A PREDICTIVE MODEL OF THE RESIDENTIAL DISTRIBUTION PATTERN OF INDUSTRIAL OCCUPATION GROUPS: A CASE STUDY

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A SPECIAL WORD OF THANKS IS EXTENDED TO THE CENTRAL MORTGAGE AND HOUSING CORPORATION FOR THE FELLOWSHIP GRANT WHICH MADE THIS STUDY POSSIBLE.

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CHAPTER I

INTRODUCTION

A) Statement of Intent

Since the early 40's, the study of the locational patterns of workmen's residences and work places have become very much in vogue with urban researches. The end result of this concentrated effort has been a considerable volume of literature, assessing these patterns from different points of view.[1] The study formats have varied from detailed descriptive analysis of causes and effects, to attempts at formulating causal models with the capacity for simulation and prediction.

As urban structure has become increasingly complex, the use of the in-depth descriptive approach has been replaced by the use of dynamic models. Town planners are no longer asked to consider development proposals in the light of only drainage, amenity, compliance with a development plan or zoning. Increasingly, their terms of reference include the intensity, distribution and type of traffic from a new development, with respect to the local environment and the existing traffic flows and the capacity of the adjacent road

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[1] Basic concepts and conclusions of important location studies are discussed in Chapters II and III.

NETWORK. THE DEGREE OF COMPREHENSIVENESS IMPLIED IN THIS APPROACH NECESSITATES CONSIDERABLE KNOWLEDGE OF EXISTING AND FUTURE LOCATIONAL FORCES AND THEIR INTERACTION.[1] IN ORDER TO MODEL INCREASING URBAN COMPLEXITY ALL FORCES MUST BE ISOLATED INDIVIDUALLY, SO THAT IN ABSTRACTION ONLY THOSE FACTORS FROM THE TOTAL ENVIRONMENT, WHICH ARE NECESSARY TO SOLVE THE PROBLEM ARE CONSIDERED. MODEL ANALYSIS FACILITATES THIS ABSTRACTION PROCESS WHILE AT THE SAME TIME PRESERVING THE TOTALITY OF THE PROBLEM.

THIS STUDY WILL FOCUS ON THE EFFECT OF THE LOCATION OF A PROPOSED INDUSTRIAL SITE ON ITS WORKER RESIDENTIAL DISTRIBUTION, WITHIN AN URBAN AREA.[2] THE STUDY ASSUMES AN URBAN AREA WITH AN ESTABLISHED DISTRIBUTION OF WORKERS' RESIDENCES AND WORK PLACES. IT ASSUMES FURTHER THAT THE WORK FORCE REMAINS FAIRLY CONSTANT WITHIN THIS URBAN AREA, IE. THERE IS NO EXCESSIVE INCREASE OR DECREASE IN THE NUMBER OF WORKERS DUE TO HIGH IN OR OUT MIGRATION, EITHER BEFORE OR AFTER THE PROPOSED SITE IS ESTABLISHED. THE URBAN SYSTEM, THEN, IS IN A STATE OF DYNAMIC INTERNAL EQUILIBRIUM. THE PROPOSED INDUSTRIAL SITE IS ESTABLISHED AS A PLANNED UNIT AND CONSISTS OF NUMEROUS FIRMS, MOST OF WHICH HAVE BEEN RELOCATED FROM OTHER AREAS OF THE CITY, PLUS A FEW

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[1] D. N. M. STARKIE, TRAFFIC AND INDUSTRY, A STUDY OF TRAFFIC GENERATION AND SPATIAL INTERACTION. (GEOGRAPHICAL PAPER NO. 3, LONDON: LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE, 1967), PP. 21-22

[2] ACCORDING TO THE SHORTER OXFORD ENGLISH DICTIONARY (THIRD EDITION, 1956), THE TERM "WORKER" IS APPLIED TO,

> "...ONE WHO WORKS IN A CERTAIN MEDIUM AT A SPECIFIED TRADE, ETC. OR IN A CERTAIN POSITION OR STATUS."

APPLYING THIS DEFINITION BROADLY, IN THIS STUDY "WORKERS" REFERS TO ALL OCCUPATIONAL TYPES, IE. MANAGERS, OFFICE PERSONNEL, AS WELL AS LABOURERS.

INDUSTRIES RELOCATING FROM OUTSIDE THE CITY LIMITS, AS WELL AS A FEW NEWLY ESTABLISHED INDUSTRIES.[1] THE INTRODUCTION OF THIS INDUSTRIAL SITE CAUSES AN IMBALANCE IN THE INTERNAL URBAN SYSTEM. THE QUESTIONS GENERATED ARE: WHAT WOULD HAPPEN TO THE SYSTEM IN TERMS OF WORKERS' RESIDENTIAL DISTRIBUTION? WILL WORKERS WHOSE JOBS ARE DIRECTLY AFFECTED BY THE NEW INDUSTRIAL SITE MOVE CLOSER TO THE NEW JOB OR WILL THEY REMAIN AT THEIR PRESENT ADDRESS PREFERRING TO SEEK A JOB MORE NEAR AT HAND? WILL THEY CHOOSE TO TRAVEL THE EXTRA DISTANCE IN ORDER TO MAINTAIN THE "STATUS QUO"? WHAT EFFECTS, IF ANY, WILL THE NEW SITE HAVE ON ADJACENT RESIDENTIAL AREAS AND OTHER WORKERS WHOSE PRESENT JOBS ARE NOT DIRECTLY AFFECTED BY TRAVEL DISTANCE TO THIS NEW DEVELOPMENT? CAN THE TERM "WORKER" BE USED TO COVER ALL WORKING INDIVIDUALS OR WILL LOCATIONAL DECISIONS BE AFFECTED BY THE SOCIO-ECONOMIC CHARACTERISTICS OF EACH OCCUPATIONAL GROUP, EG. MANAGERS, CLERICAL PERSONNEL OR LABOURERS? THE MOST IMPORTANT QUESTION IS: CAN THE NEW RESIDENTIAL PATTERN OF THOSE WORKING AT THE SITE BE PREDICTED; IF SO CAN THIS PREDICTION BE QUANTIFIED IN TERMS OF A FORMULA AND FURTHER GENERALIZED TO EMBRACE ANY SIMILAR SITUATION?

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[1] USE OF THE TERM--A "PLANNED UNIT", IMPLIES THE RESTRICTION OF AN INDUSTRIAL SITE TO AN "INDUSTRIAL PARK" LAYOUT. HOWEVER, USED IN THE CONTEXT OF THIS STUDY AN INDUSTRIAL SITE CAN VARY FROM A SINGLE LARGE FIRM TO A LARGE NUMBER OF SMALLER, SCATTERED FIRMS. THE ONLY RESTRICTION PLACED ON SCATTERED FIRMS IS THAT THEY MUST ALL BE ESTABLISHED WITHIN A FEW YEARS OF ONE ANOTHER, AND ALL MUST BE LOCATED IN A RELATIVELY COMPACT AREA OF THE CITY, SO THAT A COMMON CENTROID CAN BE USED IN THE ROAD NETWORK TO DENOTE A FOCAL POINT OF TRAFFIC GENERATION.

B) Scope and Approach of Undertaking

Essentially this undertaking is a study in method, which explores a basic hypothesis as it relates to an industrial case study. The hypothesis is highly abstracted and is based on a limited set of variables, taken from a complex array of causes and effects.

As a result of this limited information base a general formula, which would be the end result of any study in method, if it were carried to completion, is outside the scope of this undertaking. Though the model is derived by means of a quantitative analysis, it is in part a descriptive model as opposed to a model of a causal or explanatory nature.[1] Thus it is only an aid for further more refined research and it precludes conclusive answers to the questions posed earlier.

The study is divided into two general levels of activity. First, a broad information base, extracted from the literature, is established and secondly, founded on this established knowledge, there is the model. The information base is, itself, divided into two chapters, Chapter II and Chapter III. Chapter II documents the numerous variables associated with industrial-residential location theory. Those variables thought to be the most significant as locational factors are analyzed in this section. The other segment

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[1] It is important to distinguish between models that contain controlled and proven variables and those that do not. In general, those that do are explanatory and those that do not are descriptive. It is frequently necessary, however, to construct descriptive models as a preliminary step in the development of an explanatory decision model. Refer to: Russel Ackoff and Maurice Sasieni, Fundamentals of Operations Research. (London: John Wiley and Sons Inc., 1968), p. 61

OF THE INFORMATION BASE, CHAPTER III, REVIEWS THREE MAJOR TRIP DISTRIBUTION MODELS. THE FUNDAMENTAL CONCEPTS ON WHICH THESE MODELS ARE BASED, AS WELL AS THEIR POTENTIAL FOR PREDICTING LOCATION PATTERNS ARE ANALYZED IN THIS CHAPTER. THE MAJOR FEATURES OF THESE TRIP DISTRIBUTION MODELS ARE SUMMARIZED IN TERMS OF THE ADVANTAGES AND DISADVANTAGES OF EACH METHOD TO SERVE AS A FOUNDATION FOR THE PROPOSED MODEL. THE SECOND MAJOR PART OF THE THESIS, THE DERIVATION OF THE MODEL, IS ALSO DIVIDED INTO TWO CHAPTERS, CHAPTER IV AND CHAPTER V. CHAPTER IV CONDENSES AND INTERRELATES THE MORE RELEVANT FINDINGS OF THE INFORMATION BASE. FOLLOWING THIS ASSESSMENT, A HYPOTHESIS IS PRESENTED WHICH FORMS THE BASIS FOR THE PROPOSED MODEL. THE MATHEMATICAL REPRESENTATION IS SUBSEQUENTLY DERIVED AND TESTED FOR ACCURACY BY APPLICATION TO A CASE STUDY. CHAPTER V ANALYZES THE FINDINGS OF THE CASE STUDY APPLICATION AND DISCUSSES POSSIBLE REFINEMENTS FOR BETTER REPRESENTATION IN TERMS OF BOTH HYPOTHESIS AND TECHNIQUE.

IN TESTING TWO POSSIBILITIES WERE OPEN TO CONSIDERATION. FIRST THE MODEL COULD BE TESTED THOROUGHLY FROM A LARGE SAMPLE OF INDUSTRIAL SITES AND WORKERS' RESIDENCES, WITHIN THE URBAN AREA OR SECONDLY, A CASE STUDY APPROACH COULD BE UNDERTAKEN. THE FORMER POSSIBILITY, WHILE MORE DESIRABLE FROM THE VIEWPOINT OF OBTAINING UNBIASED RESULTS, ASSUMES THAT A CONSIDERABLE AMOUNT OF REFINEMENT HAS ALREADY BEEN INCORPORATED INTO THE MODEL. THIS LEVEL OF REFINEMENT CANNOT BE OBTAINED BY A FIRST ATTEMPT AT MODEL FORMULATION, ESPECIALLY IF THE HYPOTHESIS IS BASED ON A LIMITED SET OF VARIABLES. FOR THIS REASON THE CASE STUDY APPROACH WAS CONSIDERED THE BETTER OF THE TWO ALTERNATIVES FOR THE PURPOSE OF THIS STUDY.

CHAPTER II

INDUSTRIAL-RESIDENTIAL LOCATION VARIABLES

A) INTRODUCTION

OUT OF THE MANY VARIABLES AFFECTING THE PATTERN OF INDUSTRIAL-RESIDENTIAL DEVELOPMENT IN AN URBAN AREA, ONLY A SELECTION IS INCLUDED FOR DISCUSSION IN THIS CHAPTER. THIS ASSESSMENT IS BASED ON GENERALITIES OF LOCATION CRITERIA IN ORDER TO AVOID EXCESSIVE, ISOLATED DETAIL. VARIABLES LIKE, PROXIMITY TO FRIENDS OR RELATIVES, ETHNIC OR RELIGIOUS AFFILIATION, PROXIMITY TO SPECIFIC AREA AMENITIES, SUCH AS A GOLF COURSE, ETC., MAY AFFECT THE INDIVIDUAL'S CHOICE OF HOME AND WORK LOCATION, BUT ON THE AVERAGE THESE CONDITIONS AFFECT ONE INDIVIDUAL AND NOT THE OTHER. DIFFICULT-TO-MEASURE DETAILS ARE CONSIDERED NEGLIGIBLE AND ARE NOT DISCUSSED HERE. CONSEQUENTLY, THE VARIABLES CHOSEN FOR DISCUSSION IN THIS CHAPTER, HAVE ENOUGH SIGNIFICANCE ON RESIDENTIAL-WORK PLACE LOCATIONAL DECISIONS TO WARRANT ATTENTION.

THOUGH MUCH INTERACTION AND OVERLAP CAN BE EXPECTED IN A DISCUSSION OF THIS NATURE, THE LOCATION VARIABLES ARE HERE CONSIDERED IN ISOLATION. INTERACTION AND SIMPLIFICATION OF VARIABLES IS ATTEMPTED AT A LATER STAGE OF THIS STUDY.

B) Influence of Industrial and Urban Characteristics on Location Variables

The term "industry", in this study, is used collectively to facilitate the discussion and to simplify the model hypothesis. This macro-scale treatment of industry may deceive the reader into believing that all industrial firms are subject to the same variables of location. However, because all firms do not require the same inputs, their locational needs also will differ. In Winnipeg, as in most North American cities the manufacturing sector of industry has undergone the largest outward migration from the center. In 1966 only 30.2% of all manufacturing employment in Winnipeg was located in the downtown area.[1] The firms showing the highest rate of decentralization are light and heavy manufacturing plants, most of which relocate in one storey layouts in suburban industrial parks.

An important variable influencing the location of this type of firm is availability of land. On the other hand, certain industrial types do not require large amounts of land for efficient operation. In Winnipeg over 90% of all clothing manufacturing establishments are located in the downtown area. These firms are generally small in size; over 90% had fewer than twenty-five employees. Other small firms, whose prime location is downtown, are: manufacturing of scientific and professional equipment, jewellery and silverware,

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[1] Reid, Crowther and Partners Ltd., A Market Analysis For Metropolitan Winnipeg. (Unpublished Report: Winnipeg, 1967), p. 31.

BROOMS, SPORTING GOODS, SIGNS, ETC.[1] THE LOCATION CRITERIA OF THESE FIRMS ARE BASED ON TWO MAJOR CONDITIONS: 1) THE DOWNTOWN AREA, ESPECIALLY ON ITS FRINGE, IS CHARACTERIZED BY THE AVAILABILITY OF VACATED, INEXPENSIVE RENTAL SPACE. SMALL FIRMS IN THE PROCESS OF BECOMING ESTABLISHED REQUIRE CONSIDERABLE CAPITAL. THEY CAN ILL AFFORD THE LARGE INVESTMENT OF A NEW BUILDING IN A SUBURBAN LOCATION. ALSO, 2) NO FIRM WOULD ENTER THE INDUSTRIAL SECTOR WITH SUCH A DIVERSIFIED PRODUCTION LINE, SO AS TO OPERATE INDEPENDENT OF OTHER SIMILAR FIRMS. A CENTRAL LOCATION FACILITATES INITIAL SPECIALIZATION AND INTERPLAY BETWEEN VARIOUS SMALL FIRMS IN AN EFFORT TO CREATE ECONOMIES OF SCALE. THE IMPORTANT POINT TO OBTAIN FROM THIS DISCUSSION IS THAT FIRMS, LIKE INDIVIDUALS CANNOT BE STEREOTYPED COMPLETELY IN TERMS OF LOCATION CRITERIA. HENCE, THE RAMIFICATIONS FOR WORKER RESIDENTIAL LOCATION MAY NOT BE NOTICED BY CONSIDERING INDUSTRY COLLECTIVELY.

JUST AS LOCATIONAL CRITERIA ARE AFFECTED BY INDUSTRIAL TYPE, THEY ARE ALSO AFFECTED BY THE CHARACTERISTICS OF THE URBAN AREA UNDER CONSIDERATION. ALTHOUGH THIS STUDY ALSO EMPLOYS THE TERM "URBAN AREA" IN A GENERIC SENSE, IT IS IMPORTANT TO EMPHASIZE THAT EACH CITY EXPERIENCES DIFFERENT CONDITIONS BOTH IN TERMS OF HISTORICAL DEVELOPMENT AS WELL AS IN OTHER RELATED FACTORS. THIS COMPLICATES MATTERS CONSIDERABLY IN THAT SOME LOCATION VARIABLES APPLYING TO NEW YORK WOULD NOT NECESSARILY APPLY TO WINNIPEG. LOEWENSTEIN, SPEAKING OF THE DIFFERENCES IN INTENSITY OF DEVELOPMENT AS RELATED TO ALL TYPES OF WORK TRIPS FOR A LARGE AND SMALL CITY STATES:

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[1] IBID., P. 32.

> "THE HIGHER COST OF LAND IN THESE AREAS [LARGE CITIES] NECESSITATES HIGHER DENSITIES WITH RESPECT TO BOTH HOMES AND WORK PLACES. MOREOVER, SINCE THE DISTANCES ARE LESS IN SMALLER AREAS, STORES AND PLANTS CAN OCCUPY LAND AT A RELATIVELY GREATER DISTANCE FROM THE CITY CENTER AND STILL BE ALMOST AS ACCESSIBLE TO THE SAME PERCENT OF WORKERS AND CUSTOMERS AS THEY WOULD IF THEY WERE IN THE CORE. IN OTHER WORDS, THE MARGINAL ACCESSIBILITY OF THIS SPACE DROPS OFF MORE RAPIDLY IN LARGE CITIES THAN IN SMALLER ONES AND HENCE THERE IS A RELATIVELY GREATER TENDENCY TO LOCATE BOTH HOMES AND WORK PLACES NEAR THE CENTER IN LARGER CITIES. AS A CONSEQUENCE WE MIGHT EXPECT A GREATER PROPORTION OF WORK TRIPS ORIGINATING AND TERMINATING IN THE DOWNTOWN AREAS OF LARGER CITIES THAN SMALLER CITIES."[1]

THIS STUDY ALSO TAKES A RATHER CONFINED VIEW OF THE CITY IN ITS REGIONAL CONTEXT. FOR THE PURPOSE OF THE CASE STUDY THE CITY IS STUDIED AS A SINGLE ISOLATED UNIT WITH LITTLE OR NO DEVELOPMENT OUTSIDE ITS ESTABLISHED LIMITS. HOWEVER BOTH INDUSTRY AND RESIDENCES LOCATE WITHIN THE CITY WITH A VIEW TO THAT CONDITIONS IN THE OVERALL REGION. REGIONS WHICH ARE NOT DEPOPULATED BY URBANIZATION, FUNCTION AS AN IMPORTANT SUPPLIER OR MARKET FOR INDUSTRY. FURTHERMORE THE LOCATION OF ANY NUMBER OF LARGE CENTERS IN A REGION WILL SET UP A NETWORK OF ATTRACTION OR REPULSION FORCES FOR INDUSTRIAL AND RESIDENTIAL LOCATION. THE PROXIMITY OF ST. PAUL TO MINNEAPOLIS SETS UP AN ATTRACTION POLE FOR INDUSTRY TO LOCATE BETWEEN THE TWO CENTERS. WORK TRIPS LIKEWISE REACH A HIGH LEVEL OF INTENSITY IN THIS ZONE OF

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[1]LOUIS LOEWENSTEIN, RESIDENCES AND WORK PLACES IN URBAN AREAS (NEW YORK AND LONDON: THE SCARECROW PRESS, 1965), P. 266.

IT IS DOUBTFUL IN VIEW OF WHAT HAS BEEN SAID AND WHAT WILL BE SAID REGARDING THE LOCATION OF INDUSTRY IN THE CENTRAL AREA OF A LARGE CITY WHETHER THIS STATEMENT ALSO APPLIES TO INDUSTRIAL WORK TRIPS.

OVERLAP.[1]

C) HISTORICAL DEVELOPMENT

HISTORICAL CONDITIONS IN TERMS OF BOTH INDUSTRIAL DEVELOPMENT AND URBAN STRUCTURE, ARE IMPORTANT ASPECTS EXPLAINING EXISTING RESIDENTIAL-WORK PLACE LOCATION. CERTAINLY LOS ANGELES WHICH EXPERIENCED MOST OF ITS DEVELOPMENT IN THE "AUTOMOBILE AGE" WILL HAVE A PATTERN SOMEWHAT DIFFERENT FROM NEW YORK, ALREADY AN IMPORTANT INDUSTRIAL CENTER IN THE "HORSE AND BUGGY DAYS". IT IS GENERALLY BELIEVED THAT THE VARIABLES STABILIZING INDUSTRIAL OR RESIDENTIAL LOCATION ARE DEPENDENT TO SOME EXTENT ON HISTORICAL DEVELOPMENT. THESE VARIABLES ARE INERTIA, CAUSED BY INVESTMENT; TRADITION, USUALLY BASED ON HISTORICAL VALUES; THE DESIRE TO BE CLOSE TO FRIENDS OR CLIENTS, AND FINALLY TRANSPORTATION DEVELOPMENTS.[2] THESE HISTORICAL VARIABLES ARE ASSESSED IN MORE DETAIL HERE.

THE HISTORICAL INTERDEPENDENCE OF FIRMS

THE OPTIMUM LOCATION OF INDUSTRY IN THE NINETEENTH CENTURY AMERICAN CITY WAS AS CLOSE AS POSSIBLE TO THE CORE AREA. IN THOSE EARLY DAYS OF INDUSTRIAL DEVELOPMENT, NO FIRM COULD, BY ITSELF, ENCOMPASS ALL STAGES OF THE PRODUCTION PROCESS, FROM THE IMPORT OF RAW MATERIALS OR PARTS, TO THE DISTRIBUTION OF THE FINISHED PRODUCT. THE MOVE TOWARDS HORIZONTAL DIVERSIFICATION OF PRODUCTION, WITHIN THE SINGLE FIRM HAD NOT TAKEN PLACE. THUS THERE WAS A HIGH DEGREE OF

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[1] IBID., PP. 145, 165, 172.

[2] MARKET ANALYSIS, OP. CIT., P. 34.

INTERDEPENDENCE BETWEEN NUMEROUS SMALL FIRMS EACH INVOLVED AT ONE STAGE OF THE PRODUCTION PROCESS. FOR EXAMPLE, IF A LARGE MANUFACTURING FIRM LIKE GENERAL MOTORS WAS DIVIDED INTO NUMEROUS SMALL SPECIALIZED FIRMS, THE SITUATION WOULD BE SIMILAR TO WHAT EXISTED IN THE LAST CENTURY. ONE FIRM WOULD MANUFACTURE TRANSMISSIONS, THE OTHER ELECTRICAL SYSTEMS, AND YET ANOTHER THE CARRIAGE, EACH FUNCTION BEING INDISPENSIBLE IN PRODUCING THE FINAL PRODUCT: A CAR. THIS DEPENDENCE OF ONE FIRM ON ANOTHER, COMPELLED FIRMS TO LOCATE NEAR EACH OTHER IN A CENTRAL INDUSTRIAL DISTRICT. THIS DISTRICT COULD BE A GROUP OF BLOCKS, A SINGLE STREET OR EVEN A FEW LOTS DEVOTED TO THE PRODUCTION OF SOME SPECIALIZED GOOD. IN MANUFACTURING THE GARMENT CENTER IN NEW YORK IS AN OUTSTANDING ILLUSTRATION OF THIS PHENOMENON.[1] AS WAS MENTIONED PREVIOUSLY, THIS HISTORICAL DEVELOPMENT CONTINUES TO INFLUENCE THE LOCATION OF SMALL FIRMS IN WINNIPEG.[2]

EARLY WATER TRANSPORTATION

THE CONVENIENCE AND RELATIVE LOW COST OF WATER TRANSPORT NOT ONLY ACTED TO ATTRACT URBAN CENTERS TO LOCATE AND GROW, IN PROXIMITY TO WATER BUT IT ALSO INFLUENCED THE INTERNAL STRUCTURE OF THE URBAN CENTER AFTER SETTLEMENT HAD TAKEN PLACE. THE SEARCH FOR SPACE WHETHER IN 1870 OR 1970 HAS ALWAYS BEEN CONDITIONED TO A LARGE EXTENT BY THE MANUFACTURER'S NEED TO ASSEMBLE HIS MATERIALS AND DISTRIBUTE THE FINISHED PRODUCT AT THE LOWEST UNIT COST. HAD THE RAILWAY OR THE

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[1] EDGAR M. HOOVER AND RAYMOND VERNON, ANATOMY OF A METROPOLIS. (CAMBRIDGE: HARVARD UNIVERSITY PRESS, 1959), P. 14.

[2] SUPRA, P. 8.

AUTOMOBILE NEVER BEEN INVENTED ONE CAN EASILY IMAGINE RECTILINEAR-SHAPED CITIES WITH INDUSTRIES AND NEARBY RESIDENCES SKIRTING THE BANKS OF NAVIGABLE RIVERS.

THE LAND BORDERING ON NAVIGABLE WATER HAS ALWAYS BEEN A VALUABLE PIECE OF REAL ESTATE. INDUSTRY HAVING THE HIGHEST RENT BID FOR LAND, IN THE PAST, ESTABLISHED ITSELF AS THE DOMINANT USE FOR THIS LAND.[1] IN NEW YORK AREA THIS PATTERN EMERGED AS EARLY AS 1850.

> AT THAT TIME, THE MANHATTAN SHORES OF THE HUDSON RIVER AND THE EAST RIVER WERE LINED WITH SHIPBUILDING, SLAUGHTERING, GREASE-RENDERING, AND SOAP-MAKING PLANTS WITH IRON WORKS, ENGINE WORKS, AND PLANTS OF MANY OTHER KINDS. THE BROOKLYN SHORE OF THE EAST RIVER AND OF ITS TRIBUTARY, NEWTOWN CREEK, WERE ALREADY BEGINNING TO BE CROWDED WITH CHEMICAL AND PAINT FACTORIES, AND LATER WITH PETROLEUM REFINING PLANTS. IN NEWARK, THE BANKS OF THE OLD MORRIS CANAL BORE AN ARRAY OF TANNERIES AND LEATHER-PRODUCT PLANTS. YONKERS AND POUGHKEEPSIE KEPT THEIR INDUSTRY ALONGSIDE THE HISTORIC HUDSON, AND BRIDGEPORT'S FACTORIES CLUNG TO LONG ISLAND SOUND AND ITS INLETS.[2]

SINCE LAND TRANSPORTATION AT THIS TIME WAS HIGHLY INEFFICIENT AND COSTLY, INDUSTRIAL DEVELOPMENT CONFINED, AND HELD RESIDENTIAL WORKER LOCATION TO THE CENTRAL URBAN AREA ADJACENT TO THE PLACE OF WORK.

EARLY RAIL TRANSPORTATION

EVEN AFTER THE ADVENT OF THE RAILWAY, WATER TRANSPORT STILL MANAGED TO MAINTAIN ITS ROLE OF SHIPPING MATERIALS BOTH WITHIN AND

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[1] THOUGH TRANSPORTATION CONSIDERATIONS WERE THE MOST SIGNIFICANT IN LOCATING INDUSTRY NEAR WATER, THE EARLY ROLE OF WATER FOR POWER AND SEWERAGE WAS ALSO INSTRUMENTAL. SEE: RAYMOND MURPHY, THE AMERICAN CITY. (NEW YORK: MCGRAW HILL CO., 1966), P. 341.

[2] HOOVER, OP. CIT., P. 36.

BETWEEN URBAN CENTERS. HOWEVER, THE INFLEXIBILITY OF RIVER NAVIGATION, TOGETHER WITH THE FACT THAT ONLY A FEW RIVERS COULD SERVE THIS FUNCTION SOON MADE WATER TRANSPORT LESS DESIRABLE THAN RAILWAY TRANSPORT.

THE HISTORICAL LOCATION OF THE RAILWAY MAINLINE IN THE CENTRAL AREA OF THE CITY WAS A RESULT OF SEVERAL CONDITIONS. MOST OF TODAY'S CITIES WERE SMALL TOWNS AT THE COMING OF THE RAILWAY. THE ADVANCING MAINLINE CUT THROUGH THE SMALL CENTER AND THE CITY GREW AROUND IT. IN MANY INSTANCES, THERE WAS NO TOWN AT ALL WHEN THE MAIN-LINE WAS LAID OUT. THE RAILWAY, IN THIS CASE, ACTED AS AN ATTRACTIVE FORCE, INDUCING THE FORMATION AND GROWTH OF A TOWN NEARBY.[1] SINCE THE STEAM ENGINE COULD NOT CLIMB GRADES GREATER THAN TWO FEET IN 100, TRACKS WERE LAID OUT ON RELATIVELY LEVEL GROUND, USUALLY ON A RIVER FLOOD PLAIN. HENCE THE MAINLINE PARALLELLED THE RIVER CHANNEL. SINCE THE RIVER USUALLY DIVIDED A COMMUNITY THROUGH THE CENTER, THE RAILWAY MAINLINE DID LIKEWISE.

FOR INDUSTRY, WHOSE CENTRAL LOCATION WAS A RESULT OF RELIANCE ON WATER TRANSPORT, THE ADVENT OF THE RAILWAY EMPHASIZED THE IMPORTANCE OF THIS LOCATION. FLEXIBILITY IN RAIL TRANSPORT WOULD HAVE TO EVOLVE, IF INDUSTRIAL AND RESIDENTIAL CONGESTION IN THE URBAN CENTER WAS TO BE REMEDIED.

EARLY COMMUTER PATTERNS

ALTHOUGH IN ITS INFANCY THE RAILWAY ACTED AS A CENTRALIZING FORCE ON URBAN ACTIVITY, IN TIME, THE NEED TO ALLEVIATE EXCESS CON-

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[1]THE PATTERN OF COMMUNITY DEVELOPMENT IN THE PRAIRIE REGION OF CANADA HAS BEEN VERY MUCH INFLUENCED BY THESE CONDITIONS. SEE: WEST-MAN. REGIONAL DEVELOPMENT INC., THE COMMUNITY SYSTEM IN WEST-MAN. (BRANDON, 1971), P. 6.

GESTION, COMBINED WITH AN IMPROVED TECHNOLOGY CAUSED THE MAINLINE TO BRANCH OUT FROM THE NUCLEUS TO THE FRINGE AREAS OF THE CITY. RAILWAY DECENTRALIZATION FIRST AFFECTED COMMUTER TRAVEL PATTERNS. MURRAY DESCRIBES THE SITUATION AS FOLLOWS:

> "SUBURBS, LIKE BEADS ON A STRING, REACHED OUT FROM THE CITY ALONG THE PRINCIPAL COMMUTING LINES. THEIR OUTER LIMIT WAS SET BY THE REACH OF THE COMMUTER TRAINS. THE SO-CALLED "MAIN LINE" TOWNS WEST OF PHILADELPHIA DEVELOPED IN THIS WAY. SIMILARLY, TOWNS JUST WEST OF BOSTON, ALONG THE BOSTON AND ALBANY RAILROAD, GAINED POPULATION THROUGH THE GROWTH OF COMMUTING; AND COMMUTER SETTLEMENTS DEVELOPED ON THE ST. LOUIS AND SAN FRANCISCO AND THE MISSOURI PACIFIC RAILROADS JUST WEST OF ST. LOUIS, ALONG THE RAILROAD LINES RADIATING FROM CHICAGO."[1]

THE EFFECT OF THIS DEVELOPMENT WAS TO PUT EFFICIENT, INEXPENSIVE TRANSPORTATION WITHIN THE REACH OF THE AVERAGE WAGE EARNER, AND RESULTED IN THE OUTWARD MIGRATION OF THIS GROUP FROM THE CENTRAL CITY.

THE EXTENSION OF THE RAILWAY NETWORK HAD A DIRECT INFLUENCE ON THE LOCATION OF INDUSTRY IN THE LARGER URBAN CENTERS. INDUSTRY, IN PART, FOLLOWED THE WORKERS TO THE SUBURBS, AND MANY OF THE COMMUTER TOWNS THEMSELVES BECAME SITES FOR INDUSTRY. THIS, THEN, WAS THE BEGINNING OF INDUSTRIAL DECENTRALIZATION.

AN INFREQUENTLY ASKED QUESTION WHICH ARISES FROM THIS DISCUSSION, IS, WHY DID THESE PEOPLE ABANDON THE CENTRAL CITY? THE ANSWER HAS IMPORTANT CONSEQUENCES IN THE LIGHT OF WHAT WILL BE DISCUSSED LATER. PERHAPS THE BEST ANSWER MAY BE FOUND IN THIS QUOTATION FROM

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[1] MURPHY, OP. CIT., P. 233.

LEWIS MUMFORD. ACCORDING TO MUMFORD THE CENTRAL METROPOLIS WAS AN ACCUMULATION OF PEOPLE TRYING TO ACCOMMODATE THEMSELVES TO

> ". . .AN ENVIRONMENT WITHOUT ADEQUATE NATURAL OR CULTURAL RESOURCES: PEOPLE WHO DO WITHOUT PURE AIR, WHO DO WITHOUT SOUND SLEEP, WHO DO WITHOUT A CHEERFUL GARDEN OR PLAYING SPACE, WHO DO WITHOUT THE VERY SIGHT OF THE SKY AND THE SUNLIGHT, WHO DO WITHOUT FREE MOTION, SPONTANEOUS PLAY, OR ROBUST SEXUAL LIFE. THE SO-CALLED BLIGHTED AREAS OF THE METROPOLIS [FOUND IN THE URBAN CENTER] ARE ESSENTIALLY "DO WITHOUT" AREAS. IF YOU WISH THE SIGHT OF URBAN BEAUTY WHILE LIVING IN THESE AREAS, YOU MUST RIDE IN A BUS A COUPLE OF MILES [USUALLY MORE]; IF YOU WISH A TOUCH OF NATURE, YOU MUST TRAVEL IN A CROWDED TRAIN TO THE OUTSKIRTS OF THE CITY. LACKING THE MEANS TO GET OUT, YOU SUCCUMB; CHRONIC STARVATION PRODUCES LACK OF APPETITE. EVENTUALLY YOU MAY LIVE AND DIE WITHOUT EVEN RECOGNIZING THE LOSS."[1]

BECAUSE WORKERS NEEDED TO LIVE CLOSE TO THEIR PLACE OF WORK, THE CITIZENRY WAS INITIALLY COMPELLED TO SUFFER THE INCONVENIENCES OF A CENTRAL LOCATION -- SMOKE, FOUL AIR, EXCESS NOISE AND CONGESTION -- ALL PRODUCTS OF CONCENTRATED, UNPLANNED INDUSTRIAL DEVELOPMENT. THESE UNPLEASANT CONDITIONS DEPRIVED BASIC HUMAN NEEDS. HENCE PEOPLE WERE INDUCED TO ESCAPE AT THE FIRST OPPORTUNITY. ALTHOUGH THESE CONDITIONS HAD THEIR BEGINNINGS IN THE EARLY YEARS OF INDUSTRIAL DEVELOPMENT IN AMERICA, THEY REMAINED A CHARACTERISTIC OF THE CENTRAL CITY UNTIL THE LAST FEW DECADES.[2]

BEFORE CONCLUDING THIS HISTORICAL ASSESSMENT AND DISCUSSING THE CURRENT SITUATION, ONE POINT MUST BE MADE. TO UNDERSTAND THE TOTAL IMPACT OF HISTORICAL AND CURRENT VARIABLES, IT IS IMPORTANT TO

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[1]LEWIS MUMFORD, THE CULTURE OF CITIES. (NEW YORK: HARCOURT, BRUCE AND COMPANY, 1938), P. 325.

[2]HOOVER, OP. CIT., PP. 14-15

NOTE THAT LOCATION THEORY IS BASED ON A NETWORK OF EVENTS, EACH EVENT HAVING ARISEN AT A DIFFERENT TIME AND PLACE. ALTHOUGH THESE EVENTS, (OR VARIABLES) ARE PRESENTED SEPARATELY, WHAT IS IMPORTANT IS THE EFFECT CAUSED BY THEIR INTERACTION OVER TIME. HAD THE TRUCK BEEN INVENTED BEFORE THE STEAM ENGINE IT IS UNLIKELY THAT SOME TOWNS WOULD HAVE DEVELOPED AS THEY DID. IN THE LOCATION OF INDUSTRY AND WORKERS' RESIDENCES NO SINGLE DEVELOPMENT CAN BE ISOLATED FROM THE WHOLE PATTERN OF CHANGE WITHOUT LOSING SIGHT OF THE TOTAL SITUATION.

