IBLT CRLT   3.28       0.23  6698.412        0.03727   -0.39
 64 CRLT IBLT   3.28       0.14  4254.738        0.03727   -0.39
 65 IBLT GZLT   9.67       0.19  4254.738        0.07618   -0.39
 66 GZLT IBLT   9.67       0.32  6905.239        0.07618   -0.39
 67 GZLT WTLT  79.03       0.39  4254.738        0.50758   -0.39
 68 WTLT GZLT  79.03       0.63  6905.239        0.50761   -0.39
 69 WTLT BSLT  31.95       0.04   737.786        0.19806   -0.39
 70 BSLT WTLT  31.95       0.00    65.243        0.19806   -0.39
 71 WTLT FMLT  37.74       0.64  3516.953        0.27681   -0.39
 72 FMLT WTLT  37.74       1.25  6839.995        0.36948   -0.39
 73 BSLT MNLT 122.73       0.05   575.830        0.75845   -0.39
 74 MNLT BSLT 122.73       0.00    23.541        0.75845   -0.39
 75 MNLT ATLT 128.37       0.91   102.265        0.76645   -0.39
 76 ATLT MNLT 128.37       0.00     0.000        0.76645    0.00
 77 ATLT SGLT  91.95       0.00    84.146        0.65940   -0.39
 78 SGLT ATLT  91.95       0.00     0.000        0.65940    0.00
 79 SGLT QELT 141.59       0.00     0.000        1.01387    0.00
 80 QELT SGLT 141.59       0.00     0.000        1.01387    0.00
 81 QELT ANLT 270.22       0.00     0.000        1.68341    0.00
 82 ANLT QELT 270.22       0.00     0.000        1.68341    0.00
 83 QBLT ZGLT  26.94       0.58 12688.748        0.33633   -0.39
 84 ZGLT QBLT  26.94       0.47 10209.562        0.33628   -0.39
 87 ALEX AXLT   0.00    676.40   676.404        0.26483   -0.39
 88 AXLT ALEX   0.00    722.89   722.887        0.09793   -0.39
 89 DHHR DRLT   0.00   2158.47  2158.473        0.26483   -0.39
 90 DRLT DHHR   0.00    689.64   689.636        0.09793   -0.39
 91 ETYB EBLT   0.00   1418.33  1418.325        0.33478    1.81
 92 EBLT ETYB   0.00    523.64   523.640        0.16788   -0.39
 93 KFES KSLT   0.00   1131.89  1131.890        0.27882   -0.39
 94 KSLT KFES   0.00      0.00     0.000        0.11192    0.00
 95 MHLK MKLT   0.00   6364.33  6364.335        0.16690    0.42
 96 MKLT MHLK   0.00   6270.50  6270.504        0.01430   -0.39
 97 TANT TTLT   0.00  10094.62 10094.619        0.19488   -0.39
 98 TTLT TANT   0.00  13681.33 13681.332        0.02798    2.37
 99 SHKM SKLT   0.00   4332.33  4332.330        0.22286   -0.39
100 SKLT SHKM   0.00  10013.62 10013.616        0.05596   -0.39
101 BNHA BHLT   0.00  12216.92 12216.925        0.19488    2.04
102 BHLT BNHA   0.00  17182.76 17182.764        0.02798   -0.39
103 CAIR CRLT   0.00  40467.46 40467.461        0.20857   -0.39
104 CRLT CAIR   0.00  32927.91 32927.914        0.04197   -0.24
105 ZGZG ZGLT   0.00   8793.43  8793.431        0.22286    0.53
106 ZGLT ZGZG   0.00  12427.16 12427.157        0.05596   -0.39
107 ARKB AKLT   0.00   2886.02  2886.018        0.20857   -0.39
108 AKLT ARKB   0.00   2113.85  2113.851        0.04197   -0.39
109 MNSP MRLT   0.00   6216.75  6216.747        0.26483   -0.39
110 MRLT MNSP   0.00   2296.10  2296.104        0.09793   -0.39
111 SHRF SNLT   0.00    151.41   151.405        0.22286   -0.39
112 SNLT SHRF   0.00    133.21   133.211        0.05596   -0.39
113 DMLT DTLT   0.00     60.13    60.131        0.1[illegible]   -0.39
114 DTLT DMLT   0.00    100.67   100.669        0.01430   -0.39
115 PRTS PSLT   0.00      0.00     [illegible]        0.194[illegible]    0.00
116 PSLT PRTS   0.00      0.00     0.000        0.127[illegible]    0.1[illegible]
117 ISML ILLT   0.00    206.92   206.919        0.18089   -0.39
118 ILLT ISML   0.00    743.72   743.720        0.01430   -0.39
119 EYUN ENLT   0.00   6840.00  6839.995        0.19488   -0.39
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[illegible]0 FNLT FYUM  0.00  3516.95  3516.953     0.02798    .39
121 BSWF BSLT  0.00    41.70    41.702     0.19488  -0.39
122 BSLT BSWF  0.00   161.96   161.956     0.02798  -0.39
123 MNIA MNLT  0.00    23.54    23.541     0.22286  -0.39
124 MNLT MNIA  0.00   473.56   473.564     0.05596  -0.39
125 ASYT ATLT  0.00     0.00     0.000     0.25684   0.00
126 ATLT ASYT  0.00    18.12    18.119     0.08394  -0.39
127 SHAC SGLT  0.00     0.00     0.000     0.25084   0.00
128 SGLT SHAC  0.00    84.15    84.146     0.08394  -0.39
129 QENA QELT  0.00     0.00     0.000     0.36276   0.00
130 QELT QENA  0.00     0.00     0.000     0.19566   0.00
131 ASWN ANLT  0.00     0.00     0.000     0.27882   0.00
132 ANLT ASWN  0.00     0.00     0.000     0.11192   0.00
133 AXET DRET 60.69     0.69 21591.816     0.31031  -0.39
134 DRET AXET 60.69     0.33 10656.844     0.31028  -0.39
135 DRET QNET 42.60     0.00     0.000     0.33345   0.00
136 QNET DRET 42.60     0.00    21.077     0.33345  -0.39
137 DRET EBET 25.20     1.33 32400.355     0.13603  -0.21
138 EBET DRET 25.20     0.83 20257.641     0.12765   0.02
139 EBET KZET 17.84     1.52 36919.352     0.11669  -0.23
140 KZET EBET 17.84     0.99 24002.170     0.09542  -0.04
141 KZET TTET 17.76     1.52 36919.352     0.11628  -0.23
142 TTET KZET 17.76     0.99 24002.170     0.09510  -0.04
143 TTET MHET 14.42     1.22 14832.024     0.07305  -0.18
144 MHET TTET 14.42     1.23 14897.188     0.07314   0.17
145 MHET QNET 30.58     0.01    21.077     0.23820  -0.39
146 QNET MHET 30.58     0.00     0.000     0.23820   0.00
147 QNET KSET 42.60     0.00     0.000     0.31246   0.00
148 KSET QNET 42.60     0.00     0.000     0.31246   0.00
149 KSET SNET 63.05     0.04   163.116     0.49617  -0.39
150 SNET KSET 63.05     0.07   330.623     0.49617  -0.39
151 SNET DTET 40.77     0.26  2343.529     0.26097  -0.39
152 DTET SNET 40.77     0.71  6474.669     0.26114  -0.39
153 SNET MRET 23.82     1.21 11029.058     0.19259  -0.39
154 MRET SNET 23.82     0.81  7431.273     0.17322  -0.39
155 MKET MRET 25.36     1.44 13138.429     0.18854  -0.39
156 MRET MKET 25.36     1.53 13997.915     0.20460   0.21
157 MHET MKET 13.23     1.63 14832.024     0.09823  -0.18
158 MKET MHET 13.23     1.64 14913.266     0.10013   0.17
159 MRET AKET 47.54     0.09   407.186     0.39132  -0.39
160 AKET MRET 47.54     0.16   745.561     0.39132  -0.39
161 PSET ILET 77.94     0.73  3351.097     0.35775   0.14
162 ILET PSET 77.94     0.32  1475.094     0.35761  -0.39
163 ZGET AKET 23.05     0.26  1160.404     0.20445  -0.39
164 AKET ZGET 23.05     0.18   814.443     0.20445  -0.39
165 ZGET ILET 78.32     0.61  4656.763     0.38011  -0.39
166 ILET ZGET 78.32     1.33 13145.916     0.40629   0.15
167 ZGET BHET 35.00     1.01 16256.727     0.15825  -0.06
168 BHET ZGET 35.00     0.80 13301.191     0.18764  -0.39
169 TTET BHET 41.49     1.56 42595.914     0.29816  -0.08
170 BHET TTET 41.49     1.47 40180.367     0.26991  -0.31
171 TTET SKET 28.13     1.45 [illegible]   0.34100  -0.39
172 SKET TTET 28.13     1.42  2156.953     0.31064  -0.39
173 SKET MFET 13.56     1.38  2690.456     0.13727  -0.39
174 MFET SKET 13.56     1.36  2679.711     0.13561  -0.39
175 MFET QBET 51.38     1.38  2690.456     0.49034  -0.39
176 QBET MFET 51.38     1.36  2679.711     0.47041  -0.39
177 BHET CRET 39.87     1.46 64194.516     0.29034  [illegible]
178 QBET BHET 39.87     1.65 70536.799     0.24353   0.32
179 QBET CRET 14.14     1.41 66291.945     0.08846  -0.39
180 CRET QBET 14.14     1.54 72451.484     0.09910   0.40
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181 CRET SSET 144.56       0.11    644.454      0.77965  -0.39
182 SSET CRET 144.56       0.38   2309.371      0.77963   0.43
183 CRET ILET   3.28       0.39  12333.546      0.03747   0.40
184 IBET CRET   3.28       1.07  34104.934      0.03759  -0.09
185 IBET GZET   9.67       0.39  12333.546      0.06277   0.40
186 GZET IBET   9.67       1.07  34104.934      0.06312  -0.09
187 GZET BSET 110.98       0.41  12333.546      0.54758   0.10
188 BSET GZET 110.98       1.12  34104.934      0.55440  -0.06
189 BSET MNET 122.73       0.23   5171.128      0.63999  -0.39
190 MNET BSET 122.73       1.04  23604.125      0.64313  -0.19
191 MNET ATET 128.37       0.20   4553.836      0.66224  -0.39
192 ATET MNET 128.37       0.94  19186.141      0.66266  -0.05
193 ATET SGET  91.95       0.23   4244.679      0.49703  -0.39
194 SGET ATET  91.95       0.77  14334.827      0.49728  -0.04
195 SGET QEET 141.59       0.18   2527.231      0.71459  -0.39
196 QEET SGET 141.59       0.70   9594.027      0.71474   0.06
197 QEET ANET 270.22       0.13    809.180      1.22396  -0.39
198 ANET QEET 270.22       0.68   4162.959      1.22410   0.00
199 ALEX AXET   0.00   21891.82  21891.816      0.26753  -0.39
200 AXET ALEX   0.00   10686.84  10686.844      0.09733  -0.39
201 DMHR DRET   0.00   10620.29  10620.291      0.23955   0.16
202 DRET DMHR   0.00    9703.61   9703.611      0.06995   0.43
203 ETYB EBET   0.00    6156.51   6156.507      0.29551  -0.39
204 EBET ETYB   0.00    5382.05   5382.046      0.12591  -0.39
205 KFRS KSET   0.00     160.12    160.116      0.25354  -0.39
206 KSET KFRS   0.00     330.62    330.623      0.08394  -0.39
207 MHLK MKET   0.00    2255.23   2255.225      0.16960  -0.39
208 MKET MHLK   0.00    3028.46   3028.462      0.01400   0.63
209 TANT TTET   0.00   14986.21  14986.215      0.19758   0.59
211 TTET TANT   0.00   25519.80  25519.803      0.02798  -0.16
212 SHKM SKET   0.00    4255.25   4255.252      0.21157  -0.39
213 SKET SHKM   0.00    4279.80   4279.796      0.04197  -0.39
214 BNHA BHET   0.00   46161.09  46161.086      0.19758  -0.39
215 BHET BNHA   0.00   58300.39  58300.395      0.02798   0.41
217 CAIR CRET   0.00   63175.11  63175.113      0.21157   0.32
218 CRET CAIR   0.00   80451.84  80451.844      0.04197  -0.23
219 ZGZG ZGET   0.00    6811.83   6811.830      0.21157  -0.39
220 ZGET ZGZG   0.00    8361.50   8361.496      0.04197  -0.39
221 ABKB AKET   0.00    1372.57   1372.565      0.19758  -0.39
222 AKET ABKB   0.00    1365.35   1365.351      0.02798  -0.39
223 MNSP MRET   0.00    5504.15   5504.146      0.23955   1.14
224 MRET MNSP   0.00    8583.63   8583.632      0.06995  -0.39
225 SHRB SNET   0.00    5468.98   5468.984      0.21157  -0.39
226 SNET SHRB   0.00    5830.93   5830.934      0.04197  -0.39
227 DMIT DTET   0.00    6474.67   6474.669      0.18359  -0.39
228 DTET DMIT   0.00    2343.53   2343.529      0.01400  -0.39
229 PRTS PSET   0.00    3351.10   3351.097      0.19758   0.14
230 PSET PRTS   0.00    1475.09   1475.094      0.02798  -0.39
231 ISML ILET   0.00    7157.49   7157.492      0.18359   0.13
232 ILET ISML   0.00    3554.33   3554.324      0.01400  -0.44
233 SWES SSET   0.00    2309.37   2309.371      0.19758   0.43
234 SSET SWES   0.00     644.45    644.454      0.02798  -0.44
235 FYUM FMET   0.00       0.00      0.000      0.18359   0.00
236 FMET FYUM   0.00       0.00      0.000      0.01400   0.00
237 BSWF BSET   0.00   13797.25  13797.249      0.21157   0.14
238 BSET BSWF   0.00   10452.45  10452.454      0.24147   1.21
239 MNIA MNET   0.00    7263.01   7263.005      0.26753   0.13
240 MNET MNIA   0.00    3491.32   3491.319      0.10793   0.65
241 ASYT ATET   0.00   11319.71  11319.707      0.22556   0.00
242 ATET ASYT   0.00    6177.54   6177.541      0.05596   0.13
243 SHAG SGET   0.00    8265.74   8265.736      0.23955   0.00
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  4 SGET SHAG   0.00      5562.39  5562.399          0.06700   0.17
245 QENA QEET   0.00      7326.58  7326.578          0.30959   0.06
246 QEET QENA   0.00      3613.56  3613.557          0.13990  -0.39
247 ASWN ANET   0.00      4162.96  4162.959          0.25354   0.00
248 ANET ASWN   0.00       609.16   609.163          0.08354  -0.39
249 DTEB PSEB  63.00         1.00   692.962          0.35692  -0.39
250 PSEB DTEB  63.00         1.29   898.411          0.50208  -0.39
251 DTEB SNEB  42.00         1.19  1856.114          0.29447   1.38
252 SNEB DTEB  42.00         1.00  1567.817          0.24064  -0.39
253 SNEB MREB  24.10         1.01  2899.931          0.13675   0.74
254 MREB SNEB  24.10         1.02  2926.403          0.14057  -0.39
255 MREB SLEB  20.20         1.48  1928.243          0.21637  -0.39
256 SLEB MREB  20.20         1.75  2282.991          0.33939  -0.39
257 SLEB ZGEB  33.70         1.69  1322.163          0.29006  -0.39
258 ZGEB SLEB  33.70         2.20  1716.554          0.58105  -0.39
259 SLEB AKEB  30.00         1.16   696.080          0.20397  -0.39
260 AKEB SLEB  30.00         1.09   566.438          0.18691  -0.39
261 MREB BHEB  75.20         1.59   275.853          0.72240  -0.39
262 BHEB MREB  75.20         2.41   416.840          2.44413  -0.39
263 SKEB BHEB  26.00         2.21   192.447          0.63745  -0.39
264 BHEB SKEB  26.00         2.16   188.069          0.59125  -0.39
265 BHEB ZGEB  35.00         1.02  1676.129          0.20319  -0.39
266 ZGEB BHEB  35.00         1.22  2021.750          0.25764  -0.39
267 ZGEB AKEB  25.50         0.67  2073.504          0.11906  -0.39
268 AKEB ZGEB  25.50         1.00  3098.103          0.14639   0.71
269 AKEB ILEB  70.50         1.24   455.617          0.52635  -0.39
270 ILEB AKEB  70.50         1.21   421.926          0.51129  -0.39
271 ILEB PSEB  76.00         1.16   734.671          0.41263  -0.39
272 PSEB ILEB  76.00         1.07   648.757          0.36546  -0.39
273 ILEB ZGEB  81.00         0.94  2090.261          0.40662  -0.39
274 ZGEB ILEB  81.00         0.66  1461.198          0.38713  -0.39
275 ILEB SSEB  89.00         0.92   478.151          0.47431  -0.39
276 SSEB ILEB  89.00         1.26   656.887          0.68621  -0.39
277 SSEB CREB 133.50         1.30  1352.667          0.84607  -0.39
278 CREB SSEB 133.50         0.71   745.745          0.63085  -0.39
279 CREB ZGEB  77.20         1.25  2305.482          0.70528  -0.39
280 ZGEB CREB  77.20         0.96  1538.661          0.54415  -0.39
281 CREB BHEB  47.20         0.00    12.170          0.50224  -0.39
282 BHEB CREB  47.20         0.00     0.000          0.50224   0.00
283 SHKM SKEB   0.00       192.45   192.447          0.17863  -0.39
284 SKEB SHKM   0.00       188.07   188.069          0.06995  -0.39
285 BNHA BHEB   0.00      1974.64  1974.641          0.15985  -0.39
286 BHEB BNHA   0.00      2191.82  2191.824          0.04157  -0.39
287 CAIP CREB   0.00      2751.23  2751.227          0.15985  -0.39
288 CREB CAIP   0.00      2879.16  2879.157          0.04197  -0.39
289 ZGZG ZGEB   0.00      1334.78  1334.780          0.19282  -0.39
290 ZGEB ZGZG   0.00      2717.25  2717.252          0.08394   0.87
291 ABKB AKEB   0.00      3534.54  3534.543          0.16484   0.58
292 AKEB ABKB   0.00      2540.90  2540.896          0.05596  -0.39
293 HNSB MREB   0.00      1109.36  1109.361          0.24875  -0.39
294 MREB MNSB   0.00      1567.72  1567.725          0.13990   1.70
295 SHRB SNEB   0.00      1774.86  1774.863          0.19282  -0.39
296 SNEB SHRB   0.00      2132.43  2132.431          0.08394  -0.39
297 DHIT DTEB   0.00      1769.13  1769.126          0.13686   1.45
298 DTEB DHIT   0.00      1697.38  1697.379          0.52705  -0.39
299 PRTS PSEB   0.00      1357.42  1357.424          0.13676  -0.39
300 PSEB PRTS   0.00       307.89   307.899          0.22740  -0.39
301 ISML ILEB   0.00      2265.73  2265.771          0.13636  -0.39
302 ILEB ISML   0.00      1771.18  1771.178          0.02755  -0.39
303 SWES SSEB   0.00      2909.55  2909.555          0.13686  -0.39
304 SSEB SWES   0.00      1225.90  1225.855          0.02795  -0.39
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305 AXMB DRMB  56.50        1.92   416.830        0.54468  -0.39
306 DRMB AXMB  56.50        1.36   294.541        0.31401  -0.39
307 DRMB EBMB  25.70        1.99   431.344        0.26643  -0.39
308 EBMB DRMB  25.70        1.40   304.138        0.14761  -0.39
309 EBMB TTMB  39.00        2.00   433.097        0.41133  -0.39
310 TTMB EBMB  39.00        1.41   305.276        0.22490  -0.39
311 TTMB KSMB  39.00        1.27  2710.361        0.30657  -0.39
312 KSMB TTMB  39.00        1.34  2650.472        0.33671  -0.39
313 KSMB SNMB  63.30        0.99   517.664        0.35933  -0.39
314 SNMB KSMB  63.30        0.97   507.672        0.35327  -0.39
315 MKMB MRMB  19.50        1.42  2351.693        0.19150  -0.39
316 MRMB MKMB  19.50        1.49  2456.346        0.21161  -0.39
317 TTMB MKMB  26.50        1.46  4441.159        0.15939  -0.39
318 MKMB TTMB  26.50        1.65  5017.141        0.16963   0.50
319 TTMB ZGMB  55.00        1.44   941.337        0.55745  -0.39
320 ZGMB TTMB  55.00        1.38   900.292        0.50592  -0.39
321 BHMB MRMB  75.20        1.45   506.144        0.60603  -0.39
322 MRMB BHMB  75.20        1.70   596.069        0.94551  -0.39
323 TTMB BHMB  43.00        1.41  4834.631        0.33616  -0.39
324 BHMB TTMB  43.00        1.41  4845.163        0.33734  -0.39
325 TTMB SKMB  26.00        1.52  6140.621        0.21990  -0.39
326 SKMB TTMB  26.00        1.54  6219.033        0.22565   1.66
327 SKMB BHMB  26.00        1.71  2660.657        0.30036  -0.39
328 BHMB SKMB  26.00        1.56  2435.554        0.24078  -0.39
329 SKMB CRMB  65.50        1.32  3560.516        0.67074  -0.39
330 CRMB SKMB  65.50        1.37  3692.554        0.71195  -0.39
331 CRMB BHMB  47.20        0.04   213.197        0.50224  -0.39
332 BHMB CRMB  47.20        0.00     0.000        0.50224   0.00
333 KSMB MKMB  26.00        1.26  2410.422        0.20091   1.74
334 MKMB KSMB  26.00        1.25  2395.373        0.19877  -0.39
335 ALEX AXMB   0.00      416.83   416.830        0.20651  -0.39
336 AXMB ALEX   0.00      294.54   294.541        0.09733  -0.39
337 DMHR DRMB   0.00       21.10    21.098        0.26277  -0.39
338 DRMB DMHR   0.00       16.18    16.183        0.15389  -0.39
339 ETYB EBMB   0.00        3.76     3.758        0.36070  -0.39
340 EBMB ETYB   0.00        3.14     3.142        0.25182  -0.39
341 KFES KSMB   0.00     5708.04  5708.039        0.27676   0.51
342 KSMB KFES   0.00     5542.89  5542.886        0.16766  -0.39
343 MHLK MKMB   0.00     5202.78  5202.777        0.10688   0.47
344 MKMB MHLK   0.00     4746.50  4746.496        0.01359   0.6[illegible]
345 TANT TTMB   0.00    12324.21 12324.215        0.13686  -0.39
346 TTMB TANT   0.00    13215.93 13215.927        0.02754   0.91
347 SHKM SKMB   0.00 [illegible] [illegible]      0.17853   0.66
348 SKMB SHKM   0.00    11909.39 11909.395        0.06995  -0.39
349 BNHA BHMB   0.00     7573.66  7573.663        0.15085  -0.39
350 BHMB BNHA   0.00     8105.38  8105.384        0.04197  -0.39
351 CAIR CRMB   0.00     3905.75  3905.751        0.15085  -0.39
352 CRMB CAIR   0.00     3560.62  3560.616        0.04197  -0.39
353 ZGZG ZGMB   0.00      900.29   900.292        0.19282  -0.39
354 ZGMB ZGZG   0.00      941.34   941.337        0.08394  -0.39
355 MKSP MKMB   0.00     3046.42  3046.416        0.24679  -0.39
356 MKMB MKSP   0.00     2857.64  2857.637        0.13530  -0.39
357 SNKP SNMB   0.00      507.67   507.672        0.19282  -0.39
358 SNMB SNKP   0.00      517.66   517.664        0.08394  -0.39
359 AXWB DRWB  56.50        1.25 [illegible]      0.29167  [illegible]
360 DRWB AXWB  56.50        1.08 [illegible]      0.26759  -0.39
361 DRWB KSWB  57.40        1.74 [illegible]      0.23173  -0.39
362 KSWB DRWB  57.40        1.67 [illegible]      0.74542  -0.39
363 DRWB EBWB  25.70        0.26 [illegible]      0.10799  -0.39
364 EBWB DRWB  25.70        0.36 [illegible]      0.10119  -0.39
365 EBWB CRWB 126.70 [illegible] [illegible]      0.14218  -0.39
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 66 CRWB EBYB 126.70       1.72    599.148         1.60425   -0.39
367 ALEX AXWB   0.00    3250.43   3250.428         0.20681    2.80
368 AXWB ALEX   0.00    2206.09   2206.094         0.04793   -0.39
369 DMHB DRWB   0.00    1505.98   1505.969         0.26277   -0.39
370 DRWB DMHB   0.00    2140.38   2140.381         0.15349    4.45
371 EBYB EBWB   0.00     203.53    203.531         0.36070   -0.39
372 EBWB EBYB   0.00     146.64    146.640         0.25182   -0.39
373 KFRS KSWB   0.00     581.68    581.682         0.27676   -0.39
374 KSWB KFRS   0.00     605.62    605.617         0.16765   -0.39
375 CAIR CRWB   0.00     599.15    599.148         0.15055   -0.39
376 CRWB CAIR   0.00     440.44    440.437         0.04197   -0.39
377 CRUB SSUB 133.50       2.30    599.028         2.90776   -0.39
378 SSUB CRUB 133.50       1.37    357.165         0.36899   -0.39
379 CRUB GZUB  10.00       0.91   1166.745         0.08915   -0.39
380 GZUB CRUB  10.00       0.89   1165.212         0.08794   -0.39
381 GZUB FMUB  97.50       1.57   1157.372         0.93379   -0.39
382 FMUB GZUB  97.50       1.58   1165.210         0.94390   -0.39
383 GZUB BSUB 116.50       0.04     29.372         0.61955   -0.39
384 BSUB GZUB 116.50       0.00      0.000         0.81955    0.00
385 FMUB BSUB  43.00       1.16   1666.426         0.23417   -0.39
386 BSUB FMUB  43.00       1.53   2188.500         0.33145   -0.39
387 BSUB MNUB 130.00       0.51    550.301         0.56528   -0.39
388 MNUB BSUB 130.00       0.67    731.772         0.57863   -0.39
389 SWES SSUB   0.00     357.17    357.165         0.13686   -0.39
390 SSUB SWES   0.00     599.03    599.028         0.02708   -0.39
391 CAIR CRUB   0.00    1739.71   1739.705         0.15055   -0.39
392 CRUB CAIR   0.00    1476.31   1476.307         0.04197   -0.39
393 FYUM FMUB   0.00    2831.45   2831.450         0.15055   -0.39
394 FMUB FYUM   0.00    3345.69   3345.688         0.04197   -0.39
395 BSWF BSUB   0.00    2052.09   2052.090         0.19282   -0.39
396 BSUB BSWF   0.00    1740.86   1740.859         0.08394   -0.39
397 MNIA MNUB   0.00     731.77    731.772         0.29075   -0.39
398 MNUB MNIA   0.00     550.30    550.301         0.18197   -0.39
399 AXTX DRTX  56.50       0.00    166.786         0.46046   -0.39
400 DRTX AXTX  56.50       0.00      0.000         0.46048    0.00
401 DRTX EBTX  25.70       0.00      0.000         0.20946    0.00
402 EBTX DRTX  25.70       0.00      0.000         0.20946    0.00
403 DRTX KSTX  57.40       0.13    639.501         0.47643   -0.39
404 KSTX DRTX  57.40       0.10    495.101         0.47642   -0.39
405 KSTX TTTX  39.00       0.64   3115.041         0.34337   -0.39
406 TTTX KSTX  39.00       0.26   1266.643         0.33639   -0.39
407 KSTX MKTX  26.00       0.36   1776.311         0.22463   -0.39
408 MKTX KSTX  26.00       0.21   1023.147         0.22418   -0.39
409 TTTX MKTX  26.50       0.02    509.642         0.215[illegible]   -0.39
410 MKTX TTTX  26.50       0.03    655.330         0.21548   -0.39
411 KSTX SNTX  63.30       0.01     71.062         0.54565   -0.39
412 SNTX KSTX  63.30       0.01     24.647         0.54565   -0.39
413 SNTX DTTX  42.00       0.06    269.257         0.36204   -0.39
414 DTTX SNTX  42.00       0.02    111.504         0.36204   -0.39
415 MKTX SNTX  48.00       0.24    193.214         0.41376   -0.39
416 SNTX MKTX  48.00       0.00      0.000         0.41376    0.00
417 MRTX SNTX  24.10       0.24   1177.191         0.20763   -0.39
418 SNTX MRTX  24.10       0.69   [illegible]      0.21384    0.02
419 MKTX MRTX  19.50        .25   [illegible]      [illegible]   [illegible]
420 MRTX MKTX  19.50        .46   [illegible]      .16[illegible]7   -0.39
421 MRTX SLTX  20.20       0.45   [illegible]      0.17585   -0.39
422 SLTX MRTX  20.20       0.22   1554.711         0.17417   -0.39
423 MKTX SLTX  32.00       0.73   [illegible]      [illegible]   [illegible]
424 SLTX MKTX  32.00       0.03   [illegible]      0.26567   -0.39
425 SLTX AKTX  30.00       0.11    553.570         0.25861   -0.39
426 AKTX SLTX  30.00       0.11    547.214         0.25861   -0.39
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 27 SLTX ZGTX  30.70    0.43  3291.071    0.25281   0.39
428 ZGTX SLTX  30.70    0.22  1661.302    0.25238  -0.39
429 EBTX TTTX  39.00    0.30   157.413    0.31785  -0.39
430 TTTX EBTX  39.00    0.51   175.962    0.31785  -0.39
431 TTTX ZGTX  55.00    0.00     0.000    0.47410   0.00
432 ZGTX TTTX  55.00    0.00     0.000    0.47410   0.00
433 TTTX BHTX  43.00    0.31   313.250    0.39335  -0.39
434 BHTX TTTX  43.00    0.31   411.495    0.39335  -0.39
435 TTTX SKTX  26.00    0.38  1675.1[illegible]    0.22475  -0.39
436 SKTX TTTX  26.00    0.17   842.265    0.22415  -0.39
437 SKTX BHTX  26.00    0.43  7690.673    0.21845  -0.39
438 BHTX SKTX  26.00    0.48  3666.062    0.21880  -0.39
439 SKTX DHTX  39.50    0.62  3037.962    0.34708  -0.39
440 DHTX SKTX  39.50    0.67  3361.156    0.34968  -0.39
441 EBTX DHTX 109.70    0.00     0.000    0.82775   0.00
442 DHTX EBTX 109.70    0.00     0.000    0.82775   0.00
443 DHTX GZTX  29.00    0.00     0.000    0.33198   0.00
444 GZTX DHTX  29.00    0.10   492.739    0.33198  -0.39
445 DHTX CRTX  26.00    0.62  3037.962    0.29846  -0.39
446 CRTX DHTX  26.00    0.57  2896.416    0.29729  -0.39
447 GZTX AXTX 173.50    0.00     0.000    1.81505   0.00
448 AXTX GZTX 173.50    0.00     0.000    1.81505   0.00
449 CRTX BHTX  47.20    0.00     0.000    0.59768   0.00
450 BHTX CRTX  47.20    0.00     0.000    0.59768   0.00
451 BHTX ZGTX  35.00    0.34  1684.910    0.30225  -0.39
452 ZGTX BHTX  35.00    0.40  1943.349    0.30269  -0.39
453 ZGTX CRTX  77.20    0.00     0.000    0.73546   0.00
454 CRTX ZGTX  77.20    0.00     0.000    0.73546   0.00
455 ZGTX AKTX  25.50    0.04   176.229    0.21981  -0.39
456 AKTX ZGTX  25.50    0.11   527.640    0.21981  -0.39
457 DTTX PSTX  63.00    0.03   161.770    0.54306  -0.39
458 PSTX DTTX  63.00    0.02    96.127    0.54306  -0.39
459 PSTX ILTX  76.00    0.00     4.690    0.62472  -0.39
460 ILTX PSTX  76.00    0.00     0.000    0.62472   0.00
461 ILTX AKTX  70.50    0.05   228.762    0.60771  -0.39
462 AKTX ILTX  70.50    0.06   265.336    0.60771  -0.39
463 ILTX ZGTX  81.00    0.00     0.000    0.66015   0.00
464 ZGTX ILTX  81.00    0.00     0.000    0.66015   0.00
465 ILTX CRTX 123.50    0.00     0.000    1.28317   0.00
466 CRTX ILTX 123.50    0.00     0.000    1.28317   0.00
467 ILTX SSTX  89.00    0.01    32.152    0.76718  -0.39
468 SSTX ILTX  89.00    0.01    53.107    0.76718  -0.39
469 SSTX CRTX 133.50    0.00     0.000    1.14837   0.00
470 CRTX SSTX 133.50    0.01    75.968    1.14837  -0.39
471 CRTX GZTX  10.00    0.06   816.106    0.10250  -0.39
472 GZTX CRTX  10.00    0.16  2212.614    0.10250   1.64
473 GZTX FMTX  97.50    0.11   916.176    0.90236  -0.39
474 FMTX GZTX  97.50    0.35  2705.353    0.90361   1.43
475 GZTX BSTX 118.50    0.00     0.000    1.19157   0.00
476 BSTX GZTX 118.50    0.00     0.000    1.19157   0.00
477 FMTX BSTX  43.00    0.01    56.358    0.35346  -0.39
478 BSTX FMTX  43.00    0.00    19.437    0.35346  -0.39
479 BSTX MNTX 130.00    0.00     0.000    1.06863   0.00
480 MNTX BSTX 130.00    0.00     0.000    1.06863   0.00
481 MNTX ATTX 135.50    0.00     0.000    1.11341   0.00
482 ATTX MNTX 135.50    0.00     0.000    1.11341   0.00
483 ATTX SGTX  95.00    0.00     0.000    0.78[illegible]   0.00
484 SGTX ATTX  95.00    0.00     0.000    0.78[illegible]   0.00
485 SGTX QNTX 141.50    0.00     0.000    1.16413   0.00
486 QNTX SGTX 141.50    0.00     0.000    1.16413   0.00
487 QNTX ANTX 271.00    0.00     0.000    2.24[illegible]   0.00
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488 ANTY QNTX 271.00      0.00      0.000          0.24935    0.00
489 LHTY MRTX  75.00      0.38   1991.734          0.61911   -0.39
490 MRTX BHLX  75.00      0.64   4337.563          0.64002    0.63
491 ALEX AXTY   0.00    106.79    106.766          0.24793   -0.39
492 AXTY ALEX   0.00      0.00      0.000          0.09793    0.00
493 DMHR DRTX   0.00    532.72    532.716          0.24793   -0.39
494 DRTX DMHR   0.00    495.10    495.101          0.09793   -0.39
495 ETYB EBTX   0.00    157.41    157.417          0.31798   -0.39
496 EBTX ETYB   0.00    170.96    170.962          0.16788   -0.39
497 KFRS KSTY   0.00   5457.22   5457.218          0.26192   -0.39
498 KSTX KFRS   0.00   2976.03   2976.027          0.11192   -0.39
499 MHLK MKTX   0.00    957.19    957.190          0.16399   -0.39
500 MKTX MHLK   0.00   1835.36   1835.358          0.01799   -0.39
501 TANT TTTX   0.00    434.36    434.361          0.17798   -0.39
502 TTTY TANT   0.00   1657.27   1657.269          0.02798   -0.39
503 SHKM SKTX   0.00  11571.86  11571.855          0.20596   -0.39
504 SKTX SHKM   0.00  13857.68  13857.877          0.05596   -0.39
505 BNHA BHTY   0.00   9139.54   9139.542          0.17798   -0.39
506 BHTX BNHA   0.00  10664.88  10664.876          0.02798    0.02
507 CAIR CRTX   0.00   3626.10   3626.098          0.19197   -0.39
508 CRTX CAIR   0.00   5181.18   5181.184          0.04197    0.56
509 ZGZG ZGTX   0.00   3082.01   3082.011          0.20596   -0.39
510 ZGTX ZGZG   0.00   4799.71   4799.710          0.05596   -0.39
511 ABKB AKTX   0.00    871.93    871.933          0.19197   -0.39
512 AKTX ABKB   0.00    471.33    471.325          0.04197   -0.39
513 MNSR MRTX   0.00   5559.10   5559.099          0.24793   -0.39
514 MRTX MNSR   0.00   3102.38   3102.378          0.09793   -0.39
515 SHRB SNTX   0.00   3311.33   3311.330          0.20596    0.95
516 SNTX SHRB   0.00   1201.52   1201.517          0.05596   -0.39
517 DMIT DTTY   0.00     39.46     39.461          0.16399   -0.39
518 DTTX DMIT   0.00    129.51    129.511          0.01399   -0.39
519 PRTS PSTX   0.00     96.13     96.127          0.17798   -0.39
520 PSTX PRTS   0.00    157.08    157.079          0.02798   -0.39
521 ISML ILTX   0.00    199.96    199.958          0.16399   -0.39
522 ILTY ISML   0.00    282.16    282.158          0.01399   -0.39
523 SWES SSTY   0.00     53.11     53.107          0.17798   -0.39
524 SSTY SWES   0.00    103.12    103.118          0.02798   -0.39
525 FYUM FMTX   0.00   2795.71   2795.710          0.17798    1.37
526 FMTX FYUM   0.00    634.60    634.603          0.02798   -0.39
527 PSWF PSTX   0.00     12.50     12.497          0.20596   -0.39
528 BSTX BSWF   0.00     99.36     99.358          0.05596   -0.39
529 MNIA MNTX   0.00      0.00      0.000          0.27591    0.00
530 MNTX MNIA   0.00      0.00      0.000          0.12591    0.00
531 ASYT ATIX   0.00      0.00      0.000          0.23394    0.00
532 ATTX ASYT   0.00      0.00      0.000          0.08394    0.00
533 SHAG SGTX   0.00      0.00      0.000          0.23394    0.00
534 SGTX SHAG   0.00      0.00      0.000          0.08394    0.00
535 QENA QNTX   0.00      0.00      0.000          0.34586    0.00
536 QNTX QENA   0.00      0.00      0.000          0.19586    0.00
537 ASWN ANTY   0.00      0.00      0.000          0.26192    0.00
538 ANTY ASWN   0.00      0.00      0.000          0.11192    0.00


