"EVALUATION OF ORIGIN-DESTINATION DATA FOR AN EXTERNAL CORDON LINE SURVEY"

BY

Washington State Highway Commission
Department of Highways
Division of Planning, Research & State Aid

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

A. ACKNOWLEDGEMENTS

This report is the result of a research project sponsored and conducted by the Washington State Department of Highways in an effort to improve external cordon line origin-destination survey procedures. The project was intended to both substantiate current theory used in the design and conduct of external origin destination surveys and furthermore to determine if a reduction in the level of effort could be accomplished while maintaining the required level of confidence in the data collected and the results obtained.

We would like to acknowledge the U.S. Department of Transportation, Federal Highway Administration and the University of California, Health Sciences Department whose respective batteries of computer programs made the efficient handling and analysis of the O-D data possible.

B. INTRODUCTION

The importance of the external cordon line origin-destination survey in relation to the other functions of a comprehensive transportation planning program has long been recognized by private and governmental planning bodies. The survey is widely recognized as the most reliable means of establishing current travel patterns for the internal to external and through trips of the study area. Too often, however, the magnitude of this portion of the study in terms of cost, manpower, and pure bulk of data collected has resulted in a resource drain which could have been more advantageously applied to other phases of the study.

This report addresses the problem of determining procedures for estimating the desirable amount of O-D data to collect.

C. OBJECTIVES

This research study is composed of two main parts, the objectives of which are: 1) to determine whether the characteristics of outbound traffic crossing an external cordon line are acceptably mirrored by the characteristics of the inbound traffic for a twenty-four hour period, and 2) to evaluate selected time periods as statistical bases for the expansion of interview data to a twenty-four period.

For the first part, three basic travel characteristics are to be investigated and used as a basis for determining the validity of the following hypothesis: "Inbound traffic patterns are effectively mirrored by outbound traffic patterns." First, does the distribution of trip origins by zone of the outbound traffic compare favorably with the distribution of trip destinations by zone of the inbound traffic for a twenty-four period? Second, does the trip purpose distribution of the inbound trips match the purpose distribution of the outbound trips? Finally, how well do the trip length frequency distributions of the inbound and outbound trips compare? A statistically reliable correlation for these three areas of concern would allow the conclusion that the hypothesis is valid within a predetermined level of reliability.

As a second phase of the research project, various sample time periods of the day are to be selected and expanded to represent the total twenty-four hour traffic volume. These selected periods will then be evaluated in relation to the full 24-hour interview data for both directions. If the expanded origin-destination trip matrix from a selected time period adequately reflects the characteristics of the

total universe of interviews, then it can be reasonably assumed that interviewing for fewer hours will adequately provide the required data base.

Specifically, the major objective of this study is to permit a more knowledgeable evaluation of the alternatives available with respect to planning and design of an external origin-destination survey, resulting in greater economies of funds and an increase in the confidence in the data obtained.

The origin-destination data used in this research project was obtained from an external origin-destination survey conducted in the Longview-Kelso, Washington area in August, 1967. There were eight external interview stations (Figure I-1). At four of these, interviews were obtained for a twenty-four hour period in both directions and at the remaining four, interviews were obtained for thirteen daylight hours only, also in both directions. This accounted for a total of nearly 37,000 personal auto-driver interviews. The four twenty-four hour stations accounted for 85% of the total traffic crossing the external cordon line while the remaining four stations amounted to 14% of the total crossings, resulting in nearly all the traffic being represented. Table I-1 shows a summary of the external interview stations by volume and number of interviews collected. The average interview sample rate varied from a low of 45% at station #6 to a high of nearly 88% for station #3.

The enormity of this data is probably an example of statistical "over-sampling" however, it does provide a stable population for use in comparing inbound and outbound samples for goodness of distribution, trip purpose and trip lengths.

D. ABSTRACT

The primary travel characteristic in question is the mirroring of the magnitude and distribution of the inbound trip patterns to the patterns of the outbound trips. The linear regression analysis for the internal-external (IE) trips plotted by direction and zone volume provided a correlation of 0.9885 for all survey stations combined. The association of the regression lines with the expected 45° line when plotting inbound versus outbound trips by zone is a second indicator, and showed an average intercept of about +2.6 trips with a slope of 0.989. The standard error of the estimate was calculated to be 37 trips for all stations combined. The average number of trips per zone is 237.5.

A similar analysis of the external-external (EE) trips produced a regression correlation of 0.9954 and the regression lines had an average intercept of +1.5 trips with a line slope of 0.996.

In addition to studying the distribution of the trips by zone, the O-D data was stratified into four purposes: 1) work, 2) personal business and shopping, 3) social recreation, and 4) other. Percent trips by purpose and by direction were calculated and for all stations combined there was less than a 2% discrepancy for any single purpose. The best match was work trips (0.4% difference) and the greatest difference was in the social-recreation trips, with a 1.9% difference.

A comparison of the distribution of trips by trip length was final area investigated. For IE trips inside the cordon line the inbound direction showed an average trip length of 8.86 minutes with a standard deviation of 3.44 minutes and the outbound direction produced

an average trip length of 8.89 minutes with a standard deviation of 3.43 minutes.

The total analysis performed shows a very high degree of association between directions of interview for the studied characteristics of trip ends, trip purposes, and trip length distributions for the Longview-Kelso, Washington area.

In analyzing the data it was found that the inbound direction was statistically closer to the expected distribution than was outbound, however; the difference is small (about 2 trips difference in the standard error). The two trip difference should not be construed to indicate that inbound interviewing is "better" than outbound, but rather that the difference is so small that, in fact, the two directions "mirror" one another.

The second part of the research study dealt with determining the optimum time period for interviewing. Sample time periods ranging from three to eleven hours in each direction and both directions were selected and compared to the total O-D file. Standard deviations were calculated by purpose for each sample indicating how close each one approximated the distribution found in the universe. The best time period tested was a four hour sample in both directions from 2 p.m. to 6 p.m. which resulted in an overall average standard deviation of 14 trips, which indicates that 68% of the zones were numerically less than 14 trips different than the universe. Since there are about 60,000 trips in total, this difference is acceptable especially when one considers the numerous other phases of a comprehensive transportation planning study where uncalculated probablistic decisions are necessary.

E.

CHAPTER 1

PROCEDURES

The data obtained from any external origin-destination survey around an urban area contains two types of trips: 1) internal-external (IE) trips having one end inside the cordon and the other end outside, and 2) external-external (EE) trips having both ends of the trip outside the cordon line. These two trip types are frequently analyzed differently and used in diverse applications so it was necessary to determine if each type independently displayed the mirroring effect under investigation.

The actual origins and destinations obtained in any external O-D survey are normally dispersed over a large geographic area and, depending on the kind of analysis for which they were gathered, are manually coded to a fixed set of analysis zones. The trips which end outside of the cordon line may be coded to large zones throughout the state such as counties or they may be coded to the external stations at which they were intercepted. Both of these zonal arrangements are discussed and investigated in this research paper in order to determine the extent that the mirroring effect is applicable, if at all. To accomplish this task, the origins and destinations were originally coded to a base array of 541 analysis zones. Of these, 131 are inside the study area, 391 are codes for cities or areas inside the State of Washington and 19 are external to the State. For the research study, the analyses could be performed with greater economy if fewer zones were used in the comparisons of trips, so the 541 zones were grouped into larger districts, both inside and outside the study cordon line.

The origins and destinations were recoded to provide three basic configurations for use in the research.

Configuration 1. Trips inside the cordon (66 zones).

All internal-external trips in the inbound (IE-IB) direction begin at an external station where they were intercepted and end inside the cordon. All internal-external trips in the outbound (IE-OB) direction begin inside the cordon and end at an interview station. All external-external trips regardless of direction (EE-IB or EE-OB) begin and end at the cordon line.

This configuration allows for the determination of whether the distribution of the OB origins mirrors the distribution of the IB destinations for trips as far as the cordon line but not beyond, representing the type of situation used in a transportation study. The cordon area is the original 131 zones collapsed tc a total of 66 zones, 58 of which are zones inside the cordon and 8 are external interview stations on the cordon itself.

Configuration 2. Trips outside the cordon (48 zones).

The cities inside the state were recoded (collapsed) into a set of 48 zones corresponding to counties for the most part. The proximity of the study area to the Washington-Oregon border required that some special zones be created to accommodate special areas of trips. The zones inside the cordon were collapsed to one "area", for Longview and Kelso. The remainder of Cowlitz County was divided into three zones.

This zonal organization allows for the anlysis of directional distributions for the trip ends beyond the cordon line and also for

trip purpose comparisons for the trip ends beyond the cordon line.

Configuration 3. Trips outside the cordon (406 zones).

In order to analyse the trip length frequency distribution for the trips outside the cordon line an existing street and highway network was utilized which was composed of all state and interstate highways in Washington as well as connections to border states and Canada. The zone numbers as originally coded correspond with the centroid numbers of this network.

These three zonal configurations allowed the analysis of the desired travel characteristics without altering the statistical reliability of the information. Also, a smaller sample size (number of zones) was achieved for cost economy of the analysis while maintaining samples large enough for accurate statistical comparisons.

This report contains the summary data from the research study for all the interview stations combined. A file of the voluminous background material is compiled and contains the individual station analyses as well as the techincal data on computer techniques used in data editing, reformatting and trip expansion procedures.

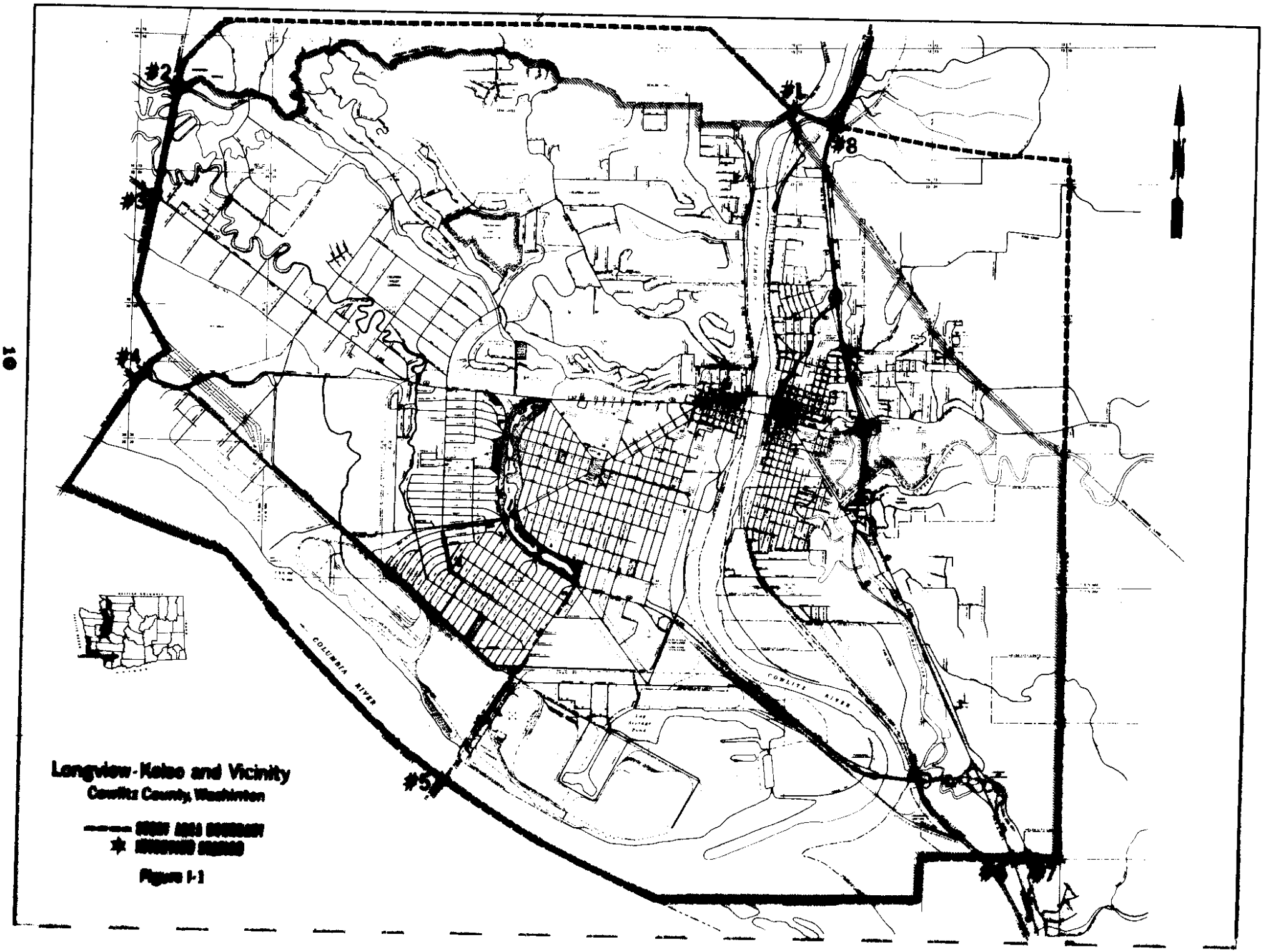

#2
#1
#8
#4
#5
COWLITZ RIVER
COLUMBIA RIVER
Longview-Kelso and Vicinity
Cowlitz County, Washington