D) Developments in Production Technology

The assembly line process

THE DRAMATIC ADVANCES IN INDUSTRIAL PRODUCTION TECHNOLOGY HAVE RESULTED IN THE EMERGENCE OF A SERIES OF NEW INDUSTRIAL REQUIREMENTS WHICH HAVE UPSET THE HISTORICAL PATTERNS OF LOCATION. ALTHOUGH FORCES OF OBSOLESCENCE HAVE DIFFERED FOR EACH LINE OF MANUFACTURE, COMMON FEATURES HAVE BEEN EVIDENT. THE "GRAVITY FLOW" PRODUCTION LINE WHICH CHARACTERIZED THE THREE STOREY INDUSTRIAL STRUCTURE HAS BEEN REPLACED IN THE PAST THIRTY OR FORTY YEARS BY THE WIDESPREAD INTRODUCTION OF CONTINUOUS-MATERIAL-FLOW SYSTEMS AND AUTOMATIC CONTROLS IN PROCESSING. LOOKING AT FOOD FACTORIES, REFRIGERATION TUNNELS AND BAKE OVENS WITH MOVING FLOORS COMMONLY RUN MANY HUNDREDS OF FEET ON A STRAIGHT LINE, OFTEN RUNNING LONGER THAN THE NORMAL CITY BLOCK.[1] INTRODUCTION OF THESE DEVELOPMENTS, NECESSITATES A STRUCTURE WHICH FITS THE PROCESS. THUS, BUILDINGS DESIGNED FOR GRAVITY FLOW HAVE BE-

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[1] IBID., P. 31.

COME OBSOLETE.

IN THE LIGHT OF THESE DEVELOPMENTS, THE DISADVANTAGES INHERENT IN OPERATING IN A LESS-THAN-IDEAL STRUCTURE HAVE GROWN RAPIDLY TODAY. THE COMMON PRACTICE IN MANY LINES OF MANUFACTURE IS TO FIND A SITE WHICH IMPOSES THE LEAST RESTRAINTS ON THE SHAPE OF THE STRUCTURE, TO PLAN A PRODUCTION LAYOUT SUITABLE FOR MODERN PROCESSES AND TO "WRAP" THE BUILDING AROUND THE LAYOUT.[1]

FIRM AMALGAMATIONS

AS MENTIONED, THE CENTRAL CITY INDUSTRIAL DISTRICT WAS ESTABLISHED AT A TIME WHEN VARIOUS SMALL FIRMS OPERATED INTER-DEPENDENTLY. EACH FIRM WAS ONE LINK IN THE OVERALL PRODUCTION PROCESS. TODAY SMALL FIRMS HAVE TENDED TO AMALGAMATE IN ORDER TO INTRODUCE DIVERSIFICATION INTO THE PRODUCTION PROCESS. THE ADVANTAGES OF THIS DEVELOPMENT ARE:[2]

1) HIGHER ECONOMIES OF SCALE IN PRODUCTION

2) A MORE EFFICIENT MANAGEMENT STRUCTURE

3) THE REDUCTION OF THE POSSIBILITY OF FINANCIAL OR LABOUR DIFFICULTIES CLOSING PRODUCTION PERMANENTLY

THE MAJOR CONSEQUENCE, OF INTEREST, GENERATED BY SMALL FIRM AMALGAMATION IS INNOVATIONS IN INDUSTRIAL SITE DESIGNS. LARGE AREAS OF LAND ARE REQUIRED TO EMBRACE COMPLEX INDUSTRIAL ESTABLISHMENTS, WITH DIVERSE, MULTI-LEVELLED PRODUCTION PROCESSES. THE AVAILABILITY OF LAND, IN AN URBAN AREA DICTATES THE LOCATIONAL PREFERENCE OF THESE

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[1] IBID., P. 31.

[2] FOR AN ELABORATION OF THESE CONDITIONS REFER TO, JOSEPH L. MASSIE, ESSENTIALS OF MANAGEMENT (ENGLEWOOD CLIFFS, NEW JERSEY: PRENTICE-HALL INC., 1964.).

LARGE OPERATIONS.

LAND ASSEMBLY

DEVELOPMENTS IN PRODUCTION TECHNOLOGY HAVE MADE A CENTRAL INDUSTRIAL LOCATION SOMEWHAT OF A LIABILITY. IT IS EXTREMELY DIFFICULT TO ASSEMBLE SUFFICIENT LAND IN THE CITY CENTER, TO MEET THE DEMAND OF INDUSTRY FOR INCREASED FLEXIBILITY IN SITE LAYOUT. THIS SITUATION IS MAINTAINED BY TWO CHARACTERISTICS OF CENTRAL CITY LAND, 1) LAND VALUE AND 2) LAND OWNERSHIP. THE HIGH COST OF LAND IN THE CENTRAL AREA (TO BE DISCUSSED LATER) DISCOURAGES LAND ACQUISITION FOR LOW DENSITY INDUSTRIAL USE. ALSO ADDING TO THIS COST IS A CORRESPONDING HIGH TAXATION RATE. HOWEVER, ASSUMING THAT AN INDUSTRY IS PERMITTED BY EXISTING ZONING BYLAWS TO ACQUIRE LAND IN THE CENTRAL CITY AND EXPAND ITS OPERATION IN ORDER TO TAKE ADVANTAGE OF MODERN TECHNOLOGICAL DEVELOPMENT. ASSUMING FURTHER THAT ACQUISITION CAPITAL IS NOT A LIMITATION. NEVERTHELESS, THE MULTIPLE OWNERSHIP OF LANDS IN THE AREA CREATES OTHER PROBLEMS. THIS FIRM WILL HAVE TO DEAL WITH A MULTITUDE OF SMALL LANDOWNERS IN ORDER TO ASSEMBLE THE REQUIRED LAND. A HOLD OUT BY ANYONE OF THESE LANDOWNERS COULD PROBABLY DELAY THE EXPANSION PROJECT, IF NOT FORCE ITS ENTIRE ABANDONMENT.[1]

THE LIABILITY OF A DOWNTOWN LOCATION FOR FIRMS WISHING TO EXPAND OR TO ESTABLISH THERE, HAS FORCED THESE FIRMS TO LOOK TOWARDS THE SUBURBS AND BEYOND FOR BETTER LOCATION POSSIBILITIES. FIRMS

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[1] LACK OF PUBLIC SUPPORT FOR CENTRAL CITY INDUSTRIAL RENEWAL HAS RULED OUT THE USE OF EXPROPRIATION BY GOVERNMENT OF SMALL LANDOWNERS FOR PRIVATE ASSEMBLY PROJECTS.

LOCATING AT A CONSIDERABLE DISTANCE FROM THE URBAN CENTER CAN USUALLY OBTAIN LAND AT THE LOWEST COST, WITH THE LEAST EFFORT.

E) Land Value and Taxation

Land value as a function of location

If a city follows an ideal development pattern with no irregularities introduced by specific economic or physical constraints then it can be said that land value decreases exponentially as one moves outward from the center, reaching a low point in the agricultural land surrounding the city. The situation would be as illustrated in Figure 1.[1] Where P(t) is the price of land at any given time-distance t, from the center. Introducing irregularities, (eg. shopping centre) to interfere with land price, the graph would have a series of small peaks or dips where these irregularities occur.

High land value in the developed core areas of the city attracts only high density land use. The income (or satisfaction)[2] obtained from the land must at least equal the cost of owning the land. Neither industry nor low density residences constitute high density land use. Accordingly, in terms of land values versus income and satisfaction, a central location is undesirable for these two

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[1]This theory of land value was proposed by William Alonso in his thesis, Location and Land Use, Toward a General Theory of Land Rent (Cambridge, Mass.: Harvard University Press, 1964), pp. 19-35. This initial proposal was later elaborated upon, to include land costs, commuting cost, and goods and other services as a function of income, infra, pp. 24-25.

[2]The term "satisfaction" is used here to mean the monetary benefit obtainable from the use of a specific parcel of land.

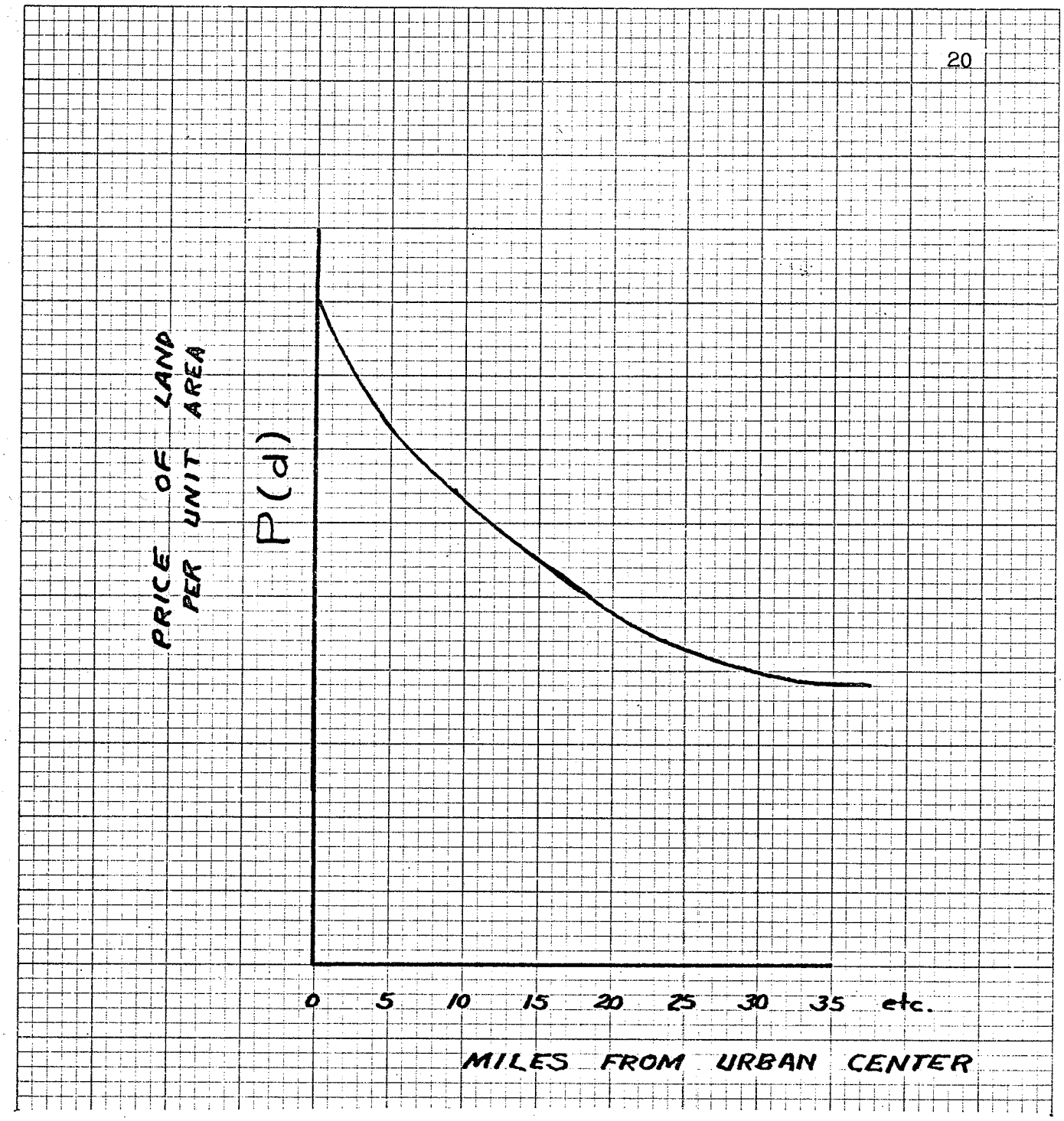

FIGURE 1. The Alonso function showing the decrease of land value with distance from the city center.

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F. F. Saccomanno May 1972

NOTE: Short title in figures and maps used for convevience.

ACTIVITIES. THE EXISTING DEVELOPMENT PATTERN OF URBAN LAND TENDS TO SUBSTANTIATE THIS THEORY. HIGH RISE OFFICES AND APARTMENT BUILDINGS ARE REPLACING OLD INDUSTRIAL AND RESIDENTIAL STRUCTURES. IN CENTRAL NEW YORK, THERE HAS BEEN AN EXPLOSION OF OFFICE SPACE SINCE WORLD WAR II. ACCORDING TO JANE JACOBS, FORTY MILLION SQUARE FEET OF FLOOR AREA (40% OF THE CITY'S TOTAL) HAS BEEN ADDED TO THE CORE AREA.[1]

TAXATION

CLOSELY RELATED TO LAND VALUE IS THE TAXATION RATE, WHICH ALSO SERVES TO DECENTRALIZE INDUSTRY AND LOW DENSITY RESIDENCES. THE TAXATION RATE IS BASED ON THE ASSESSED VALUE OF PROPERTY (INCLUDING LAND); THIS VALUE, IN TURN, IS A FIXED PERCENTAGE OF THE MARKET VALUE (OR WHAT THE PROPERTY WOULD BE WORTH IF OFFERRED ON THE OPEN MARKET). SINCE TAXATION IS A FUNCTION OF LAND VALUE, IT FOLLOWS THAT LAND CENTRALLY LOCATED ALSO HAS THE HIGHEST TAXES.[2]

TAXATION HAS SPECIAL RAMIFICATIONS ON INDUSTRIAL LOCATION. INDUSTRY UNLIKE RESIDENCES, MUST BE CONSCIOUS OF COMPETITION. IT STANDS TO REASON, THAT INDUSTRIES IN A CENTRAL LOCATION OPERATE AT A DISADVANTAGE WITH THEIR SUBURBAN COUNTERPARTS IF ONLY LAND VALUES AND TAXATION ARE CONSIDERED. HIGH TAXES MEANS HIGH OVERHEAD, WHICH HAS THE EFFECT OF CUTTING INTO THE FIRM PROFIT, OR INCREASING THE PRICE OF THE PRODUCT. FURTHERMORE, IN RECENT YEARS RURAL MUNICIPALITIES

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[1] MABEL WALKER, BUSINESS ENTERPRIZE AND THE CITY. (CAMBRIDGE: HARVARD UNIVERSITY PRESS, 1958), P. 67.

[2] A BRIEF DESCRIPTION OF THE VARIOUS TYPES OF LAND VALUE MAY BE FOUND IN: THE APPRAISAL INSTITUTE OF CANADA, APPRAISAL REFERENCE MANUAL. (FIFTH EDITION. WINNIPEG, MANITOBA: THE APPRAISAL INSTITUTE, 1963), PP. 1-1 TO 1-7.

CLOSE TO URBAN CENTERS HAVE WAGED A CONTINUAL WAR WITH THE CITIES IN AN EFFORT TO ATTRACT MIGRATING INDUSTRIES. IN ADDITION TO OFFERING THE AMENITIES OF PROXIMITY TO THE URBAN CENTER, THESE MUNICIPALITIES ALSO EXTEND GENEROUS TAX INCENTIVES. THE END RESULT IS TO AGGRAVATE THE COMPETITIVE DISADVANTAGE OF FIRMS MAINTAINING A CENTRAL LOCATION.

THE EFFECT OF LAND VALUE ON RESIDENTIAL LOCATION

ALTHOUGH AN INDIVIDUAL DOES NOT GENERALLY CHOOSE A RESIDENTIAL LOCATION TO MAINTAIN COMPETITIVE ADVANTAGE, LAND VALUE DOES PLAY A ROLE IN HIS ULTIMATE DECISION. IN 1939, HOMER HOYT, WITH THE ASSISTANCE OF THE UNITED STATES FEDERAL HOUSING ADMINISTRATION, CONDUCTED PERHAPS THE MOST DETAILED STUDY INTO THE EFFECT OF LAND VALUE ON RESIDENTIAL LOCATION.[1] THE REPORT LISTS EIGHT COMMON ASPECTS OF HIGH RENT RESIDENTIAL AREAS.

1) HIGH GRADE RESIDENTIAL GROWTH TENDS TO PROCEED FROM THE GIVEN POINT OF ORIGIN, ALONG ESTABLISHED LINES OF TRAVEL OR TOWARD ANOTHER EXISTING NUCLEUS OF BUILDINGS OR TRADE CENTERS.

2) THE ZONE OF HIGH RENT AREAS TENDS TO PROGRESS TOWARD HIGH GROUND, WHICH IS FREE FROM THE RISK OF FLOODS AND TO SPREAD ALONG LAKE, BAY, RIVER AND OCEAN FRONTS, NOT ALREADY USED BY INDUSTRY.

3) THEY TEND TO GROW TOWARD THE SECTION OF THE CITY WHICH HAS FREE, OPEN COUNTRY BEYOND THE EDGES AND AWAY FROM THE "DEAD END ZONES", LIMITED BY NATURAL OR MAN-MADE BARRIERS.

4) THE HIGHER PRICED RESIDENTIAL NEIGHBOURHOOD TENDS TO GROW TOWARDS THE HOMES OF THE LEADERS OF THE COMMUNITY.

5) TRENDS OF MOVEMENT OF OFFICE BUILDINGS, BANKS AND STORES, PULL THE HIGHER PRICED RESIDENTIAL NEIGHBOURHOOD IN THE

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[1] HOMER HOYT ET AL, THE STRUCTURE AND GROWTH OF RESIDENTIAL NEIGHBOURHOODS IN AMERICAN CITIES. (WASHINGTON: UNITED STATES FEDERAL HOUSING ADMINISTRATION, 1939), PP. 117-119.

SAME DIRECTION.

6) HIGH GRADE RESIDENTIAL AREAS TEND TO DEVELOP ALONG THE FASTEST EXISTING TRANSPORTATION LINES.

7) THE GROWTH OF HIGH RENT NEIGHBOURHOODS CONTINUES IN THE SAME DIRECTION FOR A LONG PERIOD OF TIME.

8) DELUXE HIGH RENT APARTMENT AREAS TEND TO BE ESTABLISHED NEAR THE BUSINESS CENTER IN OLD RESIDENTIAL AREAS.

HOYT FURTHER SUBDIVIDED THE RESIDENTIAL PATTERN INTO HIGH, MEDIUM AND LOW-RENT AREAS. THE HIGHEST QUALITY LAND COMMANDS THE HIGHEST VALUE AND HENCE PREEMPTS THE MOST DESIRABLE RESIDENTIAL LAND. INTERMEDIATE RENTAL GROUPS TEND TO OCCUPY THE SECTORS IN EACH CITY THAT ARE ADJACENT TO THE HIGH RENT AREAS. LOW INCOME GROUPS MOVE OUTWARD FROM THE CENTER OF THE CITY AND TEND TO RELOCATE IN AREAS VACATED BY THE MIDDLE INCOME GROUPS.[1]

OF COURSE THESE FINDINGS, RELATING LAND VALUE TO RESIDENTIAL LOCATION DO NOT APPLY EQUALLY TO ALL CITIES, SINCE CERTAIN IRREGULARITIES SUCH AS LAND SPECULATION AND INDIVIDUAL AS WELL AS REGIONAL CONSIDERATION, MAY APPRECIABLY ALTER SOME CONDITIONS. HOWEVER HOYT'S FINDINGS ARE BASED ON EXTENSIVE DATA, AND DO REPRESENT THE PATTERN QUITE ACCURATELY, GIVEN THE COMPLEXITY OF THE TOPIC.

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[1]THE RATE OF CONSTRUCTION IN GOVERNMENT SUBSIDIZED, LOW INCOME HOUSING HAS OFFSET THIS NATURAL PATTERN CONSIDERABLY. THOUGH LAND VALUE PLAYS A SIGNIFICANT ROLE IN THE LOCATION OF PUBLIC HOUSING, A CENTRAL LOCATION IN DETERIORATED NEIGHBOURHOODS, BECAUSE OF ECONOMIC LAND SUITABILITY FOR OTHER HIGH DENSITY USES, IS NOT CONSIDERED IDEAL FOR THIS TYPE OF RESIDENTIAL ACCOMMODATION.

F) The Effect of Income on Housing Location

So far existing residential location has been assessed in terms of land value. Viewing the situation in this way would tend to underplay the individual's role in the choice of housing. Indeed without looking at the individual who purchases the house, all discussion related to the effect of land value would be irrelevant to the study.

Recalling the Alonso "cone" of urban land value from the last section, a pricing function $P(t)$ was obtained which decreased almost exponentially at time-distance t, from a peak value at the center of the city. Alonso elaborated considerably on this simplistic model by introducing income as the dependent variable in the residential location junction.

If q is the quantity of land desired by a consumer, then $P(t) \cdot q$ is the total expenditure on land. Furthermore commuting costs are a function of distance; the further one travels, the higher the cost. This function can be represented by the term $K(t)$.[1] Assuming that expenditures on goods and services are independent of distance t from the center, then it follows that if Z units are purchased at a cost of $\$P_Z$ per unit, the third term would be $P_Z Z$. Given that an individual has an income of Y dollars, from which there are no savings or investments, then it follows from all possibilities of spending

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[1] Although $K(t)$ here includes all commuting costs, for the purpose of this study it may be applied to work trips. This assumes shopping trips are close to home and that distance is not a factor; also that other trips are sporadic and infrequent and can be neglected.

MONEY THAT

2A) $$Y = P(T)\ Q + K(T) + P_Z Z$$

IT ALSO FOLLOWS THAT THE COST OF COMMUTING DEPENDS ON THE LOCATION AND COST OF LAND, AS WELL AS THE INCOME OF THE INDIVIDUAL.

OPTIMIZING THE EQUATION WITH RESPECT TO T WE OBTAIN;

$$\frac{\partial}{\partial T}[Y] = Q\frac{\partial}{\partial T}[P(T)] + \frac{\partial}{\partial T}[K(T)] + \frac{\partial}{\partial T}[P_Z Z]$$

2B) $$Q\ \frac{\partial}{\partial T}[P(T)] + \frac{\partial}{\partial T}[K(T)] = 0$$

WHERE $T = T_0$.

AT DISTANCE T_0 WE HAVE THE MOST ECONOMICAL POINT OF LOCATION RELATING COMMUTING COSTS AND LAND VALUES FOR A GIVEN INCOME LEVEL.

ON CLOSER OBSERVATION OF THE THEORY, SOME OBVIOUS DOUBTS ARISE AS TO THE VALIDITY OF EQUATION 2A. AS HOYT FOUND, HOUSING QUALITY IS NOT UNIFORMLY DISTRIBUTED THROUGHOUT THE CITY BUT RATHER IS A FUNCTION OF NUMEROUS CHARACTERISTICS. THESE CHARACTERISTICS IN TURN AFFECT THE LAND VALUE TERM P(T). ALSO GIVEN A CERTAIN INCOME, AN INDIVIDUAL MAY DETERMINE HIS "T_0" POINT ACCORDING TO THE FORMULA, ONLY TO REALIZE THAT THERE ARE NO SUITABLE HOUSES FOR HIM AT THIS LOCATION. THUS HOUSING MAY BE SEEN AS A COMMODITY FOLLOWING THE RULES OF THE MARKET PRINCIPLE. AS A COMMODITY IT MUST BE PRODUCED, DISTRIBUTED, FINANCED AND PURCHASED. THE LOCATION FUNCTION IS AS MUCH DEPENDENT ON THE WHIMS OF THE DEVELOPER AND THE IMPORTANCE OF THE BUYER'S VOICE IN THE MARKET PLACE AS IT IS ON INCOME AND DISTANCE. THIS POINT IS ESPECIALLY SIGNIFICANT IN LIGHT OF THE FOLLOWING DISCUSSION.

G) Social Variables in Residential Preference

The nature of housing demand

In the previous section the Supply-Demand notion of housing was implied but not defined. Understanding the role of the buyer requires some knowledge of the demand function. According to O. E. Nelson[1] demand for housing is a function of four basic elements.

$$D = F\ (P, T, Pr, I)$$

where P = population characteristics

T = taste

Pr= price

I = income

Although all four elements are complexly inter-related, and should also be viewed as social variables for the purpose of this discussion only the first two will be considered.

Demand and population characteristics

Different groups of people are attracted by different housing amenities. The bachelor executive's general preference for an expensive apartment differs from the middle income family's desire for the homogeneity and stability of the neighbourhood unit[2] and the single family dwelling. This condition further limits flexibility of

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[1] O. E. Nelson, The Economics of Housing. A lecture presented to the School of Planning, University of Manitoba, January 14, 1971.

[2] For an illuminating insight into the concept of the neighbourhood unit refer to, Suzanne Keller, The Urban Neighbourhood (A Sociological Perspective, New York: Random House, 1968), pp. 87-147.

LOCATION. THE HOME BUYER AND TO A LESSER EXTENT THE APARTMENT TENANT MUST BALANCE THE AMENITIES OFFERED BY A CERTAIN LOCATION AGAINST THE INHERENT DISADVANTAGES OF EXCESS TRAVEL TIME TO WORK. A POINT OF COMPROMISE MUST BE FOUND BASED NOT ONLY ON INCOME BUT ALSO ON THE INDIVIDUAL BUYER AND/OR HIS FAMILY NEEDS. TO THE BACHELOR PROXIMITY TO A SCHOOL MAY BE IRRELEVANT TO THE FAMILY THIS ELEMENT MAY DICTATE WHETHER OR NOT THIS LOCATION IS SUITABLE.

DEMAND AND TASTE

WHEREAS POPULATION CHARACTERISTICS ARE REFLECTED IN THE PHYSICAL CHARACTERISTICS OF HOUSING (EG. NUMBER OF BEDROOMS, PROXIMITY TO SCHOOL, ETC.) TASTE IS A MORE INTANGIBLE VARIABLE. THE BACHELOR EXECUTIVE MAY HAVE THE SAME LEVEL OF TASTE AS THE MIDDLE-INCOME FAMILY, BUT HIS SPECIAL NEEDS REQUIRE DIFFERENT HOUSING.

IN TERMS OF LOCATION, THEN, GIVEN THAT A HOME SATISFIES THE PERSONAL OR FAMILY NEEDS OF THE BUYER, WILL THIS BUYER LOWER HIS TASTE IN ORDER TO BE CLOSER TO WORK OR WILL HE PREFER TO TRAVEL FURTHER? SOME RESEARCHERS BELIEVE THAT THE QUALITY OF HOUSING AS REFLECTED BY TASTE, LOCAL INTRINSIC CONVENIENCE AS REFLECTED BY PERSONAL OR GROUP NEEDS AND SOCIAL CLIMATE ARE MORE IMPORTANT IN THE LOCATION OF A HOME THAN THE INCONVENIENCE OF THE JOURNEY TO WORK. OTHER RESEARCHERS CONTEND THAT THE JOURNEY TO WORK IS A SIGNIFICANT VARIABLE IN THE SELECTION OF A RESIDENTIAL SITE, ESPECIALLY FOR SETTING AN OUTSIDE LIMIT TO THE DISTANCE BETWEEN HOME AND WORK.[1] THE "PRINCIPLE OF LEAST EFFORT" PROPOSED BY ZILF, AND THE MINIMIZATION OF WORK TRIP LENGTH, AS

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[1]HOWARD LAPIN, STRUCTURING THE JOURNEY TO WORK. (PHILADELPHIA: UNIVERSITY OF PENNSYLVANIA PRESS, 1964), P. 152.

INVESTIGATED BY CARROLL,[1] STILL APPEARS VALID. HOWEVER, DEPENDING ON INCOME LEVELS AND ASPIRATIONS IT IS MODERATED TO SOME EXTENT BY INTERVENING FACTORS SUCH AS TASTE AND ITS CLOSE RELATIVE - STATUS.[2]

THE STATUS OF HOUSING

ALTHOUGH HOUSING IS IN PART A COMMODITY IT IS ALSO A STATUS SYMBOL. AS SUCH IT TENDS TO DISCOURAGE INDIVIDUALS FROM SELECTING AN OPTIMUM LOCATION POINT SOLELY ON THE BASIS OF INCOME AND DISTANCE VARIABLES. COLLISON FOUND THAT CLERKS AND SHOP ASSISTANTS TENDED TO HAVE BETTER ACCOMMODATION THAN SKILLED MANUAL WORKERS DESPITE SIMILAR INCOME LEVELS.[3] OTHER STUDIES HAVE ALSO SHOWN THIS CORRESPONDENCE OF HOUSING QUALITY TO SOCIAL STATUS.[4]

STATUS CONSIDERATIONS EMPHASIZE THE SOCIAL HOMOGENEITY OF THE NEIGHBOURHOOD UNIT. MOST WRITERS HAVE FOUND THAT CLASS DIFFERENCES ARE UNPOPULAR, ESPECIALLY BETWEEN SIDE NEIGHBOURS. THE MOST INFLUENTIAL ASPECTS OF SOCIAL CLASS APPEAR TO BE OCCUPATION AND ECONOMIC STATUS. TYPE OF OCCUPATION AND VISIBLE MATERIAL PROSPERITY

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[1] INFLUENCED BY THE ZIPF CONCEPT OF MINIMIZATION OF ENERGY IN TRAVEL, CARROLL SOUGHT TO SHOW THAT "ANY CHANGE IN WORKERS RESIDENTIAL LOCATION WILL BE IN THE DIRECTION OF REDUCING WORK TRAVEL DISTANCE". CARROLL PRESENTS THIS IDEA IN TWO WORKS HUMAN BEHAVIOR AND THE PRINCIPLE OF LEAST EFFORT. (CAMBRIDGE: ADDISON-WESLEY PRESS, 1949, AND "THE HYPOTHESIS OF THE MINIMUM EQUATION AS A SYNTHESIS," AMERICAN SOCIOLOGICAL REVIEW XII (DECEMBER, 1947).

[2] FOR A BRIEF DISCUSSION OF THE STATUS VALUE ASSOCIATED WITH HOUSING SEE: RACHEL ALTERMAN, "INTERVENTION OF VALUES IN THE PLANNING PROCESS" (UNPUBLISHED MASTER'S THESIS, THE UNIVERSITY OF MANITOBA, WINNIPEG, 1970), PP. 199-200.

[3] R. N. MORRIS AND JOHN MOGEY, THE SOCIOLOGY OF HOUSING (LONDON: ROUTLEDGE & KEGAN PAUL, 1965), P. 123.

[4] FOR A LIST OF REFERENCES CONCERNING THE FACTORS INFLUENCING NEIGHBOURHOOD BEHAVIOR SEE: IBID., PP. 123-124 AND PP. 187-190.

ARE PERHAPS THE MOST IMPORTANT SINGLE INDICES OF SOCIAL CLASS. SIMILARLY, IN LIFE CHANCES HAVE OFTEN BEEN SHOWN TO INCREASE NEIGHBOURLINESS. SUCH FAMILIES FEEL THEY ARE "ALL IN THE SAME BOAT".[1] CARRYING THIS IDEA ONE STEP FURTHER, KNOWLEDGE OF THE OCCUPATIONAL MAKE-UP OF AN AREA MAY PERMIT A RESEARCHER TO ASSIGN CERTAIN SOCIAL INDICES TO THIS AREA, WHICH DESCRIBES THE AREA'S ATTRACTION OR REPULSION FOR PERSPECTIVE RESIDENTS.

H) THE WORK TRIP

"PATTERNS OF TRAVEL IN A CITY ARE AFFECTED BY AND IN TURN HELP TO FORM THE CITY'S STRUCTURAL CHARACTERISTICS".[2] THE INDIVIDUAL'S DECISION ON HIS RESIDENTIAL LOCATION AND WORK PLACE REPRESENT STRONG CITY-FORMING FORCES. AT ANY POINT IN TIME, HOWEVER, THE ESTABLISHED PHYSICAL URBAN STRUCTURE, ALSO CONDITIONS THE LOCATIONS OF TRIP ENDS, TRIP LENGTHS, THE MODES AND OTHER ELEMENTS OF TRIPS MADE BY THE INDIVIDUAL. THIS CAUSE-EFFECT RELATIONSHIP IS AN IMPORTANT ASPECT OF INTRAURBAN LOCATION THEORY.

SO FAR THE DISCUSSION HAS FOCUSED ON THE PATTERN OF INDUSTRIAL-RESIDENTIAL LAND USE IN THE CITY AND THE MAJOR CONDITIONS WHICH GOVERN THIS PATTERN. EXCEPT FOR A BRIEF HISTORICAL SKETCH, THE ANALYSIS HAS CONCENTRATED ON THE ORIGIN AND THE DESTINATION POINTS OF THE WORK TRIP, WITHOUT CONSIDERING THE LINKS BETWEEN THEM. DESPITE

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[1] MORRIS, OP. CIT., PP. 122-124.

[2] LAPIN, OP. CIT., P. 101.

THIS APPARENT OMISSION THE STUDY HAS UNDERLINED THE FIRST TWO OF THE THREE BASIC ASSUMPTIONS COMPRISING THE TRIP-MAKING FUNCTION.[1]

1) THE LAND USE PATTERN AND DEVELOPMENT IN THE STUDY AREA.

2) THE SOCIO-ECONOMIC CHARACTERISTICS OF THE TRIP-MAKING POPULATION,

3) THE NATURE, EXTENT AND CAPABILITIES OF THE TRANSPORTATION SYSTEM IN THE STUDY AREA.

THE FIRST ASSUMED VARIABLE WAS STUDIED IN TERMS OF INDUSTRIAL-RESIDENTIAL LOCATION CRITERIA. THE SECOND ASSUMPTION WAS STUDIED FROM A PURELY RESIDENTIAL POINT OF VIEW. AN ATTEMPT WAS MADE TO ANSWER THE QUESTION OF WHY VARIOUS GROUPS OF PEOPLE LOCATE DIFFERENTLY. IN THIS SECTION, THE DISCUSSION OF SOCIO-ECONOMIC POPULATION CHARACTERISTICS WILL BE EXPANDED IN ORDER TO EXPLAIN THEIR RELATIONSHIP TO WORK TRIP CHARACTERISTICS. THE THIRD FUNCTIONAL ASSUMPTION WILL BE DISCUSSED HERE SOLELY IN TERMS OF WORK TRIP CHARACTERISTICS AND NOT IN TERMS OF THE CAPACITY OF ANY INDIVIDUAL SYSTEM TO ACCOMMODATE THESE WORK TRIPS.

WORK TRIP LENGTHS CAN BE MEASURED EITHER IN UNITS OF DURATION, TIME OR MILES OF TRAVEL. THE CONSENSUS AMONG TRANSPORTATION PLANNERS IS THAT VARIATIONS IN TIME HAVE SIGNIFICANTLY MORE EFFECT ON TRAVEL BEHAVIOR THAN DISTANCE.[2] THE DECISION TO CHOOSE A SPECIFIC ROUTE IS BASED GENERALLY ON THE COMMUTERS' DESIRE TO "CUT DOWN" ON TRAVEL TIME. A RECENT SURVEY OF RESIDENTS IN RURAL MANITOBA ASKED THIS

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[1] M. J. BRUTON, INTRODUCTION TO TRANSPORTATION PLANNING (LONDON: HUTCHINSON TECHNICAL EDUCATION, 1970), P. 78.

[2] INFRA, PP. 42 AND 53.

QUESTION.[1]

> "How far would you be willing to travel for the above services if they were available in one place?"

It was found that the respondents invariably expressed distance in terms of time usually to the nearest five minutes for close destinations and to the quarter hour for more distant destinations.

Length of work trip is found to vary with the size of the city and the location of workers' residences within that city.[2] This of course is related to the density of development, time of travel and the effect of these factors on the propensity to travel. Lapin found that commuters living and working in outlying areas of the city tend to travel further than their inner city counterparts.[3] Congestion caused by density of development close to the urban core results in commuters seeking other less congested routes. Lacking alternatives, delay may persuaade travellers to cancel their trips all together; or force them to seek other jobs or residences.

The previous section described a mathematical relationship between income and travel time. There is an apparent contradiction between this result and the findings of the Philadelphia Standard

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[1] Carvalho-Page Group, Regional Analysis Program, Questionnaire survey, June 8, 1971. The writer was directly involved with the study group which conducted the survey. This finding was substantiated by the opinion of other members of the group and in no way must be regarded as a statistical finding of the study.

[2] Lapin, op. cit., p. 112.

[3] Ibid., p. 113.

METRO AREA STUDY WHICH FOUND THAT SHORTER WORK TRIPS ARE THE PRIVILEGES OF THE LOW AND RELATIVELY HIGH INCOME GROUPS. THE LONGEST TRIPS (33 MINUTES) WERE MADE BY HEADS OF HOUSEHOLD IN THE $7,000 - 8,000 ANNUAL INCOME GROUP. THE GREATER THE DIFFERENCE IN INCOME EITHER ABOVE OR BELOW THIS AMOUNT, THE SHORTER THE NUMBER OF MINUTES OF THE MEDIAN TRIP.[1]

ALONSO'S INCOME FORMULA, AS WELL AS THE LIMITED AMOUNT OF SUITABLE HOUSING FOR HIGH INCOME INDIVIDUALS, WOULD SEEM TO DENY THE RESULTS OF THE PHILADELPHIA STUDY. THE CONTRADICTION HOWEVER, IS ONLY AN APPARENT ONE. THE ALONSO FUNCTION APPLIES TO ALL TRIPS, AND THE INFLEXIBILITY OF HIGH INCOME GROUP IN RESIDENTIAL LOCATION APPLIES ESSENTIALLY TO HOME OWNERSHIP. INSTEAD THE PHILADELPHIA STUDY INCLUDES ONLY WORK TRIPS CONSISTING OF A SIGNIFICANT PERCENTAGE OF BUSINESS AND COMMERCIAL, AS WELL AS INDUSTRIAL WORK TRIPS. SINCE OFFICE AND RETAIL ACTIVITIES ARE LOCATED IN THE CENTRAL CITY ADJACENT TO EXPENSIVE APARTMENTS THE SHORTER WORK TRIPS FOR THE WEALTHY CAN BE EXPLAINED BY NOTING THAT A FAIR NUMBER OF THESE TRIPS HAVE BOTH ORIGIN AND DESTINATION POINT IN THE CORE AREA OF THE CITY.