FLOW IS OVER CAPACITY ON    96 OUT OF   534 [illegible] LINKS IN THE NETWORK.


CPU TIME FOR DIRECTION FINDING=             2.57    SECONDS
CPU TIME FOR ONE DIMENSIONAL SEARCH=        1.[illegible]    SECONDS
CPU TIME FOR CONVERGENCE TEST=              0.28    SECONDS
CPU TIME FOR OUTPUT CALCULATIONS=           0.66    SECONDS
```

APPENDIX E

EQUILIBRIUM RESULTS OF NET3 AND NET4

EAUILIBRIUM RESULTS
OF
NET3*
[ITERATION NO. 200]

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* Express Train, Local Train, Normal Bus and Taxi

```
OUTPUT OF THE MODEL:   NET3
==================


ITERATION NUMBER 200     :
-------------------------
THE OBJECTIVE VALUE IS                      -5641919.000
PREVIOUS VALUE IS WITHIN                              0.000%   OF THE CURRENT ONE

THE %DIFFERENCE IN FLOW BETWEEN LAST TWO ITERATIONS:
FOR    24    OUT OF    24    ORIGINS,
AND  551    OUT OF  552    O-D PAIRS,
AND  528    OUT OF  534    LINKS.
IS WITHIN     5.00  PERCENT


NUMBER OF INNER ITERATIONS=    1
OPTIMUM STEP SIZE=        0.00038


TOTAL TRAVEL COST =                       528731.125
TOTAL TRAVEL DISTANCE =                 52206160.00


ROOTE MEAN SQUARE ERRORS OF:
EQUILIBRIUM=                  11.438
TRIP GENERATION=               0.289
TRIP DISTRIBUTION=             7.802
MODAL LINK FLOWS=              9.949



LOGIT CONVERGENCE TEST:
----------------------

IT CALCULATES THE %DIFFERENCE BETWEEN PREDICTED O-D DEMAND AND THAT CALCULATED BY A LOGIT MODEL.


PREDICTIONS OF     81 OUT OF    552 O-D PAIRS ARE WITHIN      5% OF THE LOGIT MODEL
PREDICTIONS OF    179 OUT OF    552 O-D PAIRS ARE WITHIN     10% OF THE LOGIT MODEL
PREDICTIONS OF    268 OUT OF    552 O-D PAIRS ARE WITHIN     20% OF THE LOGIT MODEL
PREDICTIONS OF    300 OUT OF    552 O-D PAIRS ARE WITHIN     30% OF THE LOGIT MODEL
PREDICTIONS OF    325 OUT OF    552 O-D PAIRS ARE WITHIN     40% OF THE LOGIT MODEL
PREDICTIONS OF    361 OUT OF    552 O-D PAIRS ARE WITHIN     60% OF THE LOGIT MODEL
PREDICTIONS OF    368 OUT OF    552 O-D PAIRS ARE WITHIN     80% OF THE LOGIT MODEL
PREDICTIONS OF    409 OUT OF    552 O-D PAIRS ARE WITHIN    100% OF THE LOGIT MODEL


THERE ARE    204 O-D PAIRS WHICH HAVE LESS THAN 100 TRIPS


AMONG THE REMAINING   143 O-D PAIRS,     95 HAVE PREDICTIONS LESS THAN 100 TRIPS


ROOT MEAN SQUARE ERROR BETWEEN MODEL PREDICTIONS AND LOGIT:
TOTAL RMSE=         5827.295
WEIGHTED AVERAGE=  1081.808
```

```
ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AFTER THE   200TH ITERATION:
=================================================================
IT INCLUDES TRIPS PREDICTED, TRIPS CALCULATED BY LOGIT AND %DIFFERENCE BETWEEN BOTH.


    TO  ALEX     DMHR     ETYB     KFRS     MHLK     TANT     SHKM     BNHA     CAIR     ZGZG     ABKB     MNSR     SHRB
FROM----------------------------------------------------------------------------------------------------------------------

ALEX       0.    2443.     944.     895.     764.    4159.    2335.    4434.    5484.     967.     165.    1155.     461.
           0.    2645.     811.     915.     776.    4473.    2476.    4647.    5347.    1072.     180.    1168.     511.
          0.%     -8.%     16.%     -2.%     -1.%     -7.%     -6.%     -5.%      3.%    -10.%     -9.%     -1.%    -10.%

DMHR    1492.       0.     492.     431.     564.    2376.    1277.    2304.    2629.     563.     165.     550.     367.
        1675.       0.     420.     479.     423.    2330.    1390.    2448.    3002.     602.     101.     605.     265.
        -11.%      0.%     17.%    -10.%     33.%      2.%     -8.%     -6.%    -12.%     -7.%     63.%     -9.%     39.%

ETYB     573.     423.       0.     186.     238.    1082.     814.    1215.    1371.     281.      46.     369.     223.
         563.     470.       0.     148.     221.    1216.     725.    1277.    1566.     314.      53.     314.     137.
          2.%    -10.%      0.%     26.%      8.%    -11.%     12.%     -5.%    -12.%    -11.%    -12.%     18.%     62.%

KFRS     536.     496.     299.       0.     866.    2050.    1160.    2012.    2118.     660.     145.     859.     484.
         526.     533.     143.       0.     621.    2218.    1240.    2212.    2333.     618.     142.     895.     485.
          2.%     -7.%    109.%      0.%     43.%     -8.%     -6.%     -9.%     -9.%      7.%      2.%     -4.%      0.%

MHLK     567.     374.     247.     521.       0.    1615.     958.    1749.    1995.     511.     250.     802.     437.
         366.     305.     144.     378.       0.    1986.    1110.    1980.    2179.     537.     124.     858.     352.
         55.%     23.%     71.%     38.%      0.%    -19.%    -14.%    -12.%     -8.%     -5.%    102.%     -6.%     24.%

TANT    1669.    1509.    1444.    1104.    1867.       0.    4618.    7669.    9074.    2220.     353.    1882.     844.
        1749.    1460.     677.    1111.    1476.       0.    4964.    8856.    9536.    2232.     354.    2116.     926.
         -3.%      3.%    113.%     -1.%     27.%      0.%     -7.%    -13.%     -5.%     -1.%      0.%    -11.%     -9.%

SHKM     910.     744.     394.     682.     826.    4691.       0.    8213.   10042.    1486.     257.    1309.     543.
         932.     784.     371.     635.     866.    4776.       0.    8822.   10114.    1537.     254.    1202.     494.
         -2.%     -5.%      6.%      7.%     -4.%     -2.%      0.%     -7.%     -1.%     -3.%      1.%      9.%     10.%

BNHA    1890.    2900.     939.    1287.    1893.    9230.    9321.       0.   32080.    5664.    1204.    2912.    1453.
        2061.    1720.     796.    1194.    1853.   10214.    9711.       0.   32828.    6268.    1061.    2706.    1138.
         -8.%     69.%     18.%      8.%      2.%    -10.%     -4.%      0.%     -2.%    -10.%     13.%      8.%     28.%

CAIR    3710.    2644.    1666.    1773.    2286.   12659.   15792.   38549.       0.   10627.    3460.    3427.    1679.
        2863.    2388.    1111.    1661.    2594.   14303.   14675.   41765.       0.   11910.    2004.    3601.    1516.
         30.%     11.%     50.%      7.%    -12.%    -11.%      8.%     -8.%      0.%    -11.%     73.%     -5.%     11.%

ZGZG     410.     304.     286.     334.     355.    1687.    1384.    5015.    7053.       0.     452.     993.     520.
         361.     306.     145.     268.     386.    1865.    1387.    5130.    7712.       0.     379.     827.     348.
         14.%     -1.%     98.%     25.%     -8.%    -10.%      0.%     -2.%     -9.%      0.%     19.%     20.%     50.%

ABKB     122.     142.      94.     181.     187.     574.     439.    1808.    2418.     691.       0.     482.     241.
         126.     106.      50.     127.     183.     646.     471.    1787.    2671.     780.       0.     437.     191.
         -3.%     34.%     88.%     42.%      2.%    -11.%     -7.%      1.%     -9.%    -11.%      0.%     10.%     26.%

MNSR     757.     549.     280.     878.    1047.    3143.    1845.    3924.    3834.    1422.     554.       0.    1117.
         666.     572.     266.     731.    1054.    3426.    2044.    3600.    4234.    1575.     400.       0.    1193.
         14.%     -4.%      5.%     20.%     -1.%     -8.%    -10.%      9.%     -9.%    -10.%     38.%      0.%     -6.%

SHRB     295.     336.     118.     506.     492.    1354.     649.    1628.    1762.     734.     429.    1235.       0.
         331.     276.     128.     413.     483.    1531.     676.    1709.    1925.     718.     193.    1313.       0.
        -11.%     22.%     -8.%     22.%      2.%    -12.%     -4.%     -5.%     -8.%      2.%    123.%     -6.%      0.%