Figure I-1

INTERVIEW STATION VOLUMES

STATION NUMBER	ROUTE	AVERAGE WEEKDAY 24-HOUR VOLUME	NUMBER OF INTERVIEWS	AVERAGE SAMPLE RATE
1	SR 411	3,372	2,517	74.6%
2	COAL CREEK RD.	1,513	1,282	84.7%
3*	SR 4	5,572	4,901	87.9%
4	MEMORIAL PARK	560	442	78.9%
5*	SR 433	7,738	6,179	79.8%
6*	INTERSTATE - 5	19,823	8,943	45.1%
7	US 99	2,176	1,474	67.7%
8*	INTERSTATE - 5	19,034	10,883	57.1%
TOTAL	-	59,788	36,621	61.25%

* Indicates 24 hours of interviewing

TABLE I-1

F.

CHAPTER II

TRIPS TO THE CORDON LINE

For this part of the analysis a total of 66 'compressed' zones were used: 58 inside the cordon line (internals) and eight external stations at the cordon line. The two types of trips, IE and EE, were handled separately in the comparison procedure but are summarized together in Table II-1 below.

TRIPS TO THE CORDON

	IE	EE	TOTAL
INBOUND	13,938	15,919	29,857
OUTBOUND	13,641	16,291	29,932
TOTAL	27,579	32,210	59,789

Table II-1

HISTOGRAMS:

The distribution of trips inside the cordon line for each of the external stations was the first part of the analysis for the IE trips. The eight external stations were omitted as observations themselves since, 1) the distribution inside the cordon was the major concern and 2) the EE trips were to be handled separately. This left a sample size of 58 for each station for each direction.

To determine whether the observed differences of inbound versus outbound trips by zone were normally distributed it was decided to use a percentage value instead of the actual quantity of trips. This was done to normalize differences in station volumes and to make the histograms more comparable. Each zonal observation of trips was

transgenerated to a percentage by dividing by the total trips for that station and direction. In addition, this process allowed for an accounting of the slight differences in total trips by direction which resulted from the expansion procedure. The calculated percentages were then subtracted, inbound minus outbound, and histograms were constructed of the percent differences. Figure II-1 shows the histogram of I-E trips for all stations combined and the normality of the distribution is apparent. The mean value of the observations will, of course, be zero since the data represented are percentages and the percent differences, plus and minus, will sum to zero. The standard deviation of 0.2687% indicates that 68.27% of the observations (about 40 zones) are within the range of 0.0 (mean) plus or minus 1/4 of one percent, (a value of 37 trips per zone) which is normally an acceptable error, especially when the histogram shows that in no case does the difference exceed one percent for all stations combined which represents about 140 trips.

REGRESSION:

A regression analysis was performed comparing inbound destinations to the outbound origins for the 58 internal zones for each station seperately and one for all stations combined. Scatter plots were constructed using the IB destinations on the X-axis and the OB origins along the Y-axis. If a perfect mirroring were to take place, all points in the plots would fall on a 45° line of Y=X, and, naturally this is not the case. Figure II-2 which is a scatter plot for I-E trips for all stations combined, does indicate a high degree of correlation both visually and statistically. The two equations from Figure II-2 are the result of each direction being used as the

independent variable and the other dependent. The 'Y' equation (OB=8.1285+0.9449*IB) indicates that as a result of the regression where IB was independent that the OB trips could be calculated by using this equation. Comparing this and the 'X' equation to the expected 45° line it can be seen that the intercept (-2.9348) and the slope (1.0343) of the 'X' equation is somewhat closer to the expected intercept of zero and slope of 1.00, however either relationship is acceptable in determining the number and pattern of trips in the opposite direction. The direction chosen for interviewing should depend on the conditions at any particular study site such as peaking characteristics in each direction, general trip purpose distributions and any physical constraints.

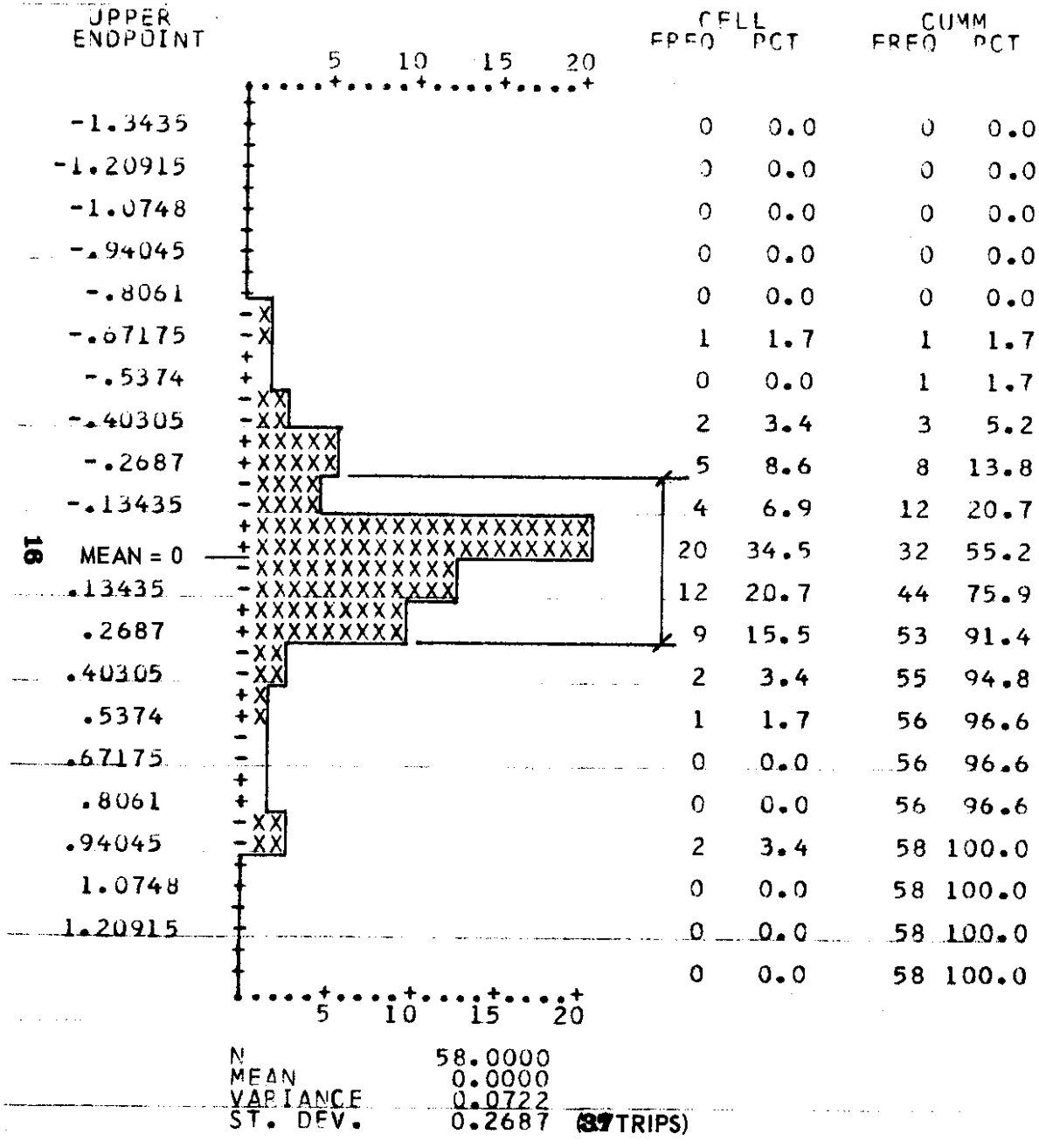
STANDARD ERROR:

The standard error of the estimate has properties analogous to the standard deviation, and was calculated for each station for both variables. If, for example, lines are constructed parallel to the regression line of Y or X above and below a vertical amount equal to one standard error than it can be said that 68.27% of the observations would be included between these lines. Standard errors of 36.00 trips (inbound independent) and 37.67 trips (outbound independent) were calculated for all stations combined using the IE trips.

These three statistical checks (percent difference, linear regression, and standard error) are summarized by individual station and for all stations combined in Table II-2. The summary shows the same high degree of correlation on an individual station basis as well as for all stations combined.

For the external-external trips to the cordon line the zones are actually the eight external stations. Figure II-3 shows the expected 45° line and the regression lines for the EE trips. The sample size (eight) is small and even through a correlation coefficient of 0.992 was calculated, more substantial analysis was indicated.

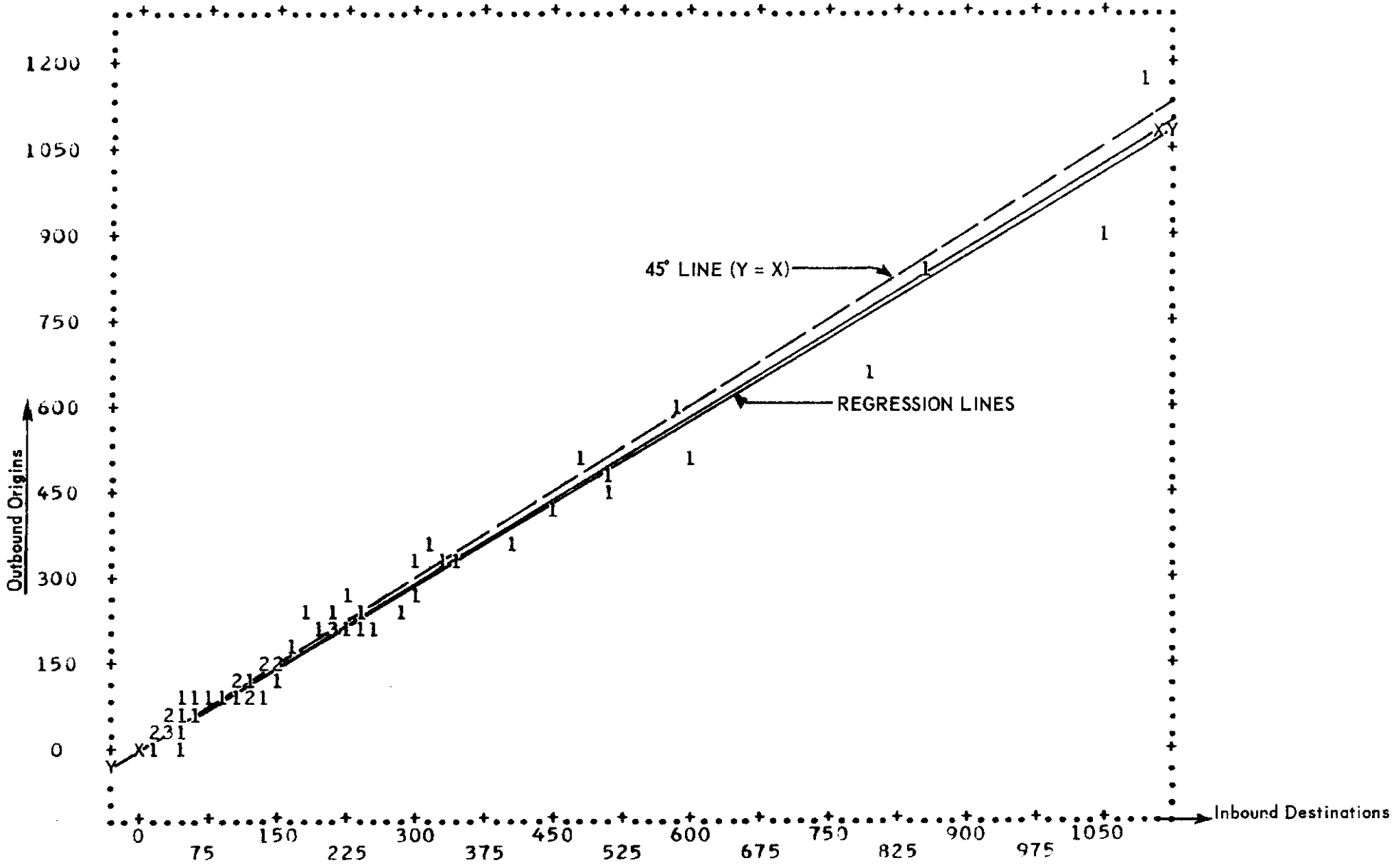
Thus, in Chapter IV, the IE and EE trips are carried beyond the cordon line to the actual county of their destination in order to determine if the correlation demonstrated here holds as well for that zonal configuration.