WHAT EFFECT DOES THE SEX OF THE COMMUTER HAVE ON THE LENGTH OF WORK TRIP? F. KAIN OF THE RAND CORPORATION PROPOSED THAT THE TRAVEL PATTERNS OF WOMEN WORKERS DIFFERED FROM THOSE OF MEN. HE FOUND THAT IN GENERAL WOMEN WERE MUCH LESS WILLING THAN MEN TO WORK AT GREAT DISTANCES FROM HOME.[2]

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[1] IBID., PP. 49-50

[2] COLIN CLARK AND G. H. PETERS, "THE 'INTERVENING OPPORTUNITIES' METHOD OF ANALYSIS," TRAFFIC QUARTERLY, VOL. XIX, NO. 1 (JANUARY, 1965), P. 107.

SCHNORE STUDIED SIX PLANTS IN FLINT, MICHIGAN, AND CAME UP WITH SIMILAR CONCLUSIONS.[1] THE RESULTS OF THESE STUDIES HAVE OBVIOUS LOCATIONAL RAMIFICATIONS. WHAT INFLUENCE DOES THE WOMAN'S EARNING ABILITY HAVE ON THE TOTAL HOUSEHOLD? IS THE WOMAN A PRINCIPAL WAGE EARNER, OR IS SHE A SUBSIDIARY EARNER. WHICH MEMBER OF THE HOUSEHOLD, ULTIMATELY DECIDES ON A HOME LOCATION? IN VIEW OF THE NUMBER OF WOMEN PRESENTLY IN THE LABOUR FORCE, AND THEIR PREDOMINANCE IN THE CLERICAL OCCUPATION GROUP, THE BREAKUP OF WORK TRIPS INTO MALE AND FEMALE, PRINCIPAL AND SUBSIDIARY WAGE EARNER MAY BRING OUT INTERESTING DISCREPANCIES IN EXISTING WORK TRIP PREDICTION MODELS.

IF WE LOOK AT THE NATURE OF THE WORK TRIP AS DISTINCT FROM OTHER TYPES OF TRIPS, SOME PECULIAR CHARACTERISTICS BASED ON COMMUTER BEHAVIOR ARE NOTED. INVARIABLY THE WORK TRIP IS HOME BASED. THE ORIGIN POINT IS THUS RELATED TO ALL THE VARIABLES AFFECTING RESIDENTIAL LOCATION.[2] UNLIKE OTHER TYPES OF TRIPS, WORK TRIPS PLACE A HEAVY LOAD ON THE TRANSPORTATION SYSTEM, BECAUSE OF THE GREAT NUMBER OF PERSON AND VEHICLE TRIPS MADE WITHIN A LIMITED TIME PERIOD OF THE DAY.[3] GENERALLY THE WORK TRIP REACHES A PEAK VOLUME AT ABOUT 9 A.M. ON AN AVERAGE WEEK DAY. THE PREDOMINANCE OF VEHICLE TRIPS WITHIN THE OVERALL WORK TRIP

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[1] LAPIN, OP. CIT., PP. 120-121.

[2] IN A STUDY TITLED, "THE STRUCTURE OF URBAN ACTIVITY LINKAGES (UNIVERSITY OF NORTH CAROLINA, 1966) G. C. HEMMENS EXPLORES THE LINKAGES OF JOURNEYS AS OPPOSED TO SINGLE PURPOSE TRIPS. A SIGNIFICANT FINDING FROM THIS STUDY WAS THAT INVARIABLY THE WORK JOURNEY BEGAN AT HOME. HEMMENS ALSO DEFINES THE TRIP TO BE THE MOVEMENT OF A MEDIUM FROM ONE POINT TO ANOTHER ONE WAY WHILE THE JOURNEY IS A SERIES OF TRIPS BEGINNING AND ENDING AT A COMMON ORIGIN.

[3] THE WINNIPEG AREA TRANSPORTATION STUDY, VOL. 1, PP. 96-97.

CATEGORY IS HIGH COMPARED TO OTHER TRIP PURPOSES. WHILE PUBLIC TRANSIT VEHICLES CARRY THEIR GREATEST LOAD DURING PERIODS OF WORK TRIP DOMINANCE, AUTO OCCUPANCY FOR WORK TRIPS IS LOWER THAN FOR ANY OTHER PURPOSE. IN THE SAN FRANCISCO BAY AREA STUDY IT WAS FOUND THAT THE AUTO OCCUPANCY FOR WORK TRIPS AVERAGED 1.5 PERSONS PER CAR, WHILE FOR OTHER PURPOSES THE RATIO WAS 1.9.[1]

WHAT EFFECT DOES THE WORK TRIP CHARACTERISTIC HAVE ON "MODAL SPLIT"? ACCORDING TO BRUTON MODAL SPLIT MAY BE DEFINED AS:

> "THE PROPORTIONATE DIVISION OF THE TOTAL NUMBER OF PERSON TRIPS BETWEEN DIFFERENT METHODS OR MODES OF TRAVEL. IT CAN BE EXPRESSED NUMERICALLY AS A FRACTION, RATIO OR PERCENTAGE OF THE TOTAL NUMBER OF TRIPS."[2]

E. R. WILSON[3] IN A STUDY OF MODAL SPLIT DETAILS NUMEROUS REASONS WHY PEOPLE CHOOSE PRIVATE AS OPPOSED TO PUBLIC TRANSPORTATION AND VICE VERSA. GENERALLY, HOWEVER, THE MODE OF TRAVEL SELECTED BY AN INDIVIDUAL IS A PERSONAL DECISION BASED ON THE INTERACTION OF FIVE MAJOR FACTORS[4]

1) THE JOURNEY LENGTH: AS THE LENGTH OF THE JOURNEY INCREASES FEWER PEOPLE ARE EXPECTED TO USE PUBLIC TRANSPORT. BECAUSE AUTOMOBILES HAVE A HIGHER OPERATNNG SPEED THAN BUSES, THE AUTOMOBILE HAS A HIGHER MARGINAL VALUE OF TIME SAVED, AT GREATER DISTANCES.

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[1] LAPIN, OP. CIT., P. 67-69.

[2] BRUTON, OP. CIT., P. 150.

[3] F. R. WILSON, JOURNEY TO WORK: MODAL SPLIT. (LONDON: MACLAREN AND SONS LTD., 1967), PP. 18-22.

[4] THE FIRST FOUR FACTORS WERE TAKEN FROM M. J. BRUTON, OP. CIT., PP. 152-5, THE FIFTH FACTOR WAS OBTAINED FROM A DISCUSSION ON THE STATUS VALUE OF THE AUTOMOBILE IN ALTERMAN, OP. CIT., PP. 213-216.

2) TRIP PURPOSE: IT IS FOUND THAT HOME BASED TRIPS GIVE RISE TO GREATER USE OF PUBLIC TRANSPORT. THIS IS ESPECIALLY TRUE OF HOME BASED WORK TRIPS TO THE CENTRAL AREA OF THE CITY.

3) INCOME: THE USE OF AN AUTOMOBILE IS DETERMINED BY THE INDIVIDUAL'S ABILITY TO PURCHASE AND MAINTAIN THE VEHICLE.

4) DENSITY OF RESIDENTIAL DEVELOPMENT: AS THE RESIDENTIAL DENSITY (OR EVEN TOTAL DEVELOPMENT DENSITY) DECREASES SO DOES TRANSIT USE. THE USE OF THE PRIVATE VEHICLE BECOMES VERY SIGNIFICANT OUTSIDE THE CITY NUCLEUS.[1]

FINALLY

5) VALUES: THE CAR TO MANY PEOPLE SYMBOLIZES PRIVACY, INDIVIDUALISM, PRIVATE OWNERSHIP, POWER AND FREEDOM. THE MOTIVATION OF HIGH STATUS GROUPS TO USE PRIVATE TRANSPORTATION IS AT TIMES BASED ON VALUES AND TRANSCENDS BASIC THEORIES OF TIME AND COST.

BECAUSE THE MAJOR PURPOSE OF THIS STUDY IS THE DETERMINATION OF A SPECIFIC LOCATION FUNCTION ONLY THE MAJOR ASPECTS OF WORK TRIPS HAVE BEEN DISCUSSED HERE. THE WORK TRIP, LIKE OTHER TRIPS IS SIMPLY A LINK BETWEEN AN ORIGIN AND A DESTINATION POINT. FOR THIS STUDY THE ORIGIN IS THE WORKER'S RESIDENCE AND THE DESTINATION IS THE PROPOSED INDUSTRIAL SITE. THE QUESTION NOW POSED IS: GIVEN ALL THE FACTORS DISCUSSED IN THIS CHAPTER, WHAT CAN BE PREDICTED ABOUT THE VOLUME, LENGTH AND ORIENTATION OF THIS LINK WITHIN THE CONTEXT OF AN ISOLATED URBAN SYSTEM?

1) SYNOPSIS OF MAJOR VARIABLES

THE MAJOR VARIABLES INFLUENCING LOCATION THEORY, BOTH DIRECTLY

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[1] REFER TO: THE WINNIPEG AREA TRANSPORTATION STUDY, OP. CIT., PP. 36-37.

AND INDIRECTLY, ARE SUMMARIZED HERE. THEY ARE SIMPLY THOSE FINDINGS FROM THE GENERAL INFORMATION BASE WHICH CAN CONTRIBUTE EFFECTIVELY TO A GENERAL HYPOTHESIS ON INDUSTRIAL-RESIDENTIAL LOCATION PATTERN. THE VARIABLES ARE AS FOLLOWS:

1) IN ORDER TO SIMPLIFY THE DISCUSSION "THE CITY" HAS BEEN ABSTRACTED TO A LEVEL WHERE ALL CITIES MAY BE SAID TO EXPERIENCE THE SAME CONDITIONS WITH EQUAL IMPACT. IN FACT, THIS IS NOT ALWAYS TRUE SINCE LOCATIONAL VARIABLES ARE INFLUENCED BY THE EXISTING NATURE, INTENSITY AND EXTENT OF DEVELOPMENT IN A SPECIFIC CITY, AS WELL AS THE CITY'S PLACE IN THE REGION.

2) ALTHOUGH FOR DISCUSSION PURPOSES VARIABLES HAVE TENDED TO REMAIN ISOLATED THEIR LOCATIONAL INFLUENCE IS A FUNCTION OF THEIR INTER-RELATIONSHIP OVER TIME. LAND VALUE AFFECTS INDUSTRIAL DEMAND FOR URBAN PERIPHERAL LAND. THIS DEMAND IS ACCELERATED BY INDUSTRIAL REQUIREMENTS FOSTERED BY TECHNOLOGICAL ADVANCES, ETC.

3) SPECIFIC INDUSTRAAL TYPES MODIFY OR STRENGHTEN THE EFFECT OF THE VARIABLES. NOT ALL FIRMS EXPERIENCE THE SAME CONDITIONS.

4) HISTORY HAS PLAYED AND CONTINUES TO PLAY AN IMPORTANT ROLE IN EXPLAINING THE LOCATION OF INDUSTRIAL AND RESIDENTIAL LAND USES.

5) FOR MOST FIRMS, NEW DEVELOPMENTS IN INDUSTRIAL PRODUCTION TECHNOLOGY, HAVE CAUSED THE OBSOLESCENCE OF THE OLD CENTRAL CITY INDUSTRIAL DISTRICT AND HAVE NECESSITATED THE REQUIREMENTS FOR LARGE TRACTS OF RELATIVELY INEXPENSIVE LAND FOR SITE DEVELOPMENT AND EXPANSION.

6) HIGH LAND VALUES HAVE INITIATED A FUNCTIONAL CHANGE FOR THE CITY'S CENTRAL AREA. THIS CHANGE ENCOURAGES HIGH DENSITY DEVELOP-MENT AND ACCELERATES INDUSTRIAL AND LOW-DENSITY RESIDENTIAL

DECENTRALIZATION. AT THE SAME TIME IT HAS BECOME GENERALLY A ZONE OF HIGH RISE APARTMENTS, HOUSING RELATIVELY WEALTHY PEOPLE WHO ALSO WORK IN THE CORE AREA.

7) THE INDIVIDUAL OR FAMILY CHOICE OF A HOME IS A FUNCTION OF THE BUYER'S NEEDS, AS WELL AS THE ABILITY OF THE HOUSE AND LOCATION TO FULFILL THESE NEEDS EFFECTIVELY. FURTHERMORE THESE NEEDS ARE RELATED TO THE LEVEL OF SOCIAL IDENTITY IN A PARTICULAR RESIDENTIAL AREA. COMPROMISE BETWEEN INDIVIDUAL OR GROUP NEEDS AND THE COST OF PROPERTY IS GOVERNED BY THE HOUSEHOLD INCOME.

8) SOCIAL STATUS, BASED USUALLY ON OCCUPATIONAL BREAKDOWN PLAYS A SIGNIFICANT ROLE IN THE CHOICE OF HOUSING TYPE AND LOCATION. NEIGHBOURHOOD UNITS TEND TO BE SOCIALLY HOMOGENEOUS AND SEGREGATED IN TERMS OF LAND USE. THESE CHARACTERISTICS DO NOT CHANGE APPRECIABLY IN THE SHORT TERM.

9) THE INDIVIDUAL'S PROPENSITY TO TRAVEL IS A FUNCTION OF TRIP PURPOSE, TIME IMPEDENCE, COMFORT AND COST AND IS FURTHER RELATED TO HIS INCOME.

CHAPTER III

SELECTED TRIP DISTRIBUTION MODELS

A) Introduction

More than theory is required in order to understand urban location patterns. This is especially true if the relevant facts are discussed in isolation of each other. Recognizing this need for interrelating and simplifying facts, researchers of urban transportation, have developed several models of analysis, three of which will be assessed here. These three models are generally believed to be the most fundamental in trip assignments. They are: The Gravity Model, the Method of Successive Approximation (The Fratar Method) and the Opportunity Model (The C.A.T.S. Method and the Tomazines Method).[1]

The models treated in this chapter apply to the overall situation of urban trip assignments. Therefore unless the present discussion remains within the framework of basic ideas and principles behind these models, there is a risk of going beyond the scope of the study. Essentially this exercise moves one step beyond the discussion of relevant isolated variables to the level of interrelating and simplifying the findings of Chapter II. This model analysis establishes a basis for further simplification for the hypothesis derived in Chapter IV.

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[1] C.A.T.S. stands for Chicago Area Transportation Study.

B) The Gravity Model

The concept

Although the gravity model is founded on the laws of Newtonian Physics its earliest application to human interaction resulted from the work of H. C. Carey who noted:

> "Man, the molecule of society, is the subject of Social Science. . . The great law of Molecular Gravitation (is) the indispensable condition of the existence of the being known as man. . . The greater the number collected in a given space, the greater is the attraction force that is there exerted. . . Gravitation is here as everywhere, in the direct ratio of the mass and the inverse one of the distance."[1]

Essentially then, when an individual is studied as a small element of a larger group, he is subject to external group forces and acts with little independence. His reaction to these forces is within the realm of prediction. The term "mass" referred to by Carey could be any variable of attraction, sales receipts, airline tickets, vehicles or people. For example: Shoppers are attracted to shopping places; the variables here are shoppers and shopping places. The number of shoppers in district A is X persons and the number of shopping places in district B is Y, it can be assumed, by the gravity principle, that the attraction of shoppers from A to B is proportional

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[1] Gerald A. P. Carrothers, "An Historical Review of Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, Vol. XXII No. 2 (Spring, 1956), p. 94. Most of the historical assessment of the gravity concept is based on this bibliographical review.

TO THE PRODUCT X•Y.[1] IN EQUATION TERMS THIS ATTRACTION FORCE MAY BE IDEALLY STATED AS

3A) $I = K\ X_A Y_B$

WHERE K IS THE CONSTANT OF PROPORTIONALITY

AND I THE FORCE OF INTERACTION.

CONTINUING THE ANALOGY, JUST AS THE GRAVITATIONAL PULL OF TWO MASSES DECREASES WITH THE DISTANCE BETWEEN THEM, SO DOES HUMAN INTERACTION. IN THE SHOPPER EXAMPLE, THE FURTHER DISTRICT A IS FROM B THE LESS THE VOLUME OF SHOPPING TRAFFIC FROM A TO B. IN EQUATION FORM:

3B) $$I = K\ \frac{X_A Y_B}{D_{A-B}}$$

WHERE D_{A-B} IS SOME MEASURE OF DISTANCE BETWEEN THE TWO DISTRICTS. ALTHOUGH THIS SIMPLE FUNCTION HELPS EXPLAIN THE BASIC IDEA BEHIND THE GRAVITY MODEL IT FAILS TO EXPLAIN THE ACTUAL INTERACTION. THE CHALLENGE OF USING THE GRAVITY MODEL IS TO BE ABLE TO ACCURATELY DESCRIBE THE HYPOTHESES BEHIND HUMAN INTERACTION. IN GENERAL THE FORMULA EXPLAINING THE BASIC IDEA IS

3C) $$I = \frac{F(X_A, X_B)}{F(D)}$$

SUMMARIZING THE REASONING BEHIND THIS GENERAL HYPOTHESIS, CARROTHERS STATES:[2]

1) TO PRODUCE INTERACTION, INDIVIDUALS MUST BE IN COMMUNICATION WITH ONE ANOTHER.

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[1] UNLIKE THIS EXAMPLE, THE TERMS OF THE PRODUCT USUALLY HAVE SIMILAR UNITS. IE. PEOPLE TIMES PEOPLE, ETC.

[2] IBID., P. 94.

2) AN INDIVIDUAL AS A UNIT OF A LARGE GROUP, MAY BE CONSIDERED TO GENERATE THE SAME INFLUENCE OF INTERACTION AS ANY OTHER INDIVIDUAL.

3) THE PROBABLE FREQUENCY OF INTERACTION GENERATED BY AN INDIVIDUAL AT A GIVEN LOCATION IS INVERSELY PROPORTIONAL TO THE DIFFICULTY OF REACHING, OR COMMUNICATING WITH THAT LOCATION.

4) THE FRICTION AGAINST THIS TRANSPORTATION OR COMMUNICATION IS DIRECTLY PROPORTIONAL TO THE INDIVIDUAL AND THE GIVEN LOCATION.

DEVELOPMENT OF THE CONCEPT

IN THE 1920'S C. E. YOUNG,[1] SUPPORTED AT THE SAME TIME BY W. J. REILLY'S[2] WORK ON RETAIL TRADE AREAS, FIRST POSTULATED THAT INTERACTION WAS DIRECTLY PROPORTIONAL TO ATTRACTION AT A DESTINATION POINT AND INVERSELY PROPORTIONAL TO THE SQUARE OF THE LINEAL DISTANCE BETWEEN THE ORIGIN AND DESTINATION POINT.

IN RECENT YEARS THE CONCEPT HAS BECOME MORE FORMAL AND COMPLEX. T. R. ANDERSON[3] FIRST EXPRESSED DOUBT ABOUT THE RELIANCE ON THE SQUARE PROPORTIONALITY FOR DISTANCE. HIS STUDIES LEAD HIM TO CONCLUDE THAT THE EXPONENTIAL DEPENDED ON THE SIZE OF THE URBAN CENTER OR AREA UNDER CONSIDERATION. HIS FORMULA WAS

3D) $$IV_J = K \frac{P_J}{D_{IJ}^{\alpha}}$$

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[1] C. E. YOUNG, "THE MOVEMENT OF FARM POPULATION," ITHICA: CORNELL AGRICULTURAL EXPERIMENT STATION, BULLETIN 426: 1924.

[2] W. J. REILLY, THE LAW OF RETAIL GRAVITATION. (NEW YORK: W. J. REILLY CO., 1931).

[3] T. R. ANDERSON, "INTERMETROPOLITAN MIGRATION: A COMPARISON OF THE HYPOTHESIS OF ZILF AND STOUFFER," AMERICAN SOCIOLOGICAL REVIEW, 20:3 (JULY, 1956), PP. 287-291.

WHERE P_J = THE POPULATION AT DESTINATION POINT J.

(ATTRACTION FORCE)

D_{IJ} = LINEAR DISTANCE BETWEEN I AND J

AND α = SOME FUNCTION OF THE ATTRACTION FORCE AT J. $[\alpha = F(1/P_J)]$

J. Q. STEWART[1] BEGAN TO DEVIATE FROM THE REGIMENTED MOLECULAR-HUMAN BEHAVIORAL PREMISE OF THE EARLY MODELS, BY ASSERTING THAT POPULATION CHARACTERISTICS INFLUENCED THE DEGREE OF INTERACTION. HIS FORMULA STATED

3E) $$E_{IJ} = K \frac{U_I P_{KI} \cdot U_J P_J}{D_{IJ}}$$

WHERE U_I = MOLECULAR WEIGHT OF AN INDIVIDUAL AT I BASED ON BEHAVIORAL CHARACTERISTICS, SIMILARLY FOR U_J.

THIS STATEMENT BRINGS UP THE CONCEPT OF "LIFE SPACE"; THE FACT THAT CERTAIN INDIVIDUALS BECAUSE OF BACKGROUND INHABIT A LARGER SUBJECTIVE WORLD THAN OTHERS. THE INTERACTION POSSIBILITIES ARE ACCORDINGLY ENHANCED FOR THE INDIVIDUAL WITH SUCH AN EXTENDED LIFE SPACE. IN SHORT IF AN INDIVIDUAL'S ONLY MEANS OF TRANSPORTATION WERE HIS LEGS, HIS WORLD WOULD POSSIBLY EXTEND ABOUT AN HOUR'S WALKING DISTANCE FROM HOME. HIS INTERACTION WOULD LIKEWISE BE LIMITED TO THIS RADIUS.

IN APPLYING THE GRAVITY PRINCIPLE TO TRAFFIC ANALYSIS, VOORHEES[2] INTRODUCED ONE MORE REFINEMENT TO THE MODEL, BY EMPLOYING TIME RATHER THAN LINEAL DISTANCE AS A MEASURE OF REPELLING FORCES.

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[1] J. Q. STEWART, "SOCIOMETRY," VOL. II, 1948; AND "GEOGRAPHICAL REVIEW", VOL. 37, 1947.

[2] ALAN VOORHEES, "A GENERAL THEORY OF TRAFFIC MOVEMENT." THE 1955 PAST PRESIDENTS AWARD PAPER, INSTITUTE OF TRAFFIC ENGINEERS, NEW HAVEN, CONNECTICUT.

HE ALSO SUGGESTED CLASSIFYING TRIPS, EMPLOYING THE GRAVITY PRINCIPLE, BY PURPOSE, EG. SHOPPING AS SEPARATED FROM WORK TRIPS.

RECENT GRAVITY THEORY

RECENT STUDIES IN GRAVITY POTENTIAL THEORY SEEM TO REFLECT AN UNCERTAINTY, WITH REGARD TO ONCE ACCEPTED CONSTANTS OF INTERACTION. THE LATEST MODELS ARE CHARACTERIZED BY A LACK OF THESE INTERACTION CONSTANTS AND THE INTRODUCTION OF ADJUSTMENT FACTORS. AS A REPRESENTATION OF TRIP ASSIGNMENTS THE PUGET SOUND TRANSPORTATION STUDY[1] MODEL IS INDICATIVE OF THIS SITUATION. THE FORMULA STATES.

3F) $T_{IJ} = C\ P_I\ A_J\ F_{IJ}\ K_{IJ}$

WHERE T_{IJ} = TRIPS PRODUCED AT I AND ATTRACTED AT J

P_I = TOTAL TRIP PRODUCTION AT I

A_J = TOTAL TRIP ATTRACTION AT J

F_{IJ} = CALIBRATION TERM FOR INTERCHANGE I - J

K_{IJ} = SOCIO-ECONOMIC ADJUSTMENT FACTOR FOR INTERCHANGE I-J

$I = 1, 2, 3 \ldots n$ WHERE n IS ALL ZONES IN AREA

C = CONSTANT OF PROPORTIONALITY

THE CALIBRATION TERM F_{IJ}, ARRIVED AT ITERATIVELY, IS GENERALLY FOUND TO BE AN INVERSE EXPONENTIAL FUNCTION OF IMPEDANCE, USUALLY TRIP TIME T. ITS USAGE IS EXTENDED AND GENERALIZED BY USING A TABLE RATHER THAN A FORMULA. INDIVIDUAL VALUES ARE RELATED TO INCREMENTS OF TRIP TIME. THE F-FACTOR CHOSEN FOR EACH INTERCHANGE IS THUS A FUNCTION OF

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[1]BUREAU OF PUBLIC ROADS, UNITED STATES DEPARTMENT OF TRANSPORTATION, URBAN TRANSPORTATION PLANNING, VOL. IV (WASHINGTON: GOVERNMENT PRINTING OFFICE, 1970), PP. 19-20.

THE TRIP TIME FOR THAT INTERCHANGE.[1]

THE SOCIO-ECONOMIC ADJUSTMENT TERM, KIJ IS APPLIED DIRECTLY TO THE INTERCHANGE IJ. THIS FACTOR IS ONLY USED WHEN A FEW EXTREME SOCIO-ECONOMIC VARIATIONS CAN BE DISTINGUISHED.

ONE CAN SEE THAT THE DEGREE OF DETAIL DEMANDED BY THE F AND K FACTORS RESTRICTS THE GENERALITY OF APPLICATION OF THIS MODEL, INHERENT IN THE EARLIER LESS REFINED ATTEMPTS.

ADVANTAGES AND DISADVANTAGES

ACCORDING TO BRUTON ONE OF THE MAJOR ADVANTAGES OF THE GRAVITY MODEL IS THAT, "IT IS EASY TO UNDERSTAND AND USE".[2] IT WOULD APPEAR THAT THIS STATEMENT DOES NOT TAKE ACCOUNT OF RECENT DEVELOPMENTS IN GRAVITY THEORY. HOWEVER THE GRAVITY CONCEPT DOES RECOGNIZE THAT TRIP PURPOSE IS A MAJOR INFLUENCE IN DETERMINING TRAVEL PATTERNS AND ACCOUNTS FOR THE COMPETITION BETWEEN DIFFERENT LAND USES.

A BASIC OPERATIONAL DIFFICULTY OF THE GRAVITY MODEL IS THAT A CONSIDERABLE AMOUNT OF ADJUSTMENT AND MANIPULATION IS REQUIRED TO ACHIEVE SATISFACTORY RESULTS. MUCH OF THIS ADJUSTMENT IS BASED ON THE ASSUMPTION THAT TRAVEL FRICTION RATES FIJ, OR THE SOCIO-ECONOMIC CONDITIONS REPRESENTED BY KIJ WILL REMAIN CONSTANT UP TO SOME DESIGN YEAR.[3] DEPENDING ON THE AREA UNDER OBSERVATION THIS ASSUMPTION MAY BE INVALID.

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[1]FOR A DETAILED DISCUSSION OF HOW THE F-FACTOR IS CALIBRATED SEE: IBID., PP. 17-39.

[2]BRUTON, OP. CIT., P. 112.

[3]IBID., P. 112.

THERE IS OF COURSE A BASIC CONCEPTUAL ARGUMENT AGAINST GRAVITY POTENTIAL MODELS. ALTHOUGH GRAVITY LAWS HOLD TRUE FOR THE PHYSICAL CONDITIONS TO WHICH THEY WERE FIRST APPLIED, HUMAN INTERACTION MAY NOT ADHERE TO THESE LAWS. IN EXPLAINING THIS DISADVANTAGE CARROTHERS STATES:

> ". . . THE INDIVIDUAL HUMAN BEING CAN MAKE DECISIONS WITH RESPECT TO HIS ACTIONS, WHILE THE INDIVIDUAL MOLECULE (PRESUMABLY) CANNOT. THIS DOES NOT IMPLY THAT INTERACTION OF HUMANS IN LARGE NUMBERS CANNOT BE DESCRIBED MATHEMATICALLY, BUT IT DOES MEAN THAT THE THRESHOLD WHERE THE POWER OF INDIVIDUAL DECISION-MAKING CRITICALLY AFFECTS THE RESULTS MUST BE DETERMINED BEFORE THE CONCEPTS CAN BE BROADLY APPLIED IN PRACTICE."[1]

IN ESSENCE THIS ARGUMENT APPLIES NOT ONLY TO GRAVITY CONCEPTS, BUT ALSO TO ALL CONCEPTS WHICH ATTEMPT TO DESCRIBE HUMAN BEHAVIOR PATTERNS MATHEMATICALLY.

C) THE FRATAR METHOD OF SUCCESSIVE APPROXIMATIONS[2]

THE CONCEPT

THE FRATAR METHOD IS USED FOR ESTIMATING THE FUTURE DESIRED MOVEMENTS OF TRAFFIC WITHOUT REGARD TO EXISTING ROUTES. ACCORDING TO FRATAR, THE MODEL LENDS ITSELF MORE READILY TO ANALYSIS BY A METHOD OF SUCCESSIVE APPROXIMATIONS THAN DOES THE PROCEDURE OF TRIP DISTRIBUTION

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[1] CARROTHERS, OP. CIT., P. 99

[2] THE METHOD DESCRIBED HERE HAS BEEN APPLIED PREVIOUSLY TO OTHER ENGINEERING PROBLEMS, EXAMPLES: WATER SUPPLY, SEWERAGE, IRRIGATION, ETC. IN HYDRAULIC STUDIES IT IS BETTER KNOWN AS THE HARDY CROSS METHOD. THE FIRST APPLICATION OF SUCCESSIVE APPROXIMATION TO TRANSPORTATION WAS UNDERTAKEN BY THOMAS J. FRATAR, "VEHICULAR DISTRIBUTION BY SUCCESSIVE APPROXIMATIONS," TRAFFIC QUARTERLY, VOL. VIII, NO. 1 (JANUARY, 1954), PP. 53-55.

ON COMPETITIVE ROUTES.[1]

THE METHOD FOR PREDICTING FUTURE INTERZONAL VOLUMES BY SUCCESSIVE APPROXIMATIONS IS BASED ON THE PREMISE THAT, IF CHARACTER AND GROWTH CONDITIONS OF A TRAFFIC ZONE ARE KNOWN, OR PREDICTABLE, THEN IT WOULD BE POSSIBLE TO ESTIMATE WITH EQUAL DEPENDABILITY THE TOTAL TRIPS THAT WILL BE MADE TO AND FROM EACH ZONE, AS WELL AS THE DISTRIBUTION OF THESE TRIPS WITHIN THE ENTIRE URBAN ZONAL SYSTEM. "BY THIS METHOD, THE ANTICIPATED TRAFFIC OF EACH ZONE IS ASSIGNED TO THE DESIRE LINES OF THAT ZONE ACCORDING TO THE APPARENT RELATIVE IMPORTANCE OF EACH DESIRE LINE".[2]

THE BASIC PREREQUISITE OF THIS METHOD IS A THOROUGH ANALYSIS OF THE URBAN AREA ON A ZONAL OR DISTRICT SCALE. IF THE FOCUS IS ON WORK TRIP DISTRIBUTION BETWEEN TWO DISTRICTS, THEN EACH DISTRICT MUST BE STUDIED TO DETERMINE THE NUMBER OF POSSIBLE JOB SITES EACH WILL HAVE AT SOME FUTURE DATE. QUESTIONS SIMILAR TO THE FOLLOWING MUST BE ANSWERED FOR EACH DISTRICT, TO ARRIVE AT SOME EXPECTED FUTURE WORK TRIP INTERCHANGE BETWEEN THEM. WHAT PERCENTAGE OF THE CITY'S OVERALL INDUSTRIAL, COMMERCIAL, SERVICE AND BUSINESS ACTIVITIES WILL ESTABLISH, GROW OR DECLINE IN THESE DISTRICTS DURING THIS TIME? WHAT PERCENTAGE OF THE WORK FORCE LIVES HERE? IS AN INCREASE IN WORK FORCE EXPECTED FOR THESE DISTRICTS? OF COURSE, IF THE SYSTEM WERE COMPOSED OF ONLY TWO DISTRICTS IT WOULD BE RELATIVELY EASY TO KEEP TRIP ASSIGNMENTS BALANCED, IE. TRIPS IN = TRIP OUT. IN A LARGE URBAN SYSTEM WITH MANY

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[1] IBID., PP. 54-65.

[2] FOR A DISCUSSION OF "DESIRE LINES", SEE IBID., P. 54.

DISTRICTS, SUCCESSIVE APPROXIMATION IS USED TO BALANCE THE SYSTEM. THE METHOD IS SIMPLY AN ITERATION PROCESS.

THE METHOD

ACCORDING TO FRATAR THE STEPS EMPLOYED IN THE METHOD ARE AS FOLLOWS:[1]

> "1. THE FIRST STEP IS THE PREPARATION OF THE TOTAL NUMBER OF AUTOMATIC TRIPS THAT CAN BE EXPECTED TO ENTER AND LEAVE EACH TRAFFIC ZONE OF THE AREA UNDER STUDY AT THE FUTURE DATE FOR WHICH THE DISTRIBUTION IS DESIRED. THESE ESTIMATES MUST HAVE A POSSIBLE DISTRIBUTION--NO ONE ZONE CAN HAVE MORE TRIPS INTO AND OUT OF IT THAN ENTER AND LEAVE ALL THE OTHER ZONES COMBINED.[2]
>
> 2. THE TOTAL TRIPS OF EACH ZONE ARE DISTRIBUTED TO THE OTHER ZONES IN PROPORTION TO THE ATTRACTIVENESS INDICATED BY EXISTING INTERZONAL VOLUMES AND BY THE ANTICIPATED GROWTH OF EACH OF THE OTHER ZONES.
>
> 3. THE DISTRIBUTION OF TRIPS FOR ALL ZONES WILL PRODUCE TWO TENTATIVE VALUES FOR EACH INTERZONAL MOVEMENT. THESE PAIRS OF TENTATIVE VALUES ARE AVERAGED TO OBTAIN THE FIRST APPROXIMATION OF THE INTERZONAL VOLUMES.

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[1] IBID., P. 62.

[2] THESE ESTIMATIONS CAN BE MADE ON THE BASIS OF VARIOUS TRENDS AND THE PROSPECTIVE CHANGES IN THE CHARACTERISTICS OF THE INDIVIDUAL ZONES. FRATAR SUGGESTS TWO APPROACHES FOR DETERMINING THE GROWTH FACTOR.

1) A SINGLE EXPANSION FACTOR IS APPLIED UNIFORMLY TO ALL INTERZONAL MOVEMENTS. THIS APPROACH IS VERY INACCURATE FOR ZONES WITH NUMEROUS ACTIVITIES AND MULTI-PURPOSE TRIPS.
2) EACH ZONE IS EXPANDED BY MULTIPLYING IT BY THE ARITHMETIC OR GEOMETRIC MEAN OF THE FACTORS REPRESENTING THE PROBABLE TRAFFIC GROWTH OF THE TWO ZONES INVOLVED IN THE MOVEMENT. HERE THERE IS AN OBVIOUS DISCREPANCY INTRODUCED BETWEEN THE SUMMATION OF THE EXPANDED TRIPS TO AND FROM ANY ZONE AND THE EXPECTED TRIPS FOR THAT ZONE.

4. FOR EACH ZONE, THE SUM OF THE FIRST APPROXIMATION VOLUMES IS DIVIDED INTO THE TOTAL VOLUME DESIRED FOR THE ZONE TO OBTAIN FIRST APPROXIMATION GROWTH FACTORS TO BE USED IN THE COMPUTATIONS FOR THE SECOND APPROXIMATIONS.

5. THE ORIGINALLY ESTIMATED TRIPS FOR EACH ZONE ARE AGAIN DISTRIBUTED TO INTERZONAL MOVEMENTS, THESE NEW ASSIGNMENTS BEING IN PROPORTION TO THE INTERZONAL VOLUMES AND GROWTH FACTORS OBTAINED BY THE FIRST APPROXIMATION. THE PAIRS OF TENTATIVE VOLUMES OBTAINED BY THIS DISTRIBUTION ARE AVERAGED AS BEFORE, AND THE PROCESS REPEATED UNTIL THE DESIRED CONFORMITY IS OBTAINED."