DMIT     222.     170.     113.     296.     475.     942.     514.    1026.    1240.     402.     120.     839.     599.
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           233.     194.      90.     291.     340.    1079.     574.    1121.    1188.     440.     136.     926.     694
           -5.%    -13.%     26.%      2.%     40.%    -13.%    -10.%     -9.%      4.%     -9.%    -12.%     -9.%    -14.%

FRTS        55.      51.      81.      96.      79.     287.     280.     777.     880.     290.     137.     175.     165.
            65.      55.      25.      52.      67.     303.     220.     931.     969.     356.      60.     164.     135.
          -16.%     -6.%    221.%     65.%     18.%     -5.%     28.%    -16.%     -9.%    -19.%    127.%      7.%     22.%

ISML       164.     154.     197.     110.     128.     729.     516.    1966.    2740.     848.     191.     337.     137.
           158.     132.      61.      83.     139.     733.     531.    2252.    2907.     867.     173.     290.     127.
            3.%     17.%    221.%     33.%     -8.%     -1.%     -3.%    -13.%     -6.%     -2.%     11.%     16.%      8.%

SWES        34.      34.      27.      56.      43.     165.     129.     457.    2164.     193.      62.      86.      30.
            34.      29.      13.      16.      27.     158.     142.     487.    2696.     126.      27.      49.      21.
            0.%     20.%    107.%    249.%     56.%      4.%     -9.%     -6.%    -19.%     53.%    128.%     77.%     48.%

FYUM       133.     114.     178.      87.      99.     420.     498.    1311.    5968.     462.     113.     177.     157.
           100.      90.      43.      61.      89.     493.     535.    1419.    6586.     410.      69.     124.      50.
           33.%     27.%    318.%     43.%     11.%    -15.%     -7.%     -8.%     -9.%     13.%     63.%     43.%    217.%

BSWF       230.     147.      48.     177.     179.     525.     476.    1616.    7647.     470.     114.     185.     100.
           126.     105.      49.      57.     101.     581.     537.    1785.    8349.     438.      74.     152.      66.
           83.%     41.%     -1.%    213.%     77.%    -10.%    -11.%     -9.%     -8.%      7.%     55.%     22.%     50.%

MNIA        62.      72.      44.      92.      88.     257.     271.     746.    3043.     186.      64.     167.      33.
            54.      45.      21.      24.      43.     248.     215.     762.    3565.     165.      28.      65.      28.
           17.%     61.%    113.%    261.%    105.%      4.%     26.%     -2.%    -15.%     13.%    132.%    158.%     15.%

ASYT       146.     136.      27.      36.     185.     283.     349.     810.    3581.     230.      43.      82.      86.
            62.      52.      24.      28.      50.     288.     250.     885.    4139.     189.      32.      75.      33.
          135.%    162.%     10.%     29.%    270.%     -2.%     40.%     -9.%    -13.%     22.%     36.%      9.%    162.%

SHAG        97.      94.      18.      19.      66.     158.     218.     477.    2102.     138.      42.      58.      19.
            32.      27.      12.      15.      26.     149.     129.     457.    2139.      98.      17.      39.      17.
          203.%    251.%     41.%     27.%    154.%      6.%     69.%      4.%     -2.%     42.%    155.%     50.%     10.%

QENA        23.      55.       9.      69.      22.     116.     133.     281.    1161.     112.      12.      83.      33.
            20.      16.       8.       9.      16.      91.      79.     281.    1313.      60.      10.      24.      10.
           15.%    236.%     14.%    674.%     37.%     26.%     68.%      0.%    -12.%     87.%     18.%    248.%    220.%

ASWN         7.       5.       6.       6.       5.      51.      33.      98.     417.      47.       7.      11.      37.
             6.       5.       2.       3.       5.      29.      25.      89.     418.      19.       3.       8.       3.
           16.%      1.%    152.%    105.%      2.%     77.%     32.%     10.%      0.%    146.%    115.%     51.%   1005.%
-------------------------------------------------------------------------------------------------------------------------
ATTR     14125.   13898.    7953.    9820.   12776.   48555.   44208.   88104.  110823.   29205.    8385.   18178.    9765.
         13127.   12315.    5414.    8697.   11839.   53138.   44319.   94705.  117717.   31331.    5873.   17957.    8742.
            8.%     13.%     47.%     13.%      8.%     -9.%      0.%     -7.%     -6.%     -7.%     43.%      1.%     12.%
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O-D MATRIX (CONTINUED)

	DMIT	PRTS	ISML	SWES	FYUM	BSWF	MNIA	ASYT	SHAG	QENA	ASWN	GENERATN
ALEX	351.	42.	164.	240.	179.	320.	38.	28.	10.	104.	4.	25688.
	161.	36.	178.	20.	92.	120.	21.	12.	4.	1.	1.	
	94.%	18.%	-8.%	1073.%	95.%	166.%	80.%	136.%	154.%	10332.%	289.%	
DMHR	109.	120.	116.	83.	156.	250.	23.	9.	5.	10.	2.	14093.
	94.	19.	92.	12.	52.	66.	11.	6.	2.	1.	1.	
	16.%	545.%	26.%	621.%	202.%	279.%	110.%	40.%	116.%	853.%	141.%	
ETYB	65.	10.	74.	12.	90.	34.	18.	21.	27.	7.	10.	7187.
	49.	10.	48.	6.	27.	34.	6.	3.	1.	1.	1.	
	33.%	6.%	55.%	96.%	233.%	-1.%	214.%	560.%	2377.%	630.%	920.%	
KFRS	157.	65.	72.	19.	85.	82.	120.	18.	4.	2.	2.	12331.
	162.	23.	77.	9.	37.	42.	8.	4.	1.	1.	1.	
	-3.%	176.%	-7.%	111.%	132.%	93.%	1491.%	341.%	167.%	96.%	113.%	
MHLK	130.	81.	68.	11.	126.	71.	21.	13.	2.	56.	38.	10644.
	124.	19.	80.	8.	34.	46.	8.	4.	2.	1.	1.	
	4.%	337.%	-15.%	36.%	270.%	55.%	158.%	202.%	50.%	5531.%	3714.%	
TANT	430.	63.	591.	198.	133.	506.	62.	320.	9.	35.	5.	36644.
	327.	65.	322.	37.	150.	218.	39.	21.	7.	2.	1.	
	31.%	-3.%	83.%	443.%	-11.%	132.%	60.%	1401.%	19.%	1867.%	365.%	
SHKM	170.	78.	247.	52.	274.	236.	48.	157.	312.	6.	38.	31719.
	174.	48.	240.	39.	159.	206.	37.	20.	7.	2.	1.	
	-2.%	60.%	3.%	34.%	73.%	15.%	32.%	677.%	4399.%	247.%	3681.%	
BNHA	382.	462.	1037.	191.	935.	815.	171.	112.	34.	26.	11.	74949.
	398.	226.	1121.	136.	515.	758.	135.	74.	26.	6.	1.	
	-4.%	105.%	-8.%	40.%	81.%	8.%	27.%	51.%	33.%	318.%	1017.%	
CAIR	586.	430.	2049.	1129.	3740.	4706.	1275.	1253.	545.	622.	132.	114739.
	535.	314.	1811.	1070.	4377.	4733.	843.	464.	159.	38.	2.	
	9.%	37.%	13.%	6.%	-15.%	-1.%	51.%	170.%	242.%	1529.%	5240.%	
ZGZG	153.	110.	329.	66.	115.	190.	32.	165.	28.	3.	10.	19992.
	107.	76.	353.	30.	121.	151.	24.	13.	4.	1.	1.	
	43.%	45.%	-7.%	124.%	-5.%	26.%	34.%	1165.%	530.%	173.%	901.%	
ABKB	79.	46.	183.	23.	107.	64.	14.	36.	5.	3.	1.	7939.
	68.	31.	145.	12.	42.	52.	8.	5.	2.	1.	1.	
	17.%	46.%	26.%	87.%	154.%	22.%	76.%	684.%	193.%	182.%	28.%	
MNSR	387.	91.	249.	39.	66.	258.	28.	62.	143.	7.	28.	20708.
	442.	63.	223.	20.	66.	85.	15.	8.	3.	1.	1.	
	-12.%	46.%	12.%	94.%	-1.%	202.%	84.%	645.%	4879.%	638.%	2654.%	
SHRB	337.	81.	113.	20.	74.	71.	17.	15.	14.	2.	38.	10519.
	356.	55.	107.	9.	30.	41.	7.	4.	1.	1.	1.	
	-5.%	47.%	5.%	115.%	144.%	73.%	132.%	277.%	917.%	85.%	3665.%	
DMIT	0.	118.	253.	45.	26.	88.	43.	10.	46.	7.	10.	7605.
	0.	106.	123.	12.	19.	29.	5.	3.	1.	1.	1.	
	0.%	11.%	106.%	269.%	39.%	202.%	728.%	246.%	4481.%	580.%	908.%	

PRTS	128. 130. -1.%	0. 0. 0.%	190. 210. -9.%	54. 16. 239.%	24. 15. 59.%	40. 24. 67.%	4. 4. -2.%	6. 2. 135.%	2. 1. 55.%	1. 1. -31.%	2. 1. 90.%	3805.
ISML	114. 82. 38.%	110. 114. -4.%	0. 0. 0.%	165. 53. 208.%	42. 46. -8.%	150. 58. 158.%	10. 10. -1.%	10. 6. 80.%	4. 2. 94.%	3. 1. 212.%	1. 1. 41.%	8827.
SWES	48. 13. 273.%	30. 17. 78.%	171. 99. 73.%	0. 0. 0.%	38. 42. -11.%	82. 57. 46.%	74. 10. 629.%	26. 6. 374.%	6. 2. 200.%	46. 1. 4507.%	48. 1. 4734.%	4070.
FYUM	24. 16. 52.%	18. 11. 64.%	57. 62. -9.%	33. 26. 29.%	0. 0. 0.%	1267. 1280. -1.%	260. 241. 8.%	82. 86. -4.%	131. 29. 346.%	121. 7. 1620.%	118. 1. 11650.%	11826.
BSWF	152. 23. 550.%	22. 14. 62.%	272. 68. 298.%	72. 35. 109.%	865. 1014. -15.%	0. 0. 0.%	307. 298. 3.%	183. 161. 14.%	154. 55. 178.%	142. 13. 968.%	17. 1. 1609.%	14102.
MNIA	68. 10. 581.%	10. 6. 71.%	34. 29. 17.%	44. 15. 194.%	429. 454. -5.%	775. 711. 9.%	0. 0. 0.%	447. 505. -12.%	156. 173. -10.%	45. 42. 10.%	74. 3. 2661.%	7211.
ASYT	110. 12. 848.%	11. 7. 65.%	40. 34. 19.%	16. 17. -5.%	340. 343. -1.%	820. 815. 1.%	974. 1066. -9.%	0. 0. 0.%	1379. 1567. -12.%	573. 375. 53.%	108. 24. 345.%	10368.
SHAG	7. 6. 22.%	11. 4. 206.%	34. 17. 93.%	11. 9. 26.%	162. 177. -9.%	386. 421. -8.%	503. 551. -9.%	2110. 2359. -11.%	0. 0. 0.%	843. 903. -7.%	90. 59. 54.%	7662.
QENA	10. 4. 176.%	4. 2. 83.%	127. 11. 1080.%	9. 5. 72.%	97. 109. -11.%	255. 259. -1.%	462. 338. 37.%	1281. 1448. -11.%	2026. 2313. -12.%	0. 0. 0.%	374. 329. 14.%	6754.
ASWN	27. 1. 2222.%	5. 1. 393.%	6. 3. 75.%	17. 2. 652.%	53. 35. 54.%	105. 82. 27.%	100. 108. -7.%	506. 461. 10.%	661. 737. -10.%	1452. 1618. -10.%	0. 0. 0.%	3664.
ATTR	4124. 3312. 21.%	2018. 1265. 60.%	6476. 5454. 19.%	2550. 1598. 60.%	8156. 7955. 3.%	11571. 10290. 12.%	4607. 3793. 21.%	6871. 5676. 21.%	5702. 5099. 12.%	4115. 3019. 36.%	1162. 435. 167.%	473045.

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ORIGIN-DESTINATION PERCEIVED COST MATRIX AFTER THE  0TH ITERATION:
==================================================================
     TO  ALEX     DMHR     ETYB     KFRS     MHLK     TANT     SHKM     BNHA     CAIR     ZGZG     ABKB     MNSR     SHRB
FROM-------------------------------------------------------------------------------------------------------------------------
ALEX    0.000    0.656    0.856    1.206    1.227    1.057    1.351    1.432    1.884    1.589    1.791    1.458    1.609
DMHR    0.644    0.000    0.509    0.854    0.847    0.707    0.952    1.074    1.484    1.189    1.391    1.111    1.262
ETYB    0.844    0.497    0.000    1.109    0.755    0.615    0.660    0.982    1.392    1.097    1.299    1.023    1.174
KFRS    1.330    0.854    1.140    0.000    0.510    0.657    0.945    1.059    1.568    1.088    1.083    0.769    0.778
MHLK    1.145    0.798    0.710    0.502    0.000    0.305    0.593    0.707    1.188    0.757    0.751    0.372    0.565
TANT    0.960    0.613    0.538    0.640    0.363    0.000    0.452    0.567    1.062    0.664    0.907    0.626    0.777
SHKM    1.269    0.917    0.826    0.902    0.607    0.467    0.000    0.460    0.914    0.803    1.018    0.892    1.085
BNHA    1.305    0.958    0.882    1.046    0.665    0.525    0.460    0.000    0.695    0.432    0.631    0.916    1.093
CAIR    1.811    1.464    1.386    1.551    1.166    1.026    0.911    0.715    0.000    0.731    0.934    1.451    1.628
ZGZG    1.512    1.154    1.065    1.088    0.757    0.704    0.803    0.433    0.707    0.000    0.365    0.754    0.931
ABKB    1.711    1.356    1.268    1.083    0.751    0.907    1.018    0.632    0.910    0.365    0.000    0.676    0.826
MNSR    1.433    1.086    1.009    0.769    0.437    0.648    0.892    1.015    1.452    0.747    0.676    0.000    0.460
SHRB    1.583    1.236    1.161    0.814    0.621    0.848    1.113    1.176    1.641    0.934    0.826    0.460    0.000
DMIT    1.826    1.479    1.403    1.057    0.864    1.091    1.412    1.466    1.972    1.270    1.069    0.703    0.496
PRTS    2.265    1.918    1.843    1.603    1.540    1.530    1.646    1.186    1.704    1.007    1.205    1.449    1.178
ISML    1.882    1.535    1.460    1.688    1.256    1.148    1.263    0.803    1.179    0.620    0.708    1.273    1.423
SWES    2.612    2.265    2.189    2.493    2.047    1.877    1.852    1.533    0.941    1.612    1.653    2.168    2.345
FYUM    2.798    2.398    2.310    2.507    2.160    2.020    1.867    1.718    1.245    1.725    1.928    2.445    2.656
BSWF    2.519    2.172    2.096    2.424    1.954    1.784    1.738    1.440    0.961    1.555    1.758    2.185    2.335
MNIA    3.240    2.893    2.817    3.145    2.675    2.505    2.502    2.161    1.682    2.361    2.563    2.906    3.056
ASYT    3.879    3.532    3.456    3.764    3.314    3.144    3.141    2.800    2.321    3.006    3.205    3.545    3.695
SHAG    4.403    4.056    3.980    4.309    3.836    3.668    3.665    3.324    2.845    3.531    3.729    4.069    4.219
QENA    5.208    4.861    4.765    5.113    4.643    4.473    4.470    4.129    3.650    4.335    4.534    4.874    5.024
ASWN    6.414    6.068    5.992    6.320    5.850    5.680    5.677    5.335    4.857    5.542    5.741    6.080    6.231
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O-D MATRIX (CONTINUED)