INTERNAL - EXTERNAL TRIPENDS TO CORDON FOR ALL STATIONS COMBINED

HISTOGRAM OF PERCENT DIFFERENCE (INBOUND - OUTBOUND)

Figure II-1



INTERNAL - EXTERNAL TRIPENDS TO
CORDON FOR ALL STATIONS COMBINED

MEAN OF X 240.3103
MEAN OF Y 235.1896
VARIANCE OF X 61212
VARIANCE OF Y 55922
CORRELATION .9885
Y=8.1285+.9449*X
X=-2.9348+1.0343*Y

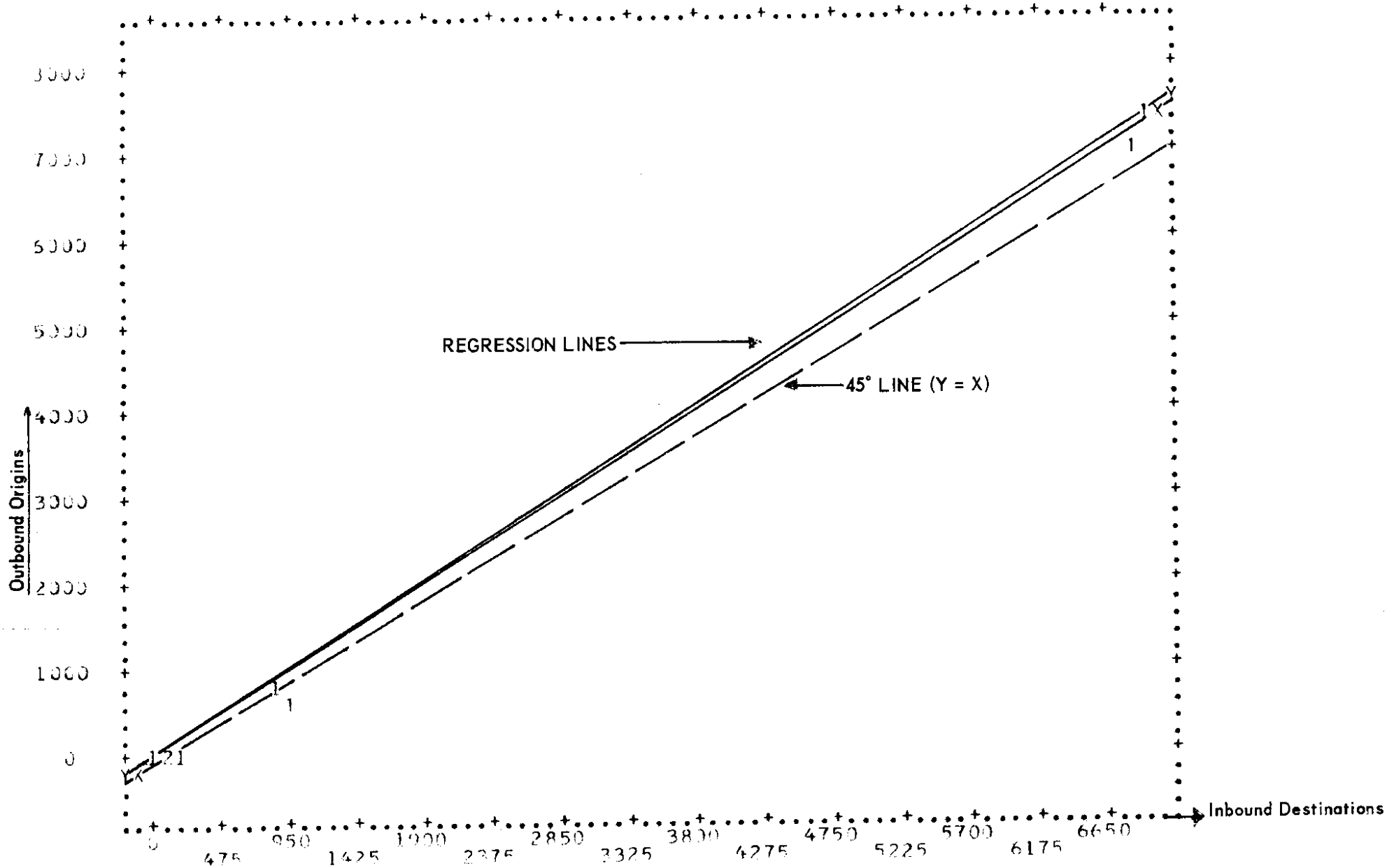
Figure II-2

IE TRIPS TO CORDON
SUMMARY

INTV STA.	DIR	MEAN TRIPS	STATN. VOLUME	CORREL. (r)	DETER. (r^2)	STD. DEV.	VAR. (STD^2)	STD. ERROR	REGRESSION LINE INTCPT	REGRESSION LINE SLOPE	STD.DEV. % DIFF.
1	IB	26.16	1518			36.67	1344.69	12.86	3.7	.9008	
	OB	27.26	1581			35.40	1253.63	13.31	-0.2	.9663	
	TOTAL			0.933	0.870						0.8701
2	IB	11.19	651			13.47	181.59	5.00	1.4	.8729	
	OB	11.12	646			12.76	162.92	5.28	0.4	.9730	
	TOTAL			0.922	0.850						0.8085
3	IB	33.09	1916			30.38	923.24	11.12	1.0	.9123	
	OB	31.21	1811			29.83	889.85	11.32	3.5	.9466	
	TOTAL			0.929	0.863						0.6109
4	IB	3.95	231			4.58	20.96	2.86	1.3	.7057	
	OB	4.07	238			4.30	18.49	3.05	0.7	.8002	
	TOTAL			0.752	0.566						1.3572
5	IB	50.98	2960			59.88	3585.35	14.58	0.5	.9784	
	OB	50.38	2924			60.34	3640.87	14.46	2.4	.9635	
	TOTAL			0.971	0.943						0.4949
6	IB	51.79	3003			53.19	2828.80	16.00	7.0	.7790	
	OB	47.31	2741			44.26	1959.13	18.88	-1.4	1.1248	
	TOTAL			0.936	0.876						0.6245
7	IB	16.74	971			20.88	436.09	7.09	2.5	.8769	
	OB	17.21	998			19.61	384.69	7.55	-0.4	.9940	
	TOTAL			0.934	0.872						0.7718
8	IB	46.41	2691			56.23	3162.00	11.82	1.7	.9688	
	OB	46.64	2706			55.73	3105.29	11.92	0.4	.9865	
	TOTAL			0.978	0.956						0.4396
ALL	IB	240.3	13941			247.41	61212.00	36.00	8.1	.9449	
	OB	235.2	13645			236.48	55922.00	37.67	-3.0	1.0343	
	TOTAL			0.989	0.978						0.2687

MEAN SEO(X) = 10.16
MEAN SEO(Y) = 10.72

TABLE II-2



MEAN OF X 1089.3736
MEAN OF Y 2036.3744
VARIANCE OF X 9181226
VARIANCE OF Y 10539360
CORRELATION .9992
Y=-93.9709+1.0706*X
X=90.6829+.9326*Y

EXTERNAL-EXTERNAL TRIPENDS TO CORDON FOR ALL STATIONS COMBINED

Figure II-3

CHAPTER III

TRIPS TO COUNTIES

The 541 original zones were grouped into 48 county size zones. The zones inside the cordon became one county (number eight) and other special areas such as Rainier and Portland, Oregon were recoded to a separate county zone also. With the study area compressed to a point source and the cordon line eliminated as an end for the trips it was possible to analyse the trips on a statewide basis to determine whether the mirroring as determined in Chapter II for the study area also holds true for statewide area. Similar analyses to those performed for the study area zones were accomplished for the county zones, ie, regression, standard error and percent difference. The breakdown of the total trips by direction and type is shown in Table III-1.

TRIPS TO COUNTIES

	IE	EE	TOTAL
INBOUND	13941	15917	29858
OUTBOUND	13641	16285	29926
TOTAL	27582	32202	59784

TABLE III-1

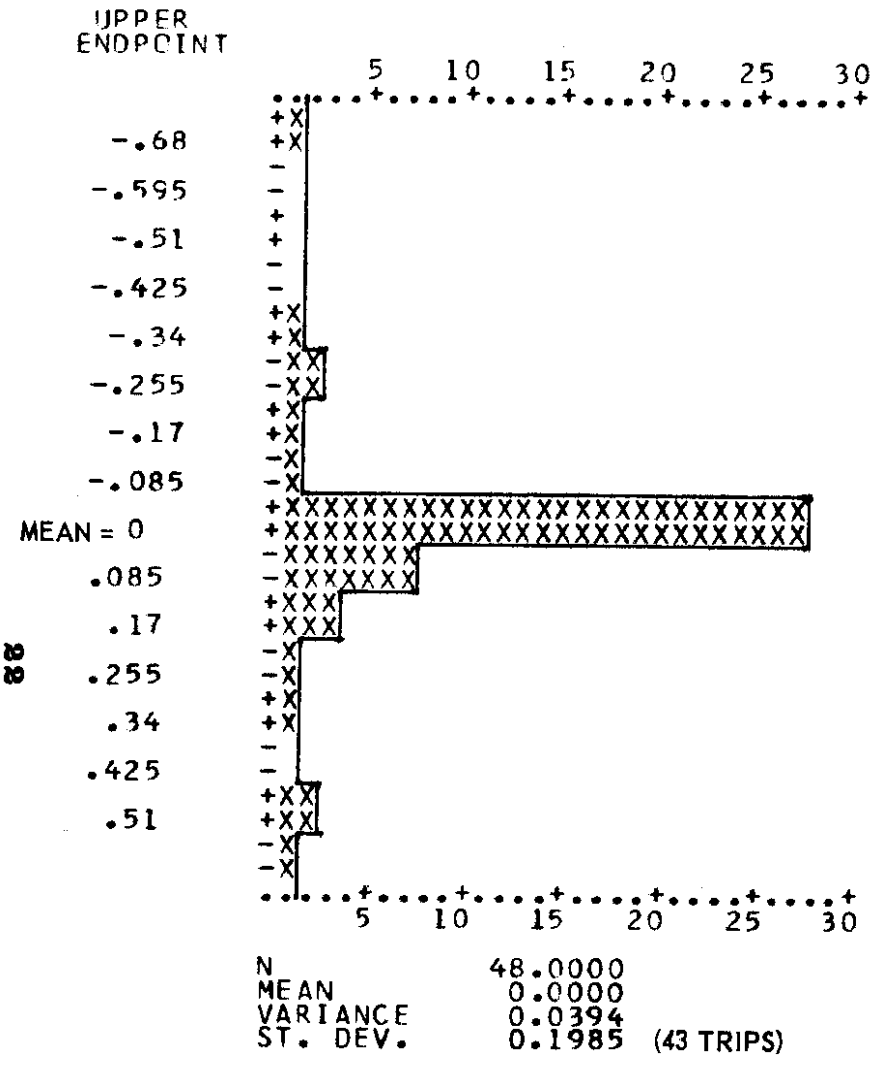
A histogram showing the percent differences for the total I-E inbound and outbound trips to the county zones was developed (Figure III-1). The standard deviation is 0.1985% or about 43 trips per zone.