ADVANTAGES AND DISADVANTAGES

THE MAIN ADVANTAGE OF THIS METHOD IS ITS FLEXIBILITY IN ATTEMPTING TO DETERMINE THE GROWTH RATES OF THE ZONAL TRIPS. EACH AREA IS ASSESSED INDIVIDUALLY AND A SOCIO-ECONOMIC GROWTH RATE SIMILAR (BUT MORE INVOLVED) TO K(T) IN THE GRAVITY MODEL IS OBTAINED. THIS FACTOR INFLUENCES THE NUMBER OF EXPECTED TRIPS IN AND OUT OF A SPECIFIC ZONE. USE OF THIS METHOD ALLOWS MAXIMUM LEEWAY IN ASSIGNING CERTAIN ACTIVITY PRIORITIES WITHIN GIVEN AREAS. THEREFORE THE ASSIGNMENT OF ACTIVITIES MUST REFLECT THE GENERAL TRENDS IN URBAN STRUCTURE. IF THE TREND FOR INDUSTRY IS DECENTRALIZATION AND THE MAJORITY OF WORKERS' RESIDENCES REMAIN OUTSIDE THE CENTRAL URBAN AREA, THEN IT CAN BE ASSUMED THAT THE INDUSTRIAL WORK TRIPS FROM THE SUBURBS TO THE CENTRAL CITY WILL DECREASE IN THE FUTURE AND INTERZONAL TRIPS IN THE SUBURBS WILL INCREASE.

THERE ARE TWO MAJOR DISADVANTAGES TO THIS METHOD. IT IS DIFFICULT TO DETERMINE ACCURATELY THE RATES OF GROWTH WITHIN EACH ZONE AND TO EXPRESS THIS GROWTH IN TERMS OF INTERZONAL TRIPS. CHAPTER II INDICATED THAT INDUSTRIAL (AS WELL AS RESIDENTIAL) LOCATION IS DEPEN-

DENT ON A MULTIPLICITY OF INTERRELATED VARIABLES, EACH CHANGING IN INFLUENCE OVER TIME AND SPACE. FOR EXAMPLE: MOVING OUT FURTHER FROM THE CENTRAL AREA, INDUSTRY'S DEMAND FOR STILL LESS EXPENSIVE LAND IS NEUTRALIZED BY COUNTER VARIABLES SUCH AS DISTANCE FROM A CENTRAL MARKET PLACE ETC. ALL THESE ASPECTS MUST BE CONSIDERED IF THE GROWTH FACTOR IS TO HAVE ANY MEANING. ALSO THIS METHOD DOES NOT ACCOUNT FOR DISTANCE OR TRAVEL TIME. IT SEEMS REASONABLE TO ASSUME THAT TRIPS WILL DISTRIBUTE THEMSELVES BY PURPOSE IN ORDER TO LESSEN TRAVEL IMPEDANCE.

THE VALUE OF THE FRATAR METHOD FOR THE PURPOSE OF THIS STUDY, IS NOT SO MUCH BASED ON ITS ABILITY TO DISTRIBUTE FUTURE TRIPS BUT RATHER FOR ITS CAPACITY TO BE INTEGRATED WITH SOME OTHER MODEL FOR THE PURPOSE OF ADJUSTMENT.[1]

D) THE OPPORTUNITY MODELS[2]

BASED ON THE THEORY OF PROBABILITY THERE ARE TWO BASIC "OPPORTUNITY" METHODS WHICH ARE DISCUSSED HERE. 1) THE INTERVENING OPPORTUNITY MODEL (HENCEFORTH ALSO CALLED THE C.A.T.S. METHOD) AND 2) THE COMPETING OPPORTUNITY MODEL (ALSO CALLED THE TOMAZINIS METHOD).

THE CONCEPT OF INTERVENING OPPORTUNITIES

ALTHOUGH THE INTERVENING OPPORTUNITY MODEL RECEIVED ITS GREATEST RECOGNITION IN THE CHICAGO AREA TRANSPORTATION STUDY (C.A.T.S.),

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[1]THE TOMAZINIS METHOD DISCUSSED LATER USES SUCCESSIVE APPROXIMATIONS IN THIS WAY.

[2]THE OPPORTUNITY MODEL, LIKE THE GRAVITY MODEL PRESENTED EARLIER DOES HAVE A PHYSICAL ANALOGY. THE PHYSICAL LAW CONCERNS THE PRINCIPLES GOVERNING THE DISTRIBUTION OF LENGTHS OF PATHS OF MOLECULES IN A GAS. CLARK, OP. CIT., PP. 105-106.

IT OWES ITS EARLIEST SOCIO-SCIENTIFIC ORIGIN TO STOUFFLER'S WORK IN POPULATION MIGRATION.[1] IN AN ATTEMPT TO REPUDIATE, IN PART, THE BASIC IDEA BEHIND THE GRAVITY METHOD, STOUFFER SUGGESTED THAT THERE WAS NO NECESSARY RELATIONSHIP BETWEEN DISTANCE AND MOBILITY BUT THAT "THE NUMBER OF PERSONS GOING A GIVEN DISTANCE WAS A DIRECT PROPORTION OF THE NUMBER OF OPPORTUNITIES AT THAT DISTANCE AND INVERSELY PROPORTIONAL TO THE NUMBER OF INTERVENING OR COMPETING OPPORTUNITIES."[2]

THE C.A.T.S. METHOD USES THE PREMISE THAT TRIP PATTERNS ARE NOT ACCIDENTAL BUT RATHER FORM AN ORDERLY PREDICTABLE PATTERN. THIS PATTERN IS AFFECTED BY TWO CONTRAVENING FORCES, A REPELLING FORCE CAUSING AN INCREASE IN TRIP LENGTHS AND AN ATTRACTION FORCE CAUSING A DECREASE IN TRIP LENGTHS. THE FORMER IS BASED ON THE LURE OF PARTICULAR REWARDS SUCH AS TASTE, WHILE THE LATTER DEPENDS ON THE "NATURAL AND UNIVERSAL" TENDENCY TO ECONOMIZE (E.G. THE OPTIMIZATION OF THE ALONSO FUNCTION).[3] THE ACTUAL DISTRIBUTION REPRESENTS A BALANCE OR POINT OF EQUILIBRIUM BETWEEN THE TWO FORCES AT A POINT IN TIME, FOR A GIVEN PATTERN OF URBAN ACTIVITIES AND LAND USES.

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[1] SAMUEL A. STOUFFER, "INTERVENING OPPORTUNITIES: A THEORY RELATING MOBILITY AND DISTANCE" AMERICAN SOCIOLOGICAL REVIEW, VOL. 5 NO. 6, (DECEMBER, 1940), PP. 845-857.

[2] THE FORMULA IS:

$$\frac{\Delta Y}{\Delta S} = A \, X \, \frac{\Delta X}{\Delta S}$$

WHERE ΔY = THE NUMBER OF PERSONS MOVING FROM ORIGIN TO A CIRCULAR BAND OF WIDTH ΔS. X = THE NUMBER OF OPPORTUNITIES BETWEEN ORIGIN A DESTINATION S X = THE NUMBER OF OPPORTUNITIES WITHIN THE BAND OF WIDTH ΔS AND A = A CONSTANT.

[3] CHICAGO AREA TRANSPORTATION STUDY FINAL REPORT. VOL. II (JULY, 1960), P. 81.

THE CHICAGO STUDY ATTEMPTED TO QUANTIFY THE RESULTING PATTERN OF THE TWO COMPETING TENDENCIES BASED ON THE ASSUMPTION THAT,

> ". . . IN MAKING A TRIP, THE TRAVELLER WILL SEEK TO KEEP IT AS SHORT AS POSSIBLE. HOWEVER, THE TRIP HAS A REASON FOR BEING MADE THAT IS PECULIAR TO THE PARTICULAR TRAVELLER. THIS MAY BE STATED AS A REQUIREMENT OF THE TRAVELLER FOR WHICH A SATISFACTION IS SOUGHT. THE MORE SELECTIVE THIS REQUIREMENT THE LONGER THE JOURNEY IS LIKELY TO BE."[1]

ELABORATING ON THIS EFFECT OF JOURNEY LENGTH SCHNEIDER STATED:

> ". . . THE EFFECT OF DISTANCE MIGHT BE EXPECTED TO MATTER VERY CONSIDERABLY IN DETERMINING TRAVEL PATTERNS. THE IMPORTANT POINT WHICH EMERGES TO THE [C.A.T.S.] STUDY, HOWEVER, IS THAT THIS IS NOT THE CASE. DISTANCE DOES NOT HAVE ITS EXPECTED EFFECTS AT ANY RATE UNTIL IT BECOMES LARGE , AND THE SLOPES OF THE OPPORTUNITY CURVES, IN GENERAL, HAVE A REMARKABLE CONSTANCY. IT IS OPPORTUNITIES, AS SUCH, RATHER THAN DISTANCE, WHICH PROVIDE THE CONTROLLING INFLUENCE."[2]

THE METHOD FOR INTERVENING OPPORTUNITIES

TO ILLUSTRATE THE METHOD, THE C.A.T.S. STUDY PROVIDES AN ANALOGY OF A TRIP MADE TO BUY A CARTON OF MILK. MILK AS A COMMODITY HAS A LOW SELECTIVITY SINCE IT IS FOUND VIRTUALLY EVERYWHERE. IT CAN BE ESTABLISHED BY SURVEY THAT OF Y DESTINATIONS X ARE PLACES SELLING MILK E.G. ONE OUT OF ONE HUNDRED OR 1/100. THE TRAVELLER THEN HAS A 1/100 CHANCE THAT THE NEAREST DESTINATION WILL BE A MILK STORE. IF HE WISHES A PARTICULAR BRAND, SOLD AT ONLY HALF OF THE MILK STORES, THEN HIS CHANCES OF A SUCCESSFUL NEAREST PICK IS 1/200. THE CHANCE

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[1] IBID., P. 81.

[2] MORTON SCHNEIDER, WAS A MEMBER OF THE C.A.T.S. SURVEY STAFF AND WAS THE CHIEF DEVELOPER OF THE INTERVENING OPPORTUNITIES METHOD. IBID., PP. 81-92.

THAT THE NEXT NEAREST DESTINATION WILL BE SUITABLE IS AGAIN 1/200. HOWEVER, NOW THERE IS ALSO THE CHANCE THAT THE NEAREST DESTINATION WAS SUITABLE, HENCE THE TRAVELLER WOULD NEVER HAVE REACHED THE SECOND POINT. THEREFORE THE CHANCE OF STOPPING AT THE SECOND DESTINATION WOULD BE THE CHANCE OF GETTING THERE (1-1/200) MULTIPLIED BY THE CHANCE OF STOPPING THERE 1/200, OR $1/200^{X}$ (1-1/200). FOR THE THIRD STATION THE PROBABILITY BECOMES

$$1/200 \quad ^{X} \quad (1-1/200)^{2}$$

IN GENERALIZING THE FORMULA, THE PROBABILITY OF A TRIP STOPPING AT A GIVEN POINT DEPENDS NOT ONLY ON THE SELECTIVITY OF THE TRIP (TERMED L) BUT ALSO UPON OTHER POINTS (V)LOCATED CLOSER THAN THIS GIVEN POINT TO THE ORIGIN. SO THAT THE CHANCE OF STOPPING AT A PARTICULAR DESTINATION IS EQUAL TO THE PROBABILITY OF GETTING TO IT, $(1-L)^{V}$ MULTIPLIED BY THE PROBABILITY OF STOPPING THERE, L.

THEREFORE,

3G) $$P = L\ (1-L)^{V}$$

ZONES OR CLUSTERS OF DESTINATIONS ARE FORMED BY ASSUMING THAT ALL DESTINATIONS AT ANY ZONE ARE AT A COMMON POINT - THE ZONE CENTER. THUS, FORMULA BECOMES

3H) $$P = (1-L)^{V} - (1-L)^{V + V_J}$$

WHERE $(1-L)^{V + V_J}$ = THE PROBABILITY OF STOPPING AT ANY DESTINATION CLOSER AND INCLUDING ZONE J.

$(1-L)^{V}$ EXCLUDES ZONE J

P = PROBABILITY OF DESTINATION IN ZONE J.

FINDINGS FROM THE CHICAGO STUDY DISPROVED THE ORIGINAL HYPOTHESIS THAT THE L VALUE WAS UNIFORM BASED ON TRIP PURPOSE. AN ADJUSTMENT

WAS REQUIRED TO VARY L WITH LENGTH OF JOURNEY AS WELL AS TRIP PURPOSE. THE FINAL RESULTING FORMULA IS,

$$31) \qquad P_{IJ} = \sum_{LMIN}^{LMAX} (1-L)^{V} - (1-L)^{V + V_J} \quad [1]$$

THE ORDERING OF V VALUES MAY BE ACCOMPLISHED BY EMPLOYING ANY OF THE THREE VARIABLES: DISTANCE, TRAVEL TIME OR COST. DISTANCE IS INACCURATE ESPECIALLY IN AN URBAN SYSTEM WHERE CONGESTION IS A PROBLEM. TIME DOES NOT INCLUDE BARRIERS SUCH AS TOLL BRIDGES.[2] TRAVEL COSTS ARE PROBABLY THE MOST INDICATIVE MEASURE OF IMPEDANCE, BUT THEY ARE VERY DIFFICULT TO MEASURE HENCE THE COMPROMISED USE OF "TIME" IN THE CHICAGO STUDY.

BASED ON TRAVEL TIMES, THE ORDERING OF ZONES WITH RESPECT TO THEIR PROXIMITY TO A SELECTED ZONE OF ORIGIN WAS OBTAINED BY COMPUTER ASSIGNMENT. THE COMPUTER, BY SEARCHING OUTWARD FROM ANY ORIGIN POINT COULD FIND THE PATH WITH THE SHORTEST ELAPSED TIME FROM THAT ZONE TO EVERY OTHER ZONE.[3]

THE CONCEPT OF COMPETING OPPORTUNITIES[4]

CONCEPTUALLY THIS METHOD IS VERY SIMILAR TO THE INTERVENING

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[1] A DETAILED DISCUSSION OF THE NATURE OF THE L VALUE IS FOUND IN C.A.T.S. OP. CIT., PP. 82-92.

[2] THIS POINT MIGHT NOT SEEM SIGNIFICANT IN A CITY SUCH AS WINNIPEG, BUT IN LARGER AMERICAN CITIES EG. LOS ANGELES, TOLL BRIDGES AND TOLL ROADS FORM A NOTICEABLE PERCENTAGE OF THE OVERALL TRANSPORTATION SYSTEM.

[3] A GENERAL SUMMARY OF THE METHOD USED FOR THIS PROCESS MAY BE FOUND IN APPENDIX A.

[4] ANTHONY TOMAZINIS, "A NEW METHOD OF TRIP DISTRIBUTION IN AN URBAN AREA," HIGHWAY RESEARCH BOARD, BULLETIN 347, JANUARY, 1962, PP.77-99.

OPPORTUNITIES MODEL. WHILE THE C.A.T.S. APPROACH WAS BASED ON "INTERVENING OPPORTUNITIES", THE TOMAZINIS APPROACH IS BASED ON "COMPETING OPPORTUNITIES". THE LATTER INVOLVES THE DIRECT APPLICATION OF PROBABILITY THEORY IN CONJUNCTION WITH ASPECTS OF THE GRAVITY MODEL AND FRATAR'S TECHNIQUE OF SUCCESSIVE APPROXIMATIONS.[1]

AS TOMAZINIS STATES, THIS METHOD ATTEMPTS TO EXTRACT THE BASIC DEFICIENCIES "WHICH OBLIGE RESEARCHERS TO EITHER IMPOSE EXTENSIVE PERSONAL SUBJECTIVE JUDGEMENT, OR TO EXPAND TRENDS AND RELATIONSHIPS THAT THEY KNOW WELL NOT NECESSARILY HOLD TRUE FOR THE FUTURE."[2] (EG. THE K-FACTOR IN THE GRAVITY MODEL OR THE L-FACTOR IN THE C.A.T.S. MODEL.)

THE METHOD FOR COMPETING OPPORTUNITIES

THE PROCEDURE FOR THIS MODEL IS BASED ON THE GENERAL FORMULA.[3]

3J) $T_{IJ} = T_{I(G)} \times P_J$

WHERE T_{IJ} = NUMBER OF ONE WAY TRIPS FROM ZONE I TO J

$T_{IJ(G)}$ = TOTAL NUMBER OF TRIPS ORIGINATING IN I

P_J = ADJUSTED PROBABILITY OF STOPPING AT DISTANCE J.

THE PURPOSE OF THE PROCEDURE IS TO OBTAIN A FORMULA TO DESCRIBE P_J.

FIGURE 2 SHOWS SCHEMATICALLY AN URBAN AREA HAVING A POPULATION N. THE QUESTION IS: HOW MANY TRIPS ORIGINATING AT O WILL HAVE DISTRICT S AS A DESTINATION POINT, GIVEN THAT S IS LOCATED AT TIME DISTANCE T FROM THIS ORIGIN? THE TERMS S, H AND N ARE ALL ATTRACTION

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[1] IBID., P. 77.

[2] SINCE THE PROPOSED MODEL OF CHAPTER IV IS BASED ESSENTIALLY ON THE TOMAZINIS METHOD THE VALIDITY OF THIS CLAIM IS CONSIDERED A MAJOR ASPECT OF INVESTIGATION IN THIS STUDY.

[3] BRUTON, OP. CIT., P. 117.

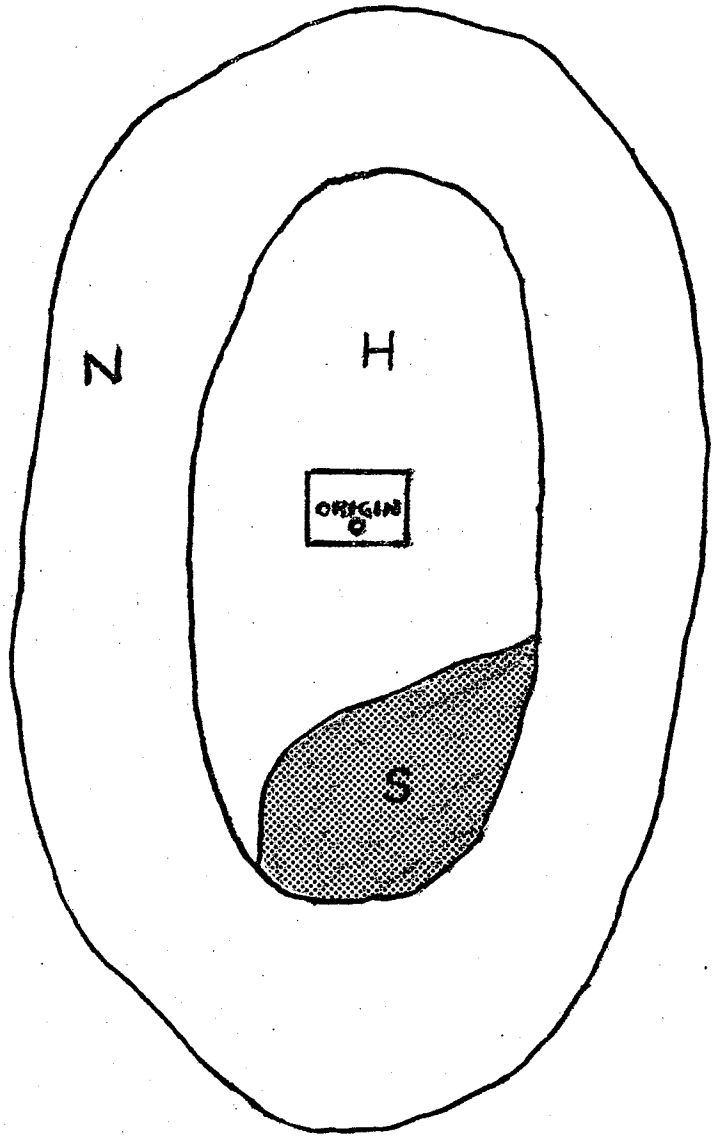

FIGURE 2. Schematic diagram of the urban area for the Tomazinis Method.

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(OR OPPORTUNITY)[1] FIGURES. S IS THE TOTAL NUMBER OF OPPORTUNITIES IN THE DISTRICT; H IS THE TOTAL NUMBER OF OPPORTUNITIES LOCATED WITHIN THE GIVEN TIME ISOLINE (INCLUDES S) AND FINALLY N IS TOTAL NUMBER OF OPPORTUNITIES IN THE URBAN AREA. IF THE DISTRIBUTION OF TRIPS FROM ORIGIN POINT (O) IS FOR WORK, THEN THE OPPORTUNITIES S, H AND N MAY BE JOB OPPORTUNITIES. S IS THE NUMBER OF JOBS IN THE DISTRICT BEING CONSIDERED AND H IS THE COMPETING JOB OPPORTUNITIES WITHIN THE SAME TIME LIMIT FROM O. THE ASSUMPTION IS MADE THAT JOBS IN DISTRICT S WILL ONLY COMPETE WITH OTHER JOBS WITHIN THE SAME TIME INTERVAL OF THE ORIGIN O.

BY APPLYING CONDITIONAL PROBABILITIES IT IS POSSIBLE TO DETERMINE THE CHANCE THAT A COMMUTING WORKER AT O WILL CHOOSE A JOB FROM JOB POPULATION S, IF IT IS GIVEN THAT JOB OPPORTUNITIES ARE RESTRICTED TO THE H JOB SUB-POPULATION. CONSIDERING ALL TRIP PURPOSES COLLECTIVELY, THE PROBABILITY THAT A TRIP IS ATTRACTED BY OPPORTUNITIES IN DISTRICT H BECOMES

$$P(H) = H/N$$

ALSO $$P(S) = S/N$$

SINCE S IS A SUBSET OF H, THE PROBABILITY THAT BOTH S AND H ARE PICKED IS THE SAME AS IF S WERE PICKED. THEREFORE,

$$P(SH) = \frac{S}{H} \quad \text{WHERE } S \cap H$$

ALSO $$P(S/H) = \frac{P(SH)}{P(H)} = \frac{S/N}{H/N} = \frac{S}{H}$$

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[1] THE TERM "OPPORTUNITY" AS USED HERE MEANS THE CHANCE THAT A TRIP WILL BE ATTRACTED BY A GIVEN AREA. THIS CHANCE IS DIRECTLY RELATED TO THE NUMBER OF ATTRACTION SITES IN A GIVEN DISTRICT.

SINCE THE TOTAL TRIPS DISTRIBUTED SHOULD EQUAL THE TRIPS AVAILABLE IN THE DISTRICT OF ORIGIN THE SUMMATION OF THE PROBABILITIES OF EACH DISTRICT WITHIN THE AREA, SHOULD BE UNITY.

$$P_J = 1$$

WHERE $J = 1, 2, 3 \ldots$ (ALL THE DISTRICTS INTO WHICH TRIPS ARE DISTRIBUTED)

TO OBTAIN $P_J = 1$ THE CONDITIONAL PROBABILITY IN DISTRICT J IS DIVIDED BY ALL CONDITIONAL PROBABILITIES.

3K) $$P_I{}^1 = \frac{P_I\,(S/H)}{\sum_1 P_I\,(S/H)}{}^1$$

ADVANTAGES AND DISADVANTAGES OF THE OPPORTUNITY MODELS

ACCORDING TO BRUTON, THE OPPORTUNITY METHODS OF TRIP DISTRIBUTION ENJOY CERTAIN ADVANTAGES.[2]

1) THEY ARE BASED ON A LOGICAL CONCEPT IE. TRIPS LENGTHEN ONLY BECAUSE THEY FAIL TO FIND ACCEPTABLE DESTINATIONS CLOSER TO THEIR ORIGIN. THIS REASONING CAN FLEXIBLY EMBRACE A COMPLEXITY OF LOCATION VARIABLES, NOT RELATED TO DISTANCE.

2) THE FORMULAS ARE COMPUTATIONALLY CONVENIENT AND WELL BEHAVED MATHEMATICALLY, EMPLOYING AS THEY DO PROBABILITY THEORY BASED ON LOGICAL ASSUMPTIONS.

3) THERE IS THE POSSIBILITY THAT ONCE THESE MODELS HAVE BEEN SHOWN TO BE RELIABLE FOLLOWING THE CALIBRATION OF THEIR PARAMETERS, THE FUTURE NEED FOR COMPREHENSIVE, COSTLY ORIGIN-DESTINATION SURVEYS WILL BE ELIMINATED.[3]

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[1] THIS METHOD IS NOT ELABORATED UPON, SINCE MANY OF THE ASPECTS OF THE TECHNIQUE ARE REFERRED TO IN THE NEXT PART DEALING WITH THE PROPOSED MODEL. FOR DETAILED INFORMATION THE READER MAY REFER TO TOMAZINIS, OP. CIT., PP. 77-99.

[2] BRUTON, OP. CIT., PP. 124-125.

[3] ESSENTIALLY THIS IS THE PRIME GOAL OF ALL TRIP DISTRIBUTION MODELS. THERE ARE THOSE WHO BELIEVE, THAT GIVEN THE COMPLEXITY OF LOCATION VARIABLES (SOME OF WHICH WERE PRESENTED IN CHAPTER II), THAT THIS GOAL IS UTOPIAN. REFER TO HANS BLUMENFELD. "ARE LAND USE PATTERNS PREDICTABLE?" JOURNAL OF THE AMERICAN INSTITUTE OF PLANNERS, VOL. XV NO. 2 (MAY, 1959), PP. 61-66.

THE INHERENT DISADVANTAGES ASSOCIATED WITH OPPORTUNITY TECHNIQUES ARE APPLICABLE TO ALL THREE MAJOR MODELS DISCUSSED IN THIS CHAPTER.[1] THEY ARE, NEVERTHELESS, DISADVANTAGES.

1) THE METHODS HAVE LOST THEIR SIMPLICITY AND THE COMPLEXITIES OF THESE NEW METHODS HAVE NECESSITATED EXPERIENCED STAFF AND LARGE COMPUTER FACILITIES. THIS ISSUE IS BASICALLY OPERATIONAL.

2) AN ITERATIVE PROCESS IS NECESSARY TO ENSURE THAT THE NUMBER OF TRIPS ARRIVING AT A PARTICULAR DESTINATION ZONE REFLECTS THE NUMBER OF TRIPS ESTABLISHED AT THE ORIGIN.

3) THE MOST SERIOUS OF THE DISADVANTAGES IS THAT, THE METHOD CAN ACCOUNT ONLY FOR A RELATIVE CHANGE IN DISTANCE-TIME RELATIONSHIP BETWEEN ALL ZONES IN THE STUDY AREA. AS A RESULT, A MAJOR CHANGE IN LAND USE OR IN THE TRANSPORTATION SYSTEM WOULD MAKE FORECASTING INACCURATE.

4) THE INTERVENING OPPORTUNITY METHOD HAS THE ADDED DISADVANTAGE OF QUANTIFYING THE SELECTIVITY FACTOR L FOR GENERAL TRIP DISTRIBUTION.

5) THE QUESTION AS TO WHETHER COMPETITION IS LIMITED EXCLUSIVELY BY TIME FACTOR PREFERENCES REMAINS AN UNCERTAINTY OF THE TOMAZINIS METHOD.

THE MODEL THEORY DESCRIBED IN THIS CHAPTER MUST BE EVALUATED IN THE LIGHT OF THE THEORETICAL INFORMATION BASE OF CHAPTER II. THE TWO LEVELS OF ACTIVITY SHOULD BE SEEN AS INTERRELATED IN AN EFFORT TO ARRIVE AT A SUITABLE HYPOTHESIS TO SOLVE THE PROBLEM IN THIS STUDY. THE INTERRELATING OF THE ACCUMULATED INFORMATION, WITHIN THE FRAMEWORK OF THE PROPOSED MODEL THEORY AND ITS ASSUMPTIONS, FORMS THE BASIS OF THE NEXT SECTION, AND THE FIRST STAGE OF MODEL FORMULATION.

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[1] REASONS 1-3 ARE TAKEN FROM BRUTON, OP. CIT., P. 125.

CHAPTER IV

THE PROPOSED MODEL

A) Restatement of Purpose

The models that were discussed in Chapter III dealt with general purpose trip distribution, (usually home based) in the overall urban area. The model derived here, reverses the frame of reference, in that it seeks to <u>collect</u> trips rather than to distribute them. Instead of having numerous destination points, only one point is considered, to receive work trips from numerous points of origin.

The preceding two chapters have deviated slightly from the frame of reference established for this study. This deviation was thought necessary however, in order to obtain an extensive information base for the theory that follows. To re-orient the reader a restatement of the study's purpose (briefly mentioned in the Introduction) is in order. The purpose of the study, then, is to establish a reliable method for predicting the effect which a proposed industrial site would have on the residential distribution patterns of its workers in terms of occupational types, ie. managers, clerks, and labourers.

B) Assumptions and Theory

Urban growth rate

Figure 3 shows a hypothetical urban area, whose boundaries

DEFINE THE LIMITS OF A "CLOSED SYSTEM". ESSENTIALLY, THERE IS NEITHER INPUT NOR OUTPUT OF WORKERS ACROSS THIS BOUNDARY. ALL WORK TRIPS ARE ASSUMED TO BE UNDERGOING A NORMAL (PREDICTABLE) RATE OF GROWTH WITH RESPECT TO LABOUR FORCE AND INDUSTRIAL ACTIVITY. THERE IS NO UNEXPECTED SUDDEN INCREASE OR DECREASE IN SPECIFIC OCCUPATIONAL TYPES. ALTHOUGH THE ASSUMPTION OF A NORMAL GROWTH RATE IS QUITE VALID FOR AN ESTABLISHED URBAN CENTER (WITH DIVERSITY IN LABOUR AND INDUSTRY) A SIMILAR ASSUMPTION FOR THE INTERNAL RESIDENTIAL DISTRICTS COULD INTRODUCE ERROR. UNLESS DEVELOPED RESIDENTIAL AREAS IN THE INNER CITY ARE IN A STATE OF DETERIORATION[1] AND SUBJECT TO RENEWAL, THEY ARE UNLIKELY TO SEE HIGH GAINS OR LOSSES IN SPECIFIC TYPES OF WORKER-RESIDENTS. THE SAME CANNOT BE SAID OF THE SUBURBS.[2] NEVERTHELESS, GIVEN A TEN-

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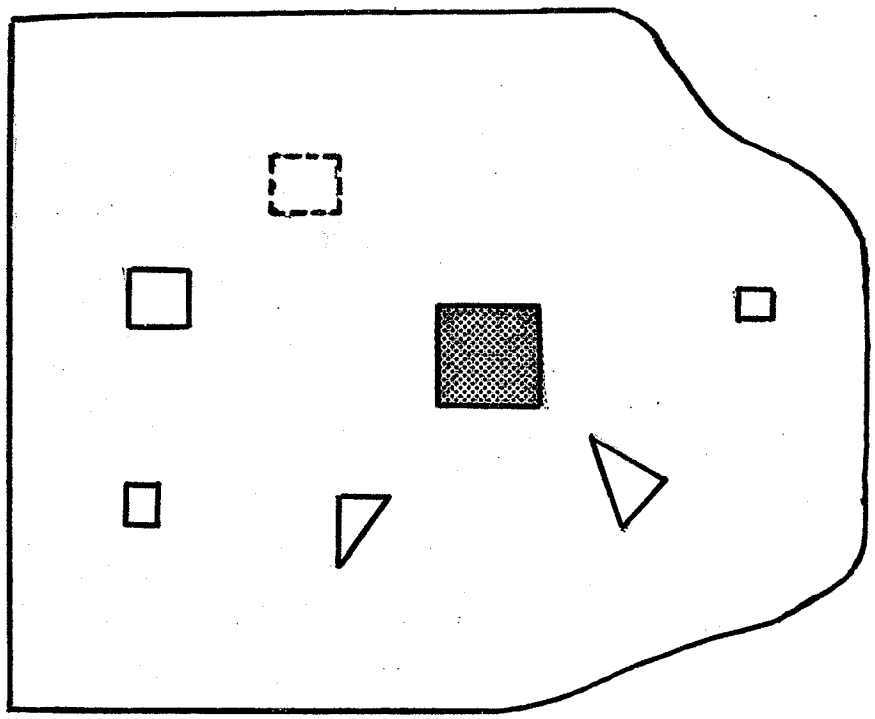
[1]DETERIORATION IN RESIDENTIAL AREAS MAY INDUCE ACCELERATED CHANGE OF DISTRICT CHARACTER. AN EXAMPLE OF THIS SITUATION MAY BE NORTH POINT DOUGLAS IN THE CITY OF WINNIPEG. REFER TO: WINNIPEG HOUSING AND URBAN RENEWAL DEPARTMENT, "NEIGHBOURHOOD IMPROVEMENT; NORTH POINT DOUGLAS," UNPUBLISHED REPORT, WINNIPEG, 1968. FOR A PERIOD OF TEN YEARS, THE LENGTH OF TIME USED IN THIS STUDY, A NEGLIGIBLE RATE OF CHANGE IN NON-DETERIORATING AREAS MAY BE ASSUMED.

[2]ALTHOUGH WINNIPEG, THE CITY IN THE CASE STUDY, HAS EXPERIENCED LITTLE OVERALL GROWTH IN THE LAST TEN YEARS, VARIOUS INTERNAL RESIDENTIAL DISTRICTS HAVE UNDERGONE CONSIDERABLE CHANGE OVER THIS TIME PERIOD. SINCE THE STUDY MODEL USES 1961 BASE YEAR DATA TO PREDICT WORKER RESIDENTIAL PATTERNS IN THE PROJECTION YEAR 1971, GROWTH FACTORS ARE REQUIRED TO ACCOUNT FOR CHANGES IN DISTRICT OCCUPATIONAL RESIDENTIAL CHARACTER. ANY ATTEMPT TO PREDICT THIS CHANGE BY USING 1951-61 CENSUS DATA, WOULD BE INACCURATE SINCE A SIGNIFICANT PERCENTAGE OF SUBURBAN DEVELOPMENT HAS TAKEN PLACE IN THIS LAST DECADE (1961-71). MAP VII, IN APPENDIX E, SHOWS THE TOTAL POPULATION GROWTH RATE FOR YEAR 1961-66 FOR VARIOUS AREAS OF THE CITY, BUT OCCUPATIONAL TYPES ARE NOT SPECIFIED. INSUFFICIENT DATA AND NOT A MODEL LIMITATION MAKES REFINEMENT IMPOSSIBLE AT THIS STAGE.



LEGEND

Existing Industrial Districts

Central Industrial District

Proposed Industrial District

Urban Boundary

FIGURE 3. A hypothetical urban area showing a system of work places.

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YEAR OBSERVATION PERIOD GROWTH RATES IN ALL INTERNAL DISTRICTS ARE ASSUMED NEGLIBIBLE FOR THE PURPOSE OF THIS STUDY.

THE CENTRAL INDUSTRIAL DISTRICT (SHADED) SHOWN IN FIGURE 3 IS SURROUNDED BY SMALLER DISTRICTS OF SUBURBAN INDUSTRIAL DEVELOPMENT CALLED INDUSTRIAL PARKS. THESE PARKS ARE SITUATED AT VARIOUS DISTANCES FROM EACH OTHER AND FROM THE CENTRAL AREA. LARGE TRACTS OF LAND, INTERSPERSED BETWEEN THE WORK AREAS, ARE DEVOTED TO VARIOUS TYPES OF RESIDENTIAL DEVELOPMENT. THE QUALITY AND VALUE OF RESIDENTIAL PROPERTY CAN BE ASSUMED TO FOLLOW THE CRITERIA ESTABLISHED IN CHAPTER II. THE OCCUPATIONAL MAKEUP OF THE RESIDENTIAL DISTRICTS FOLLOW THE PATTERN ESTABLISHED BY THE VALUE AND QUALITY OF PROPERTY AND IS BASED ON SOCIO-ECONOMIC CONSIDERATIONS.[1]

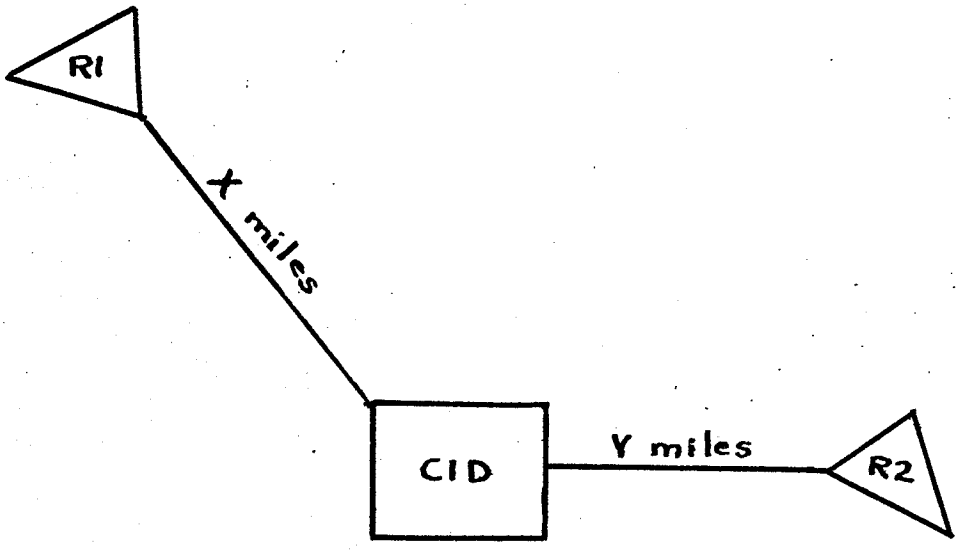
THE ISOLATED STATIC SITUATION

A SIMPLIFIED, ISOLATED SUBSYSTEM FROM THE URBAN SYSTEM SHOWN IN FIGURE 3 IS EXTRACTED. FIGURE 4 INDICATES TWO RESIDENTIAL DISTRICTS R1 AND R2, LOCATED AT DISTANCE X AND Y MILES RESPECTIVELY FROM THE NEAREST ASSUMED JOB SOURCE, THE CENTRAL INDUSTRIAL DISTRICT. (CID,) AN EXAMINATION OF THE OCCUPATIONAL BREAKDOWN OF DISTRICTS R1 AND R2 SHOWS THAT R1 IS OF CONSIDERABLY HIGHER RESIDENTIAL QUALITY THAN R2. OCCUPATIONAL FIGURES FOR R1 AND R2 ARE:

TABLE I

OCCUPATION	R1	R2
MANAGERIAL	1,500	500
CLERICAL	1,000	1,200
LABOUR	500	1,900
TOTAL	3,000	3,600

[1] SUPRA, P. 22-29.