         DMIT     PRTS     ISML     SWES     FYUM     BSWF     MNIA     ASYT     SHAG     QENA     ASWN
-------------------------------------------------------------------------------------------------------------
ALEX    1.851    2.385    2.002    2.738    2.791    2.616    3.330    3.968    4.490    5.297    6.504
DMHR    1.504    2.038    1.655    2.338    2.391    2.232    2.983    3.621    4.143    4.950    6.157
ETYB    1.417    1.950    1.568    2.246    2.299    2.141    2.895    3.534    4.055    4.863    6.070
KFRS    1.057    1.803    1.688    2.422    2.537    2.442    3.155    3.794    4.315    5.123    6.329
MHLK    0.808    1.530    1.242    2.042    2.157    1.970    2.683    3.322    3.843    4.651    5.857
TANT    1.019    1.553    1.170    1.916    2.031    1.784    2.498    3.137    3.658    4.466    5.672
SHKM    1.328    1.638    1.256    1.768    1.882    1.711    2.425    3.064    3.585    4.393    5.599
BNHA    1.342    1.178    0.795    1.496    1.663    1.410    2.123    2.762    3.283    4.091    5.298
CAIR    1.871    1.685    1.203    0.854    0.968    0.919    1.633    2.272    2.793    3.601    4.807
ZGZG    1.266    0.954    0.614    1.561    1.676    1.531    2.331    2.969    3.490    4.298    5.505
ABKB    1.069    1.043    0.703    1.653    1.878    1.734    2.529    3.168    3.689    4.497    5.704
MNSR    0.671    1.429    1.266    2.161    2.420    2.257    2.970    3.609    4.130    4.938    6.145
SHRB    0.480    1.178    1.416    2.348    2.610    2.407    3.121    3.759    4.281    5.088    6.295
DMIT    0.000    0.758    1.339    2.205    2.940    2.650    3.363    4.002    4.523    5.331    6.538
PRTS    0.758    0.000    0.583    1.572    2.673    2.370    3.064    3.722    4.244    5.051    6.258
ISML    1.263    0.505    0.000    0.992    2.147    1.987    2.701    3.340    3.861    4.669    5.875
SWES    2.265    1.497    0.992    0.000    1.910    1.720    2.433    3.072    3.593    4.401    5.607
FYUM    2.965    2.679    2.196    2.080    0.000    0.546    1.224    2.152    2.673    3.481    4.687
BSWF    2.576    2.392    2.010    1.761    0.571    0.000    0.955    1.606    2.127    2.935    4.141
MNIA    3.299    3.113    2.731    2.482    1.261    0.966    0.000    1.004    1.525    2.333    3.540
ASYT    3.938    3.752    3.370    3.121    2.185    1.613    1.004    0.000    0.803    1.611    2.817
SHAG    4.462    4.277    3.894    3.645    2.709    2.138    1.529    0.806    0.000    1.114    2.321
QENA    5.267    5.081    4.699    4.450    3.514    2.943    2.333    1.611    1.111    0.000    1.656
ASWN    6.474    6.288    5.905    5.657    4.721    4.149    3.540    2.817    2.318    1.656    0.000
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MODAL SPLIT AND TRIP ASSIGNMENT:
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LINK FROM  TC  LENGTH  FLOW/CAP     FLOW        COST    %CHANGE OF FLOW
---- ---- ---- ------ --------- ---------  ----------- --------------
   1 AXLT QNIT 121.68      0.00     0.000     1.08765     0.00
   2 QNLT AXIT 121.68      0.00     0.000     1.08765     0.00
   3 AXLT DRIT  60.69      0.65  5325.168     0.39994     0.15
   4 DRLT AXIT  60.69      0.24  1936.219     0.39993    -0.04
   5 DRLT QNIT  42.60      0.00     0.000     0.39778     0.00
   6 QNIT DRIT  42.60      0.00     0.000     0.39778     0.00
   7 QNIT KSIT  17.96      0.00    89.670     0.17659    -0.04
   8 KSLT QNIT  17.96      0.00     0.000     0.17659     0.00
   9 KSLT SNIT  63.05      0.00     0.000     0.58523     0.00
  10 SNLT KSIT  63.05      0.00     0.000     0.58523     0.00
  11 SNLT DTIT  40.77      0.02   372.980     0.34128    -0.04
  12 DTLT SNIT  40.77      0.10  1591.322     0.34128    -0.04
  13 SNLT MRIT  23.82      0.15  2966.212     0.26283    -0.04
  14 MRLT SNIT  23.62      0.03   485.935     0.26283    -0.04
  15 MKLT MRIT  25.36      0.12  4288.909     0.20074    -0.04
  16 MRLT MKIT  25.36      0.21  7567.515     0.20074    -0.04
  17 MKLT MHIT  13.23      0.32 13057.575     0.07462    -0.04
  18 MHLT MKIT  13.23      0.23  9614.566     0.07462    -0.04
  19 QNLT MHIT  30.58      0.00     0.000     0.28923     0.00
  20 MHLT QNIT  30.58      0.00    89.670     0.28923    -0.04
  21 DRIT EBIT  25.20      0.85 11608.127     0.16187     0.10
  22 EBLT DRIT  25.20      0.34  4641.005     0.15812    -0.04
  23 EBLT KZIT  17.84      0.91 12467.226     0.12641     0.04
  24 KZLT EBIT  17.84      0.25  3480.619     0.11079    -0.04
  25 KZLT TTIT  17.76      0.91 12467.226     0.12609     0.04
  26 TTIT KZIT  17.76      0.25  3480.619     0.11047    -0.04
  27 TTLT MHIT  14.42      0.13  8936.509     0.07945    -0.04
  28 MHLT TTIT  14.42      0.19 12925.704     0.07945    -0.04
  29 MHLT ZTIT  30.49      0.05   131.867     0.22289    -0.04
  30 ZTLT MHIT  30.49      0.28   767.726     0.22289    -0.04
  31 MRLT AKIT  47.54      0.05  1626.092     0.48623    -0.04
  32 AKLT MRLT  47.54      0.05  1729.160     0.48623    -0.04
  33 AKLT ZGIT  23.00      0.12  4706.255     0.21653    -0.04
  34 ZGLT AKIT  23.00      0.15  5830.139     0.21653    -0.04
  35 ZTLT ZGIT  29.92      0.14  3855.200     0.25063     0.22
  36 ZGLT ZTIT  29.92      0.10  2869.842     0.25063     0.24
  37 ILLT ZGIT  78.32      0.15  2841.995     0.51337    -0.04
  38 ZGLT ILIT  78.32      0.11  2057.110     0.51337    -0.04
  39 BHIT ZGIT  35.00      0.00     0.000     0.23283     0.00
  40 ZGLT BHIT  35.00      0.01   363.578     0.23283    -0.04
  41 BHLT ZTLT  33.76      0.02   575.104     0.29840    -0.04
  42 ZTLT BHIT  33.76      0.07  1681.934     0.29840    -0.04
  43 TTLT ZTIT  26.29      0.20  5405.269     0.20285     0.15
  44 ZTLT TTIT  26.29      0.10  2677.219     0.20285     0.26
  45 TTLT BHIT  41.40      1.01 13778.633     0.36723    -0.04
  46 BHLT TTIT  41.40      0.97 13216.712     0.30198     0.21
  47 TTLT SKIT  28.13      0.20  7536.124     0.21638    -0.04
  48 SKLT TTIT  28.13      0.20  7735.948     0.21638    -0.04
  49 KZLT MFIT  49.87      0.00     0.000     0.46123     0.00
  50 MFLT KZIT  49.87      0.00     0.000     0.46123     0.00
  51 EBLT IBIT 119.57      0.18  2472.170     0.97742     0.31
  52 IBLT EBIT 119.57      0.19  2561.932     0.97742    -0.04
  53 SKLT MFIT  13.56      0.10  3775.107     0.12642    -0.04
  54 MFLT SKIT  13.56      0.35 13590.259     0.12642    -0.04
  55 MFLT BHIT  26.85      0.00     0.000     0.25566     0.00
  56 BHLT MFIT  26.85      0.00     0.000     0.25566     0.00
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 57 BHLT QBIT  30.87         1.02 16826.045      0.36239   -0.04
 58 QBLT BHIT  30.87         1.03 16965.270      0.39174   -0.01
 59 MFLT QBIT  51.38         0.13  3775.107      0.42713   -0.04
 60 QBIT MFIT  51.38         0.45 13590.259      0.42713   -0.04
 61 QBLT CRIT  14.14         1.35 34279.863      0.09579   -0.04
 62 CRLT QBIT  14.14         0.52 50930.734      0.09579   -0.03
 63 IBLT CRIT   3.28         0.31  9413.222      0.03778    0.10
 64 CRLT IBIT   3.28         0.24  7294.088      0.03778   -0.04
 65 IBLT GZIT   9.67         0.25  5439.927      0.07767   -0.04
 66 GZLT IBIT   9.67         0.35  7648.797      0.07767    0.02
 67 GZLT WTIT  79.03         0.50  5439.927      0.51975   -0.04
 68 WTLT GZIT  79.03         0.70  7648.797      0.51962    0.02
 69 WTLT BSIT  31.95         0.00    45.962      0.20298   -0.04
 70 BSLT WTIT  31.95         0.14  2216.773      0.20298   -0.04
 71 WTLT FMIT  37.74         0.99  5394.025      0.36133   -0.04
 72 FMLT WTIT  37.74         0.99  5432.026      0.37264    0.05
 73 BSLT MNIT 122.73         0.00     2.542      0.77735   -0.04
 74 MNLT BSIT 122.73         0.04   481.699      0.77735   -0.04
 75 MNLT ATIT 128.37         0.00     0.000      0.78622    0.00
 76 ATIT MNIT 128.37         0.00     0.000      0.78622    0.00
 77 ATLT SGIT  91.95         0.00     0.000      0.67356    0.00
 78 SGLT ATIT  91.95         0.00     0.000      0.67356    0.00
 79 SGLT QEIT 141.59         0.00     0.000      1.03568    0.00
 80 QELT SGIT 141.59         0.00     0.000      1.03568    0.00
 81 QELT ANIT 270.22         0.00     0.000      1.72502    0.00
 82 ANLT QEIT 270.22         0.00     0.000      1.72502    0.00
 83 QBLT ZGIT  26.94         0.93 20375.195      0.37052   -0.04
 84 ZGLT QBIT  26.94         0.62 13678.713      0.34666   -0.04
 87 ALEX AXIT   0.00   5325.17  5325.168      0.26483    0.15
 88 AXIT ALEX   0.00   1936.22  1936.219      0.09793   -0.04
 89 DMHR DRIT   0.00   6282.95  6282.954      0.26483    0.05
 90 DRLT DMHR   0.00   2704.79  2704.786      0.09793   -0.04
 91 ETYB EBIT   0.00   3331.27  3331.269      0.33478    0.05
 92 EBLT ETYB   0.00   1401.52  1401.517      0.16788   -0.04
 93 KFRS KSIT   0.00      0.00     0.000      0.27882    0.00
 94 KSLT KFRS   0.00     89.67    89.670      0.11192   -0.04
 95 MHIK MKIT   0.00   5490.06  5490.057      0.16690   -0.04
 96 MKLT MHIK   0.00   5325.65  5325.655      0.01400   -0.04
 97 TANT TTIT   0.00  10579.14 10579.140      0.19468   -0.04
 98 TTLT TANT   0.00  20462.79 20462.795      0.02798    0.16
 99 SHKM SKIT   0.00   8836.76  8836.759      0.22286   -0.04
100 SKLT SHKM   0.00  18454.09 18454.094      0.05596   -0.04
101 BNHA BHIT   0.00  15672.44 15672.437      0.19468    0.14
102 BHLT BNHA   0.00  17843.99 17843.994      0.02798   -0.04
103 CAIR CRIT   0.00  51730.61 51730.609      0.20887   -0.04
104 CRLT CAIR   0.00  37198.87 37198.871      0.04197   -0.01
105 ZGZG ZGIT   0.00   8977.23  8977.229      0.22286    0.05
106 ZGLT ZGZG   0.00  15956.50 15956.495      0.05596    0.02
107 ABKB AKLT   0.00   3078.17  3078.166      0.20887   -0.04
108 AKLT ABKB   0.00   4100.98  4100.976      0.04197   -0.04
109 MNSR MRIT   0.00   6229.40  6229.396      0.26483   -0.04
110 MRLT MNSR   0.00   5532.14  5532.136      0.09793   -0.04
111 SHRB SNIT   0.00   1374.89  1374.889      0.22286   -0.04
112 SNLT SHRB   0.00    112.95   112.955      0.05596   -0.04
113 DMIT DTIT   0.00   1591.32  1591.322      0.18089   -0.04
114 DTLT DMIT   0.00    372.98   372.980      0.01400   -0.04
115 PRTS PSIT   0.00      0.00     0.000      0.19468    0.00
116 PSLT PRTS   0.00      0.00     0.000      0.02798    0.00
117 ISML ILIT   0.00   2841.99  2841.995      0.18089   -0.04
118 ILLT ISML   0.00   2057.11  2057.119      0.01400   -0.04
119 FYUM FMIT   0.00   5432.03  5432.026      0.19468    0.05
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120 FMLT FYUM    0.00   5394.02  5394.025        0.0279     -0.04
121 BSWF BSLT    0.00   1735.07  1735.073        0.19488    -0.04
122 BSLT BSWF    0.00     43.36    43.360        0.02798    -0.04
123 MNIA MNIT    0.00    481.70   481.639        0.22286    -0.04
124 MNIT MNIA    0.00      2.54     2.542        0.05596    -0.04
125 ASYT ATIT    0.00      0.00     0.000        0.25084     0.00
126 ATLT ASYT    0.00      0.00     0.000        0.08394     0.00
127 SHAG SGIT    0.00      0.00     0.000        0.25064     0.00
128 SGLT SHAG    0.00      0.00     0.000        0.08394     0.00
129 QENA QEIT    0.00      0.00     0.000        0.36276     0.00
130 QELT QENA    0.00      0.00     0.000        0.19566     0.00
131 ASWN ANIT    0.00      0.00     0.000        0.27882     0.00
132 ANLT ASWN    0.00      0.00     0.000        0.11192     0.00
133 AXET DRET   60.69      0.53 16999.018        0.31897    -0.04
134 DRET AXET   60.69      0.29  9220.007        0.31897    -0.04
135 DRET QNET   42.60      0.00    30.104        0.34873    -0.04
136 QNET DRET   42.60      0.00     0.000        0.34873     0.00
137 DRET EBET   25.20      0.90 21868.785        0.14355    -0.04
138 EBET DRET   25.20      0.71 17239.506        0.13148    -0.04
139 EBET KZET   17.84      0.97 23541.387        0.14985    -0.04
140 KZET EBET   17.84      0.89 21636.900        0.10733    -0.04
141 KZET TTET   17.76      0.97 23541.387        0.14952    -0.04
142 TTET KZET   17.76      0.89 21636.900        0.10701    -0.04
143 TTET MHET   14.42      0.72  8705.812        0.07328    -0.04
144 MHET TTET   14.42      0.74  8967.715        0.07338     0.01
145 MHET QNET   30.58      0.00     0.000        0.24917     0.00
146 QNET MHET   30.58      0.01    30.104        0.24917    -0.04
147 QNET KSET   42.60      0.00     0.000        0.32774     0.00
148 KSET QNET   42.60      0.00     0.000        0.32774     0.00
149 KSET SNET   63.05      0.06   265.397        0.51879    -0.04
150 SNET KSET   63.05      0.06   295.951        0.51879    -0.04
151 SNET DTET   40.77      0.20  1854.152        0.27071    -0.04
152 DTET SNET   40.77      0.42  3875.802        0.27071     0.04
153 SNET MRET   23.82      0.64  5802.857        0.17853     0.04
154 MRET SNET   23.82      0.50  4527.689        0.17852    -0.04
155 MKET MRET   25.36      0.79  7161.620        0.17480    -0.04
156 MRET MKET   25.36      0.96  8745.255        0.21721     0.01
157 MHET MKET   13.23      0.96  8735.915        0.11057    -0.04
158 MKET MHET   13.23      0.98  8967.715        0.13968     0.01
159 MRET AKET   47.54      0.33  1501.167        0.40838    -0.04
160 AKET MRET   47.54      0.20   912.938        0.40838    -0.04
161 PSET ILET   77.94      0.65  2962.506        0.36879     0.02
162 ILET PSET   77.94      0.30  1354.724        0.36677    -0.04
163 ZGET AKET   23.00      0.24  1088.323        0.21270    -0.04
164 AKET ZGET   23.00      0.37  1696.525        0.21270    -0.04
165 ZGET ILET   78.32      0.50  3830.198        0.39131    -0.04
166 ILET ZGET   78.32      0.88  6654.289        0.39832     0.04
167 ZGET BHET   35.00      0.79 13165.065        0.19342    -0.01
168 BHET ZGET   35.00      0.64 10733.174        0.19260    -0.04
169 TTET BHET   41.40      1.02 27772.984        0.37476    -0.04
170 BHET TTET   41.40      1.00 27419.369        0.34425    -0.04
171 TTET SKET   28.13      1.08  1639.323        0.65529    -0.04
172 SKET TTET   28.13      1.00  1514.250        0.29466    -0.04
173 SKET MFET   13.56      1.00  1515.863        0.19265    -0.04
174 MFET SKET   13.56      1.01  1527.618        0.20674    -0.04
175 MFET QBET   51.38      1.00  1515.863        0.43702    -0.04
176 QBET MFET   51.38      1.01  1527.616        0.45292    -0.04
177 BHET QBET   30.87      1.02 45071.246        0.34214    -0.04
178 QBET BHET   30.87      1.02 44954.473        0.33425    -0.04
179 QBET CPET   14.14      0.99 46587.035        0.15215    -0.04
180 CRET QBET   14.14      0.99 46482.105        0.15664    -0.04
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181 CRET SSET 144.56          0.11    673.578      0.8142[illegible]  -0.04
182 SSET CRET 144.56          0.34   2039.023      0.81420  -0.04
183 CRET IBET   3.28          0.46  14691.392      0.03794  -0.04
184 IBET CRET   3.28          0.89  28285.506      0.04665  -0.01
185 IBET GZET   9.67          0.46  14691.392      0.06416  -0.04
186 GZET IBET   9.67          0.89  28285.506      0.07307  -0.01
187 GZET BSET 110.98          0.46  14691.392      0.56378  -0.04
188 BSET GZET 110.98          0.93  28285.506      0.56742  -0.01
189 BSET MNET 122.73          0.34   7719.718      0.65748  -0.04
190 MNET BSET 122.73          0.88  20034.752      0.66501   0.00
191 MNET ATET 128.37          0.28   6445.104      0.68062  -0.04
192 ATET MNET 128.37          0.75  17043.479      0.68092  -0.01
193 ATET SGET  91.95          0.30   5531.691      0.51020  -0.04
194 SGET ATET  91.95          0.69  12633.202      0.51027  -0.01
195 SGET QEET 141.59          0.25   3450.862      0.73486  -0.04
196 QEET SGET 141.59          0.63   8592.095      0.73487   0.01
197 QEET ANET 270.22          0.19   1161.977      1.26266  -0.04
198 ANET QEET 270.22          0.60   3664.024      1.26267   0.00
199 ALEX AXET   0.00      16999.02  16999.018      0.26753  -0.04
200 AXET ALEX   0.00       9220.01   9220.007      0.09793  -0.04
201 DMHR DRET   0.00       5772.13   5772.132      0.23955  -0.04
202 DRET DMHR   0.00       8871.76   8871.763      0.06995  -0.04
203 ETYB EBET   0.00       3132.62  -3132.624      0.29551  -0.04
204 EBET ETYB   0.00       5877.42   5877.423      0.12591  -0.04
205 KFRS KSET   0.00        265.40    265.397      0.25354  -0.04
206 KSET KFRS   0.00        295.95    295.951      0.08394  -0.04
207 MHLK MKET   0.00       2073.64   2073.637      0.16960  -0.04
208 MKET MHLK   0.00       3425.27   3425.272      0.01400  -0.04
209 TANT TTET   0.00      17326.24  17326.242      0.19758  -0.04
211 TTET TANT   0.00      19013.93  19013.926      0.02798  -0.02
212 SHKM SKET   0.00       3030.05   3030.053      0.21157  -0.04
213 SKET SHKM   0.00       3166.94   3166.939      0.04197  -0.04
214 BNHA BHET   0.00      41415.67  41415.668      0.19758  -0.04
215 BHET BNHA   0.00      44084.42  44084.422      0.02798  -0.03
217 CAIR CRET   0.00      45783.18  45783.180      0.21157  -0.04
218 CRET CAIR   0.00      60847.69  60847.691      0.04197  -0.03
219 ZGZG ZGET   0.00       5880.98   5880.975      0.21157  -0.04
220 ZGET ZGZG   0.00       6881.37   6881.367      0.04197  -0.01
221 ABKB AKET   0.00       1770.28   1770.276      0.19758  -0.04
222 AKET ABKB   0.00       1758.30   1758.304      0.02798  -0.04
223 MNSR MRET   0.00       5095.98   5095.979      0.23955  -0.04
224 MRET MNSR   0.00       4199.49   4199.490      0.06995  -0.04
225 SHRB SNET   0.00       2617.31   2617.311      0.21157   0.13
226 SNET SHRB   0.00       3333.24   3333.239      0.04197   0.06
227 DMIT DTET   0.00       3875.80   3875.802      0.18359   0.04
228 DTET DMIT   0.00       1854.15   1854.152      0.01400  -0.04
229 PRTS PSET   0.00       2962.51   2962.506      0.19758   0.02
230 PSET PRTS   0.00       1354.72   1354.724      0.02798  -0.04
231 ISML ILET   0.00       3984.25   3984.255      0.18359   0.05
232 ILET ISML   0.00       2767.95   2767.950      0.01400  -0.04
233 SWES SSET   0.00       2039.02   2039.023      0.19758  -0.04
234 SSET SWES   0.00        673.58    673.578      0.02798  -0.04
235 FYUM FMET   0.00          0.00      0.000      0.18359   0.00
236 FMET FYUM   0.00          0.00      0.000      0.01400   0.00
237 BSWF BSET   0.00      11646.35  11646.352      0.21157  -0.04
238 BSET BSWF   0.00      10367.28  10367.282      0.04197  -0.04
239 MNIA MNET   0.00       5753.55   5753.550      0.26753   0.01
240 MNET MNIA   0.00       4036.89   4036.892      0.09793  -0.04
241 ASYT ATET   0.00      10367.62  10367.615      0.22556   0.00
242 ATET ASYT   0.00       6870.75   6870.751      0.05596   0.01
243 SHAG SGIT   0.00       7662.19   7662.186      0.23955   0.06
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244 SGET SHAG    0.00   5701.88  5701.882        0.067[illegible]    0.04
245 QENA QEET    0.00   6753.94  6753.937        0.30950     0.00
246 QEET QENA    0.00   4114.78  4114.776        0.13990    -0.04
247 ASWN ANET    0.00   3664.02  3664.024        0.25354     0.00
248 ANET ASWN    0.00   1161.98  1161.977        0.08394    -0.04
249 DTEB PSEB   63.00      1.12   781.036        1.29072    -0.04
250 PSEB DTEB   63.00      1.09   757.016        0.82479    -0.04
251 DTEB SNEB   42.00      1.06  1660.310        0.51812    -0.04
252 SNEB DTEB   42.00      0.98  1534.399        0.25929    -0.04
253 SNEB MREB   24.10      0.97  2771.945        0.16037    -0.04
254 MREB SNEB   24.10      0.93  2675.401        0.13485    -0.04
255 MREB SLEB   20.20      1.07  1399.944        0.50598    -0.04
256 SLEB MREB   20.20      1.11  1451.615        0.94634    -0.04
257 SLEB ZGEB   30.70      1.12   872.374        1.02805    -0.04
258 ZGEB SLEB   30.70      1.14   892.321        1.53748    -0.04
259 SLEB AKEB   30.00      1.01   527.570        0.26073    -0.04
260 AKEB SLEB   30.00      1.07   559.295        0.53464    -0.04
261 MREB BHEB   75.20      1.08   187.482        0.78035    -0.04
262 BHEB MREB   75.20      1.08   187.237        0.76889    -0.04
263 SKEB BHEB   26.00      1.06    91.914        0.41636    -0.04
264 BHEB SKEB   26.00      1.08    93.826        0.56948    -0.04
265 BHEB ZGEB   35.00      1.07  1764.634        0.53395    -0.04
266 ZGEB BHEB   35.00      1.10  1810.084        0.78191    -0.04
267 ZGEB AKEB   25.50      0.63  1948.492        0.11653    -0.04
268 AKEB ZGEB   25.50      0.70  2159.498        0.11660     0.11
269 AKEB ILEB   70.50      1.07   371.275        0.68718    -0.04
270 ILEB AKEB   70.50      1.10   382.187        0.97368    -0.04
271 ILEB PSEB   76.00      0.79   483.317        0.34007    -0.04
272 PSEB ILEB   76.00      1.12   664.485        1.37409    -0.04
273 ILEB ZGEB   81.00      0.87  1918.611        0.39906    -0.04
274 ZGEB ILEB   81.00      0.55  1220.813        0.39349    -0.04
275 ILEB SSEB   89.00      1.14   594.655        1.76152    -0.04
276 SSEB ILEB   89.00      1.11   577.898        1.17160    -0.04
277 SSEB CREB  133.50      1.01  1058.551        0.76253     0.13
278 CREB SSEB  133.50      1.03  1074.250        0.80769    -0.04
279 CREB ZGEB   77.20      1.06  1702.271        0.76439    -0.04
280 ZGEB CREB   77.20      1.06  1697.403        0.76690    -0.04
281 CREB BHEB   47.20      1.05  2728.671        0.75697    -0.04
282 BHEB CREB   47.20      0.04   104.047        0.50951    -0.04
283 SHKM SKEB    0.00     91.91    91.914        0.17863    -0.04
284 SKEB SHKM    0.00     93.83    93.828        0.06995    -0.04
285 BNHA BHEB    0.00   2030.92  2030.920        0.15085    -0.04
286 BHEB BNHA    0.00   4699.52  4699.522        0.04197    -0.04
287 CAIR CREB    0.00   5314.19  5314.195        0.15085    -0.04
288 CREB CAIR    0.00   2666.81  2666.805        0.04197     0.03
289 ZGZG ZGEB    0.00   2534.77  2534.768        0.19282    -0.04
290 ZGEB ZGZG    0.00   3383.23  3383.233        0.08394     0.06
291 ABKB AKEB    0.00   2391.69  2391.694        0.16484     0.10
292 AKEB ABKB    0.00   2159.86  2159.863        0.05596    -0.04
293 MNSR MREB    0.00   2228.50  2228.496        0.24878    -0.04
294 MREB MNSR    0.00   2376.47  2376.469        0.13990    -0.04
295 SHRB SNEB    0.00   2065.17  2065.169        0.19282    -0.04
296 SNEB SHRB    0.00   2094.54  2094.535        0.08394    -0.04
297 DMIT DTEB    0.00   1723.44  1723.437        0.13686    -0.04
298 DTEB DMIT    0.00   1573.51  1573.506        0.02798    -0.04
299 PRTS PSEB    0.00    726.53   726.529        0.13686    -0.04
300 PSEB PRTS    0.00    549.38   549.381        0.02798    -0.04
301 ISML ILEB    0.00   2048.32  2048.320        0.13686    -0.04
302 ILEB ISML    0.00   1523.82  1523.822        0.02798    -0.04
303 SWES SSEB    0.00   1580.66  1580.658        0.13686     0.06
304 SSEB SWES    0.00   1613.31  1613.314        0.02798    -0.04
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305 AXMB DRMB  56.50      1.09   237.018      0.83[illegible]03   -0.04
306 DRMB AXMB  56.50      1.02   220.353      0.38189    6.38
307 DRMB EBMB  25.70      1.09   237.018      0.69593   -0.04
308 EBMB DRMB  25.70      0.90   195.890      0.12461    7.19
309 EBMB TTMB  39.00      1.11   243.285      0.93774   -0.04
310 TTMB EBMB  39.00      1.06   229.942      0.48834    6.12
311 TTMB KSMB  39.00      1.09  2329.560      0.77784   -0.04
312 KSMB TTMB  39.00      1.03  2189.871      0.35230    0.19
313 KSMB SNMB  63.30      1.01   526.415      0.41692   -0.04
314 SNMB KSMB  63.30      1.05   546.255      0.53727   -0.04
315 MKMB MRMB  19.50      0.95  1564.843      0.12293   -0.04
316 MRMB MKMB  19.50      1.08  1781.826      0.54316   -0.04
317 TTMB MKMB  26.50      1.06  3211.335      0.40892   -0.04
318 MKMB TTMB  26.50      0.97  2947.596      0.16826    0.11
319 TTMB ZGMB  55.00      1.03   673.641      0.44346   -0.04
320 ZGMB TTMB  55.00      1.05   683.530      0.50848   -0.04
321 BHMB MRMB  75.20      1.11   386.001      1.13017   -0.04
322 MRMB BHMB  75.20      1.08   375.354      0.78971    2.13
323 TTMB BHMB  43.00      1.03  3536.606      0.38782    0.10
324 BHMB TTMB  43.00      1.05  3616.453      0.48924 . -0.04
325 TTMB SKMB  26.00      1.01  4183.079      0.24557   -0.04
326 SKMB TTMB  26.00      1.04  4190.984      0.31844   -0.04
327 SKMB BHMB  26.00      1.04  1630.540      0.34345   -0.04
328 BHMB SKMB  26.00      1.07  1670.742      0.48603   -0.04
329 SKMB CRMB  65.50      1.09  2942.062      0.99625   -0.04
330 CRMB SKMB  65.50      1.10  2972.188      1.12685   -0.04
331 CRMB BHMB  47.20      0.90  5262.195      0.52261   -0.04
332 BHMB CRMB  47.20      0.12   719.928      0.50951    1.78
333 KSMB MKMB  26.00      1.12  2135.457      1.02145   -0.04
334 MKMB KSMB  26.00      1.00  1919.035      0.22531   -0.04
335 ALEX AXMB   0.00    237.02   237.018      0.20681   -0.04
336 AXMB ALEX   0.00    220.35   220.353      0.09793    6.38
337 DMHR DRMB   0.00    157.28   157.279      0.26277   -0.04
338 DRMB DMHR   0.00    132.82   132.815      0.15389   -0.04
339 ETYB EBMB   0.00      3.27     3.267      0.36070   -0.04
340 EBMB ETYB   0.00     34.05    34.052      0.25182   -0.04
341 KFRS KSMB   0.00   4742.42  4742.420      0.27676    0.07
342 KSMB KFRS   0.00   4683.53  4683.526      0.16788   -0.04
343 MHIK MKMB   0.00   3693.01  3693.006      0.10888    0.08
344 MKMB MHIK   0.00   4390.15  4390.147      0.01399   -0.04
345 TANT TTMB   0.00   8522.98  8522.984      0.13686    0.13
346 TTMB TANT   0.00   8310.54  8310.541      0.02798    0.01
347 SHKM SKMB   0.00   7800.90  7800.897      0.17863   -0.04
348 SKMB SHKM   0.00   7780.31  7780.312      0.06995   -0.04
349 BNHA BHMB   0.00   5093.22  5093.215      0.15085   -0.04
350 BHMB BNHA   0.00   9504.79  9504.786      0.04197   -0.04
351 CAIR CRMB   0.00   8234.38  8234.384      0.15085   -0.04
352 CRMB CAIR   0.00   3661.99  3661.992      0.04197    0.32
353 ZGZG ZGMB   0.00    683.53   683.530      0.19282   -0.04
354 ZGMB ZGZG   0.00    673.64   673.641      0.08394   -0.04
355 MNSR MRMB   0.00   2031.07  2031.067      0.24878    0.36
356 MRMB MNSR   0.00   1824.73  1824.731      0.13990   -0.04
357 SHRB SNMB   0.00    546.25   546.255      0.19282   -0.04
358 SNMB SHRB   0.00    528.42   528.415      0.08394   -0.04
359 AXWB DRWB  56.50      0.99  2579.671      0.32639   -0.04
360 DRWB AXWB  56.50      0.95  2482.365      0.28325    1.79
361 DRWB KSWB  57.40      1.05   363.805      0.50538   -0.04
362 KSWB DRWB  57.40      1.09   378.465      0.79801   -0.04
363 DRWB EBWB  25.70      0.34   757.622      0.11190   -0.04
364 EBWB DRWB  25.70      0.44   992.234      0.11190    4.55
365 EBWB CRWB 126.70      1.09   378.634      1.23010   -0.04
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366 CRWB EBWB 126.70          1.17    407.077         2.990[illegible]     11.13
367 ALEX AXWB   0.00       2579.67   2579.671         0.20681     -0.04
368 AXWB ALEX   0.00       2482.37   2482.365         0.09793      1.79
369 DMHR DRWB   0.00       1454.12   1454.122         0.26277     -0.04
370 DRWB DMHR   0.00       1800.70   1800.700         0.15389     -0.04
371 ETYB EBWB   0.00        585.16    585.157         0.36070     -0.04
372 EBWB ETYB   0.00        378.99    378.989         0.25182     -0.04
373 KFRS KSWB   0.00        378.47    378.465         0.27676     -0.04
374 KSWB KFRS   0.00        363.80    363.805         0.16788     -0.04
375 CAIR CRWB   0.00        407.08    407.077         0.15085     11.13
376 CRWB CAIR   0.00        378.63    378.634         0.04197     -0.04
377 CRUB SSUB 133.50          0.99    257.990         0.67493     -0.04
378 SSUB CRUB 133.50          1.09    284.718         1.16514     -0.04
379 CRUB GZUB  10.00          0.57    745.651         0.07585     -0.04
380 GZUB CRUB  10.00          0.63    818.727         0.07586     -0.04
381 GZUB FMUB  97.50          1.01    745.651         0.69964     -0.04
382 FMUB GZUB  97.50          1.11    818.727         1.35608     -0.04
383 GZUB BSUB 118.50          0.00      0.000         0.83871      0.00
384 BSUB GZUB 118.50          0.00      0.000         0.83871      0.00
385 FMUB BSUB  43.00          1.01   1447.839         0.31135     -0.04
386 BSUB FMUB  43.00          1.02   1461.807         0.33665      0.35
387 BSUB MNUB 130.00          0.52    567.447         0.58002     -0.04
388 MNUB BSUB 130.00          0.90    975.292         0.59145     -0.04
389 SWES SSUB   0.00        284.72    284.718         0.13686     -0.04
390 SSUB SWES   0.00        257.99    257.990         0.02798     -0.04
391 CAIR CRUB   0.00        956.01    956.013         0.15085     -0.04
392 CRUB CAIR   0.00       1055.82   1055.818         0.04197     -0.04
393 FYUM FMUB   0.00       2266.57   2266.566         0.15085     -0.04
394 FMUB FYUM   0.00       2207.46   2207.459         0.04197      0.22
395 BSWF BSUB   0.00       1339.47   1339.468         0.19282      0.38
396 BSUB BSWF   0.00       1733.34   1733.345         0.08394     -0.04
397 MNIA MNUB   0.00        975.29    975.292         0.29075     -0.04
398 MNUB MNIA   0.00        567.45    567.447         0.18187     -0.04
399 AXTX DRTX  56.50          0.02    547.064         0.47602     -0.04
400 DRTX AXTX  56.50          0.01    266.047         0.47602     -0.04
401 DRTX EBTX  25.70          0.00      0.000         0.21653      0.00
402 EBTX DRTX  25.70          0.00      0.000         0.21653      0.00
403 DRTX KSTX  57.40          0.19    973.864         0.49391     -0.04
404 KSTX DRTX  57.40          0.13    653.652         0.49391     -0.04
405 KSTX TTTX  39.00          0.96   4711.191         0.39760     -0.04
406 TTTX KSTX  39.00          0.47   2305.523         0.35051     -0.04
407 KSTX MKTX  26.00          0.32   1579.712         0.23368     -0.04
408 MKTX KSTX  26.00          0.21   1029.744         0.23368     -0.04
409 TTTX MKTX  26.50          0.01    197.383         0.22327     -0.04
410 MKTX TTTX  26.50          0.03    990.371         0.22327     -0.04
411 KSTX SNTX  63.30          0.00      0.000         0.56891      0.00
412 SNTX KSTX  63.30          0.02     78.295         0.56891     -0.04
413 SNTX DTTX  42.00          0.07    359.202         0.37748     -0.04
414 DTTX SNTX  42.00          0.11    551.982         0.37748     -0.04
415 MKTX SNTX  48.00          0.00      0.000         0.43140      0.00
416 SNTX MKTX  48.00          0.00      0.000         0.43140      0.00
417 MRTX SNTX  24.10          0.83   4079.740         0.21925     -0.04
418 SNTX MRTX  24.10          0.90   4413.797         0.22938     -0.04
419 MKTX MRTX  19.50          0.20    954.420         0.17526     -0.04
420 MRTX MKTX  19.50          0.37   1806.150         0.17526     -0.04
421 MRTX SLTX  20.20          0.53   2609.933         0.18155     -0.04
422 SLTX MRTX  20.20          0.88   4283.335         0.18856     -0.04
423 MKTX SLTX  32.00          0.30   1484.563         0.27535     -0.04
424 SLTX MKTX  32.00          0.22   1124.143         0.27535     -0.04
425 SLTX AKTX  30.00          0.09    432.819         0.26963     -0.04
426 AKTX SLTX  30.00          0.09    452.698         0.26963     -0.04
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427 SLTX ZGTX  30.70      0.48  3661.677      0.26122   -0.04
428 ZGTX SLTX  30.70      0.64  4954.780      0.26124   -0.04
429 EBTX TTTX  39.00      0.00   135.062      0.32858   -0.04
430 TTTX EBTX  39.00      0.01   261.231      0.32858   -0.04
431 TTTX ZGTX  55.00      0.00     0.000      0.49431    0.00
432 ZGTX TTTX  55.00      0.00     0.000      0.49431    0.00
433 TTTX BHTX  43.00      0.05  1451.489      0.40518   -0.04
434 BHTX TTTX  43.00      0.01   290.122      0.40518   -0.04
435 TTTX SKTX  26.00      0.56  2736.628      0.23368   -0.04
436 SKTX TTTX  26.00      0.28  1377.010      0.23368   -0.04
437 SKTX BHTX  26.00      0.48  8573.492      0.22621    0.11
438 BHTX SKTX  26.00      0.57 10304.994      0.22621   -0.04
439 SKTX DHTX  39.50      0.92  4511.588      0.37482   -0.04
440 DHTX SKTX  39.50      0.85  4173.863      0.35919   -0.04
441 EBTX DHTX 100.70      0.00     0.000      0.85685    0.00
442 DHTX EBTX 100.70      0.00     0.000      0.85685    0.00
443 DHTX GZTX  29.00      0.01    69.276      0.34264   -0.04
444 GZTX DHTX  29.00      0.10   512.527      0.34264   -0.04
445 DHTX CRTX  26.00      0.91  4442.312      0.31821   -0.04
446 CRTX DHTX  26.00      0.75  3661.355      0.30398   -0.04
447 GZTX AXTX 173.50      0.00     0.000      1.86791    0.00
448 AXTX GZTX 173.50      0.00     0.000      1.86791    0.00
449 CRTX BHTX  47.20      0.00     8.662      0.61067   -0.04
450 BHTX CRTX  47.20      0.00     0.000      0.61067    0.00
451 BHTX ZGTX  35.00      0.31  1521.912      0.31456   -0.04
452 ZGTX BHTX  35.00      0.26  1284.950      0.31456   -0.04
453 ZGTX CRTX  77.20      0.00     0.000      0.76384    0.00
454 CRTX ZGTX  77.20      0.24  1159.202      0.76384   -0.04
455 ZGTX AKTX  25.50      0.02    99.951      0.22918   -0.04
456 AKTX ZGTX  25.50      0.08   391.661      0.22918   -0.04
457 DTTX PSTX  63.00      0.03   139.832      0.56622   -0.04
458 PSTX DTTX  63.00      0.03   141.598      0.56622   -0.04
459 PSTX ILTX  76.00      0.00     0.000      0.64668    0.00
460 ILTX PSTX  76.00      0.00     0.000      0.64668    0.00
461 ILTX AKTX  70.50      0.00    21.086      0.63362   -0.04
462 AKTX ILTX  70.50      0.01    34.645      0.63362   -0.04
463 ILTX ZGTX  81.00      0.00     0.000      0.68244    0.00
464 ZGTX ILTX  81.00      0.00     0.000      0.68244    0.00
465 ILTX CRTX 123.50      0.00     0.000      1.31885    0.00
466 CRTX ILTX 123.50      0.00     0.000      1.31885    0.00
467 ILTX SSTX  89.00      0.00     4.985      0.79989   -0.04
468 SSTX ILTX  89.00      0.03   165.630      0.79989   -0.04
469 SSTX CRTX 133.50      0.00     0.000      1.18694    0.00
470 CRTX SSTX 133.50      0.00     0.006      1.18694    0.00
471 CRTX GZTX  10.00      0.00     0.000      0.10938    0.00
472 GZTX CRTX  10.00      0.22  3083.837      0.10938   -0.04
473 GZTX FMTX  97.50      0.01    69.276      0.93112   -0.04
474 FMTX GZTX  97.50      0.47  3596.364      0.93112   -0.04
475 GZTX BSTX 118.50      0.00     0.000      1.22561    0.00
476 BSTX GZTX 118.50      0.00     0.000      1.22561    0.00
477 FMTX BSTX  43.00      0.07   531.317      0.36588   -0.04
478 BSTX FMTX  43.00      0.06   485.039      0.36588   -0.04
479 BSTX MNTX 130.00      0.00     0.000      1.10616    0.00
480 MNTX BSTX 130.00      0.00     0.000      1.10616    0.00
481 MNTX ATTX 135.50      0.00     0.000      1.15296    0.00
482 ATTX MNTX 135.50      0.00     0.000      1.15296    0.00
483 ATTX SGTX  95.00      0.00     0.000      0.80835    0.00
484 SGTX ATTX  95.00      0.00     0.000      0.80835    0.00
485 SGTX QNTX 141.50      0.00     0.000      1.20401    0.00
486 QNTX SGTX 141.50      0.00     0.000      1.20401    0.00
487 QNTX ANTX 271.00      0.00     0.000      2.33186    0.00
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488 ANTX QNTX 271.00      0.00     0.000       2.33186    0.00
489 BHTX MRTX  75.20      0.64  3285.513       0.63988   -0.04
490 MRTX BHTX  75.20      1.03  5318.449       0.81467   -0.04
491 ALEX AXTX   0.00    547.06   547.064       0.24793   -0.04
492 AXTX ALEX   0.00    266.05   266.047       0.09793   -0.04
493 DMHR DRTX   0.00    426.80   426.800       0.24793   -0.04
494 DRTX DMHR   0.00    387.61   387.605       0.09793   -0.04
495 ETYB EBTX   0.00    135.06   135.062       0.31768   -0.04
496 EBTX ETYB   0.00    261.23   261.231       0.16788   -0.04
497 KFRS KSTX   0.00   6944.56  6944.558       0.26192   -0.04
498 KSTX KFRS   0.00   4387.43  4387.426       0.11192   -0.04
499 MHIK MKTX   0.00    713.74   713.744       0.16399   -0.04
500 MKTX MHIK   0.00    962.04   962.036       0.01399   -0.04
501 TANT TTTX   0.00    792.35   792.353       0.17798   -0.04
502 TTTX TANT   0.00   1343.85  1343.854       0.02798   -0.04
503 SHKM SKTX   0.00  11959.33 11959.334       0.20596    0.06
504 SKTX SHKM   0.00  14712.76 14712.758       0.05596   -0.04
505 BNHA BHTX   0.00  12595.68 12595.679       0.17798   -0.04
506 BHTX BNHA   0.00  13830.18 13830.182       0.02798    0.05
507 CAIR CRTX   0.00   4751.45  4751.452       0.19197   -0.04
508 CRTX CAIR   0.00   7448.38  7448.380       0.04197   -0.04
509 ZGZG ZGTX   0.00   4688.67  4688.668       0.20596   -0.04
510 ZGTX ZGZG   0.00   5083.64  5083.638       0.05596   -0.04
511 ABKB AKTX   0.00    623.27   823.273       0.19197   -0.04
512 AKTX ABKB   0.00    498.12   498.124       0.04197   -0.04
513 MNSR MRTX   0.00   5320.74  5320.738       0.24793   -0.04
514 MRTX MNSR   0.00   4443.53  4443.525       0.09793   -0.04
515 SHRB SNTX   0.00   3940.11  3940.109       0.20596   -0.04
516 SNTX SHRB   0.00   3720.54  3720.538       0.05596   -0.04
517 DMIT DTTX   0.00    474.65   474.652       0.16399   -0.04
518 DTTX DMIT   0.00    283.64   283.638       0.01399   -0.04
519 PRTS PSTX   0.00    141.60   141.598       0.17798   -0.04
520 PSTX PRTS   0.00    139.83   139.832       0.02798   -0.04
521 ISML ILTX   0.00     11.59    11.593       0.16399   -0.04
522 ILTX ISML   0.00    185.80   185.798       0.01399   -0.04
523 SWES SSTX   0.00    165.63   165.630       0.17798   -0.04
524 SSTX SWES   0.00      4.98     4.985       0.02798   -0.04
525 FYUM FMTX   0.00   4127.68  4127.682       0.17798   -0.04
526 FMTX FYUM   0.00    554.31   554.315       0.02798   -0.04
527 BSWF BSTX   0.00    485.04   485.039       0.20596   -0.04
528 BSTX BSWF   0.00    531.32   531.317       0.05596   -0.04
529 MNIA MNTX   0.00      0.00     0.000       0.27591    0.00
530 MNTX MNIA   0.00      0.00     0.000       0.12591    0.00
531 ASYT ATTX   0.00      0.00     0.000       0.23394    0.00
532 ATTX ASYT   0.00      0.00     0.000       0.08394    0.00
533 SHAG SGTX   0.00      0.00     0.000       0.23394    0.00
534 SGTX SHAG   0.00      0.00     0.000       0.08394    0.00
535 QENA QNTX   0.00      0.00     0.000       0.34586    0.00
536 QNTX QENA   0.00      0.00     0.000       0.19586    0.00
537 ASWN ANTX   0.00      0.00     0.000       0.26192    0.00
538 ANTX ASWN   0.00      0.00     0.000       0.11192    0.00