The regression plot for the IE trips, Figure III-2, shows a high degree of correlation between the expected 45° line and the regression

lines (0.9993). The standard error of the estimate for all stations combined in less than 44 trips. One reason for the exceptionally high correlation is the small number of counties which actually had origins or destinations to them. The 32 zones with no trips in or out had a decided influence on the correlation of the data. The plot does show, however, that the other 16 zones are near the expected 45° line.

The summary statistics for each station and for all stations combined are shown in table III-2. Since the average number of I-E tripends per zone is 281.45 and the standard error of the estimate is less than 44 and there is a good correlation from the regression, the conclusion can be made that a mirroring of the directional traffic exists both in magnitude and distribuition.

The through (EE) trips to the counties exhibited similar standard deviations, correlations, and standard errors as those from the I-E trip group. A mirroring of the directional traffic is also concluded for the E-E trip group. Figure III-3 is a histogram showing the percentage difference for traffic for this group. Figure III-4 is the regression plot and table III-3 shows the summary statistics for each station and total trips for the E-E trip group.



UPPER ENDPOINT	CELL FREQ	CELL PCT	CUMM FREQ	CUMM PCT
-.68	1	2.1	1	2.1
-.595	0	0.0	1	2.1
-.51	0	0.0	1	2.1
-.425	0	0.0	1	2.1
-.34	1	2.1	2	4.2
-.255	2	4.2	4	8.3
-.17	1	2.1	5	10.4
-.085	1	2.1	6	12.5
MEAN = 0	27	56.3	33	68.8
.085	7	14.6	40	83.3
.17	3	6.3	43	89.6
.255	1	2.1	44	91.7
.34	1	2.1	45	93.8
.425	0	0.0	45	93.8
.51	2	4.2	47	97.9
	1	2.1	48	100.0

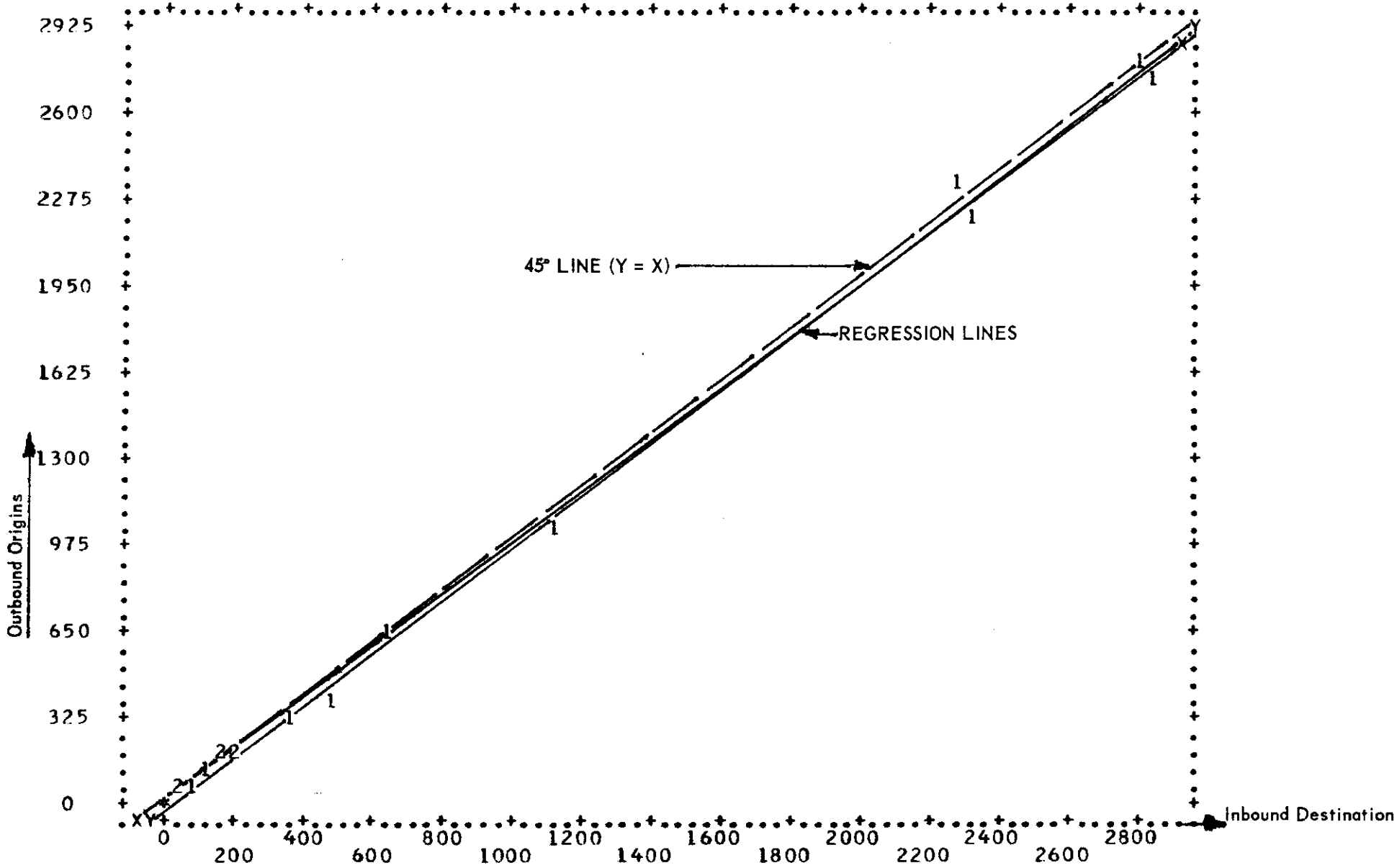
N	48.0000
MEAN	0.0000
VARIANCE	0.0394
ST. DEV.	0.1985

(43 TRIPS)

INTERNAL - EXTERNAL TRIPENDS TO COUNTY ZONES FOR ALL STATIONS COMBINED

PERCENT DIFFERENCE (INBOUND - OUTBOUND)

Figure III-1



MEAN OF X 284.51
MEAN OF Y 278.3876
VARIANCE OF X 516368
VARIANCE OF Y 494795
CORRELATION .9993
Y=.08667+.9782*X
X=.325+1.0208*Y

INTERNAL - EXTERNAL TRIPENDS TO COUNTY ZONES FOR ALL STATIONS COMBINED

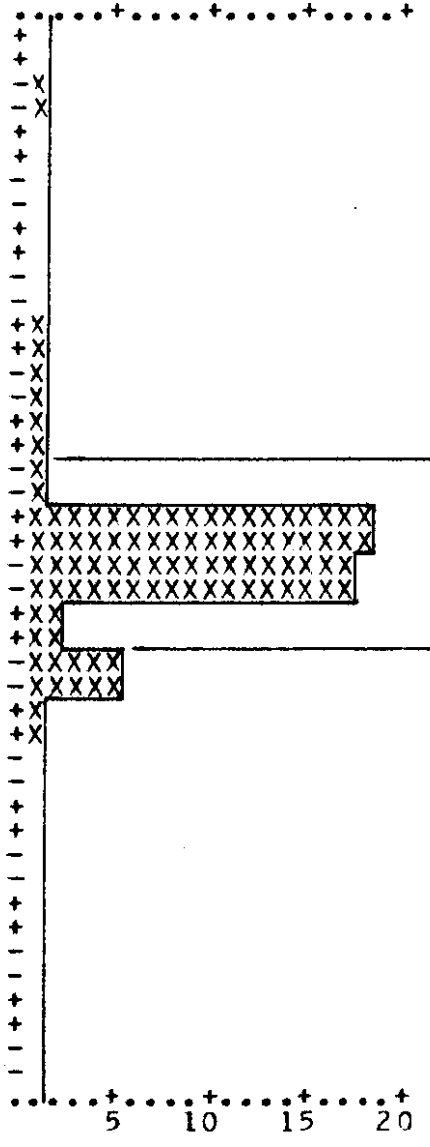
Figure III-2

IE TRIPS TO COUNTIES
SUMMARY

INTV STA.	DIR	STATN VOL	CORREL. (r)	DETER. (r^2)	MEAN TRIPS	STD. DEV.	VAR. (STD^2)	STD. ERR.	REGRESSION LINE INTCPT	REGRESSION LINE SLOPE	STD.DEV. % DIFF.
1	IB	1518			30.98	137.12	18802	21.06	-0.356	1.052	
	OB	1580			32.24	144.92	21003	20.85	0.604	0.942	
	TOTAL	3098	0.9957	0.9914							0.8684
2	IB	651			13.29	90.25	8145.7	4.22	0.192	0.978	
	OB	646			13.18	88.26	7789.9	4.30	-0.1944	1.023	
	TOTAL	1297	0.9999	0.9998							0.2769
3	IB	1916			39.10	187.51	35160	27.62	0.602	0.929	
	OB	1810			36.94	174.45	30433	29.30	-0.558	1.074	
	TOTAL	3726	0.9989	0.9978							0.4906
4	IB	232			4.73	27.50	756.4	3.18	-0.128	1.053	
	OB	238			4.86	28.97	839.3	3.05	0.126	0.949	
	TOTAL	470	0.9996	0.9992							0.4670
5	IB	2959			60.39	400.00	160003	4.74	-0.681	0.999	
	OB	238			59.65	399.67	159738	4.73	0.689	1.001	
	TOTAL	5882	0.9999	0.9998							0.2164
6	IB	3003			61.29	245.56	60299	47.56	0.554	0.904	
	OB	2742			55.96	222.13	49342	52.27	-0.538	1.105	
	TOTAL	5745	0.9994	0.9988							0.2974
7	IB	972			19.84	136.82	18720	7.50	0.013	1.026	
	OB	998			20.37	140.39	19709	7.31	-0.012	0.975	
	TOTAL	1970	1.000	1.000							0.1985
8	IB	2690			54.90	242.31	58715	15.30	1.668	0.975	
	OB	2704			55.18	236.38	55877	15.39	-1.627	1.024	
	TOTAL	5394	0.9993	0.9986							0.0677
ALL	IB	13941			284.51	718.59	516368	43.08	0.086	0.978	
	OB	13641			278.38	703.41	494795	43.38	0.325	1.021	
	TOTAL	27582	0.9993	0.9986							0.1985

TABLE III-2

VARIABLE 9 *



UPPER ENDPOINT	CELL FREQ	CELL PCT	CUMM FREQ	CUMM PCT
-2.0405	0	0.0	0	0.0
-1.83645	1	2.1	1	2.1
-1.6324	0	0.0	1	2.1
-1.42835	0	0.0	1	2.1
-1.2243	0	0.0	1	2.1
-1.02025	0	0.0	1	2.1
-.8162	1	2.1	2	4.2
-.61215	1	2.1	3	6.3
-.4081	1	2.1	4	8.3
-.20405	1	2.1	5	10.4
MEAN = 0	18	37.5	23	47.9
.20405	17	35.4	40	83.3
.4081	2	4.2	42	87.5
.61215	5	10.4	47	97.9
.8162	1	2.1	48	100.0
1.02025	0	0.0	48	100.0
1.2243	0	0.0	48	100.0
1.42835	0	0.0	48	100.0
1.6324	0	0.0	48	100.0
1.83645	0	0.0	48	100.0
2.04049	0	0.0	48	100.0
	0	0.0	48	100.0