LEGEND

R1, R2	Residential Origin District
CID	Central Industrial District

FIGURE 4. Isolated urban subsystem indicating static condition.

INKSTER INDUSTRIAL PARK CASE STUDY

F. F. Saccomanno May 1972

THE CID HAS A TOTAL JOB SOURCE OF 4,400, COMPOSED OF 1,200 MANAGERIAL JOBS, 1,500 CLERICAL JOBS AND 1,700 LABOUR JOBS. THE CENTRAL AREA HAS NO WORKERS LIVING WITHIN ITS BORDERS AND, SINCE THE SUBSYSTEM IS ISOLATED, ONLY THE 6,600 WORKERS IN R1 AND R2 COMPETE FOR THESE 4,400 JOBS. IT IS FURTHER ASSUMED THAT INDIVIDUALS WITHIN SPECIFIC OCCUPATIONAL TYPES HAVE SIMILAR ABILITY AND FURTHER THAT THE JOBS (WITHIN OCCUPATIONAL TYPE) REQUIRE THE SAME INDIVIDUAL ABILITY AND OFFER THE SAME REWARDS.[1] THUS ALL MANAGERIAL, CLERICAL AND LABOUR JOBS IN THE CENTRAL DISTRICT ARE AT THE DISPOSAL AND WITHIN THE CAPACITY OF ALL MANAGERS, CLERKS AND LABOURERS IN DISTRICTS R1 AND R2.

IF THE DISTANCES X AND Y ARE EQUAL, IT CAN BE REASONED THAT THE DESIRE TO WORK IN THE CID IS CORRESPONDINGLY EQUAL FOR OCCUPATIONAL GROUPS IN R1 AND R2. SINCE THE CENTRAL DISTRICT IS THE CLOSEST JOB SOURCE THE 2,000 MANAGERS IN R1 AND R2 WILL BE EQUALLY COMPETING FOR THE 1,200 VACANT JOBS. AFTER THE SITUATION HAS STABILIZED AND ALL THE JOBS ARE FILLED, THE LOCATION OF MANAGERS, CLERKS AND LABOURERS IN THE CID, IS A QUESTION OF SIMPLE PROBABILITY BASED, NOT ON DISTANCE, (SINCE X=Y) BUT BASED ON POPULATION NUMBERS. PICKING ONE MANAGER AT RANDOM FROM THE WORK AREA THERE IS A 75% CHANCE THAT THIS INDIVIDUAL ORIGINATES IN R1, $\left[\frac{1500}{2000} = \frac{3}{4}\right]$ AND A CORRESPONDING 25% CHANCE HE ORIGINATES IN R2, $\left[\frac{500}{2000} = \frac{1}{4}\right]$.

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[1] THIS ASSUMPTION IS A NECESSARY STEP IN ASSEMBLING INDIVIDUAL CHARACTERISTICS OF JOBS AND WORKERS INTO GROUP IDENTITIES. THESE GROUPS CAN BE STUDIED, AS STATISTICAL INDIVIDUALS ASSUMING "ALL THINGS BEING EQUAL."

MULTIPLYING THESE PROBABILITY FACTORS BY THE NUMBER OF JOBS, THE LIKELY COLLECTION OF WORK TRIPS FROM R1 AND R2 ARE OBTAINED.

TABLE II

OCCUPATION	R1	R2	TOTAL
MANAGERIAL	900	300	1,200
CLERICAL	683	817	1,500
LABOUR	354	1,346	1,700
	1,937	2,463	4,400

THE WORKERS IN DISTRICTS R1 AND R2 WHO REMAIN UNEMPLOYED (1,063 AND 1,137 RESPECTIVELY) WILL SEEK JOBS IN THE SECOND NEAREST JOB SOURCE.

HOW DOES A DISTANCE DIFFERENTIAL AFFECT THE RESULTS? ASSUME $X > Y$, ALL OTHER FIGURES REMAINING THE SAME. RECALLING THE ALONSO FORMULA FROM CHAPTER II,[1] TRAVEL COSTS $K(T)$ WERE ACKNOWLEDGED TO HAVE SIGNIFICANT EFFECT ON LOCATION. PATTERNS OF TRAVEL IN THE CITY WERE AFFECTED BY AND IN TURN AFFECT THE CITY'S STRUCTURAL CHARACTERISTICS[2]. IN THE SECTION DEALING SPECIFICALLY WITH WORK TRIPS PROPENSITY TO TRAVEL WAS ALSO MENTIONED AS AFFECTING RESIDENTIAL-WORK PLACE LOCATION. THE MODELS DISCUSSED IN CHAPTER III CONSIDERED TRAVEL DISTANCE A DEPRESSANT TO JOB OR RESIDENTIAL DESIRABILITY. ASSUMING STATIC RESIDENTIAL CONDITIONS, THE DESIRE TO FIND A JOB IN THE CENTRAL DISTRICT IS MUCH GREATER FOR RESIDENTS OF R2 THAN R1 GIVEN THAT $X > Y$.

IF JOB DESIRABILITY COULD BE EXPRESSED IN TERMS OF A FACTOR D WHERE $D = F(X \cdot Y)$ THEN THE FACT THAT $X > Y$ WOULD MEAN THAT $D_{R2} > D_{R1}$. DESIRABILITY HERE IS A MEASURE OF MARGINAL ADVANTAGE IN COST, CONVENIENCE AND TIME GAINED BY PROXIMITY TO WORK. IN SHORT ALONG WITH

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[1] SUPRA, P. 25.

[2] SUPRA, P. 29.

OTHER CONDITIONS (ASSUMED CONSTANT HERE), THE DISTANCE VARIABLE ACTS AS AN INCENTIVE TO SEEK A SUITABLE JOB. SINCE D IS ASSUMED TO BE A FUNCTION ONLY OF DISTANCE. THE FACTOR IS THE SAME FOR ALL OCCUPATION TYPES.[1] TABLE II IS MODIFIED TO SHOW NEW WORK TRIP ORIGINS FOR R1 AND R2.

TABLE III

OCCUPATION	R1	R2	TOTAL
MANAGERIAL	900D1	300D2	1,200
CLERICAL	683D1'	817D2'	1,500
LABOUR	354D1''	1346D2''	1,700
			4,400

THE ISOLATED DYNAMIC SITUATION

UP TO THIS POINT THE SUBSYSTEM HAS BEEN CONSIDERED STATIC IN TERMS OF JOB AND RESIDENTIAL MOVEMENT. TO EMPLOY PREDICTIVE THEORY, AN EVENT HAS TO OCCUR WHICH, BASED ON EXISTING CONDITIONS, COULD BE MODELED TO REVEAL THE FUTURE EFFECTS OF THIS EVENT.

RELAXING TO A DEGREE, THE ISOLATION CONSTRAINT ON THE SUBSYSTEM, A SEGMENT OF JOBS FROM THE CENTRAL INDUSTRIAL DISTRICT ARE RELOCATED AS A UNIT IN A NEW INDUSTRIAL SITE CALLED A. (SEE FIGURE 5). WHAT EFFECT WILL THIS HAVE ON THE EXISTING PATTERN OF WORK TRIP ORIGINS?

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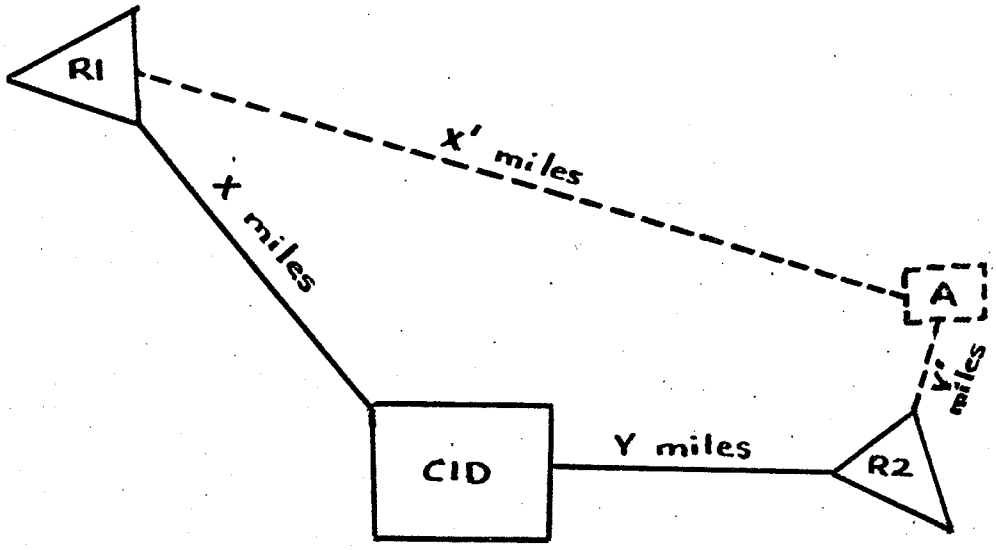
[1] THE ASSUMPTION THAT D (EXPRESSING THE DESIRABILITY OF A DESTINATION DEPRESSED BY TRAVEL IMPEDANCE) IS THE SAME FOR ALL OCCUPATIONS IS A KEY POINT OF INTEREST IN THIS STUDY. DO MANAGERS EXPERIENCE THE SAME DISPLEASURE AT TRAVEL AS DO LABOURS? DOES THIS DISPLEASURE REFLECT THEIR DESIRABILITY OF A JOB LOCATION TO THE SAME DEGREE? AS A FIRST ATTEMPT, THE ANSWER IS ASSUMED TO BE "YES". ALSO USED IN THE CONTEXT OF THE ACTUAL MODEL THE TERM D IS NOT A CONSTANT FACTOR, THOUGH HERE FOR DEMONSTRATIVE PURPOSES IT IS IMPLIED AS SUCH. TO ILLUSTRATE THIS EXAMPLE AND BALANCE THE PREDICTION TABLE, DIFFERENT NOTATIONS ARE ADOPTED FOR D FOR THE THREE OCCUPATIONAL GROUPS.

$$D \neq D' \neq D''$$



LEGEND

R1, R2	Residential Origin Districts
CID	Central Industrial District
[ ]	Relocated Industrial District

FIGURE 5. Isolated urban subsystem indicating dynamic condition.

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IT IS ESTIMATED THAT INDUSTRIAL SITE A WOULD INCLUDE 50 MANAGERIAL, 200 CLERICAL AND 500 LABOUR JOBS, MOST OF WHICH WERE PREVIOUSLY LOCATED IN THE CID AND A FEW NEWLY CREATED JOBS. FROM FIGURE 5 IT IS NOTED THAT THE DISTRICT R2 WILL BE MUCH CLOSER TO PARK A THAN TO THE CID. THE OPPOSITE HOLDS TRUE FOR DISTRICT R1.

THE DESIRABILITY RATIO D2, ASSOCIATED WITH MARGINAL TRAVEL DISSATISFACTION, WILL INCREASE FOR R2. BECAUSE OF DECREASED TRAVEL, WORKERS IN R2 BECOME MORE COMPETITIVE FOR THE NEW JOBS IN A. INDIVIDUALS WORKING ORIGINALLY IN THE SAME JOB IN THE OLD CENTRAL LOCATION WILL REAFFIRM THEIR POSITIONS AT THE NEW SITE. OTHERS WHOSE PRESENT POSITIONS ARE UNAFFECTED BY THE RELOCATION, INCREASE THEIR DESIRE FOR A JOB IN A, ALL OTHER THINGS BEING EQUAL. ON THE OTHER HAND, RELOCATION OF THE JOB SEGMENT IN A WILL HAVE A DEPRESSING EFFECT FOR WORKERS IN R1, IF DISTANCE X' IS TOO FAR TO TRAVEL A DECISION HAS TO BE MADE BY WORKERS, WHOSE JOBS HAVE BEEN RELOCATED IN A, IN REGARD TO THEIR WORK-RESIDENCE LOCATION. DEPENDING ON 1) THE SUPPLY AND DEMAND OF JOBS IN THE URBAN AREA, 2) THE INTRA URBAN LOCATION OF THESE JOBS AND 3) THEIR QUALIFICATION REQUIREMENTS, THE AFFECTED WORKERS OF R1 WILL EITHER 1) SEEK A NEW JOB CLOSER TO HOME; 2) SEEK A NEW HOME CLOSER TO THE JOB OR 3) MAINTAIN THE STATUS QUO.

ALTHOUGH IN A FIRST ATTEMPT THE OBSTACLE OF TRAVEL IS ASSUMED TO BE EQUAL FOR THE THREE MAJOR OCCUPATIONAL GROUPS THE DISTINCTIVE CHARACTERISTICS OF EACH GROUP WOULD SEEM TO REPUDIATE THIS IDEA.

TRAVELLING THE X' DISTANCE BECOMES MORE DIFFICULT FOR PEOPLE IN THE LABOUR-CLERICAL GROUP THAN FOR THE MANAGERIAL GROUP. THE LATTER ARE CHARACTERIZED BY TWO FACTORS TENDING TO LENGTHEN TRIP TIME.

1) A HIGHER INCOME TO MEET TRAVEL COSTS.

2) THEIR SELECTIVITY FOR HOME AND WORK ARE HIGH BASED ESSENTIALLY ON HIGHER STATUS, AND ASPIRATIONAL DESIRES.

THE MATTER IS COMPLICATED BY THE FACT THAT THESE TWO FACTORS, MOST NOTICEABLE IN THE MANAGERIAL GROUP, ARE ALSO PRESENT TO SOME EXTENT IN THE CLERICAL AND LABOUR GROUPS, ALTHOUGH THEIR EFFECTS ARE NOT AS INCLUSIVE AND PRONOUNCED AS IN THE FORMER OCCUPATIONAL TYPE.

IT CAN BE EXPECTED, THEREFORE, THAT SOME CHANGES WILL TAKE PLACE, THROUGH THE RELOCATION OF SITE A, THOUGH THE RATE AND EXTENT OF CHANGE WILL NOT BE THE SAME FOR THE THREE GROUPS.

IF THE DISTANCE CHANGE X TO X' IS CONSIDERABLE A JOB OR RESIDENCE LOCATIONAL CHANGE CAN BE EXPECTED IN THE LONG RUN. STUDIES HAVE SHOWN THAT UNLESS THE JOB SUPPLY EXCEEDS THE DEMAND, AN INDIVIDUAL WOULD PREFER TO CHANGE HIS PLACE OF RESIDENCE. TODAY'S URBAN DWELLER EXHIBITS HIGH RESIDENTIAL MOBILITY[1] WHICH FACILITATES A MOVE TO LESSEN WORK TRIP TIME.

IF THE SOCIO-ECONOMIC FACTORS OF RESIDENTIAL HOMOGENEITY COME INTO PLAY IT IS REASONABLE TO ASSUME, THAT AN INDIVIDUAL WILL SEEK A RESIDENTIAL DISTRICT ESSENTIALLY SIMILAR IN OCCUPATIONAL CHARACTER TO THE ONE LEFT BEHIND. UNLESS DETERIORATION HAS SET IN, THE EXISTING OCCUPATIONAL OR SOCIAL BREAKDOWN OF AN AREA WILL CONTINUE INTO THE

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[1] IN A STUDY CONDUCTED BY MARTIN MEYERSON ET AL., TITLED HOUSING, PEOPLE, AND CITIES, (NEW YORK: MCGRAW HILL, 1962,) P. 54, IT WAS FOUND THAT HIGH MOBILITY OF AMERICAN FAMILIES PROVIDES EVIDENCE OF SHIFTING PREFERENCES DURING THE FAMILY LIFE CYCLE. ALTHOUGH 20% OF ALL AMERICANS MOVE EVERY YEAR, 2/3 OF THE MOVES ARE WITHIN THE SAME METROPOLITAN AREA AND THEREFORE ARE TO SERVE A CHANGED PREFERENCE FOR SPACE LOCATION, DWELLING TYPE OR SOME RELATED DESIRE.

FUTURE.

IN CONSIDERING A RESIDENTIAL DISTRICT IN TERMS OF PRESERVATION OF CHARACTER AN OBVIOUS QUESTION IS: WHAT EFFECT, IF ANY, WILL THE WORKERS, SEEKING NEW HOME LOCATIONS, HAVE ON THE CHARACTER OF THE DISTRICT LEFT BEHIND OR ENTERED? IN THE HYPOTHETICAL SUBSYSTEM THERE WERE 1,500 AND 500 MANAGERS IN R1 AND R2 RESPECTIVELY. THIS IS THIRTY AND TEN TIMES THE NUMBER OF MANAGERIAL JOBS AFFECTED BY RELOCATING INDUSTRIAL SITE A. IT IS UNLIKELY THAT A MIGRATION OF WORKERS OF THIS SIZE WILL EFFECTIVELY ALTER THE OCCUPATIONAL PATTERNS OF DISTRICTS, R1 AND R2. THIS EXPECTATION IS ESPECIALLY SIGNIFICANT WHEN MANY RESIDENTIAL DISTRICTS, THROUGHOUT AN URBAN AREA, ARE CONSIDERED AS ORIGIN POINTS FOR ONE RELOCATED INDUSTRIAL SITE OUT OF HUNDREDS OF SIMILAR SITES IN THE CITY. AGAIN THE ESSENTIAL ASSUMPTION HERE IS THAT IN A CITY EXPERIENCING A NORMAL (BETTER STILL, SLOW) GROWTH RATE, THE CHARACTER OF RESIDENTIAL DISTRICTS WILL NOT CHANGE APPRECIABLY IN A TEN-YEAR PERIOD; SO THAT EXISTING CHARACTERISTICS CAN BE USED FOR PREDICTION PURPOSES.

IF THE HYPOTHETICAL SUBSYSTEM REMAINS ISOLATED AND RESIDENTIAL MOVEMENT FROM R1 TO R2 IS CONSIDERED UNLIKELY BECAUSE OF THE DIVERSE NATURE OF THE TWO DISTRICTS, THEN THE READJUSTED WORK TRIP ORIGIN PATTERN SIMPLY REQUIRES NEW DESIRABILITY FACTORS FOR R1 AND R2. THE SITUATION IS SIMILAR TO THE STATIC SITUATION, WHERE $X > Y$, AND ONLY THE CID WAS CONSIDERED. HERE INDUSTRIAL DISTRICT A IS CONSIDERED WITH X' VERY MUCH LARGER THAN Y'. THE RESULT IS THAT THE DESIRABILITY (COMPETITION) FACTOR FOR R1 IS VERY MUCH LESS THAN FOR R2. THE REDUCTION IN WORK TRIPS ORIGINATING IN R1 COULD BE ATTRIBUTED

TO PEOPLE SEEKING JOBS ELSEWHERE. THE CORRESPONDING INCREASE IN WORK TRIPS ORIGINATING IN R2 COULD BE DUE TO

1) FORMER UNEMPLOYED PEOPLE IN R2 GAINING COMPETITIVE ADVANTAGE AT THE NEW JOB SITE, HENCE FINDING WORK FORMERLY HELD BY RESIDENTS OF R1.

2) PEOPLE, WHO WORKED IN THE CENTRAL DISTRICT, BUT WHO WERE UNAFFECTED BY THE JOB SEGMENT RELOCATION, LEAVING A PRESENT CENTRAL JOB TO FIND A JOB AT THE NEARER SITE A.

OF COURSE THIS ASSUMES NO IN OR OUT MIGRATION OF RESIDENTS FROM EITHER R1 OR R2.

IF RESIDENTIAL MIGRATION RESTRICTIONS ARE RELAXED, SO THAT THE SUBSYSTEM IS NO LONGER ISOLATED, COMPLICATIONS ARISE. UNDER THIS SITUATION THE RELOCATION OF INDUSTRIAL SITE A NEAR R2, AFFECTS NOT ONLY RESIDENTIAL DISTRICTS R1 AND R2 BUT ALSO OTHER DISTRICTS IN THE URBAN SYSTEM. DISTRICTS, LIKE R2, WHICH ENJOY LOCATIONAL ADVANTAGES TO SITE A BECOME ATTRACTIVE TO MIGRATING WORKERS FROM R1 SEEKING TO REDUCE THE DISTANCE X^1 FROM HOME TO WORK. THE ATTRACTIVENESS OF THESE DISTRICTS IS RELATED TO THEIR EXISTING OCCUPATIONAL CHARACTERISTICS AND THE OCCUPATIONAL CHARACTERISTICS OF THE MIGRANT WORKERS. AN INCREASE IN DESIRABILITY OR COMPETITIVE ASSERTION OBSERVED AT R2 CAN NO LONGER BE EXPLAINED IN TERMS OF EXISTING RESIDENTS OF R2, BUT NOW THE OCCUPATIONAL GROUP PATTERNS OF ALL DISTRICTS IN THE URBAN SYSTEM HAVE TO BE CONSIDERED. MODELLING THE READJUSTED EQUILIBRIUM PATTERN OF WORK TRIP TO SITE A IS THE BASIS OF THE METHOD THAT FOLLOWS.

C) THE METHOD

AN ASSUMPTION WAS MADE EARLIER TO CONSIDER THE URBAN AREA AS

A CLOSED SYSTEM, WITH NO COMMUTER TRAFFIC CROSSING ITS BOUNDARIES. FOR CITIES NEAR TO OTHER POPULATION CENTERS AN ASSUMPTION SUCH AS THIS WOULD NOT BE JUSTIFIED. FOR THIS SITUATION THE BOUNDARIES OF THE STUDY AREA WOULD HAVE TO BE ENLARGED TO ENCOMPASS ALL NEARBY CENTERS AS WELL AS A CONSIDERABLE PORTION OF THEIR UMLAND. THE ASSUMPTION OF A CLOSED URBAN SYSTEM DOES NOT RESULT FROM A REQUIREMENT OR LIMITATION IN THE METHOD BUT RATHER IS A RESULT OF THE NATURE OF THE URBAN AREA IN THE CASE STUDY[1] AND THE ADOPTION OF CENSUS TRACTS AS RESIDENTIAL DISTRICTS OF ORIGIN.[2]

CENSUS TRACTS WERE ADOPTED AS DISTRICTS OF WORK TRIP ORIGIN SINCE THEY ARE DESIGNED TO BE, "RELATIVELY UNIFORM IN AREA AND POPULATION . . . SUCH THAT EACH IS FAIRLY HOMOGENEOUS WITH RESPECT TO ECONOMIC STATUS AND LIVING CONDITIONS . . . . DATA AVAILABLE FROM THESE STATISTICAL UNITS ARE OF VALUE IN COMPARISONS OF SOCIAL AND ECONOMIC FACTORS WITHIN AN URBAN COMMUNITY."[3] THIS ASPECT OF CENSUS TRACTS IS IMPORTANT IN THE LIGHT OF THE DISTRICT OCCUPATIONAL PRESERVATION MENTIONED EARLIER. ALSO SINCE CENSUS TRACTS ARE DEFINED UNIFORMLY ACROSS CANADA, USING THESE UNITS FACILITATES THE EXPANSION OF THE MODEL TO INCLUDE INTER URBAN INVESTIGATIONS.

THOUGH STATISTICS CANADA DIVIDES CENSUS LABOUR STATISTICS INTO NINE DISTINCT CLASSIFICATIONS, THE ADOPTION OF THE THREE COLLAPSED

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[1] THE STUDY AREA, WINNIPEG, HAS A VIRTUALLY UNPOPULATED UMLAND, WITHIN COMMUTER DISTANCE. POPULATION HERE CAN BE NEGLECTED.

[2] IF THE WINNIPEG UMLAND WERE CONSIDERED ORIGIN DISTRICTS WOULD HAVE TO BE EXPANDED TO COVER RURAL MUNICIPALITIES AND SMALL INCORPORATED CENTERS, AS WELL AS THE URBAN CENSUS TRACTS. THE IMPERCEPTIBLE REFINEMENT OBTAINED BY THIS INCLUSION DOES NOT JUSTIFY THE EFFORT.

[3] CENSUS OF CANADA 1961, POPULATION AND HOUSING CHARACTERISTICS BY CENSUS TRACT (WINNIPEG, BULLETIN CT-17.)

CATAGORIES -- MANAGERIAL, CLERICAL AND LABOUR -- WAS NECESSITATED BY THE NATURE OF SAMPLE DATA FROM THE CASE STUDY AND OTHER SOCIO-ECONOMIC FACTORS ASSOCIATED WITH THESE THREE GROUPS.[1]

FIGURE 6 SHOWS THE ENTIRE HYPOTHETICAL SYSTEM IN SCHEMATIC FORM. ENCIRCLING THE PROPOSED INDUSTRIAL SITE (A) THERE ARE A SERIES OF ISOLINES. EACH ISOLINE JOINS POINTS OF EQUAL TRAVEL TIME FROM THE DESTINATION, INDUSTRIAL PARK (A). THE TIME INTERVAL BETWEEN ISOLINES IS DETERMINED BY HUMAN BEHAVIOR AS WELL AS THE MODE OF TRANSPORTATION USED. TOMAZINIS, IN CHOOSING FIVE MINUTES FOR AUTOMOBILE COMMUTING, REASONED:

> "THE OBJECTIVE HERE IS TO SIMULATE HUMAN BEHAVIOR IN CHOOSING THE DESTINATION OF A TRIP WITHIN A COMPLEX SET OF TRIP DESTINATIONS OF A REGION. THIS TAKES PLACE ON THE BASIS OF TWO ELEMENTS OF EXPERIENCE; E.G., EXPERIENCE WITH THE TRANSPORTATION SYSTEM CONSIDERED, AND THE ABILITY AND SENSITIVITY TO COUNT AND UTILIZE TIME IN SMALL INCREMENTS. WHAT IS IMPLIED IS THAT ONE CANNOT HAVE A FIRST TIME CODE OF FIVE MINUTES FOR A MASS TRANSIT SYSTEM WHERE "WAITING TIME" ALONE MAY BE MORE THAN FIVE MINUTES. IT ALSO IMPLIES THAT FOR AUTO TRAVEL OR MASS TRANSIT TRAVEL ONE SHOULD NOT HAVE TIME CODES OF ODD INCREMENTS (OF SAY, 6.25 MINUTES) BUT OF BLOCKS OF TIME THAT ARE EASILY CONCEIVED AND FREQUENTLY USED BY PEOPLE IN THEIR EVERYDAY ACTIVITIES; E.G., TIME CODES OF FIVE OR TEN MINUTES.
>
> THIS CONSIDERATION OF SIMULATING HUMAN BEHAVIOR HAS PROVEN OF SUBSTANTIAL IMPORTANCE WHERE BEST RESULTS WERE ACHIEVED WITH TIME CODES OF FIVE MINUTES DRIVING TIME IN DISTRIBUTING AUTO TRIPS.[2]

TOMAZINIS FURTHER OUTLINES AN ISOLINE INCREMENT FOR PUBLIC TRANSIT;

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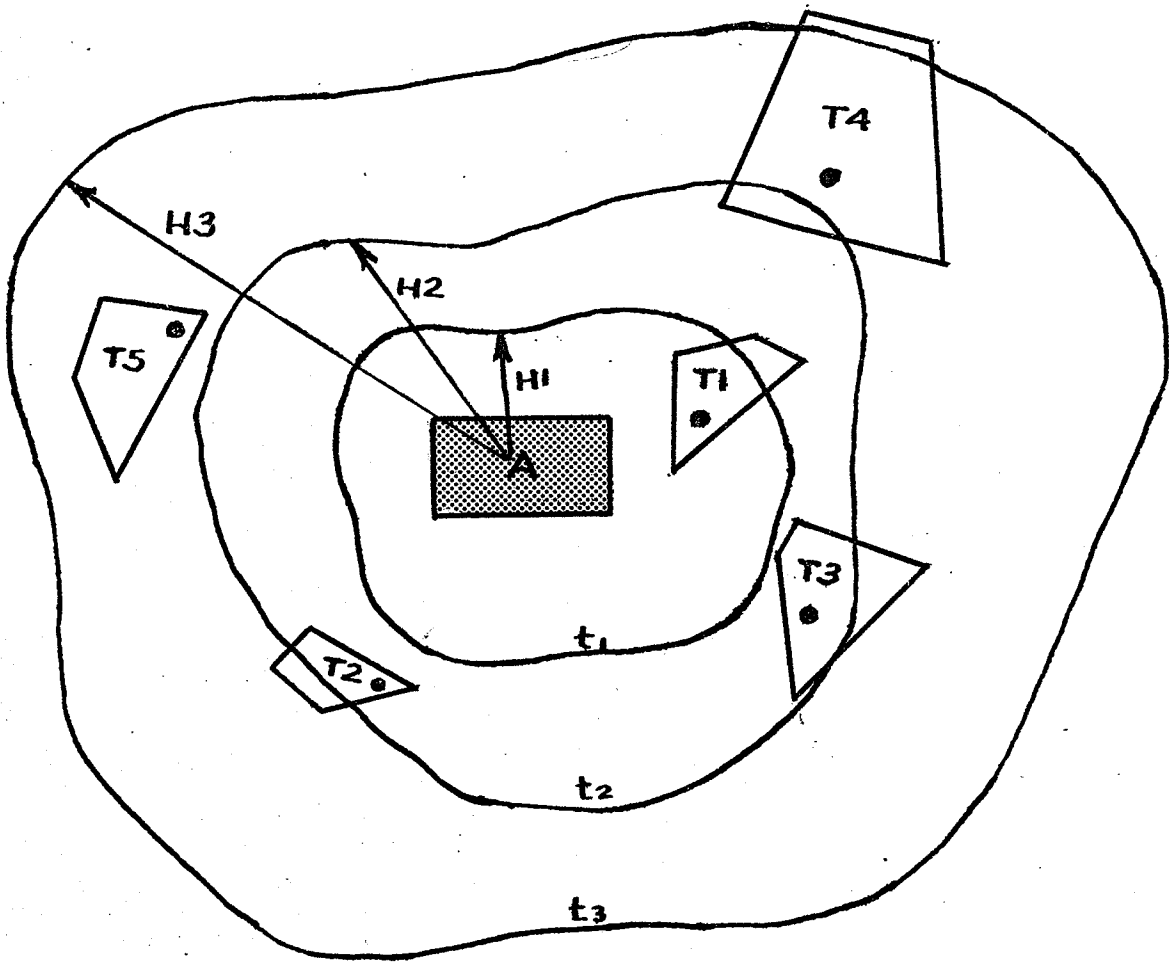
[1] FOR A MORE DETAILED DISCUSSION OF THE REASONS BEHIND THE ADOPTION OF THE THREE OCCUPATIONAL GROUPS AND THEIR COMPONENTS . SEE APPENDIX B.

[2] TOMAZINIS, OP. CIT., P. 82.



LEGEND

T — Census Tract Origin Districts

H — Subpopulation Within t Interval

• — Tract Centroid

—— — Travel Time Isoline

FIGURE 6. Schematic urban system showing industrial site A as a focus for several districts of origin.

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HOWEVER, SINCE COMMUTERS TO INDUSTRIAL PARKS (MOSTLY LOCATED IN SUBURBAN AREAS) GENERALLY USE PRIVATE TRANSPORTATION THE NEED TO CONSIDER MASS TRANSIT FOR THIS STUDY WAS DEEMED UNNECESSARY. FOR THIS REASON, AN ISOLINE INTERVAL OF FIVE MINUTES WAS CONSIDERED APPROPRAITE FOR A FIRST ATTEMPT.

FIVE CENSUS TRACTS, REPRESENTING RESIDENTIAL DISTRICTS OF ORIGIN, ARE ALSO SHOWN IN THE FIGURE, LOCATED AT VARIOUS DISTANCES FROM DISTINATION POINT A. THE CENTROID OF THE TRACT DETERMINES INTO WHICH TIME INTERVAL THE TRACT FALLS. THE CENTROIDAL POINTS ARE NOT NECESSARILY GEOMETRIC BUT ARE RATHER DICTATED BY THE SPREAD OF RESIDENTIAL DEVELOPMENT WITHIN THE RESPECTIVE TRACT. THIS ASPECT IS VERY SIGNIFICANT IN THE LESS POPULATED OUTER AREAS OF THE CITY.

THE TERMS H_1, H_2 ETC., DESIGNATE ALL WORK TRIP OPPORTUNITIES IN THE AREA WITHIN T1, T2, ETC. MINUTES OF A. H, THEN, IS A POPULATION FIGURE APPLIED TO ALL INDIVIDUALS WITHIN T MINUTES OF A WHO ARE LIKELY TO COMPETE FOR A SUITABLE JOB IN THE PROPOSED INDUSTRIAL SITE. THE H SUBPOPULATION IS ACCUMULATIVE, MOVING OUTWARD FROM A AT FIVE MINUTE INTERVALS, IE. H_2 INCLUDES H_1 HENCE $H_1 \cap H_2$. ALSO $H_2 \cap H_3$, $H_3 \cap H_4$, ETC.

CONCENTRATING ON CLERICAL PERSONNEL FOR THE PURPOSE OF DEMONSTRATING THE METHOD, INDUSTRIAL SITE A IS ASSUMED TO EMPLOY Y CLERKS.[1] CHOOSING AT RANDOM ONE CLERK FROM THIS Y GROUP, THE PROBABILITY THAT THE CHOSEN CLERK IS A MEMBER OF CLERK SUBPOPULATION H_1 IS

$$P(H_1) = \frac{H_1}{N}$$

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[1] THE TERM "CLERKS" INCLUDES ALL OFFICE PERSONNEL

WHERE N IS THE ENTIRE POPULATION OF CLERKS IN THE URBAN AREA.

THE PROBABILITY THAT THIS CLERK IS ALSO A RESIDENT OF CENSUS TRACT 1 IN SUBPOPULATION H_1 IS

$$P(T1) = \frac{T1}{N}$$

WHERE T1 IS THE NUMBER OF CLERKS IN TRACT 1.

GIVEN THAT THE RANDOM CHOICE WILL ORIGINATE FROM THE AREA LESS THAN T1 MINUTES FROM A, IE. SUBPOPULATION H_1, THEN THE PROBABILITY THAT THE CHOICE IS ALSO FROM T1 IS CONDITIONALLY

$$P\left(\frac{T1}{H1}\right) = \frac{T1}{H1}$$

WHERE H1 SUBPOPULATION INCLUDES THE CLERKS IN TRACT 1.