FLOW IS OVER CAPACITY ON    70 OUT OF   534 MODAL LINKS IN THE NETWORK.


CPU TIME FOR DIRECTION FINDING=             2.59    SECONDS
CPU TIME FOR ONE DIMENSIONAL SEARCH=        0.39    SECONDS
CPU TIME FOR CONVERGENCE TEST=              0.21    SECONDS
CPU TIME FOR OUTPUT CALCULATIONS=           2.99    SECONDS
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EQUILIBRIUM RESULTS
OF
NET4*
[ITERATION NO. 175]

* Express Train (doubled capacity), Local Train, Normal Bus and Taxi

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OUTPUT OF THE MODEL:  NET4
==================


ITERATION NUMBER 175     :
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THE OBJECTIVE VALUE IS                             -5651284.000
PREVIOUS VALUE IS WITHIN                                  0.000%   OF THE CURRENT ONE

THE %DIFFERENCE IN FLOW BETWEEN LAST TWO ITERATIONS:
FOR   24    OUT OF    24    ORIGINS,
AND  541    OUT OF   552    O-D PAIRS,
AND  519    OUT OF   534    LINKS.
IS WITHIN     5.00  PERCENT


NUMBER OF INNER ITERATIONS=     1
OPTIMUM STEP SIZE=        0.00320


TOTAL TRAVEL COST =                          507770.938
TOTAL TRAVEL DISTANCE =                     56245904.00


ROOTE MEAN SQUARE ERRORS OF:
EQUILIBRIUM=                 11.432
TRIP GENERATION=              2.365
TRIP DISTRIBUTION=           76.338
MODAL LINK FLOWS=           127.782


LOGIT CONVERGENCE TEST:
----------------------

IT CALCULATES THE %DIFFERENCE BETWEEN PREDICTED O-D DEMAND AND THAT CALCULATED BY A LOGIT MODEL.


PREDICTIONS OF    75 OUT OF    552 O-D PAIRS ARE WITHIN      5% OF THE LOGIT MODEL
PREDICTIONS OF   178 OUT OF    552 O-D PAIRS ARE WITHIN     10% OF THE LOGIT MODEL
PREDICTIONS OF   293 OUT OF    552 O-D PAIRS ARE WITHIN     20% OF THE LOGIT MODEL
PREDICTIONS OF   333 OUT OF    552 O-D PAIRS ARE WITHIN     30% OF THE LOGIT MODEL
PREDICTIONS OF   354 OUT OF    552 O-D PAIRS ARE WITHIN     40% OF THE LOGIT MODEL
PREDICTIONS OF   380 OUT OF    552 O-D PAIRS ARE WITHIN     60% OF THE LOGIT MODEL
PREDICTIONS OF   396 OUT OF    552 O-D PAIRS ARE WITHIN     80% OF THE LOGIT MODEL
PREDICTIONS OF   406 OUT OF    552 O-D PAIRS ARE WITHIN    100% OF THE LOGIT MODEL

THERE ARE    203 O-D PAIRS WHICH HAVE LESS THAN 100 TRIPS


AMONG THE REMAINING    144 O-D PAIRS,    86 HAVE PREDICTIONS LESS THAN 100 TRIPS


ROOT MEAN SQUARE ERROR BETWEEN MODEL PREDICTIONS AND LOGIT:
TOTAL RMSE=          6619.561
WEIGHTED AVERAGE=    1310.527
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TRIP GENERATION:
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NO.  ORIGIN  TRIP GENERATION ACCESSIBILITY %CHANGE OF DEMAND
---- ------ --------------- ------------- -----------------
   1 ALEX       25713.814        8.79907          0.009
   2 DMHR       14119.837        9.02918          0.017
   3 ETYB        7214.053        9.07025          0.033
   4 KFRS       12357.634        9.11317          0.019
   5 MHLK       10671.104        9.34052          0.023
   6 TANT       36671.656        9.31328          0.007
   7 SHKM       31746.393        9.33197          0.008
   8 BNHA       74975.922        9.29962          0.003
   9 CAIR      114765.336        8.89671          0.002
  10 ZGZG       20019.393        9.29694          0.012
  11 ABKR        7966.363        9.21682          0.031
  12 MNSR       20734.492        9.15251          0.012
  13 SHRB       10545.844        9.07922          0.023
  14 DMIT        7630.815        6.92907          0.031
  15 PRTS        3830.179        8.69589          0.060
  16 ISML        8853.379        8.96188          0.027
  17 FYUM       11851.988        8.74494          0.019
  18 BSWF       14127.862        8.75930          0.016
  19 MNIA        7234.378        8.10691          0.030
  20 ASYT       10389.814        7.54906          0.019
  21 SHAG        7683.392        7.21196          0.025
  22 QENA        6773.304        6.58652          0.026
  23 ASWN        3680.647        5.65324          0.041
  24 SWES        4096.317        8.67158          0.057
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ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AT EQUILIBRIUM:
==========================================================
IT INCLUDES TRIPS PREDICTED, CALCULATED BY LOGIT AND %DIFFERENCE BETWEEN BOTH.
IT ALSO INCLUDES TOTAL EMISSIONS AND ATTRACTIONS AT EACH ZONE, AS WELL AS TOTAL TRIPS IN THE SYSTEM (PER DAY).