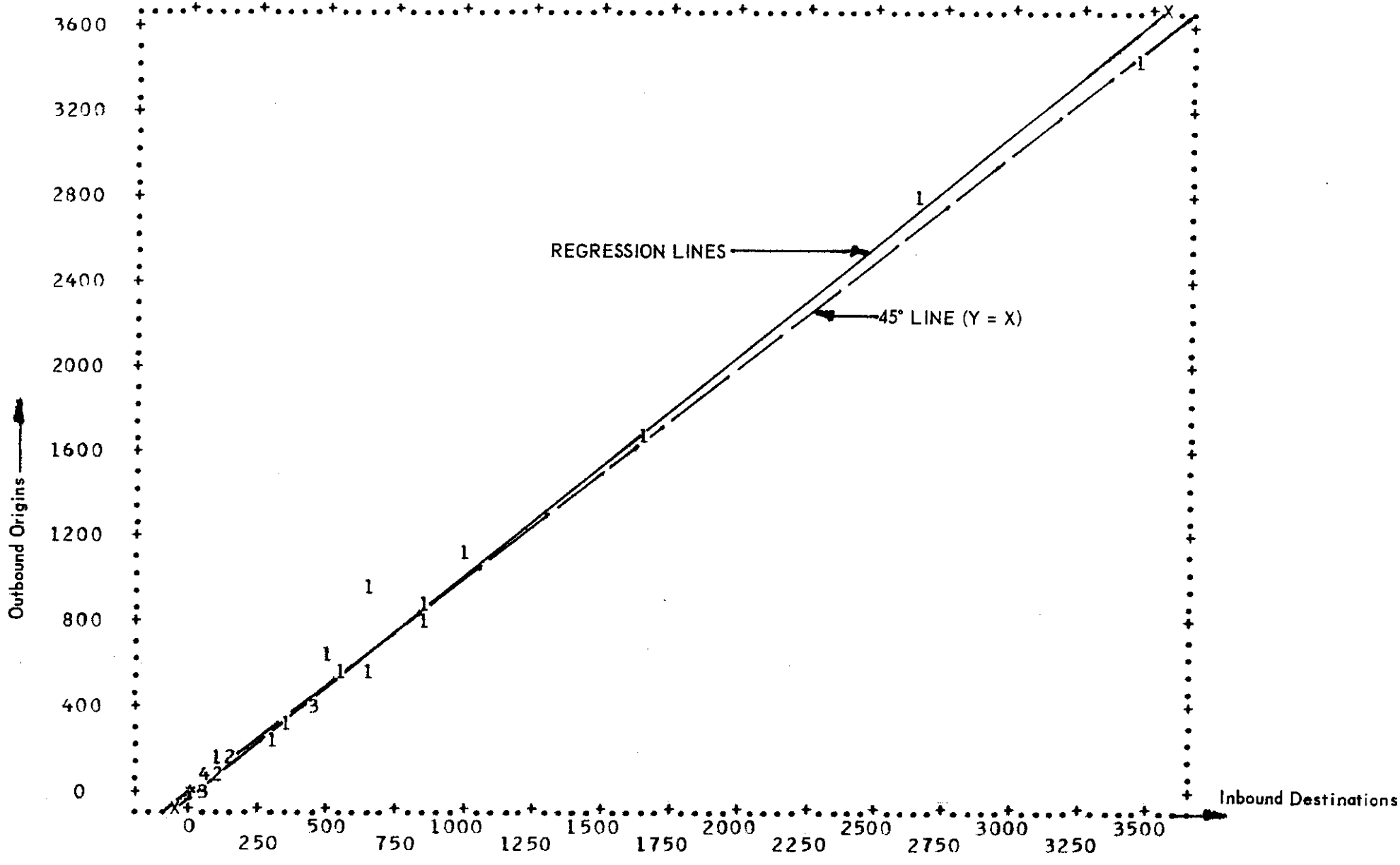
N	48.0000
MEAN	0.0000
VARIANCE	0.1665
ST. DEV.	0.4081

(65 TRIPS)

EXTERNAL - EXTERNAL TRIPENDS TO COUNTY ZONES FOR ALL STATIONS COMBINED

HISTOGRAM OF PERCENT DIFFERENCE (INBOUND - OUTBOUND)

Figure III-3



MEAN OF X 331.604
MEAN OF Y 339.2707
VARIANCE OF X 447689
VARIANCE OF Y 479497
CORRELATION .9954
Y=-2.335+1.0302*X
-.28 .9 *Y

EXTERNAL-EXTERNAL TRIPENDS TO COUNTY ZONES FOR ALL STATIONS COMBINED

Figure III-4

EE TRIPS TO COUNTIES
SUMMARY

INTV STA.	DIR	MEAN TRIPS	STATN. VOLUME	CORREL. (r)	DETER. (r^2)	STD. DEV.	VAR. (STD^2)	STD. ERROR	REGRESSION LINE INTCPT	REGRESSION LINE SLOPE	STD.DEV. % DIFF.
1	IB	3.833	184			16.27	264.74	2.7034	0.203	0.669	
	OB	2.771	133			11.22	125.93	3.9199	-0.068	1.408	
	TOTAL		317	0.9712	0.9432						2.113
2	IB	2.104	101			13.29	176.52	0.4101	0.056	0.913	
	OB	1.980	95			12.15	147.60	0.4485	-0.059	1.093	
	TOTAL		196	0.9994	0.9988						0.567
3	IB	17.917	860			72.45	5249.22	17.0564	-2.99	1.280	
	OB	20.000	960			94.51	8932.38	13.0753	2.83	0.750	
	TOTAL		1820	0.9839	0.9681						2.164
4	IB	0.812	39			5.63	31.68	0.2040	0.043	0.716	
	OB	0.625	30			4.04	16.32	0.2842	-0.057	1.392	
	TOTAL		69	0.9988	0.9976						1.191
5	IB	18.792	902			108.08	11682	5.6562	-0.991	1.097	
	OB	19.625	942			118.71	14092	5.1499	0.942	0.909	
	TOTAL		1844	0.9989	0.9978						0.848
6	IB	144.208	6922			545.40	297464	50.7343	3.241	0.023	
	OB	150.792	7238			560.30	313931	49.3858	-1.985	0.969	
	TOTAL		14160	0.9960	0.9920						0.714
7	IB	2.021	97			13.56	183.93	0.3291	0.021	1.010	
	OB	2.063	99			13.71	187.88	0.3256	-0.019	0.989	
	TOTAL		196	0.9997	0.9994						0.357
8	IB	141.912	6812			418.73	175337	31.8133	-7.139	1.047	
	OB	141.417	6788			439.50	193159	30.3137	7.513	0.950	
	TOTAL		13600	0.9974	0.9948						0.558
ALL 1-8	IB	331.604	15917			669.10	447689	67.0048	-2.335	1.030	
	OB	339.271	16285			692.46	479497	64.7442	5.285	0.962	
	TOTAL		32202	0.9954	0.9908						0.408

TABLE III-3

CHAPTER IV

TRIP PURPOSE

In addition to assuring that trip end distributions were mirrored satisfactory by direction, it was also necessary to check trip purpose compatibility for the interview data by station and direction. On the original interview form "from purpose" and "to purpose" was coded, each having a range from zero to nine. These purposes were combined and collapsed into four general purpose categories of 1) Work, 2) Personal Business and Shopping, 3) Social-Recreation and 4) Other.

The recode and collapse procedure did not influence the results of the purpose comparisons as it was performed uniformly and before any IB-OB checks were made. It is likely that some differences in the purpose categories which were grouped into the "other" purpose (serve passenger, school, eat meal, etc.), which were a small percentage overall, may have been clouded by compensating differences. These purposes are generally not handled independently, however, and their grouping into the "other" purpose category is a reasonable procedure. Table IV-1, below, shows the trips by purpose and direction for all stations combined.

TOTAL TRIPS BY PURPOSE CATEGORY

TYPE	WORK	PB&S	S-RC	OTHER	TOTAL
IE IB	4,960	4,148	3,623	1,210	13,941
IE OB	4,758	3,971	3,825	1,091	13,645
EE IB	1,821	2,358	9,881	1,855	15,915
EE OB	1,949	2,348	10,280	1,711	16,288
TOTAL	13,488	12,825	27,609	5,867	59,789
IB TOTAL	6,781	6,506	13,504	3,065	29,856
	(22.8%)	(21.8%)	(45.2%)	(10.2%)	
OB TOTAL	6,707	6,319	14,105	2,802	29,933
	(22.4%)	(21.1%)	(47.1%)	(9.4%)	

Table IV-1

Bar charts were constructed for each external station for IE and EE trips showing the percentage of the inbound and outbound trips by purpose. Figure IV-1 shows the bar chart for all stations and all IE-EE trips combined. The mirroring effect is demonstrated by the bars being of nearly equal height. The bar charts for each individual station are included in Appendix A and the mirroring is indicated on this level also.

As may be expected the social-recreation trip purpose shows the most variation on a percentage basis probably due to the fact that vacation travel patterns are generally less predictable than other purposes.