SINCE ONLY H1 IS CONSIDERED HERE, THIS EQUATION IMPLIES THAT THE PROBABILITY OF A CLERK COMMUTING FROM TRACT POPULATION T1 IS THE RATIO BETWEEN CLERICAL TRIP ORIGINS IN TRACT 1 (IE, T1) DIVIDED BY THE TOTAL CLERICAL TRIP ORIGINS INSIDE THE AREA DELINEATED BY THE TIME CODE OF THE DISTRICT OR ORIGINS (IE.H1) AND HAVING AS A BASIS THE DISTRICT OF DESTINATION (A). IN SIMPLER TERMS THE PROBABILITY THAT A TRIP WILL ORIGINATE FROM A PARTICULAR CENSUS TRACT DEPENDS ON THE RATIO BETWEEN THE TRIP OPPORTUNITIES IN THIS TRACT AND ITS <u>COMPETING</u> OPPORTUNITIES WITHIN THE SAME TIME LIMIT OF DESTINATION. FOR THIS EXAMPLE, CHOOSING A CLERK IN SITE A, THE PROBABILITY OF THIS CHOICE COMING FROM TRACT CLERICAL POPULATION T1 WILL DEPEND ON THE COMPETITION FOR JOBS AT A BETWEEN CLERKS IN THIS TRACT AND OTHER CLERKS IN THE SAME TIME CODE SUBPOPULATION H1. AS TOMAZINIS STATES:

> "ACCORDING TO THIS NEW CONCEPT [OF COMPETING OPPORTUNITIES] THE ATTRACTING POWER OF [DESTINATION] IS CONDITIONED BY THE NUMBER OF TRIP OPPORTUNITIES IN THE DISTRICT

> AND THEN ONLY BY THE TRIP OPPORTUNITIES WITHIN THE SAME TIME-DISTANCE FROM THE DISTRICT OF [DESTINATION]."[1]

CONSIDERING THE TOTAL NUMBER OF CLERICAL TRIP OPPORTUNITIES IN THE URBAN AREA, DESTINED FOR SITE A, THE EQUATION:

4A) $\sum P_I = 1$, IS OBTAINED, WHERE P_I = PROBABILITY OF EACH CENSUS CENSUS TRACT IN CITY HAVING AN EMPLOYEE IN A $I = 1, 2, 3 \ldots N$, $N = 5$

THE SUMMATION IS UNITY SINCE THE TOTAL TRIPS ORIGINATING FROM TRACTS 1 TO 5, $T_1, T_2 \ldots T_5$, MUST BE EQUAL TO THE DESTINATION OPPORTUNITIES IN PARK A. IN SHORT ALL Y CLERKS IN A MUST COME FROM SOMEWHERE IN THE URBAN AREA.

TO OBTAIN THE EQUATION $\sum P_I = 1$, THE CONDITIONAL PROBABILITIES,

$$\left[P\left(\frac{T1}{H1}\right), P\left(\frac{T2}{H2}\right), P\left(\frac{T3}{H2}\right), P\left(\frac{T4}{H3}\right) \text{ AND } P\left(\frac{T5}{H3}\right) \right]$$

MUST BE DIVIDED BY THE SUMMATION OF ALL CONDITIONAL PROBABILITIES,

$$\left[P\left(\frac{T1}{H1}\right) + P\left(\frac{T2}{H2}\right) + P\left(\frac{T3}{H2}\right) + P\left(\frac{T4}{H3}\right) + P\left(\frac{T5}{H3}\right) \right]$$

HENCE

4B) $$P_I = \frac{P_I\,(T/H)}{\sum_{I=1}^{N} P_I(T/H)}$$

IT SHOULD BE NOTED THAT THE DENOMINATOR OF THIS EQUATION, $\sum_{I=1}^{N} P_I(T/H)$ IS NOT EQUAL TO 1, SINCE THE TIME CODE SUBPOPULATIONS (H) ARE ACCUMULATIVE. (H2 INCLUDES H1, ETC.), THEREFORE

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[1] IBID., P. 79. IN THIS QUOTATION THE WORD "DESTINATION" HAS BEEN SUBSTITUTED FOR "ORIGIN" SINCE TOMAZINIS WAS DISCUSSING TRIP DISTRIBUTION AND THIS STUDY IS CONCERNED WITH TRIP COLLECTION.

$$\sum_{J} P1 \left(\frac{TJ}{H1}\right) = 1$$

BUT $$\sum_{J} P2 \left(\frac{TJ}{H2}\right) < 1$$

WHERE J ARE THOSE TRACTS WITHIN RESPECTIVE TIME CODES.

HENCE FOR TIME CODE 1

$$P\left(\frac{T1}{H1}\right) = \frac{T1}{H1} = P1$$

AND THE SUMMATION REQUIRED FOR THE ADJUSTED CONDITIONAL PROBABILITY, $\sum P1 = 1$.

FOR CODE 2

$$P\left(\frac{T2}{H2}, \frac{T3}{H2}\right) = \frac{T2 + T3}{H2} = P2$$

AND $$\sum P2 = 1 - \frac{H1}{H2}$$

THE PROBABILITY THAT H1 IS PICKED MUST BE SUBSTRACTED FROM H2 SINCE H2 INCLUDES H1.

SIMILARLY, FOR CODE 3

$$P\left(\frac{T4}{H3}, \frac{T5}{H3}\right) = \frac{T4 + T5}{H3} = P3,$$

WHERE $$\sum P3 = 1 - \frac{H2}{H3}$$

THEN

$$\sum P1 \left(\frac{T}{H}\right) = \sum P1 + \sum P2 + \sum P3$$

$$= 1 + 1 - \frac{H1}{H2} + 1 - \frac{H2}{H3} = 3 - \frac{H1}{H2} - \frac{H2}{H3}$$

$$= 3 - \left(\frac{H1}{H2} + \frac{H2}{H3}\right)$$

IN GENERAL FOR M TIME CODES,[1]

$$4c) \qquad P_I = \frac{P_I \; (T/H)}{\sum_{M-2}^{M-M} \frac{H_{M-1}}{H_M}} = \frac{T_I/H_I}{\sum_{M=2}^{M-M} \frac{H_{M-1}}{H_M}}$$

THE ASSUMPTION THAT WORKERS, WITHIN SPECIFIC OCCUPATIONS, COMPETE ONLY WITH THOSE WORKERS WITHIN COMMON TIME ZONES, REPLACES THE DESIRABILITY (OR COMPETITION) FACTOR D IN THIS FORMULA.[2] BASICALLY, THE ASSUMPTION STATES:

> CLERKS BELONGING TO GROUP T1 COMPETE ONLY WITH CLERKS IN H1 FOR JOBS AT A. HOWEVER CLERKS T5 COMPETE WITH ALL CLERKS IN SUB-POPULATION H3, WHICH ALSO INCLUDES H2 AND H1.

THE COMPETING OPPORTUNITY MODEL, BRIEFLY DESCRIBED IN CHAPTER III APPLIES TO TOTAL TRIP DISTRIBUTION. FOLLOWING AN ANALYSIS OF ALL ORIGIN AND DESTINATION POINTS IN THE URBAN AREA; THE THEORETICAL RESULTS WOULD REQUIRE BALANCING BY AN ITERATIVE PROCESS TO BETTER REPRESENT EMPIRICAL RESULTS.[3] IN A WORK TRIP DISTRIBUTION STUDY A BALANCING FUNCTION CANNOT BE ATTEMPTED UNTIL ALL RESIDENTIAL AND WORK AREA SITES ARE INCLUDED IN A CLOSED NETWORK OF ORIGIN-DESTINATION POINTS. AN EXERCISE OF THIS NATURE, COULD INTRODUCE THE FINAL REFINEMENT IN PREDICTING THE EFFECT OF INTRODUCING A NEW WORK AREA INTO AN ESTABLISHED NETWORK OF RESIDENTIAL AND WORK PLACES. IT IS DOUBTFUL HOWEVER WHETHER THE REFINEMENT OFFERED BY THIS EXERCISE JUSTIFIES THE EFFORT OF ESTABLISHING AND FREQUENTLY UPDATING THE NETWORK.

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[1] THE NOTATION M=2 TO M IS USED ONLY BECAUSE H1 WAS DESIGNATED AS THE FIRST TIME CODE.

[2] IT IS THE ACCURACY OF THIS EXCLUSIVE COMPETITION ASSUMPTION IN REPRESENTING FACTOR D WHICH MAY INTRODUCE ERROR IN THE MODEL. THIS ASSUMPTION DOES NOT SEEM TO HAVE A COMPLETELY LOGICAL FOUNDATION, BUT SERVES THE PURPOSE OF A FIRST APPROXIMATION. ADJUSTMENT MAY BE RECOMMENDED FROM THE CASE STUDY TEST RESULTS.

[3] TOMAZINIS USED THE FRATAR METHOD TO ACCOMPLISH THIS, OP. CIT., P.80

ALTHOUGH THE APPROACH ADOPTED BY THIS STUDY, WHICH FOCUSES SOLELY ON THE PROPOSED INDUSTRIAL SITE, DOES NOT INVOLVE A TRIP BALANCING FUNCTION, IT DOES REQUIRE A METHOD OF JOB ASSIGNMENT. IN THE HYPOTHETICAL SUBSYSTEM EXAMPLE, THE PROBABILITY FACTOR WAS MULTIPLIED DIRECTLY BY THE NUMBER OF JOBS TO OBTAIN TRIPS ORIGINATING IN DISTRICTS R1 AND R2.[1] HOWEVER CONSIDERING THE ENTIRE URBAN SYSTEM, IF Y JOBS ARE PROVIDED AT A, WHERE Y IS A VERY SMALL PERCENTAGE OF THE TOTAL POPULATION OF CLERKS IN THE CITY, A STRAIGHT APPLICATION OF THE PROBABILITY FACTOR WOULD BE IMPRACTICAL.

EXAMPLE:

> ASSUME A CITY HAS ONE HUNDRED CENSUS TRACTS AND A CORRESPONDING CLERK POPULATION OF 10,000. BY APPLYING THE ABOVE METHOD, THE P_I FOR TRACT FIFTY IS FOUND TO BE 0.0001. IF THE PROPOSED INDUSTRIAL SITE HAS ONE HUNDRED CLERICAL JOBS AVAILABLE, BY DIRECT APPLICATION OF PROBABILITY, THE NUMBER OF WORK TRIPS ORIGINATING AT TRACT FIFTY IS
>
> $$P_I Y = 100(0.0001) = 0.01 \ll 1$$
>
> UNLESS THE TRACTS ARE VERY CLOSE TO THE SITE, WITH A HIGH P_I VALUE, VIRTUALLY ALL TRACTS WILL HAVE NO EMPLOYMENT REPRESENTATION IN SITE A. Y WOULD HAVE TO EQUAL 10,000 BEFORE THE FIRST WORK TRIP ORIGINATED FROM TRACT FIFTY.

IN A LARGE URBAN AREA WITH MANY CENSUS TRACTS, WORK TRIP ORIGIN PREDICTION FOR ALL BUT THE LARGEST PROPOSED DEVELOPMENTS WOULD BE IMPOSSIBLE.

THE ADOPTED TECHNIQUE USES THE PROBABILITY VALUES (P_I) AS WEIGHTS FOR TRIAL ASSIGNMENTS. JOB ASSIGNMENTS TO THE INDUSTRIAL PARK, FOR EACH CENSUS TRACT OR TIME ZONE, IS ACCOMPLISHED BY MEANS OF A

---

[1] SUPRA, PP. 64-65.

MONTE CARLO METHOD OF RANDOMIZATION.[1] THIS METHOD, BASICALLY, IS A SIMULATION TECHNIQUE IN WHICH STATISTICAL DISTRIBUTION IS OBTAINED BY USING A SERIES OF RANDOM NUMBERS. THESE RANDOM NUMBERS ARE USED AS GENERATORS OF A NEW SET OF THEORETICAL DATA BASED ON PROBABILITY FACTOR PI, WHOSE BEHAVIOR FOLLOWS THE METHOD ASSUMPTIONS.

FOR THE ENTIRE URBAN AREA UNDER STUDY, ALL CENSUS TRACTS ARE ARRANGED ALONG THE ABSICCA OF A GRAPH (ORDER IS IRRELEVANT), AND THE CORRESPONDING ACCUMULATIVE PROBABILITIES (ΣPI FOR EACH TRACT) ARE PLOTTED VERTICALLY. A LINE HISTOGRAM SHOWN IN FIGURE 7 IS OBTAINED. NOTE THAT SINCE $\sum_{N=5} PI = 1$, THE ORDINATE RANGES FROM 0 TO 1.0.[2]

WHAT IS IMPORTANT IN THIS METHOD IS NOT THE ACCUMULATIVE PROBABILITY BUT RATHER THE EXCLUSIVE PROBABILITY (PI) OF EACH TRACT MIRRORED ON THE ORDINATE. THE LARGER THE PROBABILITY, THE LARGER THE INTERFACE (P1, P2, P3, P4 AND P5) AND THE GREATER THE WEIGHT FOR THE RESPECTIVE TRACT OR TIME CODE, WHICHEVER IS REQUIRED. SINCE THE NUMBER OF CLERKS TO BE ASSIGNED TO THE PROPOSED INDUSTRIAL SITE IS Y, THEN Y RANDOM NUMBERS FROM 0 TO 1 MUST BE GENERATED AND ASSIGNED TO THE CORRESPONDING CENSUS TRACTS ON THE ABSICCA.

EXAMPLE:

> FROM THE FIGURE, IF A RANDOM NUMBER OF 0.55 IS PICKED, IT WOULD BE ASSIGNED TO TRACT T2.

---

[1] "THE MONTE CARLO METHOD IS A LABEL CUSTOMARILY ASSIGNED TO ANY PRODUCE USING STATISTICAL SAMPLING TECHNIQUES IN ORDER TO OBTAIN A PROBABLISTIC MODEL OF SOME MATHEMATICAL OR PHYSICAL PROBLEM. REFER TO. GUISEPPE M. DIROCCAFERRERA, OPERATIONS RESEARCH MODELS FOR BUSINESS AND INDUSTRY (CINCINNATI: SOUTHWESTERN PUB. CO., 1964), P.861.

[2] THIS PROCEDURE CAN ALSO BE USED TO ASSIGN TRIP ORIGINS TO TIME INTERVAL SUBPOPULATIONS (H1, H2, ETC.) BY GROUPING CENSUS TRACT IN THEIR RESPECTIVE TIME INTERVALS.

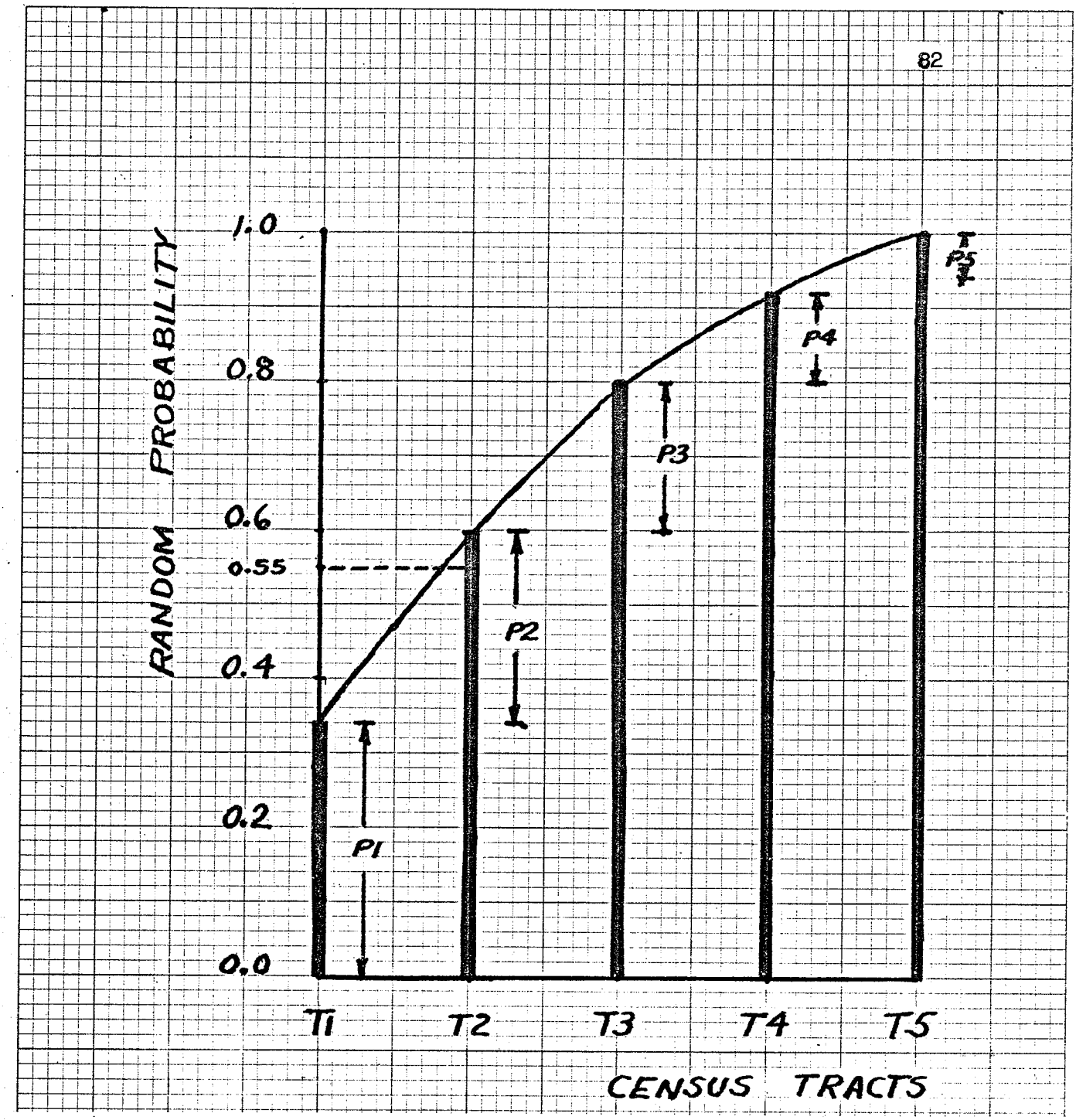

FIGURE 7. Probability histogram for 5 census tracts showing the Monte Carlo method of assignment.

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THE PROCEDURE IS REPEATED FOR ALL Y ASSIGNMENTS OF CLERKS. SIMILARLY, ASSIGNMENTS ARE CONDUCTED FOR THE MANAGERIAL AND LABOUR GROUPS UNTIL THE NUMBER OF WORK TRIP ORIGINS EQUALS THE NUMBER OF JOBS AVAILABLE.

D) TESTING

SCOPE OF TEST

THE UNIQUE METHOD INTRODUCED HERE TO PREDICT THE RESIDENTIAL DISTRIBUTION OF INDUSTRIAL WORKERS IS BASED ON SEVERAL ASSUMPTIONS, WHICH WITHIN THE CONTEXT OF THIS STUDY HAVE NOT YET BEEN PROVED. IN FACT TWO MAJOR ASSUMPTIONS ON WHICH THIS LESS REFINED FIRST ATTEMPT IS BASED HAVE BEEN QUESTIONED IN THE FORMATIVE STAGE OF MODEL DEVELOPMENT.

1) DOES TRAVEL TIME HAVE THE EFFECT OF EXCLUSIVELY ELIMINATING COMPETITION, OR DOES COMPETITION DROP OFF BY DEGREES MOVING OUTWARD FROM THE JOB SOURCE?

2) ARE ALL OCCUPATIONS AFFECTED EQUALLY BY TRAVEL IMPEDANCE, OR DO SOME GROUPS FIND TRAVELLING LESS OF A HINDRANCE THAN OTHERS?

THE NEED TO EXPLORE THESE AND OTHER QUESTIONS NECESSITATES A TESTING OF THE MODEL'S REPRESENTATIVE ACCURACY.

IDEALLY, TO VALIDATE THEORY, TESTING WOULD INVOLVE AN EXHAUSTIVE SURVEY OF MANY INDUSTRIAL SITES, FROM NUMEROUS URBAN AREAS. THE SITES, OF COURSE, WOULD DIFFER NOT ONLY IN TERMS OF THEIR LOCATIONAL CHARACTERISTICS, BUT ALSO IN TERMS OF THE NUMBER, SIZE AND TYPES OF FIRMS OF WHICH THEY CONSIST. THE NATURE OF CITIES ALSO MAY HAVE THE EFFECT OF ALTERING LOCATIONAL CRITERIA SO AS TO FORCE A CHANGE IN THE MODEL.

THE EXTENT OF TESTING REQUIRED BY THIS "BURDEN OF PROOF" WAS NOT ATTEMPTED AT THIS TIME. IN VIEW OF THE GENERALITIES REGARDING

COMPETITION, WHICH ARE ADOPTED AS FUNDAMENTAL ASSUMPTIONS ON WHICH THE MODEL IS BASED, EXTENSIVE TESTING, WITHOUT REFINEMENT, WAS CONSIDERED UNNECESSARY. INSTEAD, A CASE STUDY APPROACH ON ONE INDUSTRIAL SITE WAS THOUGHT TO BE MORE COMPATIBLE WITH THE UNPOLISHED BASIS OF THIS PRELIMINARY HYPOTHESIS. THIS TYPE OF APPROACH WOULD INDICATE THE MOST OBVIOUS DEFICIENCIES IN THE METHOD, SO THAT THESE DEFICIENCIES COULD BE CORRECTED AND A MORE REFINED PROCEDURE TESTED ON A BROADER SCALE.

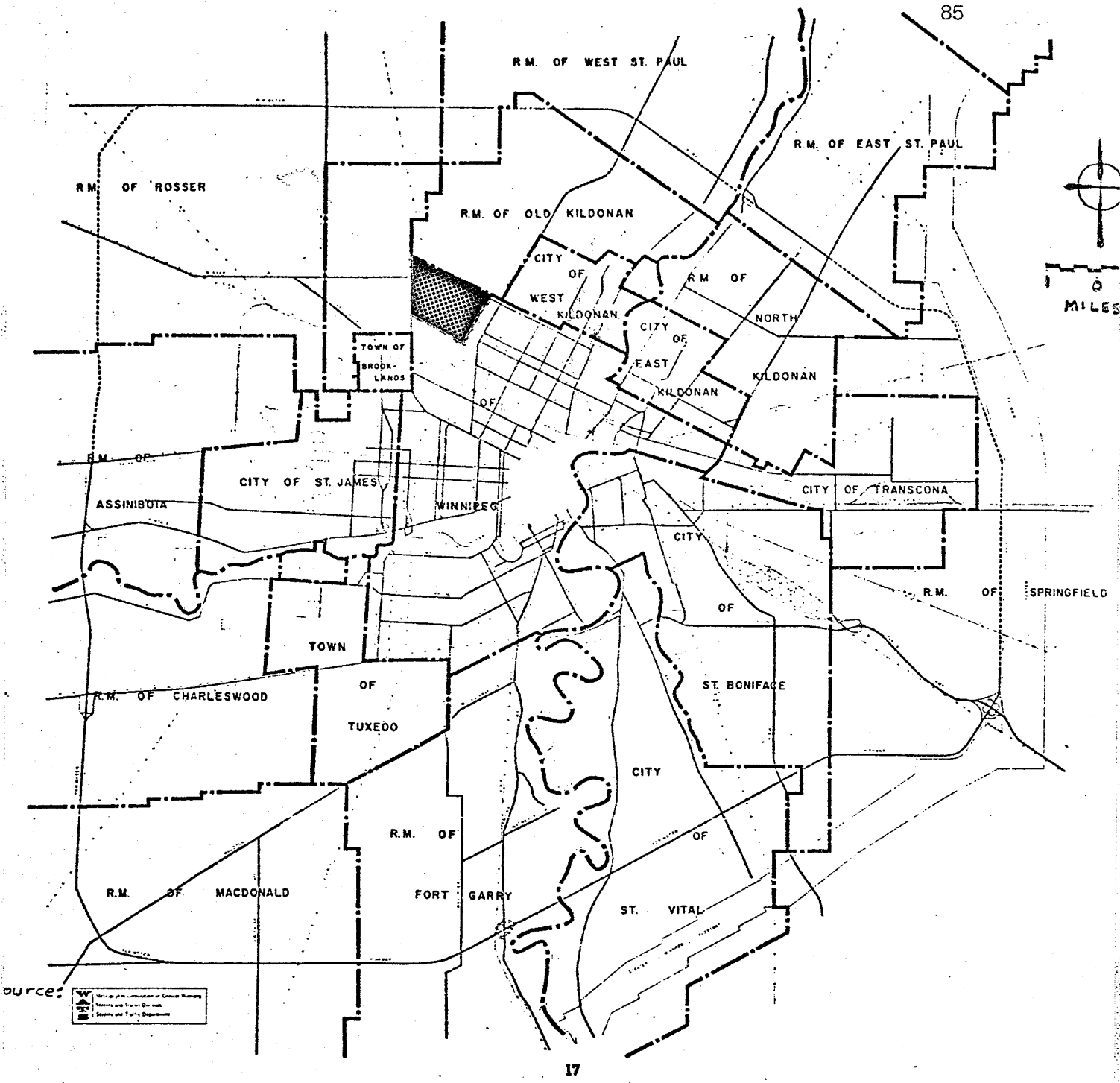
TEST AREA

TO REST THE PREDICTIVE ABILITY OF THIS METHOD A PROPOSED INDUSTRIAL SITE WOULD HAVE TO BE STUDIED BEFORE AND AFTER ITS ACTUAL ESTABLISHMENT. TESTING COULD NOT BE CARRIED OUT FOR AT LEAST TWO YEARS AFTER THE ESTABLISHMENT DATE OF MOST FIRMS, SINCE ONLY AT THIS TIME WILL ANY DEGREE OF EQUILIBRIUM IN WORKER RESIDENCE BE NOTICEABLE. IN ORDER TO SIMULATE THIS CONDITION, AN ESTABLISHED INDUSTRIAL SITE WAS CHOSEN AND ANALYZED, USING CENSUS DATA FROM A PERIOD IMMEDIATELY PRIOR TO THE ACTUAL INDUSTRIAL LOCATION.

THE INDUSTRIAL SITE CHOSEN TO TEST THE METHOD WAS INKSTER INDUSTRIAL PARK, IN NORTH CENTRAL WINNIPEG. (SEE MAP 1.) THOUGH THE PARK BECAME AVAILABLE FOR DEVELOPMENT IN 1958, IT WAS NOT UNTIL AFTER 1960 THAT MOST OF THE EXISTING FIRMS BECAME ESTABLISHED HERE. TABLE IV, LISTING THE SAMPLE FIRMS, GIVES SOME INDICATION WHEN MOST FIRMS BECOME ESTABLISHED HERE. SINCE 1961 COINCIDED WITH THE DECENNIAL CENSUS, AND CENSUS TRACT DATA, WERE REQUIRED TO CALCULATE PROBABILITIES, THIS YEAR WAS CHOSEN AS THE BASE YEAR FOR PREDICTION.[1]

---

[1] THOUGH SOME FIRMS FROM THE SAMPLE WERE ALREADY ESTABLISHED IN THE PARK JUST PRIOR TO 1961 (EG., DO-ALL COMPANY LTD.) IT WAS ASSUMED THAT THIS WAS NOT SIGNIFICANT ENOUGH TO ALTER CENSUS DATA.



MAP I. The situation of Inkster Industrial Park in the Greater Winnipeg Area.

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TABLE IV

LIST OF SAMPLE FIRMS

Name of Company	Date Established	Number of (Full Time) Employees
Reimer Express Lines Ltd.	1964	180
George Simpson Mfg.Co.Ltd.	1969	46
Century Craft Ltd.	1964	23
Winnipeg Photo Ltd.	1964	189
Dominion Tanners Ltd.	1967	136
Western Tools and Industries	1965	76
Superior Envelopes Ltd.	1961	48
MacMillan, Bloedel Ltd.	1962	100
Do-All Company Ltd.	1960	9
Parke Davis and Co. Ltd.	1961	9 *
Davis Controls	1967	2 *
Duchon Bros. Signs Ltd.	1962	13
Glesco Manufacturing Ltd.	1966	14 *
J. W. Mills and Son Ltd.	1968	8
Strong-Scott Ltd.	1963	95
Ingram and Bell Ltd.	1969	13
Electrolier Corp.	1964	62 *
Mid-West Truck Lines Ltd.	1965	14
	Total	1,037

*New industries - not relocated from any other area of the city.

WITH THE BASE YEAR ESTABLISHED AS 1961, A TEN-YEAR STUDY PERIOD, 1961-71, WAS ADOPTED AS THE TIME IN WHICH WORKER RESIDENTIAL LOCATION WITH RESPECT TO THE PARK REACHED EQUILIBRIUM. MOST OF THE FIRMS STUDIED WERE ESTABLISHED AT THE NEW SITE DURING THE PERIOD 1961-68. THE POST-LOCATION PERIOD 1968-71 GIVES A WORKER, DIRECTLY AFFECTED BY THIS WORK PLACE RELOCATION, THREE YEARS TO DECIDE ON AN ADJUSTED JOB-RESIDENCE LOCATION. THREE YEARS ARE ASSUMED SUFFICIENT FOR THIS DECISION.[1] HENCE RESIDENCE-WORK PLACE LOCATIONAL EQUILIBRIUM IS ATTAINED FOR THE PROJECTION YEAR, 1971.

THE GREATER WINNIPEG AREA HAS WITHIN ITS LEGAL BOUNDARIES SIX DISTINCT INDUSTRIAL DISTRICTS EXCLUDING THE CENTRAL WORK AREA.

1) INKSTER INDUSTRIAL PARK
2) ST. JAMES INDUSTRIAL PARK
3) FORT GARRY INDUSTRIAL PARK
4) TUXEDO INDUSTRIAL PARK
5) TRANSCONA INDUSTRIAL PARK
6) ST. BONIFACE INDUSTRIAL AREA

BESIDES THESE SIX DISTRICTS AND THE CENTRAL AREA, INDUSTRY IS LOCATED SPORADICALLY THROUGHOUT THE CITY WHERE PLANNING REGULATIONS AND ZONING BYLAWS PERMIT. THOUGH THE METHOD COULD HAVE BEEN TESTED ON ANY GROUP OF FIRMS IN THE CITY, PROVIDED DATES OF LOCATION OF ALL THESE FIRMS WERE AT LEAST WITHIN TEN YEARS OF EACH OTHER, INKSTER PARK WAS CONSIDERED MOST SUITABLE FOR THE FOLLOWING REASONS:

1) ESTABLISHMENT OF SAMPLE FIRMS AS A UNIT WAS COMPATIBLE WITH ADOPTED TEST PERIOD, 1961-1971.

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[1] SEE POPULATION MOBILITY RATES, SUPRA, P. 69.

2) Inkster Park has a compact layout (See Map II). Firms located in the St. James and Fort Garry Parks are scattered, requiring considerable effort to determine the centroid of activity for travel time calculations.

3) The test park consists of eighty-four firms (see Table V) varying in size of employment and type of activity. This condition allows for good cross-sectional sampling. Both Tuxedo and Transcona are dominated by one or two large firms, biasing locational criteria to some extent. (ie. all jobs assumed equal on the average within respective occupational groups.)

4) Finally, as already indicated by Table IV on page 86 most of the sample firms were relocated from central sites. The test area approaches the hypothetical example used in deriving the method.

The choice of Inkster Park to test the model hypothesis and the method does introduce possible peculiarities which should be noted.

1) The industrial site is located in an area near which there has been a considerable amount of new house construction in the last ten years. Without the growth factors to adjust for new residential development, the characteristics of this area using 1961 census data would have been predicted essentially vacant.

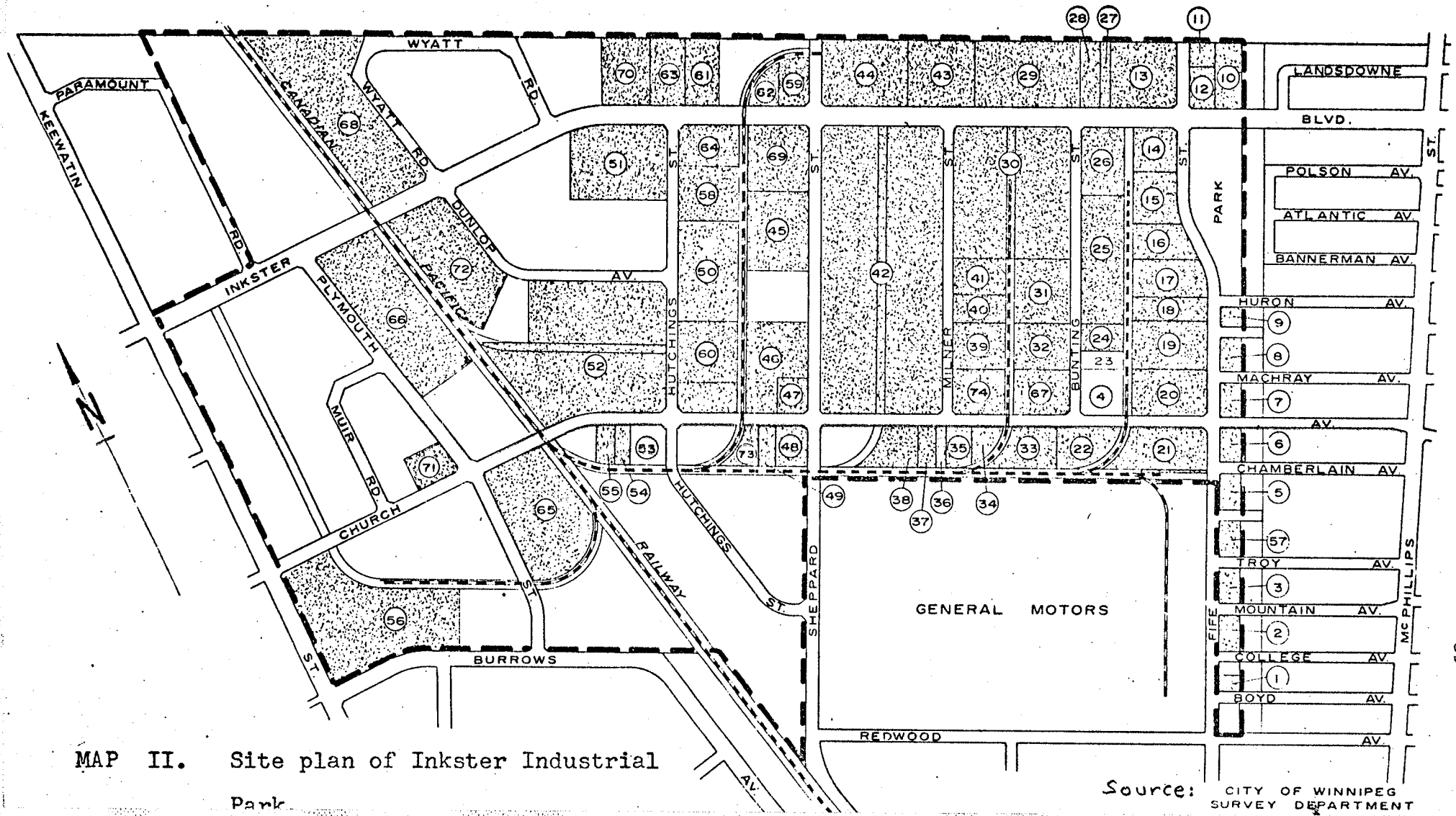
2) The residential area to the south east of Inkster Park was already established as a labour class district well before the Park was located. This aspect biases the model in favour of the "lesser distance" factor. Though it is unlikely that labourers have located here in order to be near to the Inkster development and that only a small percentage of the labour population of this area actually work at the Park, the high labour concentration, coupled with proximity, will give high theoretical probability rates for expected work trip origins.

Sampling procedure

Of the eighty four firms presently located in the Park, a sample size of eighteen firms was randomly drawn. Although expansion formulas have been developed which may allow the sample data to repre-

INKSTER INDUSTRIAL PARK

CITY OF WINNIPEG



MAP II. Site plan of Inkster Industrial Park

Source: CITY OF WINNIPEG SURVEY DEPARTMENT

TABLE V*

FIRMS LOCATED IN INKSTER
INDUSTRIAL PARK

1. PETER'S PLUMBING & HEATING LTD.
2. DO-ALL COMPANY OF CANADA LTD.
3. DUCHON BROS. SIGNS LTD.
4.
5. EAGLE DEVELOPMENT AND INVESTMENTS
   INDZEOSKI INDUSTRIES
   MELNYK BROS. LTD.
6. NALEWAY FOODS AND CATERERS
7. RADIO HOLDING CORPORATION LTD.
8. AUTOMATIC SPRINKLER CO. OF CANADA LTD.
   RODZEN CONSTRUCTION LTD.
9. STEINHAGEN VAULTS LTD.
10. GLOBE ENVELOPES WESTERN LTD.
11. HYDRO SITE
12. PARKE DAVIS AND CO. LTD.
13. LEAMINGTON TRANSPORT WESTERN LTD.
14. ABBOTT LABORATORIES LTD.
15. VICTORIA LEATHER
16. DISPRO DISPLAY PRODUCTS LTD.
17. TORONTO QUILTING & EMBROIDERY LIMITED
18. LONDON CONSTRUCTION CO.
    NORTHERN FRUIT DISTRIBUTORS LTD.
    MID-WEST TRUCK LINES LTD.
    CANDO SPORTSWEAR LIMITED
19. AETNA ROOFING
20. MANITOBA BEDDING COMPANY LIMITED

TABLE V (CONTINUED)

21. GAULTS LTD., GERHARD KENNEDY CANADA LTD.

22. HEYMANN & SCHMIDT MASONRY CONTRACTORS LTD.
SUPERIOR ENVELOPES LTD.
ESLTON INDUSTRIES LTD.
NATIONAL PAPER GOODS LIMITED

23.