    TO  ALEX     DMHR     ETYB     KFRS     MHLK     TANT     SHKM     BNHA     CAIR     ZGZG     ABKB     MNSR     SHRB
FROM----------------------------------------------------------------------------------------------------------------------

ALEX       0.    1904.     781.     634.     632.    3764.    2176.    4282.    6398.    1002.     209.     982.    1117.
           0.    2041.     637.     624.     711.    4107.    2014.    4929.    7125.    1054.     178.    1070.     469.
          0.%     -7.%     23.%      2.%    -11.%     -8.%      8.%    -13.%    -10.%     -5.%     17.%     -8.%    138.%

DMHR    1408.       0.     348.     519.     352.    2066.    1206.    2398.    3402.     546.     138.     524.     276.
        1400.       0.     339.     379.     378.    2183.    1159.    2619.    3786.     560.      95.     569.     249.
          1.%      0.%      3.%     37.%     -7.%     -5.%      4.%     -8.%    -10.%     -3.%     46.%     -8.%     11.%

ETYB     436.     461.       0.     147.     176.     987.     621.    1264.    1759.     272.      49.     267.     119.
         473.     379.       0.     119.     196.    1133.     613.    1360.    1966.     291.      49.     295.     129.
         -8.%     22.%      0.%     23.%    -10.%    -13.%      1.%     -7.%    -11.%     -6.%      0.%     -9.%     -8.%

KFRS     507.     566.     150.       0.     480.    1886.     998.    1937.    2311.     542.     220.    1102.     468.
         492.     498.     141.       0.     600.    2127.    1237.    2111.    2730.     578.     133.     837.     479.
          3.%     14.%      7.%      0.%    -20.%    -11.%    -19.%     -8.%    -15.%     -6.%     66.%     32.%     -2.%

MHLK     291.     334.     124.     294.       0.    1396.    1010.    1656.    2392.     501.      95.     720.     292.
         346.     289.     134.     348.       0.    1672.     998.    2019.    2883.     483.     111.     723.     317.
        -16.%     16.%     -7.%    -15.%      0.%    -17.%      1.%    -18.%    -17.%      4.%    -14.%      0.%     -8.%

TANT    1739.    1214.     563.     682.    1289.       0.    4178.    7821.   11396.    2253.     361.    1650.     746.
        1558.    1300.     603.     960.    1276.       0.    4198.    8491.   12153.    1882.     306.    1825.     799.
         12.%     -7.%     -7.%     -8.%      1.%      0.%      0.%     -8.%     -6.%     20.%     18.%    -10.%     -7.%

SHKM     977.     737.     347.     625.    1343.    4515.       0.    7434.    8907.    1917.    1524.    1102.     497.
        1022.     853.     396.     611.     833.    4599.       0.    8479.   10495.    1477.     244.    1198.     525.
         -4.%    -14.%    -12.%      2.%     61.%     -2.%      0.%    -12.%    -15.%     30.%    525.%     -8.%     -5.%

BNHA    1871.    2067.    1275.    1241.    1527.    9255.    7727.       0.   33967.    5149.    1011.    2370.    1066.
        2040.    1702.     790.    1033.    1679.    9255.    8407.       0.   36674.    5426.    1002.    2391.    1047.
         -8.%     21.%     61.%     20.%     -9.%      0.%     -8.%      0.%     -7.%     -5.%      1.%     -1.%      2.%

CAIR    4064.    3058.    1626.    1624.    3936.   15710.   12686.   40869.       0.    9857.    1718.    4017.    1708.
        4425.    2952.    1370.    1599.    2915.   16073.   12003.   44236.       0.   10145.    1707.    4146.    1815.
         -8.%      4.%     19.%      2.%     35.%     -2.%      6.%     -8.%      0.%     -3.%      1.%     -3.%     -6.%

ZGZG     378.     298.     310.     252.     447.    1915.    1553.    4515.    6688.       0.     380.     721.     481.
         409.     341.     158.     265.     382.    1845.    1372.    5082.    7630.       0.     375.     827.     349.
         -8.%    -13.%     96.%     -5.%     17.%      4.%     13.%    -11.%    -12.%      0.%      2.%    -13.%     38.%

ABKB     134.     277.      46.     178.     368.     575.     402.    1645.    2211.     640.       0.     687.     188.
         142.     119.      55.     125.     181.     640.     466.    1769.    2640.     749.       0.     432.     204.
         -6.%    134.%    -17.%     41.%    103.%    -10.%    -14.%     -7.%    -16.%    -15.%      0.%     59.%     -8.%

MNSR     612.     534.     274.     733.    1716.    2783.    1662.    3323.    4609.    1241.     340.       0.     929.
         670.     559.     259.     651.     938.    3049.    1820.    3720.    5256.    1402.     356.       0.    1087.
         -9.%     -4.%      6.%     13.%     83.%     -9.%     -9.%    -11.%    -12.%    -11.%     -4.%      0.%    -14.%