TRIP PURPOSE COMPARISON – TRIPS TO CORDON
ALL TRIPS COMBINED

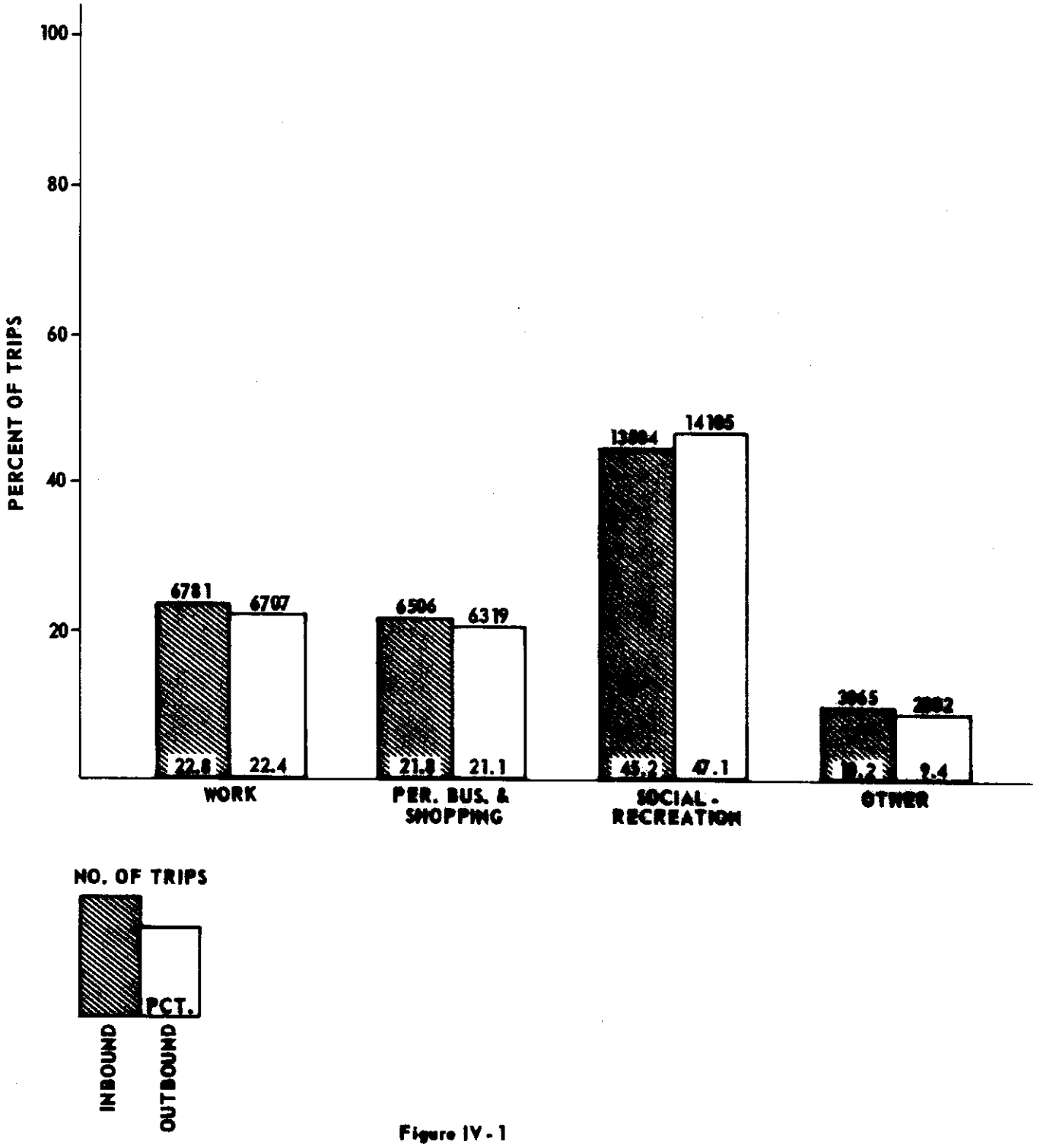


Figure IV - 1

CHAPTER V

TRIP LENGTH

The final trip characteristic investigated was trip length frequency distribution. Two networks were created for the calculation of the trip lengths, one for the street system inside the cordon, and one for statewide and beyond. The trip length frequencies are mirrored if the plots are generally coincident one with the other.

Zone to zone travel times from the networks were calculated and compared with these trip tables.

Table V-1 shows summary average trip lengths and standard deviations for the various categories, and Figures V-1 thru V-4 show the trip length frequency plots. As expected frequency distributions for the different types of trips vary significantly, however the two directions inbound and outbound are mirrored well for the same trip type.

The largest discrepancy, inbound versus outbound, is for the IE trips to the cordon line in the five to seven minute range. This is mainly a result of the relatively gross level of detail to which the internal highway network was coded. The inbound trips may use different links than the outbound, resulting in different trip lengths.

Overall, the plots indicate a good balance by direction with the differences small enough to assume reliability for all trip types. The average trip lengths and the standard deviations of these trip lengths for each direction for each trip category selected were very close. The largest difference observed being in the statewide EE trips of 11/2 %.

TRIP LENGTH FREQUENCY DISTRIBUTION SUMMARY TABLE

NETWORK USED	DIRECTION	TRIP TYPE	AVG. TRIP LENGTH (min.)	STANDARD DEVIATION
Internal	Inbound	IE	8.86	3.43
	Outbound	IE	8.88	3.42
	Inbound	EE	7.93	3.23
	Outbound	EE	7.95	3.23
Statewide	Inbound	IE	38.17	44.72
	Outbound	IE	38.18	45.53
	Inbound	EE	275.60	186.03
	Outbound	EE	280.14	189.03

TABLE V-1

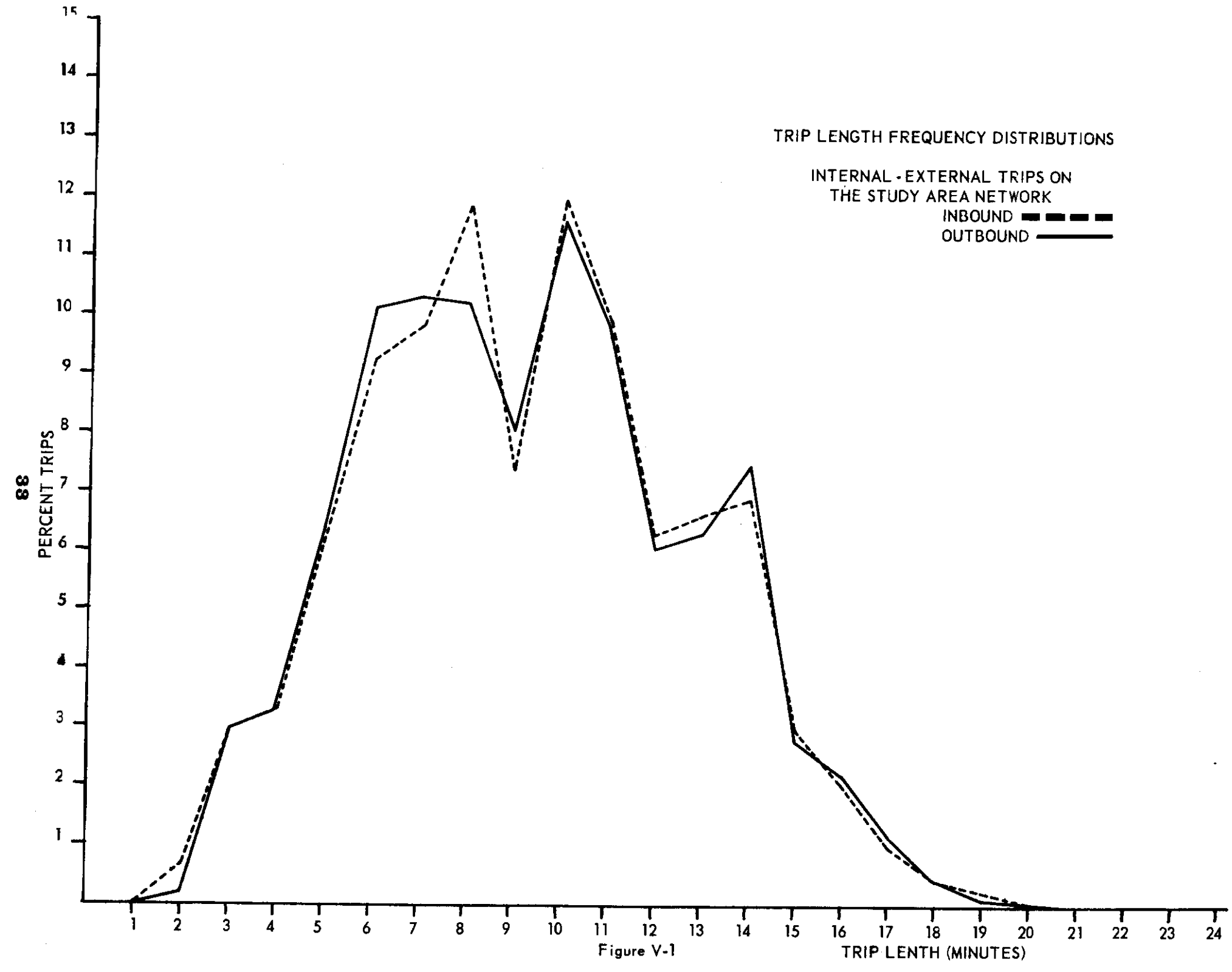

TRIP LENGTH FREQUENCY DISTRIBUTIONS
INTERNAL - EXTERNAL TRIPS ON
THE STUDY AREA NETWORK
INBOUND
OUTBOUND
PERCENT TRIPS
TRIP LENTH (MINUTES)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Figure V-1

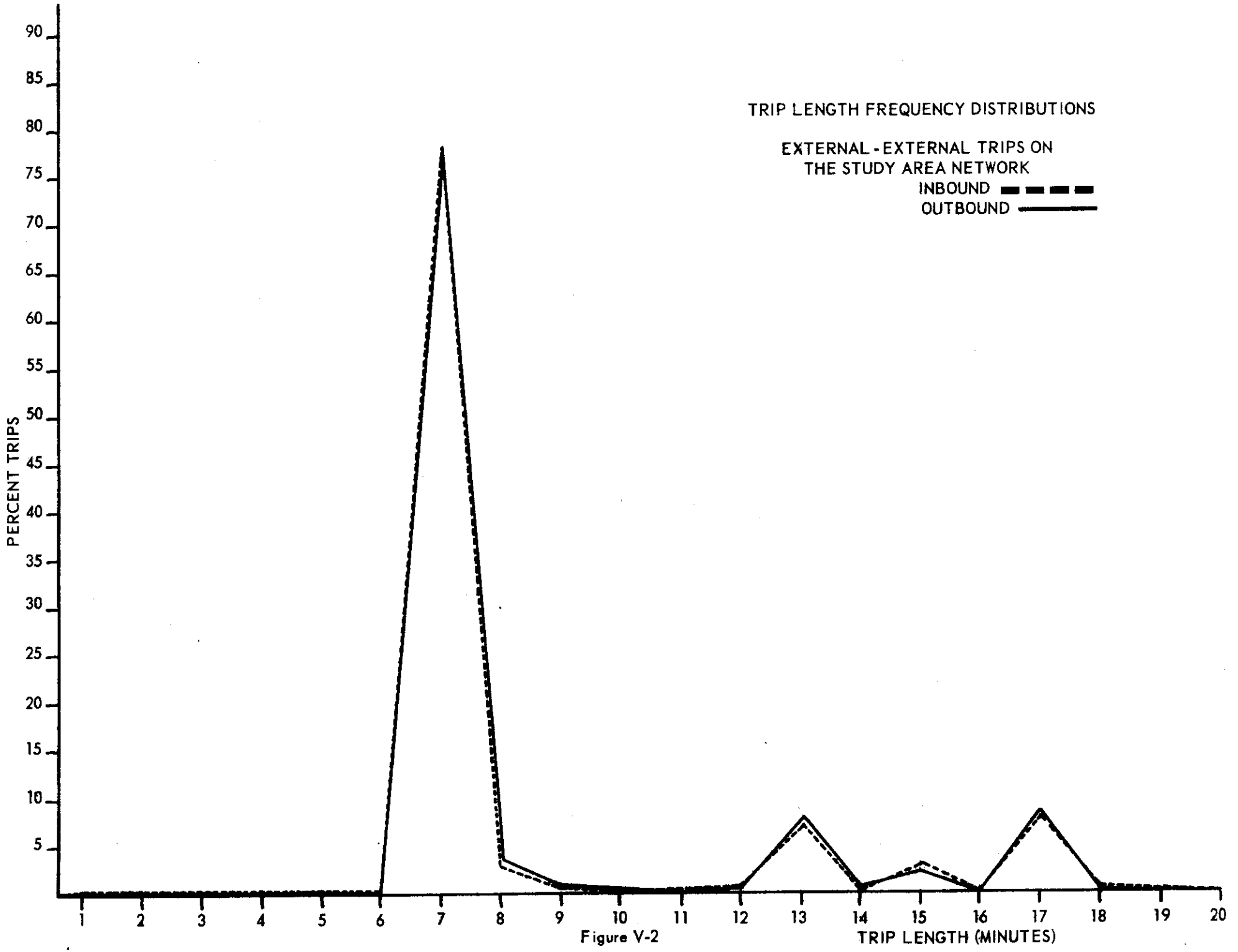

TRIP LENGTH FREQUENCY DISTRIBUTIONS
EXTERNAL - EXTERNAL TRIPS ON THE STUDY AREA NETWORK
INBOUND
OUTBOUND
PERCENT TRIPS
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
TRIP LENGTH (MINUTES)