24. MAN-MEN INDUSTRIES LTD.

25. STRONG-SCOTT LIMITED

26. VOLKSWAGEN CANADA LTD.

27. INKSTER AUTO BODY LTD.

28. INTER-COLLEGIATE PRESS OF CANADA LTD.

29. COCA-COLA LTD.

30. MACMILLAN, BLOEDEL (MANITOBA) LTD.
MACMILLAN, BLOEDEL PACKAGING LIMITED

31. WEIDMAN BROS.LTD.

32. DOMCOR ENTERPRISES LTD.

33. SELKIRK CABINET LTD.

34. PRUDENTIAL AUTOMOTIVE PRODUCTS LTD.

35. SMITH'S CORNED BEEF AND SAUSAGE MFG. CO. LTD.

36. CADORATH PLATING CO. LTD.

37. ARM. MASONRY CONSTRUCTION LTD.

38. GLESCO FURNITURE MANUFACTURING LTD.

39. STANDARD TUBE & T.I. LIMITED

40. J. R. WIRE AND METAL SPECIALTY LTD.

41. SWIFT ADHESIVES

42. REIMER EXPRESS

43. WINNIPEG PHOTO LTD.

TABLE V (CONTINUED)

44. ELECTROLIER CORPORATION

45. CENTURY CRAFT LIMITED
GEORGE D. SIMPSON MF. CO. LTD.
KILDONAN CANOE COMPANY

46. WESTERN TOOLS & INDUSTRIES LIMITED

47. FIRE HALL

48. NEPTUNE METERS LIMITED

49. GLOWA MILLWORK

50. ACME CHROME FURNITURE LTD.

51. GREB SHOES LIMITED

52. DOMINION TANNERS LIMITED

53.

54. DIAMOND METAL INDUSTRIES LTD.

55. EMILS TRANSPORT REFRIGERATION

56. CHRYSLER CANADA LTD.

57. EAGLE DEVELOPMENT AND INVESTMENTS
WONDER WHIP CANADA CO.
DAVIS CONTROLS

58. J. W. MILLS AND SON LTD.

59. CHAMPS FINE FOODS

60. W. G. MCMAHON LTD.

61. HARDING CARPETS LIMITED

62. NATIONAL PROMOTIONS LTD. & SYNDICATE PRODUCTS LTD.

63. INGRAM & BELL LIMITED

64.

65. CIBA COMPANY LIMITED

66. WOODS-DRYDEN PAPER BAGS LTD.

67. CONFEDERATION LIFE ASSOCIATION

TABLE V (CONTINUED)

68. SIMPSONS-SEARS LIMITED

69. LAKEVIEW DEVELOPMENT

70. DENTS FOODS PROCESSORS LTD.

71. MANITOBA TELEPHONE SYSTEM

72. MIDWEST STORAGE AND DISTRIBUTING

73. KIRK INVESTMENTS LTD.

74. CANFOR LIMITED

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*THE NUMBERS PRECEDING THE NAMES OF THE FIRMS INDICATE THE LOTS ON WHICH THE RESPECTIVE FIRMS ARE LOCATED. THE PLACEMENT OF THESE LOTS, IN THE INDUSTRIAL PARK ARE SHOWN ON MAP II, P. 89.

SENT THE ENTIRE INDUSTRIAL PARK, THE STUDY SAMPLE WILL BE CONSIDERED AS AN ISOLATED, DISTINCTIVE UNIT. FOR THE PURPOSE OF THIS STUDY, THE TERM "INKSTER INDUSTRIAL PARK" WILL ENCOMPASS ONLY THOSE EIGHTEEN FIRMS LISTED IN THE SAMPLE. IT IS REASONABLY ASSUMED THAT THE SAMPLE DOES REPRESENT THE ENTIRE INDUSTRIAL DISTRICT DESPITE THE LACK OF STATISTICAL VALIDATION.

IN TOTAL TWENTY-TWO FIRMS WERE DRAWN FROM THE EIGHTY-FOUR FIRM POPULATION. THE FOUR INDUSTRIES DRAWN AFTER NUMBER EIGHTEEN, WERE USED AS ALTERNATIVES IF PERMISSION FOR THE SURVEY WAS NOT GRANTED BY SOME INDIVIDUAL FIRMS. OF THE FIRST EIGHTEEN FIRMS SELECTED, ONLY TWO REFUSED THIS PERMISSION.

FOR EVERY INDIVIDUAL EMPLOYED BY EACH OF THE SAMPLE FIRMS, THEIR OCCUPATION (CLASSIFIED LATER INTO MANAGERIAL, CLERICAL OR LABOUR) AND THEIR CORRESPONDING PLACE OF RESIDENCE WAS OBTAINED.[1] THE OCCUPATIONAL SAMPLE SIZE CONSISTED OF 52 MANAGERS, 154 CLERKS OR OFFICE PERSONNEL AND, 676 LABOURERS. SEVERAL OF THE ADDRESSES OBTAINED FOR THE ORIGINAL LIST WERE RURAL. ON THE ASSUMPTION OF A CLOSED SYSTEM THIS GROUP (APPROXIMATELY 5% OF THE TOTAL) WAS OMITTED FROM THE FINAL SAMPLE. HENCE THE FINAL OCCUPATIONAL BREAKDOWN WAS 50 MANAGERS, 150 CLERKS, AND 633 LABOURERS. WITH THE OCCUPATION AND CORRESPONDING ADDRESS FOR EVERY WORKER KNOWN, THE INDIVIDUAL ADDRESSES WERE PLACED IN THEIR RESPECTIVE CENSUS TRACTS, BY OCCUPATIONAL TYPE. TABLE VI SHOWS THE FINAL SAMPLE SIZE BY CENSUS TRACT (AND UNORGANIZED

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[1] SOME OF THE FIRMS SURVEYED SHOWED RELUCTANCE TO RELEASE THE EXACT ADDRESSES OF THEIR EMPLOYEES. HENCE THE "NEAREST HUNDRED BLOCK" ADDRESS WAS OBTAINED. SEE APPENDIX B FOR OCCUPATIONAL CLASSIFICATION.

AREAS)[1] FOR THE THREE OCCUPATIONAL CLASSIFICATIONS.

SINCE THE INFORMATION REQUIRED BY THE SAMPLING PROCEDURE WAS UNIQUE, THE SAMPLE COULD NOT BE COMPARED TO A LARGER POPULATION SIZE TO ESTABLISH ITS ACCURACY IN REPRESENTING WORK TRIP ORIGIN BEHAVIOR BY OCCUPATION. THIS ACCURACY WAS ASSUMED AS PREVIOUSLY MENTIONED, AND TABLE VI LISTS THE EMPIRICAL RESULTS ON WHICH THE VALIDITY OF THE MODEL WAS ESTABLISHED.

E) CALCULATIONS

ALL ROADS USED TO ANY NOTICEABLE EXTENT BY THROUGH TRAFFIC ARE INCORPORATED INTO THE ROAD NETWORK WHICH FORMS THE "VEHICULAR GRID" USED IN ANALYSIS. THE TRANSPORTATION FACILITIES WHICH FORM THIS GRID ARE REPRESENTED BY A SYSTEM OF LINKS AND NODES WHERE A LINK IS THE TRAVEL PATH BETWEEN TWO ADJACENT NODES AND A NODE IS A POINT AT WHICH LINKS INTERSECT. ACCORDING TO THE WINNIPEG AREA TRANSPORTATION STUDY, WINNIPEG CONSISTS OF 807 LINKS AND 547 NODES[2].

SINCE THE PURPOSE OF THIS SECTION IS TO DETERMINE WORK TRIP ORIGINS, THE 9 A.M. PEAK HOUR TRAFFIC WAS USED AS THE VOLUME ASSIGNED TO THE ROAD NETWORK.[3] THIS ASSIGNMENT FACILITATED BY THE USE OF THE

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[1] MOST OF THE OUTLYING MUNICIPALITIES IN GREATER WINNIPEG, THOUGH SITUATED WITHIN THE LIMITS OF THE STUDY, WERE NOT COVERED BY REGULAR TRACT NUMBERS. THESE HAVE BEEN INCLUDED AS "UNORGANIZED" AREAS.

[2] SEE APPENDIX A FOR DETAILS OF SPEED-VOLUME ASSIGNMENT TO ROAD NETWORK. ALSO SEE W.A.T.S., OP. CIT., PP. 8-13.

[3] ALL TRANSPORTATION DATA USED IN THIS STUDY WERE TAKEN FROM W.A.T.S. THE METHOD OF TRAFFIC ASSIGNMENT EMPLOYED BY W.A.T.S. IS THE CAPACITY RESTRAINT TECHNIQUE. ACCORDINGLY, ALL TRAVEL TIME VALUES ASSIGNED TO LINKS INVOLVE CONGESTION AT THE MORNING PEAK HOUR. IBID., PP. 52-55.

TABLE VI

DISTRIBUTION OF OCCUPATIONAL TYPES BY CENSUS TRACT AND UNORGANIZED AREAS (SAMPLE FINDINGS)

TRACT NUMBER	MANAGERIAL	CLERICAL	LABOUR
1	1	9	44
2	1	4	14
3	0	7	14
4	0	0	14
5	0	1	21
6	0	4	23
7	0	0	22
8	0	4	14
9	0	1	19
10	0	0	12
11	0	0	1
12	0	0	6
13	0	2	10
14	0	2	7
15	0	3	3
16	0	0	10
17	0	0	2
18	0	0	1
19	0	0	9
20	0	3	1
21	0	4	13
22	0	0	6

TABLE VI (CONTINUED)

TRACT NUMBER	MANAGERIAL	CLERICAL	LABOUR
23	0	0	8
24	0	1	3
25	0	4	21
26	0	3	3
27	1	0	5
28	0	1	7
29	0	0	3
30	0	0	7
31	0	1	8
32	0	1	18
33	0	1	13
34	0	0	5
35	0	0	11
36	0	1	2
37	2	3	2
38	2	2	5
39	0	3	1
40	0	1	9
41	0	2	3
42	0	2	0
43	2	3	5
44	1	1	4
45	0	0	0
46	1	1	2
47	0	0	1

TABLE VI (CONTINUED)

TRACT NUMBER	MANAGERIAL	CLERICAL	LABOUR
48	2	1	0
49	0	1	5
50	0	1	6
51	0	0	6
52	0	1	6
53	0	0	4
54	0	3	5
55	0	0	0
56	0	1	2
57	0	0	0
58	2	0	1
59	0	0	6
60	2	6	4
61	0	1	4
62	1	1	0
63	0	0	0
64	0	2	1
65	0	1	4
66	0	2	3
67	1	1	13
68	0	1	4
69	0	4	2
70	1	6	13
71	0	1	1

TABLE VI (CONTINUED)

TRACT NUMBER	MANAGERIAL	CLERICAL	LABOUR
72	6	7	15
73	5	13	43
74	0	0	8
75	0	1	5
76	0	0	0
77	0	0	1
78	0	0	2
79	0	0	1
80	1	0	0
81	7	4	5
82	0	1	0
83	0	1	4
84	0	1	5
85	1	1	6
86	0	3	12
TA	0	1	0
TB	0	1	3
TC	8	3	11
TD	0	0	1
TE	1	0	2
TF	3	4	7
TG	0	0	0
GRAND TOTAL	50	150	633

COMPUTER[1] YIELDED A SERIES OF TRAVEL TIMES (SKIM TREE IMPEDANCES) BETWEEN ALL OF THE 124 TRANSFER NODES IN THE SYSTEM. THESE TRANSFER NODES CORRESPOND TO TRAFFIC DISTRICTS, DEFINED BY W.A.T.S. AND SHOWN ON MAP III.

CENTROID 114 CORRESPONDS TO THE LOCATION OF INKSTER INDUSTRIAL PARK. THE TRAVEL TIMES FROM ALL TRANSFER NODES IN THE ROAD NETWORK TO CENTROID 114 WERE OBTAINED. (SEE TABLE VII). THIS GAVE THE TIME A COMMUTER WOULD ABSORB DRIVING FROM ANY GIVEN TRANSFER NODE IN THE CITY TO INKSTER PARK DURING 9:00 A.M. PEAK HOUR CONGESTION. THE TRAVEL TIMES WERE GROUPED AT FIVE MINUTE INTERVALS AND POINTS OF EQUAL TIME (TO THE NEAREST FIVE MINUTES) FROM CENTROID 114 WERE CONNECTED. THE RESULT IS MAP IV.

HAVING DETERMINED THE FIVE MINUTE TIME INTERVALS (ALSO CALLED TIME CODES) FOR THE ENTIRE URBAN AREA, THE INDIVIDUAL CENSUS TRACTS AND UNORGANIZED DISTRICTS WERE ASSIGNED TO THEIR CORRESPONDING TIME CODES. THE PATTERN OF CENSUS TRACTS AND UNORGANIZED AREAS FOR WINNIPEG IS SHOWN IN MAP V. THE SMALL CIRCLE WITHIN EACH TRACT AREA DEFINES THE CENTER OF RESIDENTIAL DEVELOPMENT IN THAT TRACT. THE SPREAD OF RESIDENTIAL DEVELOPMENT FOR WINNIPEG IS SHOWN ON MAP VI. FOR WELL DEVELOPED AREAS NEAR THE URBAN CENTER, THE DEVELOPMENT CENTROID CORRESPONDS TO THE GEOMETRIC CENTROID. THE CENTROID OF EACH RESIDENTIAL DISTRICT WAS PLACED IN THE CORRESPONDING TIME CODE BY SUPERIMPOSING MAP IV ON MAP V. EACH TRACT WAS THEREFORE ESTABLISHED AT SOME TIME

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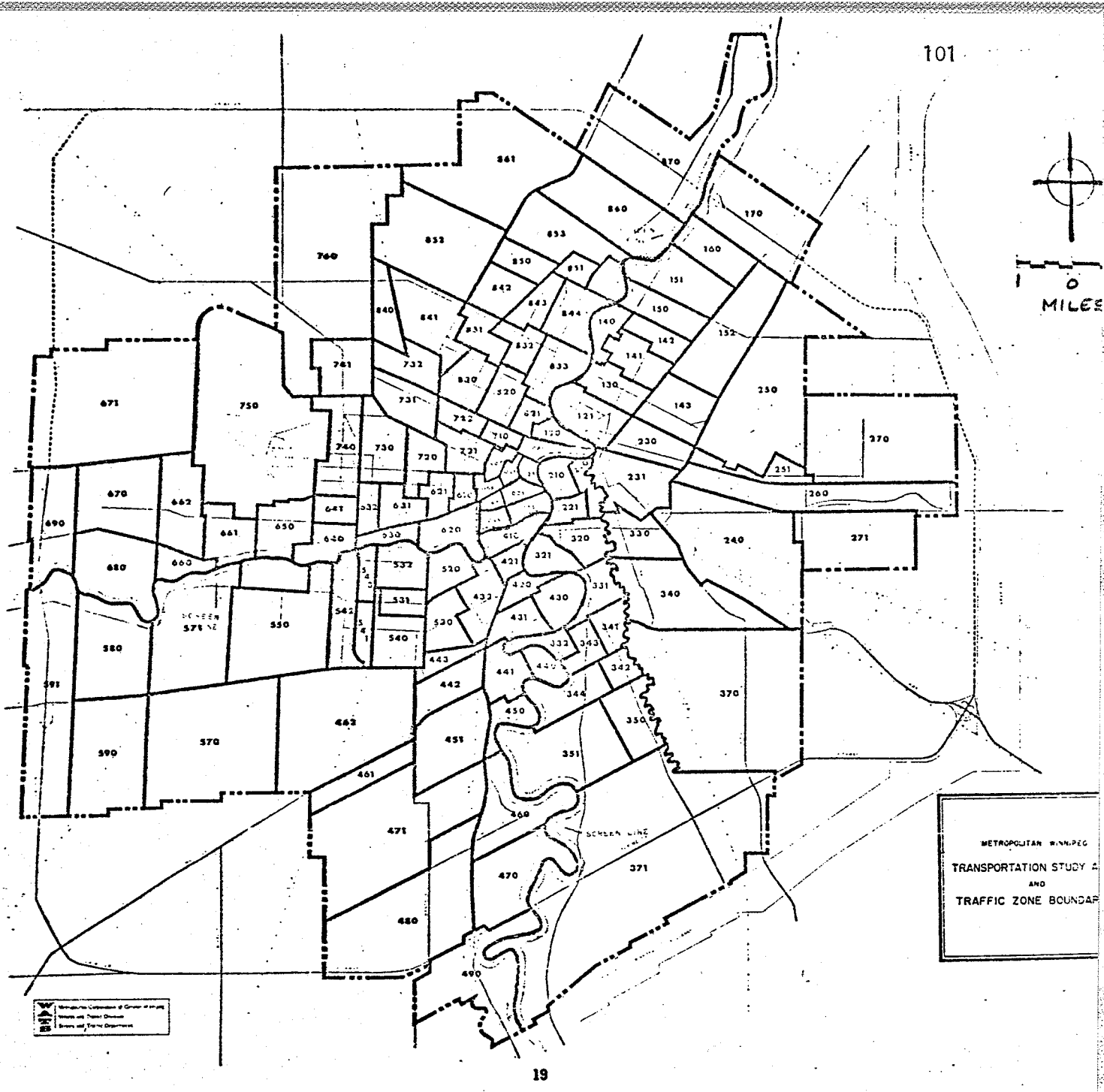
[1]THE PROGRAM WAS WRITTEN BY D.A.MOIR A RESEARCHER WITH THE CENTER FOR TRANSPORTATION STUDIES AT THE UNIVERSITY OF MANITOBA, USING DATA FROM W.A.T.S.



MAP III. Traffic zone boundaries for the Greater Winnipeg Area.

INKSTER INDUSTRIAL PARK CASE STUDY

F. F. Saccomanno May 1972

TABLE VII

TRAVEL TIMES FROM ORIGIN CENTROIDS
TO DESTINATION POINT

Unordered Origin Centroid		Ordered Origin Centroid		
Number	Time (Min.)	Number	Time (Min.)	
001	13	114	0	
002	13	110	3	
003	6	120	4	5
004	14	109	5	
005	16	115	5	
006	15	102	6	
007	12	111	6	
008	13	113	6	
009	11	118	6	
010	11	99	7	
011	12	107	7	
012	13	112	7	
013	15	116	7	17
014	16	123	7	
015	16	101	8	
016	17	104	8	
017	18	117	8	
018	18	121	8	
019	20	106	9	
020	21	108	9	

TABLE VII (CONTINUED)

Unordered Origin Centroid		Ordered Origin Centroid	
Number	Time (Min.)	Number	Time (Min.)
021	21	096	10
022	18	098	10
023	18	009	11
024	18	010	11
025	16	097	11
026	17	119	11
027	20	007	12
028	24	011	12
029	20	100	12
030	25	001	13
031	25	002	13
032	25	008	13
033	20	012	13
034	20	080	13
035	20	082	13
036	22	122	13
037	24	124	13
038	23	004	14
039	23	103	14
040	25	006	15
141	24	013	15
042	27	081	15

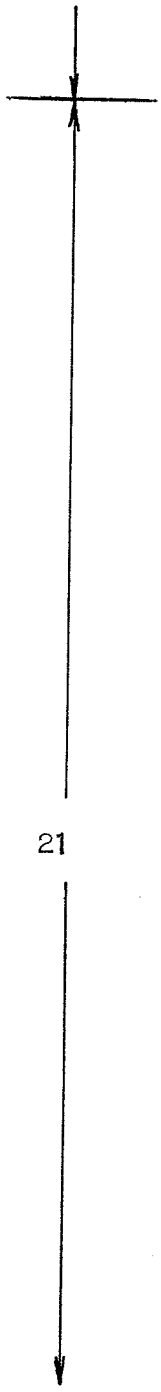


TABLE VII (CONTINUED)

Unordered Origin Centroid		Ordered Origin Centroid		
Number	Time (Min.)	Number	Time (Min.)	
043	27	084	15	
044	29	003	16	
045	25	005	16	
046	18	014	16	
047	18	015	16	
048	21	025	16	
049	18	083	16	
050	23	085	16	
051	22	016	17	
052	20	026	17	
053	25	087	17	29
054	23	017	18	
055	25	018	18	
056	24	022	18	
057	26	023	18	
058	26	024	18	
059	31	047	18	
060	28	049	18	
061	29	105	18	
062	32	066	19	
063	30	086	19	
064	32	019	20	

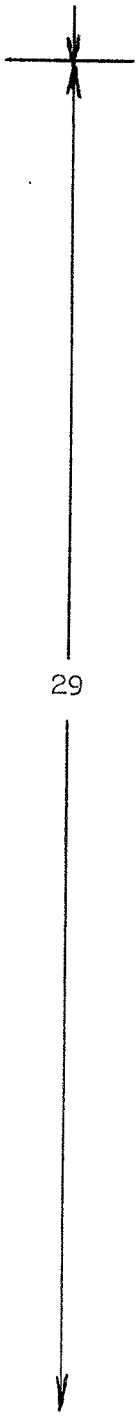


TABLE VII (CONTINUED)

Unordered Origin Centroid		Ordered Origin Centroid	
Number	Time (Min.)	Number	Time (Min.)
065	35	027	20
066	19	029	20
067	21	033	20
068	22	034	20
069	20	035	20
070	24	052	20
071	23	069	20
072	22	088	20
073	21	020	21
074	23	021	21
075	27	067	21
076	27	073	21
077	31	048	21
078	31	036	22
079	32	051	22
080	13	068	22
081	15	072	22
082	13	038	23
083	16	039	23
084	15	050	23
085	15	054	23
086	19	071	23
087	17	074	23

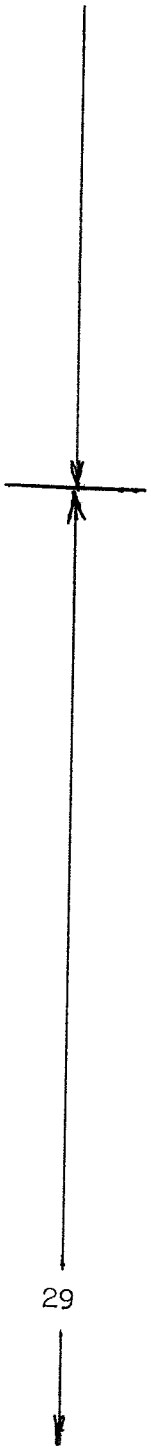


TABLE VII (CONTINUED)

Unordered Origin Centroid		Ordered Origin Centroid	
Number	Time (Min.)	Number	Time (Min.)
088	20	090	23
089	27	028	24
090	23	037	24
091	25	041	24
092	27	056	24
093	31	070	24
094	28	030	25
095	31	031	25
096	10	032	25
097	11	040	25
098	10	045	25
099	7	053	25
100	12	055	25
101	8	091	25
102	6	057	26
103	14	058	26
104	8	042	27
105	18	043	27
106	9	075	27
107	7	076	27
108	9	089	27
109	5	092	27
110	3	060	28

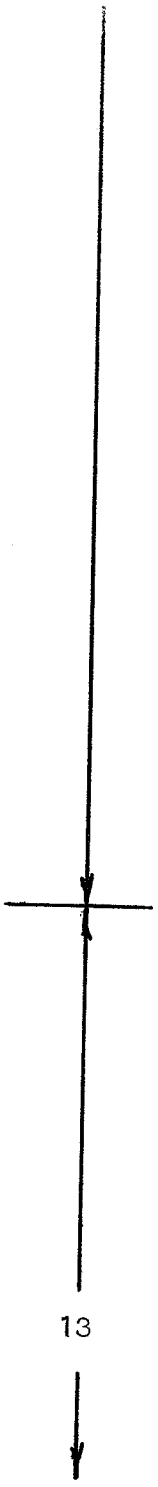
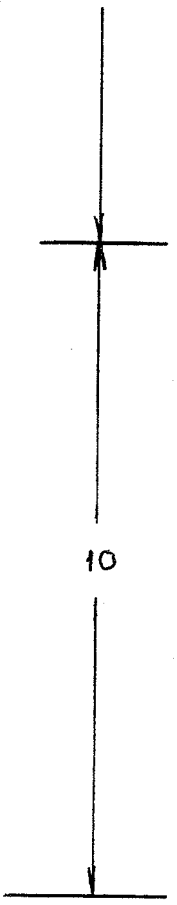


TABLE VII (CONTINUED)

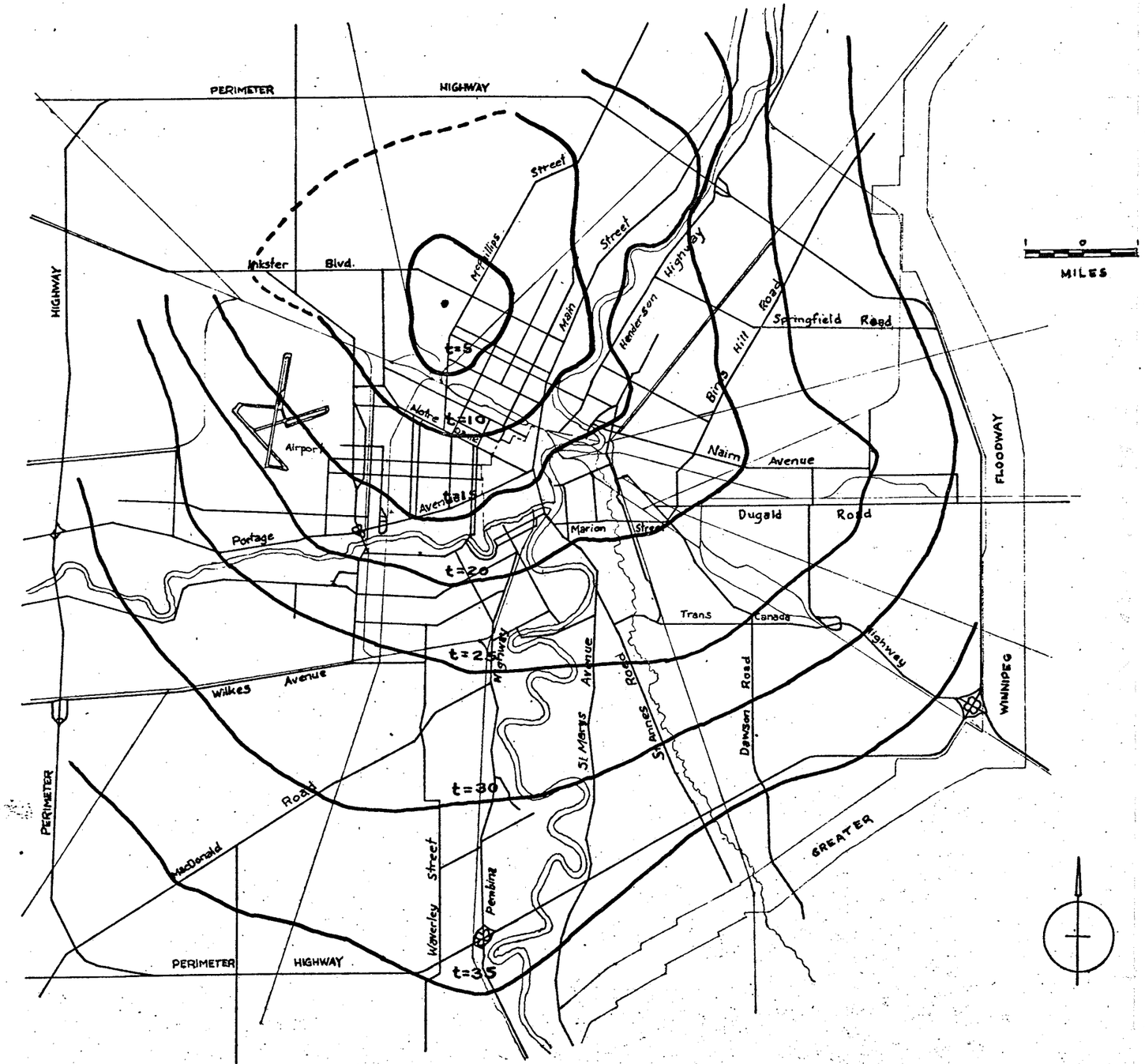
Unordered Origin Centroid		Ordered Origin Centroid	
Number	Time (Min.)	Number	Time (Min.)
111	6	094	28
112	7	044	29
113	66	061	29
114	0	063	30
115	5	046	31
116	7	059	31
117	8	077	31
118	6	078	31
119	11	093	31
120	4	095	31
121	8	062	32
122	13	064	32
123	7	079	32
124	13	065	35



Destination Centroid 114*

Destination Traffic 841

SOURCE: Winnipeg Area Transportation Study



0 MILES

Legend

Calculated Travel Time Isolines

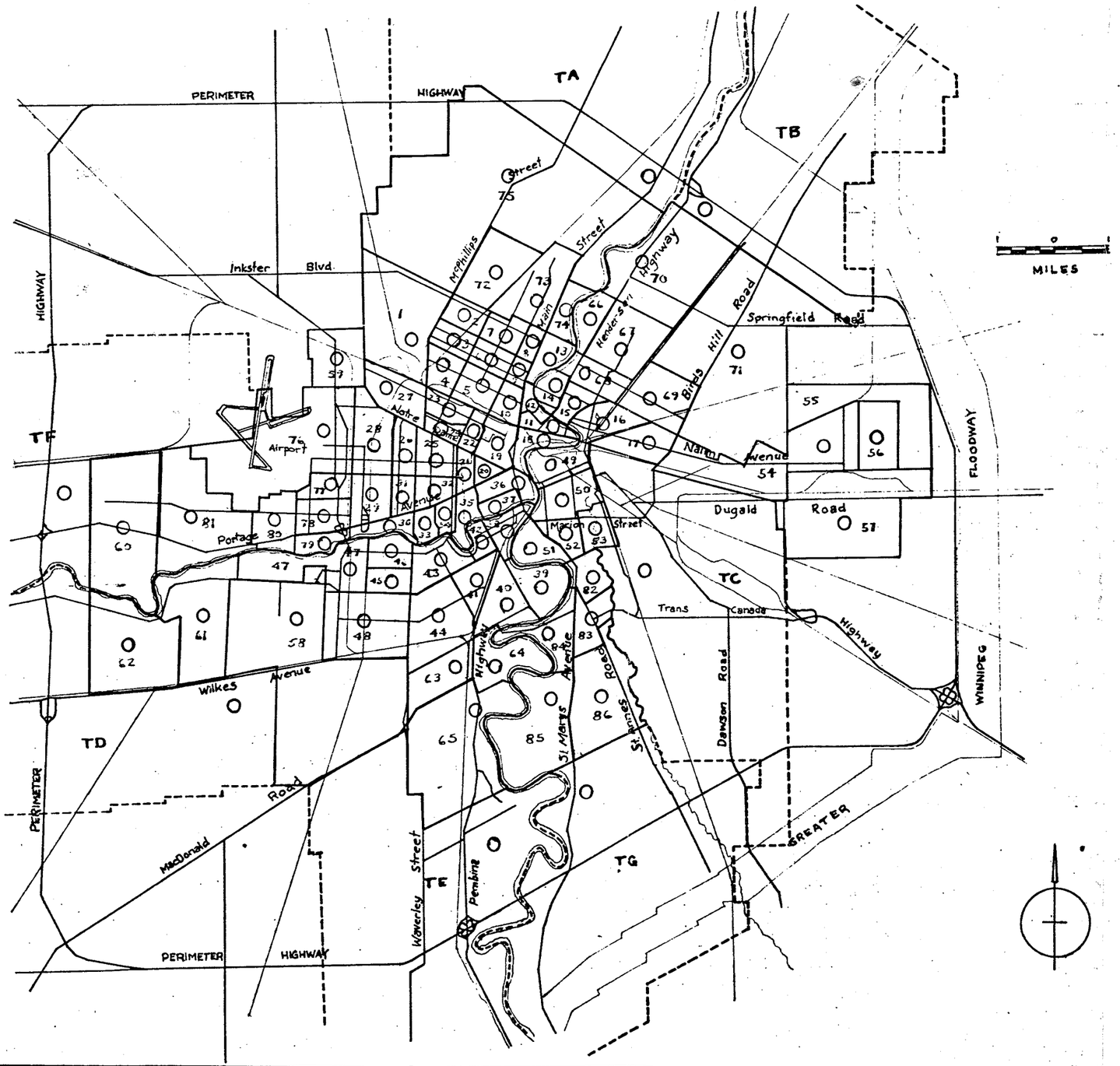
Assumed Travel Time Isolines

Map IV. TRAVEL TIME ISOLINES FROM INKSTER PARK (in minutes)

INKSTER INDUSTRIAL PARK CASE STUDY

F. F. Saccomanno

May 1972



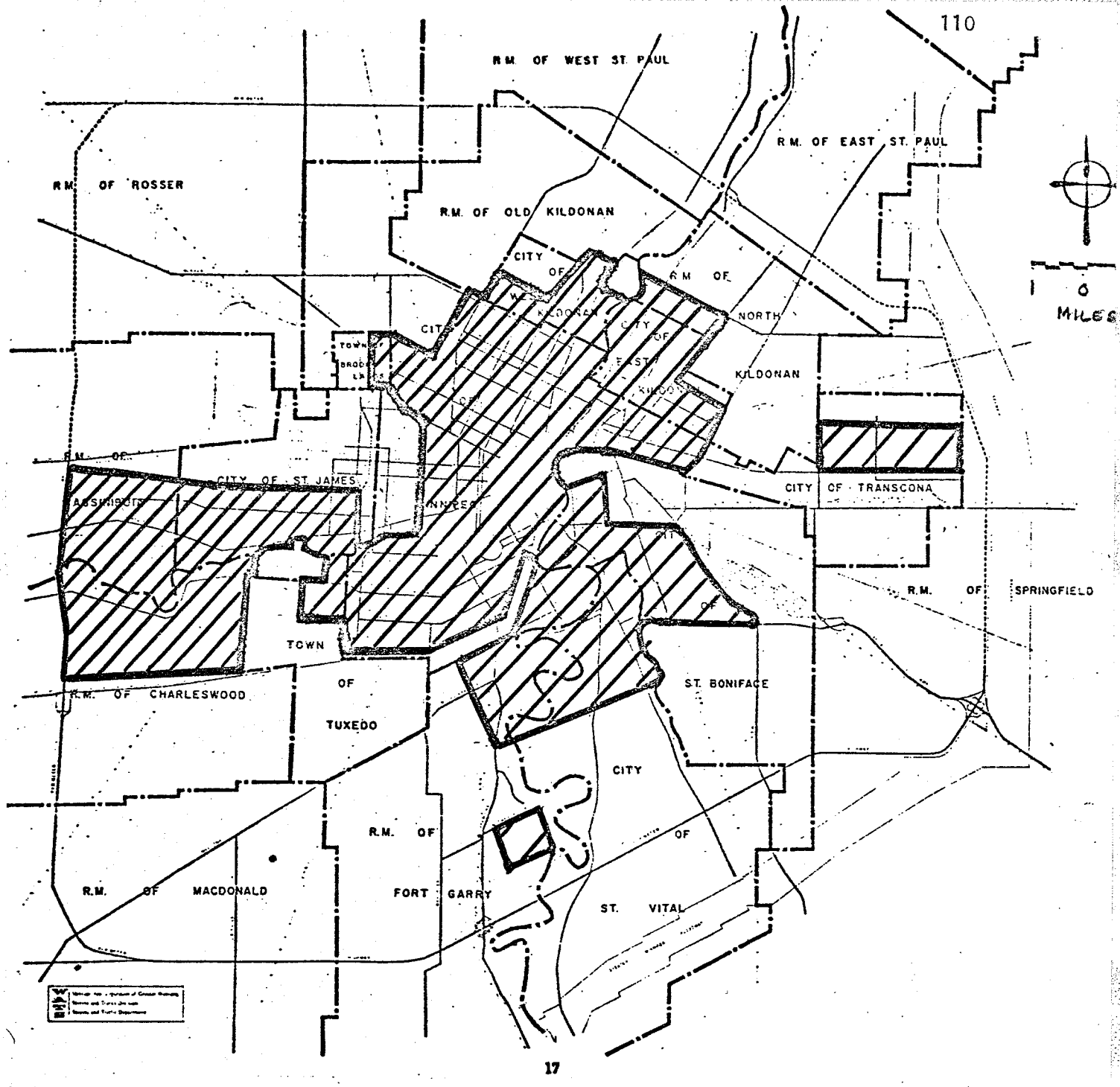
Legend

- O — Origin District Residential Centroid
- ——— Census Tract Boundary
- - - - Unorganized District Boundary

Map V. WORK TRIP ORIGIN DISTRICTS

INKSTER INDUSTRIAL PARK CASE STUDY

F. F. Saccomanno — May 1972



MAP VI. Extent of residential development in Greater Winnipeg, 1966.

INKSTER INDUSTRIAL PARK CASE STUDY

F. F. Saccomanno May 1972

INTERVAL FROM THE PARK. TABLE VIII INDICATES THIS FOR THE EIGHTY-SIX CENSUS TRACTS AND THE SEVEN UNORGANIZED DISTRICTS.