SHRB     485.     256.     128.     362.     410.    1343.     804.    1532.    2209.     751.     151.    1043.       0.
         319.     266.     123.     406.     443.    1434.     781.    1721.    2487.     643.     169.    1156.       0.
         52.%     -4.%      4.%    -11.%     -7.%     -6.%      3.%    -11.%    -11.%     17.%    -11.%    -10.%      0.%
```

IT	208.	211.	84.	242.	288.	874.	43.	1121.	1531.	429.	263.	773.	523.
	218.	182.	85.	249.	304.	983.	490.	1179.	1705.	383.	116.	839.	606.
	-5.%	16.%	[illegible].%	-2.%	-5.%	-11.%	-10.%	-5.%	-10.%	12.%	126.%	-8.%	-14.%
PRTS	311.	47.	25.	67.	77.	261.	159.	694.	985.	305.	82.	171.	125.
	65.	54.	25.	48.	59.	293.	191.	811.	1172.	310.	52.	210.	151.
	377.%	-13.%	0.%	39.%	30.%	-11.%	-17.%	-14.%	-16.%	-2.%	57.%	-18.%	-18.%
ISML	344.	133.	77.	358.	120.	697.	479.	1959.	2759.	754.	148.	273.	137.
	170.	142.	66.	77.	132.	763.	497.	2109.	3049.	809.	162.	298.	150.
	103.%	-6.%	17.%	365.%	-9.%	-9.%	-4.%	-7.%	-10.%	-7.%	-8.%	-8.%	-9.%
SWES	48.	49.	26.	21.	77.	269.	229.	571.	2042.	227.	38.	81.	42.
	53.	44.	21.	23.	42.	240.	156.	663.	2356.	142.	28.	62.	27.
	-10.%	10.%	25.%	-12.%	86.%	12.%	46.%	-14.%	-13.%	60.%	37.%	30.%	54.%
FYUM	120.	158.	61.	64.	100.	655.	465.	1641.	5850.	375.	90.	180.	55.
	124.	99.	47.	60.	110.	604.	501.	1663.	6427.	381.	64.	152.	60.
	-4.%	60.%	31.%	7.%	-9.%	8.%	-7.%	-1.%	-9.%	-2.%	40.%	18.%	-8.%
BSWF	175.	144.	66.	99.	196.	937.	691.	2109.	7040.	572.	132.	208.	80.
	175.	146.	68.	77.	136.	787.	513.	2176.	7740.	465.	79.	205.	90.
	0.%	-1.%	-2.%	29.%	44.%	19.%	35.%	-3.%	-9.%	23.%	68.%	1.%	-10.%
MNIA	74.	70.	37.	198.	99.	318.	200.	823.	2911.	189.	49.	78.	57.
	77.	64.	30.	34.	60.	346.	225.	956.	3399.	204.	35.	90.	39.
	-4.%	9.%	26.%	487.%	65.%	-8.%	-11.%	-14.%	-14.%	-8.%	41.%	-13.%	44.%
ASYT	132.	278.	107.	43.	75.	335.	632.	1041.	3261.	291.	93.	126.	61.
	91.	76.	35.	40.	70.	407.	265.	1125.	4002.	241.	41.	106.	46.
	46.%	269.%	207.%	9.%	6.%	-18.%	138.%	-7.%	-19.%	21.%	129.%	18.%	31.%
SHAG	97.	51.	89.	32.	59.	213.	179.	565.	1911.	174.	26.	134.	25.
	48.	40.	19.	21.	38.	217.	142.	601.	2136.	128.	22.	57.	25.
	101.%	26.%	374.%	51.%	58.%	-2.%	26.%	-6.%	-11.%	36.%	20.%	136.%	1.%
QENA	73.	60.	32.	14.	22.	133.	85.	475.	1215.	75.	27.	114.	16.
	30.	25.	12.	13.	24.	137.	89.	377.	1342.	81.	14.	36.	16.
	140.%	136.%	171.%	3.%	-8.%	-3.%	-5.%	26.%	-9.%	-7.%	98.%	222.%	1.%
ASWN	19.	20.	9.	5.	16.	201.	60.	158.	379.	37.	11.	47.	13.
	10.	8.	4.	4.	8.	45.	29.	123.	438.	26.	4.	12.	5.
	87.%	145.%	122.%	24.%	103.%	351.%	106.%	28.%	-13.%	40.%	154.%	302.%	153.%
ATTR	14501.	12930.	6586.	8634.	13804.	51090.	38645.	89832.	116133.	28098.	7157.	17370.	9020.
	14357.	12181.	5415.	7766.	11514.	52939.	38167.	98319.	129590.	27862.	5341.	17535.	8684.
	1.%	6.%	22.%	11.%	20.%	-3.%	1.%	-9.%	-10.%	1.%	34.%	-1.%	4.%

O-D MATRIX (CONTINUED)

	DMIT	PRTS	ISML	SWES	FYUM	BSWF	MNIA	ASYT	SHAG	QENA	ASWN	GENERATN
ALEX	291. 165. 76.%	50. 38. 32.%	169. 189. -10.%	26. 30. -13.%	652. 98. 563.%	165. 177. -7.%	171. 32. 441.%	40. 17. 128.%	138. 6. 2223.%	109. 1. 7512.%	21. 1. 1982.%	25714.
DMHR	222. 88. 153.%	27. 20. 35.%	116. 100. 16.%	34. 16. 116.%	63. 57. 11.%	175. 94. 85.%	15. 17. -11.%	74. 9. 705.%	113. 3. 3461.%	77. 1. 7631.%	20. 1. 1918.%	14120.
ETYB	56. 46. 22.%	180. 10. 1621.%	113. 52. 118.%	10. 8. 24.%	26. 30. -13.%	59. 49. 20.%	66. 9. 658.%	61. 5. 1174.%	12. 2. 644.%	31. 1. 3039.%	41. 1. 4031.%	7214.
KFRS	636. 152. 319.%	30. 22. 39.%	132. 76. 73.%	30. 14. 112.%	40. 46. -13.%	110. 65. 69.%	54. 12. 367.%	11. 6. 73.%	33. 2. 1416.%	99. 1. 9787.%	15. 1. 1397.%	12358.
MHLK	98. 112. -13.%	168. 17. 904.%	60. 72. -16.%	60. 12. 405.%	40. 49. -17.%	764. 67. 1039.%	19. 12. 57.%	124. 7. 1784.%	7. 2. 221.%	142. 1. 14057.%	83. 1. 8176.%	10671.
TANT	338. 282. 20.%	414. 65. 539.%	312. 322. -3.%	60. 51. 18.%	596. 205. 191.%	334. 302. 11.%	56. 54. 5.%	202. 30. 581.%	53. 10. 425.%	182. 2. 7369.%	29. 1. 2849.%	36672.
SHKM	317. 165. 71.%	85. 47. 82.%	228. 231. -1.%	48. 44. 11.%	176. 164. 7.%	370. 261. 42.%	56. 46. 21.%	175. 26. 583.%	247. 9. 2714.%	38. 2. 1688.%	81. 1. 8036.%	31746.
BNHA	349. 370. -5.%	344. 196. 76.%	918. 971. -5.%	716. 176. 307.%	702. 615. 14.%	1315. 912. 44.%	409. 162. 152.%	334. 89. 273.%	478. 31. 1460.%	400. 7. 5340.%	485. 1. 48415.%	74976.
CAIR	599. 641. -7.%	393. 339. 16.%	3079. 1683. 83.%	1049. 930. 13.%	2656. 2656. 0.%	3771. 3889. -3.%	642. 693. -7.%	810. 381. 112.%	189. 131. 44.%	614. 31. 1860.%	91. 2. 4396.%	114765.
ZGZG	140. 131. 7.%	130. 70. 86.%	318. 349. -9.%	60. 66. -9.%	286. 129. 122.%	790. 183. 333.%	116. 33. 255.%	89. 18. 400.%	102. 6. 1562.%	24. 1. 1535.%	28. 1. 2723.%	20019.
ABKB	96. 76. 26.%	34. 34. 0.%	149. 174. -15.%	35. 33. 6.%	103. 45. 131.%	54. 64. -15.%	47. 11. 319.%	43. 6. 597.%	12. 2. 473.%	7. 1. 596.%	36. 1. 3478.%	7966.
MNSR	428. 408. 5.%	90. 58. 56.%	250. 203. 23.%	42. 38. 10.%	88. 89. -1.%	402. 130. 209.%	159. 23. 586.%	89. 13. 600.%	267. 4. 6001.%	156. 1. 14761.%	8. 1. 656.%	20735.
SHRB	367. 314. 17.%	103. 49. 113.%	103. 97. 7.%	23. 18. 25.%	89. 38. 133.%	153. 62. 148.%	12. 11. 6.%	83. 6. 1270.%	120. 2. 5668.%	12. 1. 1080.%	6. 1. 457.%	10546.
DMIT	0. 0. 0.%	114. 90. 27.%	160. 105. 53.%	62. 18. 256.%	129. 24. 441.%	52. 42. 22.%	10. 8. 37.%	13. 4. 202.%	7. 1. 400.%	89. 1. 8761.%	4. 1. 316.%	7631.

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 RTS     119.     0.    225.     35.     16.     33.      7.      4.     24.     28.     29.     3830.
         124.     0.    180.     30.     14.     29.      5.      3.      1.      1.      1.
         -4.%    0.%    25.%    18.%    12.%    13.%    32.%    38.%  2301.%  2727.%  2811.%

ISML     134.   112.      0.     84.     46.     75.     53.     41.     47.     11.     13.     8853.
          98.    95.      0.     93.     45.     76.     14.      7.      3.      1.      1.
         37.%   17.%     0.%    -9.%     0.%    -1.%   289.%   450.%  1742.%  1007.%  1203.%

SWES      34.    25.    113.      0.     42.     74.     27.      7.     20.      4.     30.     4096.
          16.    15.    103.      0.     27.     59.     10.      6.      2.      1.      1.
        111.%   64.%    10.%     0.%    54.%    26.%   163.%    25.%   915.%   285.%  2899.%

FYUM      25.    13.    120.     58.      0.   1111.    207.    330.     83.     11.     81.    11852.
          19.    10.     56.     31.      0.   1180.    148.     79.     27.      6.      1.
         28.%   36.%   107.%    86.%     0.%    -6.%    40.%   319.%   207.%    71.%  7959.%

BSWF      42.    21.     98.     30.    796.      0.    266.    173.     90.     98.     61.    14128.
          32.    17.     83.     32.    846.      0.    260.    140.     48.     12.      1.
         33.%   26.%    18.%    -5.%    -6.%     0.%     2.%    23.%    86.%   748.%  6006.%

MNIA      18.    40.    279.     13.    354.    728.      0.    441.    152.     57.     51.     7234.
          14.     7.     37.     14.    336.    629.      0.    447.    153.     37.      2.
         30.%  442.%   662.%    -7.%     6.%    16.%     0.%    -1.%    -1.%    55.%  2045.%

ASYT      33.    30.     68.     84.    380.    630.    871.      0.   1225.    529.     63.    10390.
          16.     9.     43.     17.    298.    740.    957.      0.   1406.    337.     22.
        104.%  243.%    58.%   404.%    27.%   -15.%    -9.%     0.%   -13.%    57.%   189.%

SEAG      11.    41.     49.     14.    153.    488.    481.   1970.      0.    856.     65.     7683.
           9.     5.     23.      9.    159.    395.    511.   2187.      0.    837.     54.
         27.%  789.%   111.%    63.%    -4.%    23.%    -6.%   -10.%     0.%     2.%    21.%

QENA       7.    19.     39.     54.     91.    351.    316.   1220.   1969.      0.    366.     6773.
           5.     3.     14.      6.    100.    248.    321.   1374.   2195.      0.    312.
         28.%  553.%   170.%   873.%    -9.%    42.%    -1.%   -11.%   -10.%     0.%    17.%

ASWN       2.     5.     23.      3.     30.     70.    186.    418.    616.   1354.      0.     3681.
           2.     1.      5.      2.     33.     81.    105.    448.    716.   1572.      0.
        -13.%  393.%   378.%    87.%    -8.%   -13.%    77.%    -7.%   -14.%   -14.%     0.%
--------------------------------------------------------------------------------------------------------
ATTR    4362.  2470.   7121.   2633.   7555.  12074.   4245.   6753.   6005.   4927.   1708.   473654.
        3305.  1215.   5169.   1666.   6103.   9734.   3452.   5309.   4763.   2859.    411.
         32.%  103.%    38.%    56.%    24.%    24.%    23.%    27.%    26.%    72.%   316.%
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ORIGIN-DESTINATION TRIP DISTRIBUTION MATRIX AT EQUILIBRIUM (PREDICTED)

TO	ALEX	DMHR	ETYB	KFRS	MHLK	TANT	SHKM	BNHA	CAIR	ZGZG	ABKB	MNSR	SHRB
FROM													
ALEX	0.	1904.	781.	634.	632.	3764.	2176.	4282.	6398.	1002.	209.	982.	1117.
DMHR	1408.	0.	348.	519.	352.	2066.	1206.	2398.	3402.	546.	138.	524.	276.
ETYB	436.	461.	0.	147.	176.	987.	621.	1264.	1759.	272.	49.	267.	119.
KFRS	537.	566.	150.	0.	480.	1886.	998.	1937.	2311.	542.	220.	1102.	468.
MHLK	291.	334.	124.	294.	0.	1396.	1010.	1656.	2392.	501.	95.	720.	292.
TANT	1739.	1214.	563.	882.	1289.	0.	4178.	7821.	11396.	2253.	361.	1650.	746.
SHKM	977.	737.	347.	625.	1343.	4515.	0.	7434.	8907.	1917.	1524.	1102.	497.
BNHA	1671.	2967.	1275.	1241.	1527.	9255.	7727.	0.	33967.	5149.	1911.	2370.	1066.
CAIR	4064.	3058.	1626.	1624.	3936.	15710.	12686.	40869.	0.	9857.	1718.	4017.	1708.
ZGZG	378.	298.	310.	252.	447.	1915.	1553.	4515.	6688.	0.	380.	721.	481.
ABKB	134.	277.	46.	178.	368.	575.	402.	1645.	2211.	640.	0.	687.	188.
MNSR	612.	534.	274.	733.	1716.	2783.	1662.	3323.	4609.	1241.	340.	0.	929.
SHRB	485.	256.	128.	362.	410.	1343.	804.	1532.	2209.	751.	151.	1043.	0.
DMIT	208.	211.	64.	242.	288.	874.	443.	1121.	1531.	429.	263.	773.	523.
PRTS	311.	47.	25.	67.	77.	261.	159.	694.	985.	305.	82.	171.	125.
ISML	344.	133.	77.	358.	120.	697.	479.	1959.	2759.	754.	148.	273.	137.
SWES	48.	49.	26.	21.	77.	269.	229.	571.	2042.	227.	38.	81.	42.
FYUM	120.	158.	61.	64.	100.	655.	465.	1641.	5850.	375.	90.	180.	55.
BSWF	175.	144.	66.	99.	196.	937.	691.	2109.	7040.	572.	132.	208.	80.
MNIA	74.	70.	37.	198.	99.	318.	200.	823.	2911.	189.	49.	78.	57.
ASYT	132.	278.	107.	43.	75.	335.	632.	1041.	3261.	291.	93.	126.	61.
SHAG	97.	51.	89.	32.	59.	213.	179.	565.	1911.	174.	26.	134.	25.
QENA	73.	60.	32.	14.	22.	133.	85.	475.	1215.	75.	27.	114.	16.
ASWN	19.	20.	9.	5.	16.	201.	60.	158.	379.	37.	11.	47.	13.
ATTR	14501.	12930.	6586.	8634.	13804.	51090.	38645.	89832.	116133.	28098.	7157.	17370.	9020.

	DMIT	PRTS	ISML	SWES	FYUM	BSWF	MNIA	ASYT	SHAG	QENA	ASWN	GENERATN
ALEX	291.	50.	169.	26.	652.	165.	171.	40.	138.	109.	21.	25714.
DMHR	222.	27.	116.	34.	63.	175.	15.	74.	113.	77.	20.	14120.
ETYB	56.	180.	113.	10.	26.	59.	66.	61.	12.	31.	41.	7214.
KFRS	636.	30.	132.	30.	40.	110.	54.	11.	33.	99.	15.	12358.
MHLK	98.	168.	60.	60.	40.	764.	19.	124.	7.	142.	83.	10671.
TANT	338.	414.	312.	60.	596.	334.	56.	202.	53.	182.	29.	36672.
SHKM	317.	85.	228.	48.	176.	370.	56.	175.	247.	38.	81.	31746.
BNHA	349.	344.	918.	716.	702.	1315.	409.	334.	478.	400.	485.	74976.
CAIR	599.	393.	3079.	1049.	2656.	3771.	642.	810.	189.	614.	91.	114765.
ZGZG	140.	130.	318.	60.	286.	790.	116.	89.	102.	24.	28.	20019.
ABKB	96.	34.	149.	35.	103.	54.	47.	43.	12.	7.	36.	7966.
MNSR	428.	90.	250.	42.	88.	402.	159.	89.	267.	156.	8.	20735.
SHRB	367.	103.	103.	23.	89.	153.	12.	83.	120.	12.	6.	10546.
DMIT	0.	114.	160.	62.	129.	52.	10.	13.	7.	89.	4.	7631.
PRTS	119.	0.	225.	35.	16.	33.	7.	4.	24.	28.	29.	3830.
ISML	134.	112.	0.	84.	46.	75.	53.	41.	47.	11.	13.	8853.
SWES	34.	25.	113.	0.	42.	74.	27.	7.	20.	4.	30.	4096.
FYUM	25.	13.	120.	58.	0.	1111.	207.	330.	83.	11.	81.	11852.
BSWF	42.	21.	98.	30.	796.	0.	266.	173.	90.	98.	61.	14128.
MNIA	18.	40.	279.	13.	354.	728.	0.	441.	152.	57.	51.	7234.
ASYT	33.	30.	68.	84.	380.	630.	871.	0.	1225.	529.	63.	10390.
SHAG	11.	41.	49.	14.	153.	488.	481.	1970.	0.	856.	65.	7683.
QENA	7.	19.	39.	54.	91.	351.	316.	1220.	1969.	0.	366.	6773.
ASWN	2.	5.	23.	3.	30.	70.	186.	418.	616.	1354.	0.	3681.
ATTR	4362.	2470.	7121.	2633.	7555.	12074.	4245.	6753.	6005.	4927.	1708.	473654.

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ORIGIN-DESTINATION PERCEIVED COST MATRIX AT EQUILIBRIUM:
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    TO  ALEX     DMHR     ETYB     KFRS     MHLK     TANT     SHKM     BNHA     CAIR     ZGZG     ABKB     MNSR     SHRB
FROM-----------------------------------------------------------------------------------------------------------------------
ALEX    0.000    0.656    0.844    1.289    1.113    0.942    1.316    1.221    1.521    1.428    1.626    1.344    1.495
DMHR    0.607    0.000    0.497    0.854    0.766    0.595    0.917    0.874    1.174    1.081    1.279    0.997    1.148
ETYB    0.817    0.497    0.000    1.109    0.690    0.519    0.828    0.799    1.099    1.005    1.204    0.922    1.072
KFRS    1.330    0.654    1.109    0.000    0.487    0.640    0.902    1.046    1.420    1.088    1.083    0.769    0.742
MHLK    1.112    0.765    0.690    0.487    0.000    0.349    0.593    0.624    0.933    0.757    0.751    0.415    0.565
TANT    0.941    0.594    0.519    0.640    0.363    0.000    0.467    0.498    0.805    0.681    0.907    0.628    0.778
SHKM    1.181    0.834    0.759    0.902    0.607    0.466    0.000    0.460    0.863    0.803    1.018    0.868    1.019
BNHA    1.215    0.868    0.793    1.046    0.635    0.495    0.460    0.000    0.526    0.432    0.573    0.902    1.053
CAIR    1.392    1.194    1.118    1.446    0.959    0.819    0.914    0.547    0.000    0.707    0.910    1.227    1.378
ZGZG    1.422    1.075    1.000    1.088    0.757    0.704    0.803    0.432    0.707    0.000    0.366    0.747    0.921
ABKB    1.621    1.274    1.198    1.083    0.751    0.905    1.018    0.631    0.910    0.384    0.000    0.676    0.777
MNSR    1.371    1.024    0.948    0.769    0.437    0.648    0.892    0.916    1.231    0.747    0.676    0.000    0.444
SHRB    1.521    1.174    1.099    0.740    0.593    0.806    1.111    1.085    1.385    0.921    0.826    0.458    0.000
DMIT    1.764    1.417    1.342    1.057    0.836    1.049    1.412    1.328    1.628    1.257    1.069    0.664    0.482
PRTS    2.168    1.821    1.746    1.743    1.522    1.453    1.638    1.178    1.478    1.000    1.198    1.185    1.303
ISML    1.785    1.438    1.363    1.686    1.241    1.070    1.256    0.795    1.096    0.615    0.703    1.204    1.260
SWES    2.341    1.994    1.918    2.266    1.796    1.625    1.811    1.351    1.054    1.557    1.653    2.028    2.178
FYUM    2.653    2.334    2.246    2.512    2.024    1.884    1.911    1.613    1.260    1.773    1.975    2.309    2.530
BSWF    2.206    1.859    1.784    2.131    1.662    1.491    1.677    1.216    0.919    1.423    1.622    1.893    2.044
MNIA    2.920    2.573    2.497    2.845    2.375    2.204    2.390    1.930    1.633    2.137    2.335    2.607    2.757
ASYT    3.558    3.212    3.136    3.484    3.014    2.843    3.029    2.569    2.272    2.775    2.974    3.245    3.396
SHAG    4.083    3.736    3.660    4.008    3.538    3.367    3.553    3.093    2.796    3.299    3.498    3.769    3.920
QENA    4.887    4.541    4.465    4.813    4.343    4.172    4.358    3.898    3.601    4.104    4.303    4.574    4.725
ASWN    6.094    5.747    5.672    6.019    5.550    5.379    5.564    5.104    4.807    5.311    5.510    5.781    5.932


O-D MATRIX (CONTINUED)

         DMIT     PRTS     ISML     SWES     FYUM     BSWF     MNIA     ASYT     SHAG     QENA     ASWN
-------------------------------------------------------------------------------------------------------------
ALEX    1.737    2.174    1.791    2.321    2.574    2.187    2.901    3.539    4.060    4.868    6.075
DMHR    1.390    1.827    1.444    1.974    2.175    1.840    2.554    3.192    3.713    4.521    5.728
ETYB    1.315    1.751    1.369    1.899    2.086    1.765    2.478    3.117    3.638    4.446    5.652
KFRS    1.057    1.803    1.656    2.065    2.338    2.111    2.825    3.463    3.985    4.792    5.999
MHLK    0.808    1.528    1.242    1.734    1.851    1.642    2.355    2.994    3.515    4.323    5.530
TANT    1.021    1.457    1.075    1.605    1.725    1.471    2.184    2.823    3.344    4.152    5.359
SHKM    1.261    1.638    1.256    1.664    1.833    1.529    2.243    2.881    3.403    4.210    5.417
BNHA    1.296    1.178    0.795    1.231    1.450    1.192    1.905    2.544    3.065    3.873    5.079
CAIR    1.621    1.503    1.121    0.816    1.170    0.919    1.633    2.272    2.793    3.601    4.807
ZGZG    1.124    1.000    0.614    1.023    1.626    1.398    2.112    2.750    3.272    4.079    5.286
ABKB    0.979    0.985    0.574    0.983    1.829    1.597    2.310    2.949    3.470    4.278    5.485
MNSR    0.646    1.494    1.250    1.659    2.150    1.901    2.614    3.253    3.774    4.582    5.788
SHRB    0.479    1.178    1.400    1.809    2.371    2.051    2.765    3.403    3.925    4.732    5.939
DMIT    0.000    0.758    1.339    1.828    2.670    2.294    3.007    3.646    4.167    4.975    6.182
PRTS    0.686    0.000    0.580    1.069    2.626    2.144    2.858    3.496    4.018    4.825    6.032
ISML    1.098    0.576    0.000    0.574    2.097    1.762    2.475    3.114    3.635    4.443    5.649
SWES    2.090    1.568    0.992    0.000    2.223    1.720    2.433    3.072    3.593    4.401    5.607
FYUM    2.829    2.764    2.244    1.952    0.000    0.600    1.548    2.205    2.727    3.534    4.741
BSWF    2.286    2.169    1.786    1.720    0.600    0.000    0.955    1.606    2.127    2.935    4.141
MNIA    3.000    2.883    2.500    2.433    1.381    0.967    0.000    1.004    1.525    2.333    3.540
ASYT    3.639    3.521    3.138    3.072    2.205    1.606    1.004    0.000    0.803    1.611    2.817
SHAG    4.163    4.045    3.663    3.596    2.730    2.130    1.528    0.806    0.000    1.114    2.321
QENA    4.968    4.850    4.468    4.401    3.534    2.935    2.333    1.611    1.111    0.000    1.656
ASWN    6.174    6.057    5.674    5.607    4.741    4.141    3.540    2.817    2.318    1.656    0.000
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MODAL SPLIT AND TRIP ASSIGNMENT:
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LINK FROM  TC  LENGTH  FLOW/CAP      FLOW        COST     %CHANGE OF FLOW
---- ---- ---- ------ --------- --------- ------------ -------------
   1 AXLT QNIT 121.68      0.00     0.000      1.08765     0.00
   2 QNLT AXIT 121.68      0.00     0.000      1.08765     0.00
   3 AXLT DRIT  60.69      0.16  1312.413      0.39993    -0.32
   4 DRLT AXIT  60.69      0.00     0.000      0.39997     0.00
   5 DRLT QNIT  42.60      0.00     0.000      0.39778     0.00
   6 QNLT DRIT  42.60      0.00     0.000      0.39778     0.00
   7 QNLT KSIT  17.96      0.00     0.000      0.17659     0.00
   8 KSLT QNIT  17.96      0.04  1000.448      0.17659    -0.32
   9 KSLT SNIT  63.05      0.00     0.000      0.58523     0.00
  10 SNLT KSIT  63.05      0.00     0.000      0.58523     0.00
  11 SNLT DTIT  40.77      0.02   361.537      0.34128    -0.32
  12 DTLT SNIT  40.77      0.04   575.393      0.34128    -0.32
  13 SNLT MRLT  23.82      0.04   674.650      0.26283    -0.32
  14 MRLT SNIT  23.82      0.06  1118.560      0.26283    -0.32
  15 MKLT MRIT  25.36      0.10  3677.766      0.20074    -0.32
  16 MRLT MKIT  25.36      0.16  5518.333      0.20074    -0.32
  17 MKLT MHIT  13.23      0.29 11725.140      0.07462    -0.01
  18 MHLT MKIT  13.23      0.24  9684.718      0.07462    -0.32
  19 QNLT MHIT  30.58      0.03  1000.448      0.28923    -0.32
  20 MHLT QNIT  30.58      0.00     0.000      0.28923     0.00
  21 DRLT EBIT  25.20      0.16  2155.686      0.15812    -0.32
  22 EBLT DRIT  25.20      0.04   527.622      0.15812    -0.32
  23 EBLT KZIT  17.84      0.19  2651.594      0.11079    -0.32
  24 KZLT EBIT  17.84      0.07   898.573      0.11081    -0.32
  25 KZLT TTIT  17.76      0.19  2651.594      0.11047    -0.32
  26 TTLT KZIT  17.76      0.07   898.573      0.11047    -0.32
  27 TTLT MHIT  14.42      0.14  9646.582      0.07945    -0.32
  28 MHLT TTIT  14.42      0.18 12568.558      0.07945    -0.03
  29 MHLT ZTIT  30.49      0.06   157.033      0.22289    -0.32
  30 ZTLT MHIT  30.49      0.01    38.140      0.22289    -0.32
  31 MRLT AKIT  47.54      0.00     0.000      0.48623     0.00
  32 AKLT MRIT  47.54      0.00     0.000      0.48623     0.00
  33 AKLT ZGIT  23.00      0.03  1331.796      0.21653    -0.32
  34 ZGLT AKIT  23.00      0.02   792.765      0.21653    -0.32
  35 ZTLT ZGIT  29.92      0.06  1519.863      0.25063    -0.32
  36 ZGLT ZTIT  29.92      0.02   526.513      0.25063    -0.32
  37 ILLT ZGIT  78.32      0.00    83.844      0.51337    -0.32
  38 ZGLT ILIT  78.32      0.01   256.497      0.51337    -0.32
  39 BHLT ZGIT  35.00      0.00     0.000      0.23283     0.00
  40 ZGLT BHIT  35.00      0.00     0.000      0.23283     0.00
  41 BHLT ZTIT  33.76      0.00     0.000      0.29840     0.00
  42 ZTLT BHIT  33.76      0.00     0.000      0.29840     0.00
  43 TTLT ZTIT  26.29      0.05  1362.849      0.20285    -0.32
  44 ZTLT TTIT  26.29      0.02   488.372      0.20287    -0.32
  45 TTLT BHIT  41.40      0.93 12722.517      0.27520    -0.32
  46 BHLT TTIT  41.40      0.92 12618.775      0.27167    -0.32
  47 TTLT SKIT  28.13      0.12  4708.738      0.21638    -0.32
  48 SKLT TTIT  28.13      0.07  2802.462      0.21638    -0.32
  49 KZLT MFIT  49.87      0.00     0.000      0.46123     0.00
  50 MFLT KZIT  49.87      0.00     0.000      0.46123     0.00
  51 EBLT IPIT 119.57      0.00     0.000      0.97742     0.00
  52 IPLT EBIT 119.57      0.00     0.000      0.97742     0.00
  53 SKLT MFIT  13.56      0.00   175.892      0.12642    -0.32
  54 MFLT SKIT  13.56      0.11  4072.189      0.12642    -0.32
  55 MFLT BHIT  26.85      0.00     0.000      0.25506     0.00
  56 BHLT MFIT  26.85      0.00     0.000      0.25506     0.00
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 57 BHLT QBIT  30.87        0.52  8499.654       0.19860   -0.32
 58 QBLT BHIT  30.87        0.91 14967.227       0.21435   -0.32
 59 MFLT QBIT  51.38        0.01   175.892       0.42713   -0.32
 60 QBLT MFIT  51.38        0.14  4072.189       0.42713   -0.32
 61 QBLT CRIT  14.14        0.17 16475.307       0.09579   -0.32
 62 CRLT QBIT  14.14        0.30 29524.193       0.09579   -0.32
 63 IBLT CRIT   3.28        0.19  5643.173       0.03778   -0.32
 64 CRLT IBIT   3.28        0.16  4909.228       0.03778   -0.32
 65 IBLT GZIT   9.67        0.22  4909.228       0.07767   -0.32
 66 GZLT IBIT   9.67        0.26  5643.173       0.07767   -0.32
 67 GZLT WTIT  79.03        0.45  4909.228       0.51975   -0.32
 68 WTLT GZIT  79.03        0.52  5643.173       0.51975   -0.32
 69 WTLT BSIT  31.95        0.00     3.533       0.20298   -0.32
 70 BSLT WTIT  31.95        0.00    44.255       0.20298   -0.32
 71 WTLT FMIT  37.74        0.90  4905.695       0.29753   -0.32
 72 FMLT WTIT  37.74        1.02  5598.919       0.44446   -0.32
 73 BSLT MNIT 122.73        0.00     0.000       0.77735    0.00
 74 MNLT BSIT 122.73        0.00     0.000       0.77735    0.00
 75 MNIT ATIT 128.37        0.00     0.000       0.78622    0.00
 76 ATLT MNIT 128.37        0.00     0.000       0.78622    0.00
 77 ATLT SGIT  91.95        0.00     0.000       0.67356    0.00
 78 SGLT ATIT  91.95        0.00     0.000       0.67356    0.00
 79 SGLT QEIT 141.59        0.00     0.000       1.03568    0.00
 80 QELT SGLT 141.59        0.00     0.000       1.03568    0.00
 81 QELT ANIT 270.22        0.00     0.000       1.72502    0.00
 82 ANLT QEIT 270.22        0.00     0.000       1.72502    0.00
 83 QBLT ZGIT  26.94        0.48 10484.773       0.34665   -0.32
 84 ZGLT QBIT  26.94        0.36  7799.759       0.34667   -0.32
 87 ALEX AXIT   0.00     1312.41  1312.413       0.26483   -0.32
 88 AXLT ALEX   0.00        0.00     0.000       0.09793    0.00
 89 DMHR DRIT   0.00      843.27   843.272       0.26483   -0.32
 90 DRLT DMHR   0.00      527.62   527.622       0.09793   -0.32
 91 ETYB EBIT   0.00      495.91   495.908       0.33478   -0.32
 92 EBLT ETYB   0.00      370.95   370.951       0.16788   -0.32
 93 KFRS KSIT   0.00     1000.45  1000.448       0.27882   -0.32
 94 KSLT KFRS   0.00        0.00     0.000       0.11192    0.00
 95 MHLK MKIT   0.00     6206.80  6206.804       0.16690    0.27
 96 MKLT MHLK   0.00     6006.95  6006.954       0.01400   -0.32
 97 TANT TTIT   0.00     5883.48  5883.477       0.19488   -0.32
 98 TTLT TANT   0.00     7673.97  7673.970       0.02798    0.16
 99 SHKM SKIT   0.00     2978.35  2978.354       0.22286   -0.32
100 SKLT SHKM   0.00     8780.93  8780.927       0.05596   -0.32
101 BNHA BHIT   0.00     3610.02  3610.023       0.19488   -0.32
102 BHLT BNHA   0.00    10181.34 10181.340       0.02798   -0.32
103 CAIR CRIT   0.00    28343.81 28343.814       0.20887   -0.32
104 CRLT CAIR   0.00    16028.88 16028.877       0.04197   -0.32
105 ZGZG ZGIT   0.00     6910.63  6910.633       0.22286   -0.32
106 ZGLT ZGZG   0.00    10955.39 10955.391       0.05596   -0.32
107 ABKB AKIT   0.00     1331.80  1331.796       0.20887   -0.32
108 AKLT ABKB   0.00      792.77   792.765       0.04197   -0.32
109 MNSR MRIT   0.00     4843.69  4843.686       0.26483   -0.32
110 MRLT MNSR   0.00     2559.20  2559.205       0.09793   -0.32
111 SHRB SNIT   0.00       99.26    99.257       0.22286   -0.32
112 SNLT SHRB   0.00      757.02   757.023       0.05596   -0.32
113 DMIT DTIT   0.00      575.39   575.393       0.18089   -0.32
114 DTLT DMIT   0.00      361.54   361.537       0.01400   -0.32
115 PRTS PSIT   0.00        0.00     0.000       0.19488    0.00
116 PSLT PRTS   0.00        0.00     0.000       0.02798    0.00
117 ISML ILIT   0.00       83.84    83.844       0.18089   -0.32
118 ILLT ISML   0.00      256.50   256.497       0.01400   -0.32
119 FYUM FMIT   0.00     5598.92  5598.919       0.19488   -0.32
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120 FMLT FYUM    0.00    4905.69   4905.695        0.02798    -0.32
121 BSWF BSIT    0.00      44.26     44.255        0.19468    -0.32
122 BSLT BSWF    0.00       3.53      3.533        0.02798    -0.32
123 MNIA MNIT    0.00       0.00      0.000        0.22266     0.00
124 MNLT MNIA    0.00       0.00      0.000        0.05596     0.00
125 ASYT ATIT    0.00       0.00      0.000        0.25084     0.00
126 ATLT ASYT    0.00       0.00      0.000        0.08394     0.00
127 SHAG SGIT    0.00       0.00      0.000        0.25084     0.00
128 SGLT SHAG    0.00       0.00      0.000        0.08394     0.00
129 QENA QEIT    0.00       0.00      0.000        0.36276     0.00
130 QELT QENA    0.00       0.00      0.000        0.19586     0.00
131 ASWN ANIT    0.00       0.00      0.000        0.27862     0.00