Figure V-2

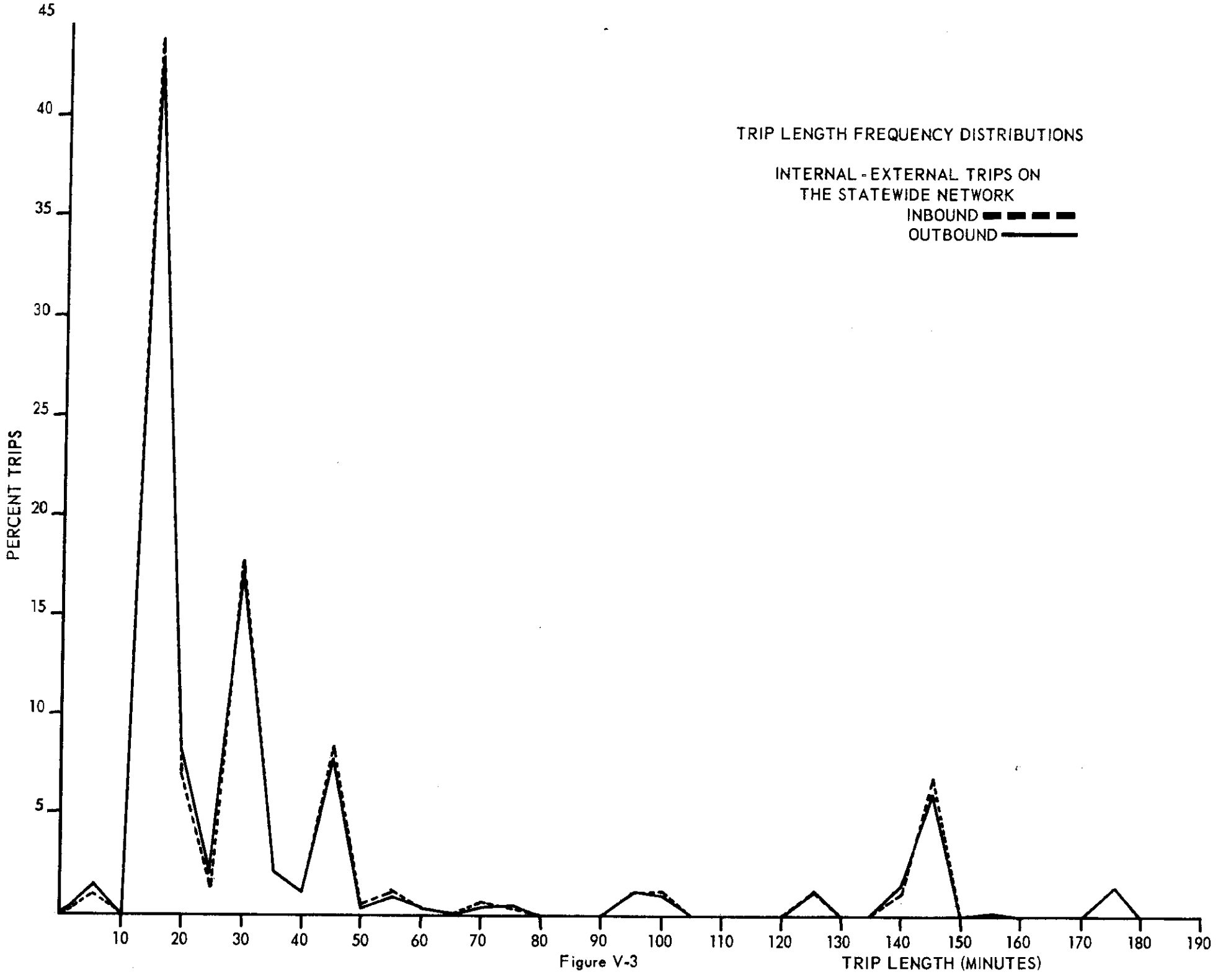

TRIP LENGTH FREQUENCY DISTRIBUTIONS
INTERNAL - EXTERNAL TRIPS ON
THE STATEWIDE NETWORK
INBOUND
OUTBOUND
PERCENT TRIPS
45
40
35
30
25
20
15
10
5
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
TRIP LENGTH (MINUTES)

Figure V-3

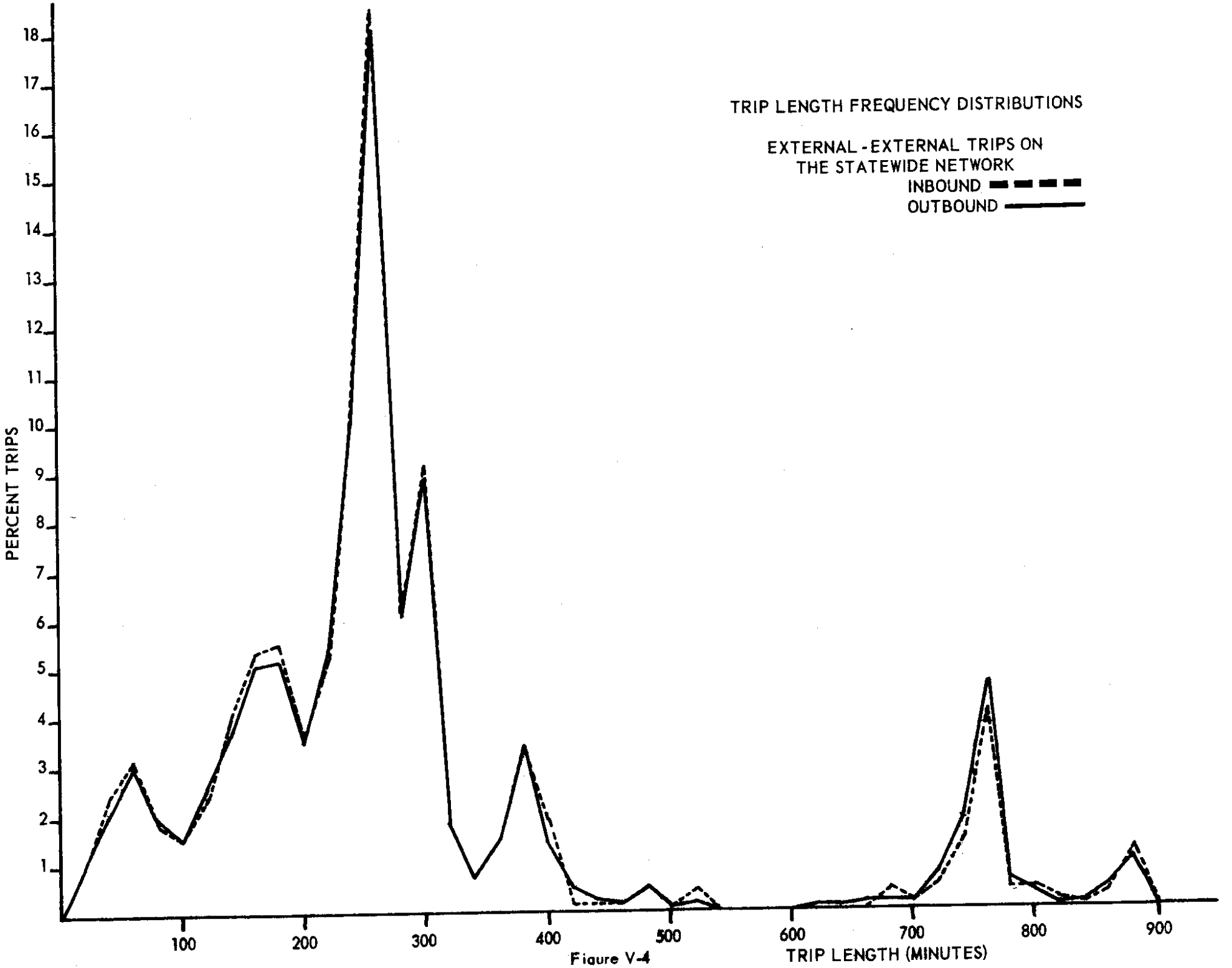

TRIP LENGTH FREQUENCY DISTRIBUTIONS
EXTERNAL - EXTERNAL TRIPS ON THE STATEWIDE NETWORK
INBOUND
OUTBOUND
PERCENT TRIPS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
100
200
300
400
500
600
700
800
900
TRIP LENGTH (MINUTES)

Figure V-4

CHAPTER VI

SAMPLING SELECTED TIME PERIODS

Introduction

Having determined that inbound travel characteristics effectively mirror the outbound for the twenty-four hour period, the second phase of the study was undertaken. This phase was to determine if acceptable results could be obtained by interviewing only selected hours of the day and expanding the interviews to represent daily travel by means of expansion factors.

A population data base from which samples could be selected was constructed using all the interview data for all stations in both directions. This universe was separated into the four general trip purposes of work, shopping, social-rec, and other for each station. The time periods chosen as samples could then be evaluated for their trip end distributions by trip purpose by station.

The results obtained by the comparison of sample data to the universe, can be evaluated by designers of potential external O-D studies to determine which hours to interview for their own needs and study area.

Sample Selection Procedure

In deciding which hourly periods would be chosen for testing against the universe, only those hours which would reasonably be expected to represent the purpose distribution in the universe and those that would be logical and efficient from the standpoint of manpower utilization were selected. Time periods of three, four,

seven, eight, and eleven hour duration were selected, each of which included at least one of the AM or PM peak periods.

While there are numerous combinations of time periods which could be investigated, it was decided that durations of less than three hours would be acceptable only for very specialized surveys and secondly that periods longer than eleven hours defeat the objective of minimizing the effort in terms of time, manpower and cost. The process of obtaining the sample was composed of three steps:

1) Select the interview from the population master file by hour and direction;

2) Expand the interviews to 24 hours and recode zones and purpose.

3) Build matrices of the results by station, zone and purpose.

The sample tables built in this manner are now in the same format as the universe tables. Subtracting the sample matrix from the master matrix resulted in a differences matrix containing positive values in cells where the master was higher and negative values where the sample matrix had more trips. Each cell of this differences matrix for each purpose, was treated as an observation in the analysis. By assuming the differences (positive and negative) normally distributed a standard deviation was calculated to get an estimate of the confidence level of the observed differences.

The sample periods tested which contained only one-directional inverviews (IB or OB) were factored by applying a double expansion factor. This was necessary to bring the samples up to a full two way traffic control volume. The samples selected which contained interviews from both directions did not require this doubling since

both directions are represented after the normal expansion factors are applied. In all cases, after the factoring was completed all the through (EE) trips were included twice since they or an equivalent trip were accounted for once upon entering the study area and again upon leaving. Since these trips are doubled, and the EE cells of the differences matrix are doubled also, a procedure was developed to average and halve symmetrically opposite cells of the differences matrix for the E-E trips i.e., cell (5,2) and cell (2,5). This step normalized the EE trips to the same base as the IE trips.

The Samples

The time periods listed below were tested in each direction IB, OB, and bothways combined, except as noted:

2 - 5 PM	(3 hours)	(BW only)
7 - 11 AM	(4 hours)	
2 - 6 PM	(4 hours)	
7 AM - 6 PM	(7 hours)	
11 AM - 6 PM	(7 hours)	
7 - 11 AM & 2 - 6 PM	(8 hours)	
7 AM - 6 PM	(11 hours)	(not BW)

In addition to the above, a twenty-four hour sample in the oubound direction was used to provide a benchmark of the magnitude of the minimum error which could be expected. This assumes subjectively that twenty-four hours would be the maximum number of interviews one would collect and further that the differences observed will minimize as the number of interviews increase.

A comparison of the universe data and the 24 hour outbound sample (Table VI-1) shows this reference point and will aid in explaining the

summaries of the other samples. These tables used in conjunction with general guidelines are intended to provide information necessary for ascertaining what interview time periods should be used for a proposed external O-D survey.