132 ANLT ASWN    0.00       0.00      0.000        0.11192     0.00
133 AXET DRET   60.69       0.33  21384.642        0.31897    -0.32
134 DRET AXET   60.69       0.19  12000.488        0.31897    -0.32
135 DRET QNET   42.60       0.00      0.000        0.34873     0.00
136 QNET DRET   42.60       0.00      0.000        0.34873     0.00
137 DRET EBET   25.20       0.67  32500.336        0.13141    -0.17
138 EBET DRET   25.20       0.45  21677.305        0.13138    -0.32
139 EBET KZET   17.84       0.76  37207.910        0.09815    -0.12
140 KZET EBET   17.84       0.53  26000.994        0.09768    -0.32
141 KZET TTET   17.76       0.76  37207.910        0.09782    -0.12
142 TTET KZET   17.76       0.53  26000.994        0.09735    -0.32
143 TTET MHET   14.42       0.72  17492.939        0.07330    -0.32
144 MHET TTET   14.42       0.73  17742.340        0.07334    -0.32
145 MHET QNET   30.58       0.00      0.000        0.24917     0.00
146 QNET MHET   30.58       0.00      0.000        0.24917     0.00
147 QNET KSET   42.60       0.00      0.000        0.32774     0.00
148 KSET QNET   42.60       0.00      0.000        0.32774     0.00
149 KSET SNET   63.05       0.08    699.019        0.51879    -0.32
150 SNET KSET   63.05       0.03    264.309        0.51879     9.83
151 SNET DTET   40.77       0.14   2569.772        0.27071    -0.32
152 DTET SNET   40.77       0.30   5456.935        0.27071     0.17
153 SNET MRET   23.82       0.59  10680.053        0.17852    -0.32
154 MRET SNET   23.82       0.39   7119.258        0.17852    -0.32
155 MKET MRET   25.36       0.80  14677.997        0.17530    -0.32
156 MRET MKET   25.36       0.91  16578.426        0.18881    -0.32
157 MHET MKET   13.23       0.96  17492.939        0.11160    -0.32
158 MKET MHET   13.23       0.97  17742.340        0.12578    -0.32
159 MRET AKET   47.54       0.11    976.265        0.40838    -0.32
160 AKET MRET   47.54       0.09    821.505        0.40838    -0.32
161 PSET ILET   77.94       0.33   3034.055        0.36877     0.16
162 ILET PSET   77.94       0.18   1596.204        0.36877    -0.32
163 ZGET AKET   23.00       0.17   1531.280        0.21270    -0.32
164 AKET ZGET   23.00       0.27   2424.671        0.21270    -0.32
165 ZGET ILET   78.32       0.45   6912.002        0.39131    -0.32
166 ILET ZGET   78.32       0.65   9868.223        0.39133     0.14
167 ZGET BHET   35.00       0.58  19468.914        0.19258    -0.09
168 BHET ZGET   35.00       0.50  16570.441        0.19258     0.12
169 TTET BHET   41.40       0.95  52223.445        0.27912    -0.18
170 BHET TTET   41.40       0.95  51901.066        0.27455    -0.27
171 TTET SKET   28.13       1.08   3286.492        0.68331    -0.32
172 SKET TTET   28.13       0.93   2833.647        0.22648    -0.32
173 SKET MFET   13.56       0.96   2904.773        0.13848    -0.32
174 MFET SKET   13.56       1.01   3064.385        0.21555    -0.32
175 MFET QBET   51.38       0.96   2904.773        0.38265    -0.32
176 QBET MFET   51.38       1.01   3064.385        0.45973    -0.32
177 BHET QBET   30.87       0.90  79096.172        0.19755    -0.30
178 QBET BHET   30.87       0.94  82642.828        0.21358    -0.29
179 QBET CRET   14.14       0.87  82002.914        0.08869    -0.30
180 CRET QBET   14.14       0.91  85707.156        0.09748    -0.29
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181 CRET SSET 144.56        0.06    942.538        0.81420    -0.32
182 SSET CRET 144.56        0.17   2117.728        0.81420     0.41
183 CRET IBET   3.28        0.28  17727.303        0.03794    -0.32
184 IBET CRET   3.28        0.50  32070.842        0.03794    -0.13
185 IBET GZET   9.67        0.28  17727.303        0.06416    -0.32
186 GZET IBET   9.67        0.50  32070.842        0.06416    -0.13
187 GZET BSET 110.98        0.29  17727.303        0.56378    -0.32
188 BSET GZET 110.98        0.53  32070.842        0.56378    -0.13
189 BSET MNET 122.73        0.22   9958.328        0.65748     0.16
190 MNET BSET 122.73        0.47  21472.512        0.65748    -0.04
191 MNET ATET 128.37        0.19   6740.435        0.68062     0.22
192 ATET MNET 128.37        0.39  17874.295        0.68062     0.03
193 ATET SGET  91.95        0.20   7413.853        0.51020    -0.32
194 SGET ATET  91.95        0.35  12910.748        0.51020     0.07
195 SGET QEET 141.59        0.18   4915.188        0.73486    -0.32
196 QEET SGET 141.59        0.32   8733.874        0.73486    -0.05
197 QEET ANET 270.22        0.14   1708.376        1.26266    -0.32
198 ANET QEET 270.22        0.30   3680.647        1.26266     0.04
199 ALEX AXET   0.00    21384.84  21384.842        0.26753    -0.32
200 AXET ALEX   0.00    12000.49  12000.488        0.09793    -0.32
201 DMHR DRET   0.00    11154.92  11154.915        0.23955     0.11
202 DRET DMHR   0.00     9716.24   9716.236        0.06995    -0.32
203 ETYB EBET   0.00     6261.98   6261.980        0.29551     0.09
204 EBET ETYB   0.00     5878.11   5878.105        0.12591    -0.32
205 KFRS KSET   0.00      699.02    699.019        0.25354    -0.32
206 KSET KFRS   0.00      264.31    264.309        0.08394     9.83
207 MHLK MKET   0.00     2720.39   2720.386        0.16960    -0.32
208 MKET MHLK   0.00     4371.42   4371.420        0.01400    -0.32
209 TANT TTET   0.00    23103.89  23103.893        0.19758    -0.32
211 TTET TANT   0.00    33782.96  33782.961        0.02798    -0.25
212 SHKM SKET   0.00     5738.42   5738.418        0.21157    -0.32
213 SKET SHKM   0.00     6352.88   6352.876        0.04197    -0.32
214 BNHA BHET   0.00    57997.25  57997.246        0.19758    -0.32
215 BHET BNHA   0.00    64762.83  64762.828        0.02798    -0.27
217 CAIR CRET   0.00    75582.77  75582.773        0.21157    -0.32
218 CRET CAIR   0.00    87397.17  87397.172        0.04197    -0.25
219 ZGZG ZGET   0.00     7533.66   7533.659        0.21157    -0.32
220 ZGET ZGZG   0.00     8484.80   8484.797        0.04197     0.54
221 ABKB AKET   0.00     2751.13   2751.133        0.19758    -0.32
222 AKET ABKB   0.00     2012.50   2012.500        0.02798    -0.32
223 MNSR MRET   0.00     7261.66   7261.657        0.23955    -0.32
224 MRET MNSR   0.00     8767.26   8767.265        0.06995    -0.32
225 SHRB SNET   0.00     5829.94   5829.937        0.21157    -0.32
226 SNET SHRB   0.00     5591.01   5591.015        0.04197    -0.32
227 DMIT DTET   0.00     5456.93   5456.935        0.18359     0.17
228 DTET DMIT   0.00     2569.77   2569.772        0.01400    -0.32
229 PRTS PSET   0.00     3034.05   3034.055        0.19758     0.16
230 PSET PRTS   0.00     1596.20   1596.204        0.02798    -0.32
231 ISML ILET   0.00     6952.87   6952.873        0.18359     0.12
232 ILET ISML   0.00     5434.51   5434.507        0.01400    -0.32
233 SWES SSET   0.00     2117.73   2117.728        0.19758     0.41
234 SSET SWES   0.00      942.54    942.538        0.02798    -0.32
235 FYUM FMET   0.00        0.00      0.000        0.18359     0.00
236 FMET FYUM   0.00        0.00      0.000        0.01400     0.00
237 BSWF BSET   0.00    13719.21  13719.214        0.21157     0.03
238 BSET BSWF   0.00    10889.87  10889.866        0.04197    -0.32
239 MNIA MNET   0.00     6152.52   6152.525        0.26753     0.09
240 MNET MNIA   0.00     3772.20   3772.203        0.09793     0.38
241 ASYT ATET   0.00    10389.81  10389.814        0.22556     0.02
242 ATET ASYT   0.00     6752.85   6752.851        0.05596     0.73
243 SHAG SGET   0.00     7683.39   7683.392        0.23955     0.02
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244 SGET SHAG   0.00   6005.18  6005.181        0.0670[illegible]  -0.32
245 QENA QEET   0.00   6773.30  6773.304        0.30950   0.03
246 QEET QENA   0.00   4926.89  4926.889        0.13990  -0.05
247 ASWN ANET   0.00   3680.65  3680.647        0.25354   0.04
248 ANET ASWN   0.00   1708.38  1708.376        0.08394  -0.32
249 DTEB PSEB  63.00      1.16   804.567        2.10362  -0.32
250 PSEB DTEB  63.00      1.04   726.149        0.52139  -0.32
251 DTEB SNEB  42.00      0.98  1536.484        0.26114  -0.32
252 SNEB DTEB  42.00      0.98  1532.597        0.25772   4.18
253 SNEB MREB  24.10      0.91  2613.728        0.12563  -0.32
254 MREB SNEB  24.10      0.81  2317.886        0.11153   2.65
255 MREB SLEB  20.20      1.07  1400.758        0.51082  -0.32
256 SLEB MREB  20.20      1.01  1317.517        0.21521  -0.32
257 SLEB ZGEB  30.70      1.07   836.514        0.52185  -0.32
258 ZGEB SLEB  30.70      1.03   806.828        0.32382  -0.32
259 SLEB AKEB  30.00      1.08   564.244        0.61125  -0.32
260 AKEB SLEB  30.00      0.98   510.690        0.20161  -0.32
261 MREB BHEB  75.20      1.08   187.363        0.77477  -0.32
262 BHEB MREB  75.20      1.12   194.677        1.28027  -0.32
263 SKEB BHEB  26.00      1.12    97.869        1.16948  -0.32
264 BHEB SKEB  26.00      1.04    90.330        0.32826  -0.32
265 BHEB ZGEB  35.00      0.99  1642.947        0.24952  -0.32
266 ZGEB BHEB  35.00      1.08  1787.892        0.64592  -0.32
267 ZGEB AKEB  25.50      0.75  2299.895        0.11680  -0.32
268 AKEB ZGEB  25.50      0.92  2838.501        0.13531   0.67
269 AKEB ILEB  70.50      0.97   338.858        0.38086  -0.32
270 ILEB AKEB  70.50      1.06   367.638        0.62193  -0.32
271 ILEB PSEB  76.00      0.98   599.291        0.41160  -0.32
272 PSEB ILEB  76.00      1.02   622.762        0.49544  -0.32
273 ILEB ZGEB  81.00      0.75  1672.196        0.39385  -0.32
274 ZGEB ILEB  81.00      0.51  1124.960        0.39349  -0.32
275 ILEB SSEB  89.00      0.83   432.848        0.40904  -0.32
276 SSEB ILEB  89.00      1.11   580.121        1.23263  -0.32
277 SSEB CREB 133.50      1.07  1115.849        1.00917  -0.32
278 CREB SSEB 133.50      0.97  1067.663        0.67987  -0.32
279 CREB ZGEB  77.20      1.09  1757.456        1.06331  -0.32
280 ZGEB CREB  77.20      1.01  1616.421        0.58281  -0.32
281 CREB BHEB  47.20      1.04    93.024        0.50951  -0.32
282 BHEB CREB  47.20      0.00     0.000        0.50951   0.00
283 SHKM SKEB   0.00     97.87    97.869        0.17883  -0.32
284 SKEB SHKM   0.00     90.33    90.330        0.06995  -0.32
285 BNHA BHEB   0.00   1807.94  1807.938        0.15085  -0.32
286 BHEB BNHA   0.00   2046.13  2046.131        0.04197  -0.32
287 CAIR CREB   0.00   2767.77  2767.765        0.15085  -0.32
288 CREB CAIR   0.00   2641.89  2641.891        0.04197  -0.32
289 ZGZG ZGEB   0.00   2567.94  2567.938        0.19282  -0.32
290 ZGEB ZGZG   0.00   3679.56  3679.557        0.08394   0.44
291 ABKB AKEB   0.00   3089.79  3089.786        0.16484   0.58
292 AKEB ABKB   0.00   2633.52  2633.515        0.05596  -0.32
293 MNSR MREB   0.00   2167.34  2167.344        0.24878   2.86
294 MREB MNSR   0.00   2387.26  2387.260        0.13990  -0.32
295 SHRB SNEB   0.00   2063.98  2063.984        0.19282  -0.32
296 SNEB SHRB   0.00   1772.03  1772.028        0.08394  -0.32
297 DMIT DTEB   0.00   1628.06  1628.056        0.13686  -0.32
298 DTEB DMIT   0.00   1545.75  1545.752        0.02798   4.14
299 PRTS PSEB   0.00    756.30   756.304        0.13686  -0.32
300 PSEB PRTS   0.00    811.25   811.251        0.02798  -0.32
301 ISML ILEB   0.00   1823.06  1823.057        0.13686  -0.32
302 ILEB ISML   0.00   1417.79  1417.786        0.02798  -0.32
303 SWES SSEB   0.00   1695.97  1695.970        0.13686  -0.32
304 SSEB SWES   0.00   1440.51  1440.511        0.02798  -0.32
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305 AXMB DRMB  56.50      1.02   220.576     0.38467   -0.32
306 DRMB AXMB  56.50      1.00   217.493     0.35064   -0.32
307 DRMB EBMB  25.70      1.05   226.782     0.35342   -0.32
308 EBMB DRMB  25.70      0.96   208.891     0.15859   -0.32
309 EBMB TTMB  39.00      1.09   235.626     0.68893   -0.32
310 TTMB EBMB  39.00      1.11   241.769     1.03838   -0.32
311 TTMB KSMB  39.00      1.14  2421.692     1.48073    9.71
312 KSMB TTMB  39.00      1.07  2276.558     0.55664   -0.32
313 KSMB SNMB  63.30      1.00   519.957     0.38170    7.76
314 SNMB KSMB  63.30      0.99   519.296     0.37938   -0.32
315 MKMB MRMB  19.50      1.02  1687.495     0.24209   -0.32
316 MRMB MKMB  19.50      1.11  1833.189     0.89068   -0.32
317 TTMB MKMB  26.50      1.01  3062.307     0.22887   -0.32
318 MKMB TTMB  26.50      1.06  3217.830     0.42103   -0.32
319 TTMB ZGMB  55.00      1.04   676.468     0.46024   -0.32
320 ZGMB TTMB  55.00      1.11   721.230     1.00384    8.92
321 BHMB MRMB  75.20      1.08   374.426     0.76777   -0.32
322 MRMB BHMB  75.20      1.15   401.157     2.05226   -0.32
323 TTMB BHMB  43.00      1.02  3516.619     0.36851   -0.32
324 BHMB TTMB  43.00      1.06  3634.832     0.51929    6.36
325 TTMB SKMB  26.00      1.03  4145.575     0.27826    2.58
326 SKMB TTMB  26.00      1.07  4341.361     0.52858   -0.32
327 SKMB BHMB  26.00      1.07  1682.093     0.53965   -0.32
328 BHMB SKMB  26.00      1.03  1605.658     0.28331    1.59
329 SKMB CRMB  65.50      1.14  3059.889     1.68561   -0.32
330 CRMB SKMB  65.50      1.17  3143.208     2.58748   11.46
331 CRMB BHMB  47.20      0.01    51.515     0.50951   -0.32
332 BHMB CRMB  47.20      0.00     0.000     0.50951    0.00
333 KSMB MKMB  26.00      0.99  1888.925     0.19643   -0.32
334 MKMB KSMB  26.00      1.00  1904.681     0.21946   -0.32
335 ALEX AXMB   0.00    220.58   220.576     0.20681   -0.32
336 AXMB ALEX   0.00    217.49   217.493     0.09793   -0.32
337 DMHR DRMB   0.00    193.48   193.479     0.26277   -0.32
338 DRMB DMHR   0.00    178.67   178.672     0.15389   -0.32
339 ETYB EBMB   0.00      8.84     8.845     0.36070   -0.32
340 EBMB ETYB   0.00     32.88    32.878     0.25182   -0.32
341 KFRS KSMB   0.00   4488.35  4488.349     0.27676    0.62
342 KSMB KFRS   0.00   4646.57  4646.573     0.16788    4.90
343 MHLK MKMB   0.00   3759.01  3759.006     0.10888   -0.32
344 MKMB MHIK   0.00   3733.42  3733.422     0.01399   -0.32
345 TANT TTMB   0.00   8930.54  8930.545     0.13686    1.02
346 TTMB TANT   0.00   9293.55  9293.546     0.02798    0.40
347 SHKM SKMB   0.00   8887.14  8887.144     0.17883   -0.32
348 SKMB SHKM   0.00   8698.24  8698.241     0.06995    5.67
349 BNHA BHMB   0.00   5563.40  5563.401     0.15085    4.60
350 BHMB BNHA   0.00   5599.87  5599.870     0.04197   -0.32
351 CAIR CRMB   0.00   3194.72  3194.724     0.15085   11.27
352 CRMB CAIR   0.00   3059.89  3059.889     0.04197   -0.32
353 ZGZG ZGMB   0.00    721.23   721.230     0.19282    8.92
354 ZGMB ZGZG   0.00    676.47   676.468     0.08394   -0.32
355 MNSR MRMB   0.00   2112.58  2112.582     0.24878   -0.32
356 MRMB MNSR   0.00   1940.16  1940.157     0.13990   -0.32
357 SHRB SNMB   0.00    519.30   519.296     0.19282   -0.32
358 SNMB SHRB   0.00    519.96   519.957     0.08394    7.76
359 AXWB DRWB  56.50      0.97  2521.097     0.29677    3.04
360 DRWB AXWB  56.50      0.78  2042.919     0.24676   -0.32
361 DRWB KSWB  57.40      1.07   370.761     0.61734   -0.32
362 KSWB DRWB  57.40      1.17   405.506     2.39221   -0.32
363 DRWB EBWB  25.70      0.23   519.489     0.11190   -0.32
364 EBWB DRWB  25.70      0.28   643.890     0.11190   -0.32
365 EBWB CRWB 126.70      1.03   357.847     0.86432   -0.32
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366 CRWB EBWB 126.70       1.00   347.124       0.78468    -0.32
367 ALEX AXWB   0.00    2521.10  2521.097       0.20681     3.04
368 AXWB ALEX   0.00    2042.92  2042.919       0.09793    -0.32
369 DMHR DRWB   0.00    1408.92  1408.923       0.26277    -0.32
370 DRWB DMHR   0.00    2046.25  2046.247       0.15389     3.82
371 ETYB EBWB   0.00     355.75   355.755       0.36070    -0.32
372 EBWB ETYB   0.00     220.63   220.631       0.25182    -0.32
373 KFRS KSWB   0.00     405.51   405.506       0.27676    -0.32
374 KSWB KFRS   0.00     370.76   370.761       0.16788    -0.32
375 CAIR CRWB   0.00     347.12   347.124       0.15085    -0.32
376 CRWB CAIR   0.00     357.85   357.847       0.04197    -0.32
377 CRUB SSUB 133.50       0.96   249.870       0.63746    -0.32
378 SSUB CRUB 133.50       1.08   282.620       1.08683    -0.32
379 CRUB GZUB  10.00       0.65   841.341       0.07587    -0.32
380 GZUB CRUB  10.00       0.61   799.258       0.07586    -0.32
381 GZUB FMUB  97.50       1.14   841.341       1.91831    -0.32
382 FMUB GZUB  97.50       1.08   799.258       1.05958    -0.32
383 GZUB BSUB 118.50       0.00     0.000       0.83871     0.00
384 BSUB GZUB 118.50       0.00     0.000       0.83871     0.00
385 FMUB BSUB  43.00       1.08  1545.963       0.63541    -0.32
386 BSUB FMUB  43.00       1.03  1479.813       0.37682    -0.32
387 BSUB MNUB 130.00       0.44   472.876       0.58002    -0.32
388 MNUB BSUB 130.00       1.00  1081.856       0.67097    -0.32
389 SWES SSUB   0.00     282.62   282.620       0.13686    -0.32
390 SSUB SWES   0.00     249.87   249.870       0.02798    -0.32
391 CAIR CRUB   0.00    1010.02  1010.015       0.15085    -0.32
392 CRUB CAIR   0.00    1000.68  1000.683       0.04197    -0.32
393 FYUM FMUB   0.00    2345.22  2345.222       0.15085    -0.32
394 FMUB FYUM   0.00    2321.15  2321.153       0.04197    -0.32
395 BSWF BSUB   0.00    1391.91  1391.913       0.19282    -0.32
396 BSUB BSWF   0.00    2067.04  2067.044       0.08394    -0.32
397 MNIA MNUB   0.00    1081.86  1081.856       0.29075    -0.32
398 MNUB MNIA   0.00     472.88   472.876       0.18187    -0.32
399 AXTX DRTX  56.50       0.01   274.887       0.47602    -0.32
400 DRTX AXTX  56.50       0.01   239.965       0.47602    -0.32
401 DRTX EBTX  25.70       0.00     0.000       0.21653     0.00
402 EBTX DRTX  25.70       0.00     0.000       0.21653     0.00
403 DRTX KSTX  57.40       0.16   794.135       0.49391    -0.32
404 KSTX DRTX  57.40       0.14   701.337       0.49391    -0.32
405 KSTX TTTX  39.00       0.67  3290.147       0.35055    -0.32
406 TTTX KSTX  39.00       0.28  1368.559       0.35051     7.30
407 KSTX MKTX  26.00       0.36  1772.833       0.23368    -0.32
408 MKTX KSTX  26.00       0.24  1188.135       0.23368    -0.32
409 TTTX MKTX  26.50       0.00   145.133       0.22327    -0.32
410 MKTX TTTX  26.50       0.02   661.444       0.22327    -0.32
411 KSTX SNTX  63.30       0.00     0.000       0.56891     0.00
412 SNTX KSTX  63.30       0.00     0.000       0.56891     0.00
413 SNTX DTTX  42.00       0.01    52.621       0.37748    -0.32
414 DTTX SNTX  42.00       0.02   115.379       0.37748    -0.32
415 MKTX SNTX  48.00       0.00     0.000       0.43140     0.00
416 SNTX MKTX  48.00       0.00     0.000       0.43140     0.00
417 MRTX SNTX  24.10       0.11   530.365       0.21660    -0.32
418 SNTX MRTX  24.10       0.46  2246.366       0.21660     1.29
419 MKTX MRTX  19.50       0.22  1075.569       0.17526    -0.32
420 MRTX MKTX  19.50       0.58  2848.513       0.17526    -0.32
421 MRTX SLTX  20.20       0.32  1563.328       0.18155    -0.32
422 SLTX MRTX  20.20       0.18   876.275       0.18155    -0.32
423 MKTX SLTX  32.00       0.25  1265.570       0.27535    -0.32
424 SLTX MKTX  32.00       0.23  1131.793       0.27535    -0.32
425 SLTX AKTX  30.00       0.07   333.850       0.26963    -0.32
426 AKTX SLTX  30.00       0.12   568.974       0.26963    -0.32
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427 SLTX ZGTX  30.70      0.32  2495.048      0.26122   -0.32
428 ZGTX SLTX  30.70      0.19  1439.093      0.26122   -0.32
429 EBTX TTTX  39.00      0.00    91.563      0.32858   -0.32
430 TTTX EBTX  39.00      0.00    82.936      0.32858   -0.32
431 TTTX ZGTX  55.00      0.00     0.000      0.49431    0.00
432 ZGTX TTTX  55.00      0.00     0.000      0.49431    0.00
433 TTTX BHTX  43.00      0.02   524.894      0.40518   -0.32
434 BHTX TTTX  43.00      0.01   280.116      0.40518   -0.32
435 TTTX SKTX  26.00      0.23  1133.262      0.23368   -0.32
436 SKTX TTTX  26.00      0.11   517.299      0.23368   19.84
437 SKTX BHTX  26.00      0.56 10122.337      0.22621   -0.32
438 BHTX SKTX  26.00      0.49  6873.591      0.22621   -0.32
439 SKTX DHTX  39.50      0.70  3404.969      0.35508   -0.32
440 DHTX SKTX  39.50      0.96  4715.448      0.40295   -0.32
441 EBTX DHTX 100.70      0.00     0.000      0.85685    0.00
442 DHTX EBTX 100.70      0.00     0.000      0.85685    0.00
443 DHTX GZTX  29.00      0.00     0.000      0.34264    0.00
444 GZTX DHTX  29.00      0.05   262.869      0.34264   -0.32
445 DHTX CRTX  26.00      0.70  3404.969      0.30375   -0.32
446 CRTX DHTX  26.00      0.91  4452.576      0.31890   -0.32
447 GZTX AXTX 173.50      0.00     0.000      1.86791    0.00
448 AXTX GZTX 173.50      0.00     0.000      1.86791    0.00
449 CRTX BHTX  47.20      0.00     0.000      0.61067    0.00
450 BHTX CRTX  47.20      0.00     0.000      0.61067    0.00
451 BHTX ZGTX  35.00      0.69  3380.465      0.31463   -0.32
452 ZGTX BHTX  35.00      0.25  1242.362      0.31456   -0.32
453 ZGTX CRTX  77.20      0.00     0.000      0.76384    0.00
454 CRTX ZGTX  77.20      0.00     0.000      0.76384    0.00
455 ZGTX AKTX  25.50      0.30  1479.974      0.22918   -0.32
456 AKTX ZGTX  25.50      0.06   301.901      0.22918   -0.32
457 DTTX PSTX  63.00      0.02    86.153      0.56622   -0.32
458 PSTX DTTX  63.00      0.01    64.948      0.56622   -0.32
459 PSTX ILTX  76.00      0.00     0.000      0.64668    0.00
460 ILTX PSTX  76.00      0.00     0.000      0.64668    0.00
461 ILTX AKTX  70.50      0.00     0.000      0.63362    0.00
462 AKTX ILTX  70.50      0.00    18.299      0.63362   -0.32
463 ILTX ZGTX  81.00      0.00     0.000      0.68244    0.00
464 ZGTX ILTX  81.00      0.00     0.000      0.68244    0.00
465 ILTX CRTX 123.50      0.00     0.000      1.31885    0.00
466 CRTX ILTX 123.50      0.00     0.000      1.31885    0.00
467 ILTX SSTX  89.00      0.00     0.000      0.79989    0.00
468 SSTX ILTX  89.00      0.00     0.000      0.79989    0.00
469 SSTX CRTX 133.50      0.00     0.000      1.18694    0.00
470 CRTX SSTX 133.50      0.00     0.000      1.18694    0.00
471 CRTX GZTX  10.00      0.00     0.000      0.10938    0.00
472 GZTX CRTX  10.00      0.23  3175.429      0.10938   -0.32
473 GZTX FMTX  97.50      0.00     0.000      0.93112    0.00
474 FMTX GZTX  97.50      0.45  3438.298      0.93112   -0.32
475 GZTX BSTX 118.50      0.00     0.000      1.22581    0.00
476 BSTX GZTX 118.50      0.00     0.000      1.22581    0.00
477 FMTX BSTX  43.00      0.06   469.548      0.36588    8.27
478 BSTX FMTX  43.00      0.04   328.325      0.36588   -0.32
479 BSTX MNTX 130.00      0.00     0.000      1.10616    0.00
480 MNTX BSTX 130.00      0.00     0.000      1.10616    0.00
481 MNTX ATTX 135.50      0.00     0.000      1.15296    0.00
482 ATTX MNTX 135.50      0.00     0.000      1.15296    0.00
483 ATTX SGTX  95.00      0.00     0.000      0.80835    0.00
484 SGTX ATTX  95.00      0.00     0.000      0.80835    0.00
485 SGTX QNTX 141.50      0.00     0.000      1.20401    0.00
486 QNTX SGTX 141.50      0.00     0.000      1.20401    0.00
487 QNTX ANTX 271.00      0.00     0.000      2.33186    0.00
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488 ANTX QNTX 271.00        0.00       0.000        2.33186     0.00
489 BHTX MRTX  75.20        0.08     439.029        0.63987    -0.32
490 MRTX BHTX  75.20        0.45    2328.232        0.63987     1.23
491 ALEX AXTX   0.00      274.89     274.887        0.24793    -0.32
492 AXTX ALEX   0.00      239.99     239.985        0.09793    -0.32
493 DMHR DRTX   0.00      519.25     519.248        0.24793    -0.32
494 DRTX DMHR   0.00      461.35     461.351        0.09793    -0.32
495 ETYB EBTX   0.00       91.56      91.563        0.31788    -0.32
496 EBTX ETYB   0.00       82.94      82.936        0.16788    -0.32
497 KFRS KSTX   0.00     5764.31    5764.314        0.26192    -0.32
498 KSTX KFRS   0.00     3350.83    3350.829        0.11192     2.79
499 MHLK MKTX   0.00      719.63     719.631        0.16399    -0.32
500 MKTX MHLK   0.00     2427.19    2427.185        0.01399    -0.32
501 TANT TTTX   0.00      624.71     624.714        0.17798    -0.32
502 TTTX TANT   0.00     2210.50    2210.498        0.02798    -0.32
503 SHKM SKTX   0.00    14044.61   14044.609        0.20596     0.42
504 SKTX SHKM   0.00    14722.30   14722.305        0.05596    -0.32
505 BNHA BHTX   0.00     8350.37    8350.372        0.17798    -0.32
506 BHTX BNHA   0.00     9595.00    9595.000        0.02798     0.06
507 CAIR CRTX   0.00     4452.58    4452.576        0.19197    -0.32
508 CRTX CAIR   0.00     6580.40    6580.399        0.04197    -0.32
509 ZGZG ZGTX   0.00     2379.55    2379.555        0.20596    -0.32
510 ZGTX ZGZG   0.00     4395.54    4395.540        0.05596    -0.32
511 ABKB AKTX   0.00      870.88     870.875        0.19197    -0.32
512 AKTX ABKB   0.00     1795.52    1795.525        0.04197    -0.32
513 MNSR MRTX   0.00     4493.71    4493.709        0.24793    -0.32
514 MRTX MNSR   0.00     1860.51    1860.506        0.09793    -0.32
515 SHRB SNTX   0.00     2130.99    2130.986        0.20596     1.38
516 SNTX SHRB   0.00      477.74     477.744        0.05596    -0.32
517 DMIT DTTX   0.00      138.58     138.584        0.16399    -0.32
518 DTTX DMIT   0.00       52.62      52.621        0.01399    -0.32
519 PRTS PSTX   0.00       64.95      64.948        0.17798    -0.32
520 PSTX PRTS   0.00       88.15      88.153        0.02798    -0.32
521 ISML ILTX   0.00        0.00       0.000        0.16399     0.00
522 ILTX ISML   0.00       18.30      18.299        0.01399    -0.32
523 SWES SSTX   0.00        0.00       0.000        0.17798     0.00
524 SSTX SWES   0.00        0.00       0.000        0.02798     0.00
525 FYUM FMTX   0.00     3907.84    3907.845        0.17798     0.71
526 FMTX FYUM   0.00      328.32     328.325        0.02798    -0.32
527 BSWF BSTX   0.00      328.32     328.325        0.20596    -0.32
528 BSTX BSWF   0.00      469.55     469.548        0.05596     8.27
529 MNIA MNTX   0.00        0.00       0.000        0.27591     0.00
530 MNTX MNIA   0.00        0.00       0.000        0.12591     0.00
531 ASYT ATTX   0.00        0.00       0.000        0.23394     0.00
532 ATTX ASYT   0.00        0.00       0.000        0.08394     0.00
533 SHAG SGTX   0.00        0.00       0.000        0.23394     0.00
534 SGTX SHAG   0.00        0.00       0.000        0.08394     0.00
535 QENA QNTX   0.00        0.00       0.000        0.34586     0.00
536 QNTX QENA   0.00        0.00       0.000        0.19586     0.00
537 ASWN ANTX   0.00        0.00       0.000        0.26192     0.00
538 ANTX ASWN   0.00        0.00       0.000        0.11192     0.00

FLOW IS OVER CAPACITY ON    53 OUT OF   534 MODAL LINKS IN THE NETWORK.

CPU TIME FOR DIRECTION FINDING=              2.59   SECONDS
CPU TIME FOR ONE DIMENSIONAL SEARCH=         0.34   SECONDS
CPU TIME FOR CONVERGENCE TEST=               0.16   SECONDS
CPU TIME FOR OUTPUT CALCULATIONS=            8.65   SECONDS
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