COMPARISON OF UNIVERSE DATA TO 24 HOUR OB SAMPLE

PURPOSE	UNIVERSE TRIPS	%TRIPS UNIVERSE	SAMPLE TRIPS	%TRIPS SAMPLE	STD.DEV. DIFFERENCE
Work	13,465	22.6%	13,420	22.4%	7.17
Personal Business and Shopping	12,808	21.5%	12,637	21.1%	6.65
Social-Rec.	27,593	46.2%	28,207	47.1%	8.64
Other	5,841	9.7%	5,609	0.4%	4.78
TOTALS	59,707	100%	59,873	100%	7.52*

* Means weighted standard deviation = ((%Trips) * Std.Dev)

TABLE VI-1

In reviewing these tables, it is important to remember that the factors calculated both for this sampling process and for the data in Chapter II controlled on station direction, hour, and vehicle type but not on trip purpose. Therefore two basic data items should be considered: 1) how close is the sample to having the proper percentage of trips for that purpose category? and 2) how good is the distribution of the sample data by zone as measured by the standard deviation of the differences? The percentages by purpose of the twenty-four hour outbound sample data compare to the actual percentages in the universe very closely with the largest observed difference of only 0.9% in the social-recreation category. The

standard deviation of the differences between the sample and the universe is the indicator of how well the sample observations were distributed on a zone to zone basis. The common and actual usage of this value is that a normal distribution is assumed and that 68.27% of the observations will be within the range of one standard deviation on either side of the mean. The values of the standard deviation obtained from this test are the best that could reasonably be achieved, in a sample of less than 24 hours. For the work purpose as tabulated 99+ percent of the zones will be different from the universe by less than 15 trips and similar errors are evident for the other purposes in the 24 hour sample.

The summary of the time periods tested is included in Table VII-2 and shows average standard deviations ranging from a high of 34 trips to a low of 14 trips. If the variability from the selected test period is considered small, and if the consequences of the variability will not be significant, then we may often choose to ignore it by assuming that the results will be equal to the best estimate available. Some general statements can be made regarding the summary tables which may assist in their interpretation.

* The bothways samples are combinations of the inbound and outbound data so that eccentricities tend to be smoothed.

* The cost effectiveness of a bothway sample (which contains many more interviews) will depend on the station volume and the value of the increased reliability.

* The IB 7-11 AM period does not mirror the OB 2-6 PM period.

* Each purpose must be close to the actual percentage or the

standard deviation will be large, however, ever if the percentages are close the standard deviation may still be excessive.

* Longer interview periods do not necessarily improve the probability of approximating the universe more closely.

* The best time period for the Longview-Kelso area may not be the best one for other areas, for example, sample #5 (11 am to 6 pm bothways) would be much better overall if there were 50% work trips and 20% social-rec instead of the actual percentages of 22.6% work and 46.2% social-rec.

The three hour sample from 2 PM to 5 PM bothways was tested to determine how much the error would increase over the 2 PM - 6 PM sample. The results of this test are as follows:

Work	14,035 trips	(23.5%)	SD=17.7	
P.B.&S.	14,047	(23.5%)	SD=16.8	Weighted Average
S-Rec.	27,009	(45.2%)	SD=18.8	Standard Deviation = 19
Other	4,675	(7.8%)	SD=26.6	

This shows that the 2-5 PM sample has an increase of five trips in the overall standard deviation when compared to the 2 - 6 PM sample. The percentages by purpose are somewhat closer to those found in the actual distribution except in the personal business and shopping category, however, the difference is slight.

An additional aid is provided which is a summary table from the master file. Table VII-3 is a cross tabulation of trips by purpose and hour for both directions combined. This table is a summary from the master O-D file and is provided as an additional investigative aid. For the Longview-Kelso area it becomes apparent which hours contain the majority of the trips for each purpose and a sample time period could be selected to accentuate the sample for the desired results.

TEST PERIODS SUMMARY TABLE

		SAMPLE 1--4 HOURS			SAMPLE 2--4 HOURS			SAMPLE 3--4 HOURS			SAMPLE 4--7 HOURS			SAMPLE 5--7 HOURS		
	TIME	7 AM TO 11 AM			2 PM TO 6 PM			7-11 AM & 2-6 PM			7 AM TO 2 PM			11 AM TO 6 PM		
	DIR/ PURP.	NO.OF TRIPS	% TRIPS	STD. DEV.	NO.OF TRIPS	% TRIPS	STD. DEV.	NO.OF TRIPS	% TRIPS	STD. DEV.	NO.OF TRIPS	% TRIPS	STD. DEV.	NO.OF TRIPS	% TRISP	STD. DEV.
INBOUND	WORK	21283	36.1	53.5	13194	22.0	23.3	16883	28.5	19.2	15163	25.5	23.3	11028	18.3	25.1
	PB&S	11846	20.1	19.8	14636	24.4	27.3	13314	22.5	15.8	13911	23.4	20.1	15418	25.7	19.1
	S.REC	19629	33.3	35.5	27511	45.9	15.1	23887	40.3	18.7	24544	41.3	34.4	28678	47.7	41.7
	OTHER	6148	10.5	17.8	4576	07.7	27.3	5214	08.7	19.3	5874	09.9	22.6	4985	08.3	27.9
	TOTAL	58906	-	34 *	59917	-	21 *	59298	-	18 *	59492	-	28 *	60109	-	32 *
OUTBOUND	WORK	14278	23.8	34.2	16326	27.3	36.8	16694	27.8	24.9	12045	20.1	30.8	13038	21.8	15.9
	PB&S	12392	20.6	22.0	13267	22.2	19.3	12500	20.8	13.3	13056	21.8	13.1	13697	22.9	14.5
	S.REC	27644	46.0	25.3	24896	43.3	14.6	25704	42.9	11.7	29261	48.8	41.1	28650	47.9	39.7
	OTHER	5735	09.6	23.4	4244	07.1	28.6	5056	08.5	22.2	5546	09.3	22.0	4442	07.4	27.3
	TOTAL	60049	-	26 *	59733	-	22 *	59954	-	16 *	59908	-	31 *	59827	-	27 *
BOTHWAYS	WORK	19256	32.3	31.9	14750	24.7	12.8	16778	28.1	17.6	13601	22.8	17.2	12031	20.1	10.8
	P3&S	11458	19.2	16.3	13948	23.3	14.8	12909	21.7	10.5	13459	22.6	11.8	14559	24.3	11.9
	S.REC	22568	37.9	26.0	26691	44.6	10.5	24798	41.6	12.6	26912	45.1	36.2	28668	47.8	40.0
	OTHER	6281	10.6	15.8	4405	07.4	27.2	5130	08.6	20.1	5713	09.5	21.1	4712	07.8	26.8
	TOTAL	59563	-	24 *	59794	-	14 *	59625	-	14 *	59724	-	25 *	59970	-	26 *

* - mean weighted standard deviation

TABLE VI-2

PURPOSE BY HOUR TABLE FROM "MASTER" FILE

HOUR	WORK	PERSONAL BUS. & SHOP	SOCIAL REC.	OTHER	TOTAL
00	138	24	409	155	726
01	79	14	244	138	475
02	97	22	163	151	433
03	53	13	84	58	208
04	119	9	128	145	401
05	211	21	126	144	502
06	815	64	264	170	1313
07	2190	265	550	258	3263
08	813	495	781	313	2402
09	576	776	1473	319	3144
10	525	891	1852	335	3603
11	424	1074	2121	317	3936
12	500	1027	2049	327	3903
13	558	988	2013	379	3938
14	733	1000	2003	379	4115
15	967	1015	2054	362	4398
16	1533	1202	1806	314	4855
17	1381	1062	1902	276	4621
18	503	868	1808	231	3410
19	302	787	1715	207	3011
20	171	447	1186	181	1985
21	191	421	1110	212	1934
22	269	266	975	225	1735
23	342	76	793	271	1482
TOTAL	13490	12827	27609	5867	59793
PERCENT	22.56%	21.45%	46.17%	9.82%	100.0%

TABLE VI-3

CHAPTER VII

CONCLUSION

PHASE I - INTERVIEW PERIODS OF TWENTY-FOUR HOURS

Overall, it is clear that there is a high degree of correlation, between the inbound and outbound, trips characteristics for the Longview-Kelso area. It has been shown that the trip end distributions, trip purpose distributions, and trip length frequency distributions mirror each other sufficiently well to warrant the decision that interviewing motorists in one direction for twenty-four hours will provide adequate information for both directions. To obtain a usable two directional trip table the internal to external trips would be doubled. It has been shown that the mirroring effect is valid for several types of analyses, long and short distance trips, IE trips and EE trips, and for different zonal re-organizations of the trip origins and destinations.

Investigation of the data detailed by individual stations indicates more variation in the analyses than is apparent in the tests using all the data combined. This result is expected, just as it might be expected to find a larger discrepancy in trip end distribution comparisons if they had been analysed separately by the nine original trip purposes. It was practical and necessary to (1) handle IE and EE trips separately, (2) perform trip purpose comparisons, for the four general trip purposes only, (3) plot trip length frequency distributions and (4) check the trip end distributions inside and outside the cordon line. It is obvious that any number of combination of trip purposes by station, by zone configuration could be used in making the inbound-outbound trip

characteristics check and it was felt that an adequate number of these were used to verify our hypothesis.

One cause of the observed differences by station is due to the proximity of one station to the next, which in some cases may provide the opportunity for the outbound trip tc enter the study area through a different station for its return trip.

Generally, the purpose comparisons were statistically very good. With respect to the bar charts one might expect some difference in the purpose reporting of a given round trip. As an example, an outbound trip may be reported as a vacation or social-rec. purpose but the driver may report his return trip as "to work" since that's the reason he's coming back home after his vacation. On a total survey basis, the standard error calculations indicate that for 68% of the zones the inbound trips will be less than 35 trips different than the outbound trips and that for 95% of the zones the difference will be less than 70 trips. Trip purposes are comparable within two percent, on a total survey basis and average trip length are nearly equal.

The decision as to what level of expected error is acceptable must be considered in relation to the accuracy of the overall study, however, for most cases the results indicated herin would verify our hypothesis that inbound travel characteristics are acceptably mirrored by outbound travel characteristics for a twenty-four hour period.

PHASE II - INTERVIEW PERIODS LESS THAN TWENTY-FOUR HOURS

Since the first phase of the study shows that on adequate mirroring of the traffic characteristics is exhibited by directional traffic for a twenty-four hour period, shorter time periods, by direction and combined, were selected and tested. Of the samples

tested, number two, a four hour period from 2 PM to 6 PM, proved to be the best sample for the Longview-Kelso data. It resulted in the lowest overall standard deviation and the closest percentage matches by purpose.

The application of the results of this study with respect to interviewing for time periods less than twenty-four hours will and rightly should vary for each particular case in which they are considered.

The Longview-Kelso area is bisected by Interstate 5 which is the main north-south highway for western Washington and Oregon. The junction of I-5 and SR#4 is located in the Longview-Kelso area and SR#4 is one of the major state routes to the Long Beach-Ilwaco-Willipa Bay areas on the Washington coast. For these reasons, and due to the fact that the interview data used in this research project was collected during the peak of the summer tourist season in August 1967, the amount of social-recreation traffic is very high.

It would <u>not</u> be reasonable to imply that the results obtained from the Longview-Kelso, Washington area would be typical of larger urban areas or even similar-sized urban areas with different urban and socio-economic charcteristics. This is not to say, however, that approximations are not useful in arriving at well founded answers. If the general trip purpose make up of a particular study area is known a sample time period can be selected by analyzing the data presented in this report and result in substantial savings in cost and manpower for the external survey.

For exapmle, the 2 - 5 PM bothways sample for Longview-Kelso contained 7,120 personal interviews or less than 20% of the 36,600

interviews collected overall. The cost savings involved for this level of effort for any study will depend on several factors, including the location of the study area, station volumes and the amount of personnel needed for the interviewing. Additional savings will also result because subsequent coding and processing of the data will be less costly in terms of the expenditures required for both man-hours by the study staff and computer processing.

The approach taken in presenting this analysis has been deliberately simple and based partly on the requirements of computational feasability and partly on the restrictions imposed by the use of non-probability sampling techniques. Statistical analysis, properly and thoroughly performed, requires a careful examination of the suppositions and uncertainties involved. It has been our intention to expose these suppositions where possible and allow each reader to draw his own conclusion as to whether the data reported will have any applications for his area.

L. ADDITIONAL RESEARCH

1) The analysis performed herein should be applied to other areas of different size and characteristics.

2) Some investigation is necessary to determine if expansion procelures used influenced the results obtained, and if so, what other procedures could be applied.

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