THE TIME CODE SUBPOPULATION (H) COULD NOW BE CALCULATED BY OCCUPATION. THE OCCUPATIONAL POPULATIONS (T) IN EACH OF THE EIGHTY-SIX CENSUS TRACTS AND SEVEN UNORGANIZED DISTRICTS WERE SUBSEQUENTLY OBTAINED. THE OCCUPATIONAL GROUP BREAKDOWN BY CENSUS TRACT AND UNORGANIZED DISTRICT, (TI) IS LISTED IN TABLE IX A AND B USING EQUATION 4c) ON PAGE 79.[1]

$$P_I = \frac{T_I/H_I}{M - \sum_{M=2}^{M} \frac{H_{M-1}}{H_M}}$$

WHERE $M = 7$

AND $I = 1$ TO 93 $(86 + 7 = 93)$

THE FINAL PROBABILITY RATIOS WERE CALCULATED FOR EACH TRACT, FOR EACH OCCUPATIONAL GROUP. THE RESULTS ARE SHOWN IN TABLES X, XI AND XII.

THE MONTE CARLO METHOD OF ASSIGNING WORK TRIP ORIGINS TO SPECIFIC CENSUS TRACTS AND SUBSEQUENTLY TO TIME CODES IS ACCOMPLISHED BY USE OF A COMPUTER PROGRAM, INCLUDED IN APPENDIX C. FOR LABOUR 633 RANDOM NUMBERS WERE GENERATED AND MATCHED WITH THE ACCUMULATIVE PROBABILITIES OF EACH CENSUS TRACT, (SIMILARLY, FOR CLERKS AND MANAGERS, ONE HUNDRED AND FIFTY ASSIGNMENTS AND FIFTY ASSIGNMENTS, RESPECTIVELY. APPENDIX C ALSO INCLUDES A SAMPLE OUTPUT FOR THE MANAGERIAL GROUP. THE ASSIGNED WORK TRIP ORIGINS WERE SUMMED FOR EACH TIME CODE FOR THE THREE OCCUPATIONAL GROUPS. THIS GAVE THE PREDICTED NUMBER OF WORKERS WHO RESIDE AT A GIVEN TIME DISTANCE FROM THE INDUSTRIAL SITE. THE LAST COLUMN OF TABLES X, XI AND XII LISTS THESE FIGURES.

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[1] THE DATA OF TABLE IX A AND B ARE OBTAINED FROM THE CENSUS OF CANADA 1961, OP. CIT.

TABLE VIII

TRAVEL TIME INTERVAL CATEGORY FOR
CENSUS DISTRICTS OF ORIGIN

Tract Number In Interval 0 - 5	Tract Number In Interval 5 - 10	Tract Number In Interval 10 - 15	Tract Number In Interval 15 - 20	Tract Number In Interval 20 - 25	Tract Number In Interval 25 - 30	Tract Number In Interval 30 - 35
1	5	11	16	39	55	62
2	6	12	17	40	56	
3	7	14	30	41	57	
4	8	15	33	44	58	TE
	9	18	34	45	60	Fort Garry
	10	19	35	47	61	
	13	20	36	48	64	TF
	22	21	37	51	65	Assiniboia
	23	25	38	54	85	
	24	26	42	63	86	TG
	27	28	43	71		St. Vital
	59	29	46	80		
	72	31	49	81	TD	
	73	32	50	83		
	74	68	52	84	Charleswood	
	75	76	53			
			66	TB		
			67	East St. Paul		
			69			
			70	TC		
			77	St. Boniface		
			78			
			79			
			TA			
			West St. Paul			

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TABLE IX A

OCCUPATION GROUP BREAKDOWN BY CENSUS TRACT AND UNORGANIZED AREA (CENSUS TRACTS)

NAME	TRACT NUMBER	MANAGEMENT	CLERICAL	LABOUR	TOTAL
WINNIPEG CITY	1	146	500	966	1,612
	2	150	379	615	1,144
	3	105	540	1,200	1,845
	4	40	211	621	872
	5	102	350	1,510	1,962
	6	184	626	1,701	2,511
	7	229	513	1,011	1,753
	8	131	300	437	868
	9	115	338	769	1,222
	10	73	186	1,073	1,332
	11	26	70	357	453
	12	30	156	857	1,043
	13	271	443	687	1,401
	14	97	306	418	821
	15	81	390	694	1,165
	16	107	419	870	1,396
	17	133	359	546	1,038
	18	24	51	268	343
	19	76	194	1,044	1,314
	20	65	442	627	1,134
	21	106	767	1,412	2,285
	22	43	197	929	1,169

TABLE IX A (CONTINUED)

NAME	TRACT NUMBER	MANAGEMENT	CLERICAL	LABOUR	TOTAL
WINNIPEG CITY	23	17	83	360	460
	24	62	322	552	936
	25	254	1,333	2,114	3,701
	26	168	522	552	1,242
	27	146	751	1,203	2,100
	28	132	317	348	797
	29	133	458	471	1,062
	30	140	446	533	1,119
	31	135	455	369	959
	32	139	928	1,317	2,384
	33	150	783	815	1,748
	34	78	548	676	1,302
	35	239	1,428	1,003	2,670
	36	32	168	203	403
	37	175	920	356	1,451
	38	242	740	489	1,471
	39	283	514	424	1,221
	40	191	680	834	1,705
	41	185	761	1,048	1,994
	42	180	572	425	1,177
	43	552	656	380	1,588
	44	315	375	607	1,497
	45	447	251	88	786
	46	399	231	110	740

TABLE IX A (CONTINUED)

NAME	TRACT NUMBER	MANAGEMENT	CLERICAL	LABOUR	TOTAL
WINNIPEG CITY	47	290	368	194	852
	48	1,086	546	220	1,852
ST. BONIFACE	49	88	339	563	990
	50	129	578	861	1,568
	51	302	496	329	1,127
	52	175	547	584	1,306
	53	115	371	652	1,138
TRANSCONA	54	157	665	1,247	2,069
	55	FIGURES NOT AVAILABLE			
	56	75	320	622	1,017
	57	5	20	91	116
TUXEDO	58	224	44	39	307
BROOKLANDS	59	54	198	700	952
ASSINIBOIA	60	124	161	349	634
CHARLESWOOD	61	109	189	261	559
	62	101	163	257	521
FORT GARRY	63	70	173	265	508
	64	407	338	201	946
	65	359	369	521	1,249
EAST KILDONAN	66	308	332	298	938

TABLE IX A (CONTINUED)

NAME	TRACT NUMBER	MANAGEMENT	CLERICAL	LABOUR	TOTAL
EAST KILDONAN	67	432	1,059	1,330	2,821
	68	166	439	726	1,331
	69	171	506	741	1,418
NORTH KILDONAN	70	232	476	1,199	1,907
	71	9	16	92	117
WEST KILDONAN	72	385	270	367	1,022
	73	559	845	1,333	2,737
	74	209	355	440	1,004
OLD KILDONAN	75	16	65	154	235
ST. JAMES	76	5	16	15	36
	77	27	105	164	296
	78	185	752	876	1,813
	79	141	271	139	551
	80	358	653	371	1,382
	81	943	758	564	2,265
ST. VITAL	82	130	416	516	1,062
	83	128	374	158	660
	84	295	470	231	996
	85	157	269	400	826
	86	208	605	969	1,782
CENSUS TRACT SUBTOTAL		16,062	37,116	52,928	106,106

TABLE IX B

OCCUPATION GROUP BREAKDOWN BY CENSUS TRACT AND UNORGANIZED AREA (UNORGANIZED DISTRICTS)

NAME	TRACT NUMBER	MANAGEMENT	CLERICAL	LABOUR	TOTAL
EAST ST. PAUL	TA	56	118	234	408
WEST ST. PAUL	TB	53	100	217	370
OLD KILDONAN		16	65	154	235
ST. BONIFACE		1,333	3,001	3,793	8,127
UNORGANIZED	TC	524	670	804	1,998
TRANSCONA		238	1,008	1,997	3,223
UNORGANIZED		1	3	17	-
ASSINIBOIA		152	221	527	900
UNORGANIZED	TF	28	60	178	266
CHARLESWOOD		225	375	572	1,172
UNORGANIZED	TD	15	23	54	92
FORT GARRY		887	986	1,332	3,205
UNORGANIZED	TE	51	106	345	502
EAST KILDONAN		1,077	2,333	3,095	6,505
UNORGANIZED		0	3	0	3
NORTH KILDONAN		241	492	1,291	2,024
UNORGANIZED		0	0	0	0
WEST KILDONAN		1,153	1,470	2,140	4,763
UNORGANIZED		0	0	0	0
ST. JAMES		1,659	2,555	2,129	6,343
UNORGANIZED		0	0	0	0
ST. VITAL		946	2,266	2,744	5,956
UNORGANIZED		28	132	470	630
UNORGANIZED SUB-TOTAL		755	1,209	2,302	4,266
GRAND TOTAL		16,817	38,325	55,230	110,372

TABLE X

CALCULATION OF WORKTRIP ORIGINS
FOR MANAGEMENT

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Number of Workers
1	146	0- 5	441	.33107	.10362	7
2	150	0- 5	441	.34014	.10646	4
3	105	0- 5	441	.23810	.07452	5
4	40	0- 5	441	.10431	.03265	1
					Σ 20.31725	17
5	102	5-10	3,037	.03359	.01051	0
6	184	5-10	3,037	.06059	.01896	1
7	229	5-10	3,037	.07540	.02360	1
8	131	5-10	3,037	.04313	.01350	1
9	115	5-10	3,037	.03787	.01185	0
10	73	5-10	3,037	.02404	.00752	0
13	271	5-10	3,037	.08923	.02793	1

TABLE X (CONTINUED)

TRACT NUMBER	TRACT POPULATION TI	TIME INTERVAL	HI	TI/HI	P(TI/HI) / ΣP(TI/HI)	NUMBER OF WORKERS
22	43	5-10	3,037	.01416	.00443	0
23	17	5-10	3,037	.00560	.00175	0
24	62	5-10	3,037	.02041	.00639	0
27	146	5-10	3,037	.04807	.01505	1
59	54	5-10	3,037	.01778	.00556	0
72	385	5-10	3,037	.12677	.03968	2
73	559	5-10	3,037	.18406	.05761	6
74	209	5-10	3,037	.06882	.02154	0
75	16	5-10	3,037	.00527	.00165	0
					Σ 0.26753	13
11	26	10-15	4,674	.00556	.00174	0
12	30	10-15	4,674	.00642	.00201	1
14	97	10-15	4,674	.02075	.00649	0

TABLE X (CONTINUED)

TRACT NUMBER	TRACT POPULATION T_i	TIME INTERVAL	H_i	T_i/H_i	$P(T_i/H_i) / \leq P(T_i/H_i)$	NUMBER OF WORKERS
15	81	10-15	4,674	.01733	.00542	0
18	24	10-15	4,674	.00513	.00161	0
19	76	10-15	4,674	.01626	.00509	0
20	65	10-15	4,674	.01391	.00435	0
21	106	10-15	4,674	.02268	.00710	0
25	254	10-15	4,674	.05434	.01701	1
26	168	10-15	4,674	.03594	.01125	2
28	132	10-15	4,674	.02824	.00884	1
29	133	10-15	4,674	.02846	.00891	1
31	135	10-15	4,674	.02888	.00904	0
32	139	10-15	4,674	.02974	.00931	1
68	166	10-15	4,674	.03552	.01112	0
76	5	10-15	4,674	.00107	.00033	0
					Σ 0.10962	7

TABLE X (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\Sigma P(Ti/Hi)}$	Number of Workers
16	107	15–20	9,157	.01169	.00366	0
17	133	15–20	9,157	.01452	.00454	0
30	140	15–20	9,157	.01529	.00479	0
33	150	15–20	9,157	.01638	.00513	1
34	78	15–20	9,157	.00852	.00267	0
35	239	15–20	9,157	.02610	.00817	0
36	32	15–20	9,157	.00349	.00109	0
37	175	15–20	9,157	.02643	.00827	0
42	180	15–20	9,157	.01966	.00615	1
43	552	15–20	9,157	.06028	.01887	1
46	399	15–20	9,157	.04357	.01364	1
49	88	15–20	9,157	.00961	.00301	0
50	129	15–20	9,157	.01409	.00410	0

TABLE X (CONTINUED)

TRACT NUMBER	TRACT POPULATION Ti	TIME INTERVAL	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	NUMBER OF WORKERS
52	175	15–20	9,157	.01911	.00598	1
53	115	15–20	9,157	.01256	.00393	1
66	308	15–20	9,157	.03364	.01053	0
67	432	15–20	9,157	.04718	.01477	0
69	171	15–20	9,157	.01867	.00584	0
70	232	15–20	9,157	.02534	.00793	0
77	27	15–20	9,157	.00295	.00092	0
78	185	15–20	9,157	.02020	.00632	0
79	141	15–20	9,157	.01540	.00482	0
TA	53	15–20	9,157	.00579	.00181	0
					Σ 0.15292	6
39	283	20–25	14,926	.01896	.00593	1
40	191	20–25	14,926	.01280	.00401	1

TABLE X (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\Sigma P(Ti/Hi)}$	Number of Workers
41	185	20-25	14,926	.01239	.00388	0
44	315	20-25	14,926	.02110	.00660	0
45	447	20-25	14,926	.02995	.00937	0
47	290	20-25	14,926	.01943	.00608	0
48	1,086	20-25	14,926	.07276	.02277	2
51	302	20-25	14,926	.02023	.00633	0
54	157	20-25	14,926	.01052	.00329	0
63	70	20-25	14,926	.00469	.00147	0
71	9	20-25	14,926	.00060	.00019	0
80	358	20-25	14,926	.02398	.00751	0
81	943	20-25	14,926	.06318	.01977	1
82	130	20-25	14,926	.00871	.00273	0
83	128	20-25	14,926	.00858	.00269	0
84	295	20-25	14,926	.01976	.00618	0

TABLE X (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\Sigma P(Ti/Hi)}$	Number of Workers
TB	56	20–25	14,926	.00375	.00117	0
TC	524	20–25	14,926	.03511	.01099	0
					Σ 0.12096	5
55	-	25–30	16,609	-	-	0
56	75	25–30	16,609	.00452	.00141	0
57	5	25–30	16,609	.00030	.00094	0
58	224	25–30	16,609	.01369	.00422	0
60	124	25–30	16,609	.00747	.00234	0
61	109	25–30	16,609	.00656	.00205	0
64	407	25–30	16,609	.02450	.00767	1
65	359	25–30	16,609	.02161	.00676	0
85	157	25–30	16,609	.00945	.00296	0
86	208	25–30	16,609	.01252	.00392	0

TABLE X (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Number of Workers
TD	15	25–30	16,609	.00090	.00028	0
					Σ 0.03255	1
62	101	30–35	16,817	.00601	.00188	1
TE	51	30–35	16,817	.00303	.00095	0
TF	28	30–35	16,817	.00166	.00052	0
TG	28	30–35	16,817	.00166	.00052	0
					Σ 0.00387	1

Total Expected = 1.0000

Total Obtained = 1.0047

Error -0.0047

$$P(Ti/Hi) = \frac{Ti}{Hi}$$

$$Pi(T/H) = M - \sum_{M=2}^{M=M} \frac{H_{M-1}}{H_M} = 7.000 - \left[\frac{H1}{H2} + \frac{H2}{H3} + \frac{H3}{H4} + \frac{H4}{H5} + \frac{H5}{H6} + \frac{H6}{H7}\right]$$

$$Pi(T) = 7.000 - \left[\frac{441}{3,037} + \frac{3,037}{4,674} + \frac{4,674}{9,157} + \frac{9,157}{14,926} + \frac{14,926}{16,609} + \frac{16,609}{16,817}\right]$$

$$= 7.000 - [.145 + .650 + .510 + .613 + .899 + .988]$$

$$= 7.000 - 3.805 = 3.195$$

TABLE XI

CALCULATION OF WORKTRIP ORIGINS
FOR CLERKS

Tract Number	Tract Population T_i	Time Interval	H_i	T_i/H_i	$P(T_i/H_i) / \Sigma P(T_i/H_i)$	Adjusted Number of Workers
1	500	0- 5	1,630	0.30675	.10081	15
2	379	0- 5	1,630	.23252	.07641	13
3	540	0- 5	1,630	.33129	.10887	14
4	211	0- 5	1,630	.12945	.04254	7
					Σ 0.32863	49
5	350	5-10	7,472	.04684	.01539	1
6	626	5-10	7,472	.08378	.02753	2
7	513	5-10	7,472	.05866	.02018	5
8	300	5-10	7,472	.04015	.01319	0
9	338	5-10	7,472	.04524	.01487	4
10	186	5-10	7,472	.02489	.00818	1
13	443	5-10	7,472	.05929	.01948	3
22	197	5-10	7,472	.02637	.00807	1

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
23	83	5–10	7,472	.01111	.00365	0
24	322	5–10	7,472	.04309	.01266	4
27	751	5–10	7,472	.10051	.03303	5
59	198	5–10	7,472	.02650	.00871	2
72	270	5–10	7,472	.03613	.01187	0
73	845	5–10	7,472	.11309	.03716	6
74	355	5–10	7,472	.04751	.01561	3
75	65	5–10	7,472	.00870	.00286	0
					Σ 0.25304	37
11	70	10–15	14,316	.00489	.00161	0
12	156	10–15	14,316	.01090	.00358	0
14	306	10–15	14,316	.02137	.00702	0
15	390	10–15	14,316	.02724	.00895	0
18	51	10–15	14,316	.00356	.00117	0

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / Σ P(Ti/Hi)	Adjusted Number of Workers
19	194	10–15	14,316	.01355	.00445	0
20	442	10–15	14,316	.03087	.01014	1
21	767	10–15	14,316	.05358	.01761	2
25	1,333	10–15	14,316	.09311	.03060	4
26	522	10–15	14,316	.03646	.01198	1
28	317	10–15	14,316	.02214	.00728	1
29	458	10–15	14,316	.03199	.01051	2
31	455	10–15	14,316	.03178	.01044	1
32	928	10–15	14,316	.06482	.02130	5
68	439	10–15	14,316	.03066	.01008	1
76	16	10–15	14,316	.00112	.00037	0
					Σ 0.15709	18
16	419	15–20	27,022	.01551	.00510	0
17	359	15–20	27,022	.01329	.00437	0

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
30	446	15–20	27,022	.01651	.00543	0
					Σ .75366	0
33	783	15–20	27,022	.02898	.00952	0
34	548	15–20	27,022	.02028	.00666	2
35	1,428	15–20	27,022	.05285	.01737	2
36	168	15–20	27,022	.00622	.00204	0
37	920	15–20	27,022	.03405	.01119	1
38	740	15–20	27,022	.02739	.00900	1
42	572	15–20	27,022	.02117	.00696	1
43	656	15–20	27,022	.02428	.00798	3
46	231	15–20	27,022	.00855	.00281	0
49	339	15–20	27,022	.01255	.00412	1
50	578	15–20	27,022	.02139	.00703	0
52	547	15–20	27,022	.02024	.00665	1

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
53	371	15–20	27,022	.01373	.00451	1
66	332	15–20	27,022	.01229	.00404	0
67	1,059	15–20	27,022	.03919	.01288	5
69	506	15–20	27,022	.01873	.00606	1
70	476	15–20	27,022	.01762	.00579	2
77	105	15–20	27,022	.00389	.00128	0
78	752	15–20	27,022	.02783	.00915	1
79	271	15–20	27,022	.01003	.00330	2
					Σ 0.15456	24
39	514	20–25	35,526	.01447	.00476	1
40	680	20–25	35,526	.01914	.00629	1
41	761	20–25	35,526	.02142	.00704	3
44	575	20–25	35,526	.01619	.00532	0
45	251	20–25	35,526	.00707	.00232	1

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
47	368	20-25	35,526	.01036	.00343	1
48	546	20-25	35,526	.01537	.00505	0
51	496	20-25	35,526	.01396	.00459	0
54	665	20-25	35,526	.01872	.00615	2
63	173	20-25	35,526	.00487	.00143	0
71	16	20-25	35,526	.00045	.00015	1
80	653	20-25	35,526	.01838	.00604	3
81	758	20-25	35,526	.02134	.00701	2
82	416	20-25	35,526	.01171	.00385	0
83	374	20-25	35,526	.01053	.00346	1
84	470	20-25	35,526	.01323	.00435	2
TB	118	20-25	35,526	.00332	.00109	0
TC	670	20-25	35,526	.01886	.00620	0
					Σ 0.07621	18

TABLE XI (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\leq P(Ti/Hi)}$	Adjusted Number of Workers
55	-	25-30	37,864	-	-	-
56	320	25-30	37,864	.00845	.00278	0
57	20	25-30	37,864	.00053	.00017	0
58	44	25-30	37,864	.00116	.00038	0
60	161	25-30	37,864	.00425	.00140	0
61	189	25-30	37,864	.00499	.00164	0
64	338	25-30	37,864	.00893	.00293	0
65	369	25-30	37,864	.00975	.00320	0
85	269	25-30	37,864	.00710	.00233	1
86	605	25-30	37,864	.00061	.00020	0
TD	23	25-30	37,864	.00061	.00020	0
					$\leq$ 0.02028	1
62	163	30-35	38,325	.00425	.00140	0
TE	106	30-35	38,325	.00277	.00091	1

TABLE XI (CONTINUED)

Tract Number	Tract Populatoon Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\leq P(Ti/Hi)}$	Adjusted Number of Workers
TF	60	30-35	38,325	.00157	.00052	0
TG	132	30-35	38,325	.00344	.00113	2
					$\leq$ 0.00396	3

Total Expected = 1.00000

Total Obtained = 0.99377

Error 0.00623

$P(Ti/Hi) = Ti/Hi$

$$Pi(T/H) = M - \sum_{M=2}^{M=M} \frac{H_{M-1}}{H_M}$$

$$= 7.000 - \left[\frac{H1}{H2} + \frac{H2}{H3} + \frac{H3}{H4} + \frac{H4}{H5} + \frac{H5}{H6} + \frac{H6}{H7}\right]$$

$$= 7.000 - \left[\frac{1,630}{7,472} + \frac{7,472}{14,316} + \frac{14,316}{27,022} + \frac{27,022}{35,526} + \frac{35,526}{37,864} + \frac{37,864}{38,325}\right]$$

$$= 7.000 - \left[.218 + .522 + .530 + .761 + .938 + .988\right]$$

$$= 7.000 - 3.957 = 3.043$$

TABLE XII

CALCULATION OF WORKTRIP ORIGINS
FOR LABOUR

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
1	966	0- 5	3,402	.28395	.10181	60
2	615	0- 5	3,402	.18078	.06482	52
3	1,200	0- 5	3,402	.35273	.12647	77
4	621	0- 5	3,402	.18254	.06545	35
					Σ0.35855	224
5	1,510	5-10	16,628	.09081	.03256	23
6	1,701	5-10	16,628	.10230	.03668	32
7	1,011	5-10	16,628	.06080	.02180	13
8	437	5-10	16,628	.02628	.00942	5
9	769	5-10	16,628	.04625	.01658	9
10	1,073	5-10	16,628	.06453	.02314	22
13	687	5-10	16,628	.04132	.01482	13

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(T_i/H_i)}{\Sigma P(T_i/H_i)}$	Adjusted Number of Workers
22	929	5-10	16,628	.05587	.02003	21
23	360	5-10	16,628	.02165	.00776	1
24	552	5-10	16,628	.03320	.01190	9
27	1,203	5-10	16,628	.07235	.02594	24
59	700	5-10	16,628	.04210	.01510	9
72	367	5-10	16,628	.02207	.00791	6
73	1,333	5-10	16,628	.08017	.02875	16
74	440	5-10	16,628	.02646	.00949	5
75	154	5-10	16,628	.00926	.00332	0
					Σ 0.28520	208
11	357	10-15	28,217	.01265	.00454	4
12	857	10-15	28,217	.03037	.01089	5
14	418	10-15	28,217	.01481	.00531	4
15	694	10-15	28,217	.02460	.00882	1

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	$\frac{P(Ti/Hi)}{\sum P(Ti/Hi)}$	Adjusted Number of Workers
18	268	10-15	28,217	.00950	.00341	1
19	1,044	10-15	28,217	.03700	.01327	10
20	627	10-15	28,217	.02222	.00797	6
21	1,412	10-15	28,217	.05004	.01794	5
25	2,114	10-15	28,217	.07492	.02686	12
26	552	10-15	28,217	.01956	.00701	2
28	348	10-15	28,217	.01233	.00442	2
29	471	10-15	28,217	.01669	.00598	2
31	369	10-15	28,217	.01308	.00469	2
32	1,317	10-15	28,217	.04667	.01673	14
68	726	10-15	28,217	.02573	.00923	7
76	15	10-15	28,217	.00053	.00019	0
					$\sum$ 0.14726	77
16	870	15-20	42,247	.02059	.00738	5

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
17	546	15–20	42,247	.01292	.00463	4
30	533	15–20	42,247	.01262	.00452	3
					Σ .80755	12
33	815	15–20	42,247	.01929	.00692	8
34	676	15–20	42,247	.01600	.00574	5
35	1,003	15–20	42,247	.02374	.00851	1
36	203	15–20	42,247	.00481	.00172	0
37	356	15–20	42,247	.00843	.00302	1
38	489	15–20	42,247	.01157	.00415	2
42	425	15–20	42,247	.01006	.00361	1
43	380	15–20	42,247	.00899	.00322	1
46	110	15–20	42,247	.00260	.00023	1
49	563	15–20	42,247	.01333	.00478	0
50	861	15–20	42,247	.02038	.00731	3

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
50	861	15–20	42,247	.02038	.00731	3
52	584	15–20	42,247	.01382	.00496	2
53	652	15–20	42,247	.01543	.00553	4
66	298	15–20	42,247	.00705	.00253	3
67	1,330	15–20	42,247	.03148	.01129	6
69	741	15–20	42,247	.01754	.00628	4
70	1,199	15–20	42,247	.02838	.01018	8
77	164	15–20	42,247	.00388	.00139	0
78	876	15–20	42,247	.02074	.00744	7
79	139	15–20	42,247	.00329	.00118	0
TA	217	15–20	42,247	.00514	.00184	1
					Σ 0.11836	70
39	424	20–25	50,473	.00840	.00301	2
40	834	20–25	50,473	.01652	.00592	2

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
41	1,048	20-25	50,473	.02076	.00744	1
44	607	20-25	50,473	.01203	.00431	1
45	88	20-25	50,473	.00174	.00062	0
47	194	20-25	50,473	.00384	.00138	0
48	220	20-25	50,473	.00436	.00156	3
51	329	20-25	50,473	.00652	.00234	1
54	1,247	20-25	50,473	.02471	.00681	8
63	265	20-25	50,473	.00525	.00188	1
71	92	20-25	50,473	.00182	.00065	1
80	371	20-25	50,473	.00735	.00264	5
81	564	20-25	50,473	.01117	.00401	2
82	516	20-25	50,473	.01022	.00366	3
83	158	20-25	50,473	.00313	.00112	2
84	231	20-25	50,473	.00458	.00164	0

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) / ΣP(Ti/Hi)	Adjusted Number of Workers
TB	234	20–25	50,473	.00464	.00166	0
TC	804	20–25	50,473	.01593	.00571	5
					Σ 0.05636	37
55	-	25–30	53,980	—	—	—
56	622	25–30	53,980	.01152	.00413	2
57	91	25–30	53,980	.00169	.00061	1
58	39	25–30	53,980	.00072	.00026	1
60	349	25–30	53,980	.00647	.00232	1
61	261	25–30	53,980	.00484	.00174	0
64	201	25–30	53,980	.00372	.00133	1
65	521	25–30	53,980	.00965	.00346	3
85	400	25–30	53,980	.00741	.00266	0
86	969	25–30	53,980	.01795	.00644	4
TD	54	25–30	53,980	.00100	.00036	0
					Σ 0.02331	13

TABLE XII (CONTINUED)

Tract Number	Tract Population Ti	Time Interval	Hi	Ti/Hi	P(Ti/Hi) ≤P(Ti/Hi)	Adjusted Number of Workers
62	257	25-30	55,230	.00465	.00167	1
TE	345	25-30	55,230	.00624	.00224	0
TF	178	25-30	55,230	.00322	.00115	0
TG	470	25-30	55,230	.00851	.00305	3
					Σ 0.00811	4

Total Expected = 1.00000

Total Obtained = 0.99715

Error 0.00285

$$P(Ti/Hi) = Ti/Hi$$

$$Pi(T/H) = M - \sum_{M=2}^{M=M} \frac{HM - 1}{HM} = 7.000 - \left[\frac{H1}{H2} + \frac{H2}{H3} + \frac{H3}{H4} + \frac{H4}{H5} + \frac{H5}{H6} + \frac{H6}{H7}\right]$$

$$Pi(T/H) = 7 - \left[\frac{3,402}{16,628} + \frac{16,628}{28,217} + \frac{28,217}{42,247} + \frac{42,247}{50,473} + \frac{50,473}{53,980} + \frac{53,980}{55,230}\right]$$

$$= 7.000 - [.205 + .589 + .668 + .837 + .935 + .977]$$

$$= 7.000 - 4.211 = 2.789$$

ALTHOUGH THESE TABLES SHOW THAT ASSIGNMENT OF WORK TRIP ORIGINS WAS CALCULATED FOR EACH CENSUS TRACT, IT WAS FELT THAT A CASE STUDY APPROACH DID NOT WARRANT THIS DEGREE OF REFINEMENT. IN A CASE STUDY, JUSTIFICATION OF ANY CONCEPT IS DIFFICULT. THE MOST A RESEARCHER CAN DO IS TO TAKE NOTICE OF GENERAL RESULTS AND REAPPLY THEM TO MORE EXTENSIVE TESTING. THE MODEL HYPOTHESIS IN THIS STUDY IS A FIRST ATTEMPT AND IT WOULD BE DECEPTIVE TO BESTOW UPON IT A DETAILED PREDICTIVE POWER WHICH IT MAY NOT POSSESS. ONLY BY TESTING THE THEORY ON BROAD TERMS CAN DISCREPANCIES BE BETTER BROUGHT OUT. THERE ARE APPROXIMATELY 55,000 LABOUR, 38,000 CLERKS AND 17,000 MANAGERS[1] IN THE WINNIPEG AREA. THE SAMPLE SIZE USED IN THIS STUDY IS 633 LABOURERS, 150 CLERKS AND 50 MANAGERS[2] OR 1.15%, 0.40% AND 0.30% OF THE ENTIRE LABOUR FORCE, RESPECTIVELY. THE SAMPLE IS OBVIOUSLY TOO SMALL TO SUPPORT REFINEMENT.

THEREFORE, THOUGH THE PREDICTIVE ABILITY OF THE MODEL THROUGH A MORE REFINED SAMPLING TECHNIQUE COULD FOCUS ON CENSUS TRACTS, THE ANALYSIS OF THIS STUDY WILL CONSIDER ONLY WORK TRIP ORIGINS FROM INDIVIDUAL TIME CODES. IN SHORT, THE PI VALUE FOR EACH RESIDENTIAL DISTRICT, IS SUMMED TO GIVE THE PROBABILITY OF WORK TRIP ORIGINS FROM THE TIME INTERVAL IN WHICH THE RESIDENTIAL DISTRICTS ARE LOCATED.[3]

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[1] 1961 CENSUS DATA.

[2] 1971 SURVEY DATA.

[3] FROM THE THEORY ON PAGES 77-79, WHAT IS OBTAINED HERE IS NOT $P\left(\frac{T1}{H1}\right)$ BUT RATHER

$$PH_1 = \sum_{I} P\left(\frac{T_I}{H_I}\right) \text{ FOR ALL I'S IN } H_1$$

SIMILARLY FOR ALL H'S.

CHAPTER V

ANALYSIS, CONCLUSIONS AND RAMIFICATIONS

A) Analysis and Conclusions

The bar graphs, Figures 8, 9 and 10, indicate the theoretical and empirical residential distribution patterns, by time codes, for the three occupational groups considered. The theoretical value is the value obtained from prediction and the empirical value is obtained from the sample data. The line plots, Figures 11, 12 and 13, show better than the bar graphs, the pronounced discrepancy between the theoretical and empirical results, within the first five minute interval ($T<5$). For all three occupation groups there is a large positive imbalance when $T< 5$ and a moderate negative imbalance for all time codes when $T>5$. The incremental differences are indicated in Table XIII and are plotted for the labour and clerical groups in Figures 14 and 15. From these figures it appears that labour empirical results follow the closest to theory, showing the lowest percentage deviation; as opposed to the managerial group that have the highest percentage deviation.

The inaccuracy of the model in predicting expected work trip origins can be explained from essentially two points of view. If the result is assessed from a purely mathematical viewpoint, the differences result from the behavior of random number assignments. Since more theoretical than empirical trips were assigned to the first time interval ($T<5$), this interval absorbed more than its share of random choices,

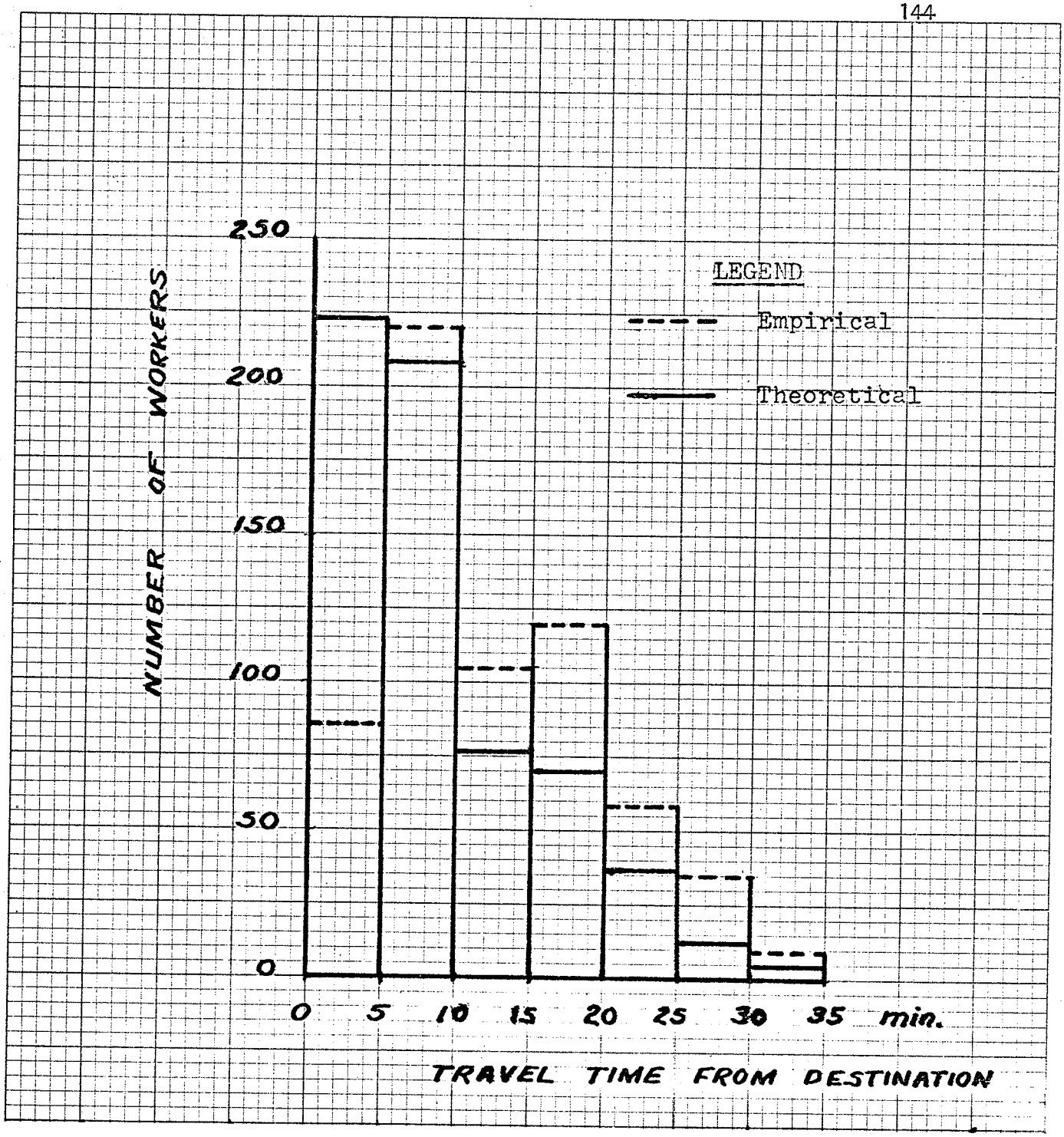

FIGURE 8. Theoretical and empirical trip origins by time interval for the labour group.

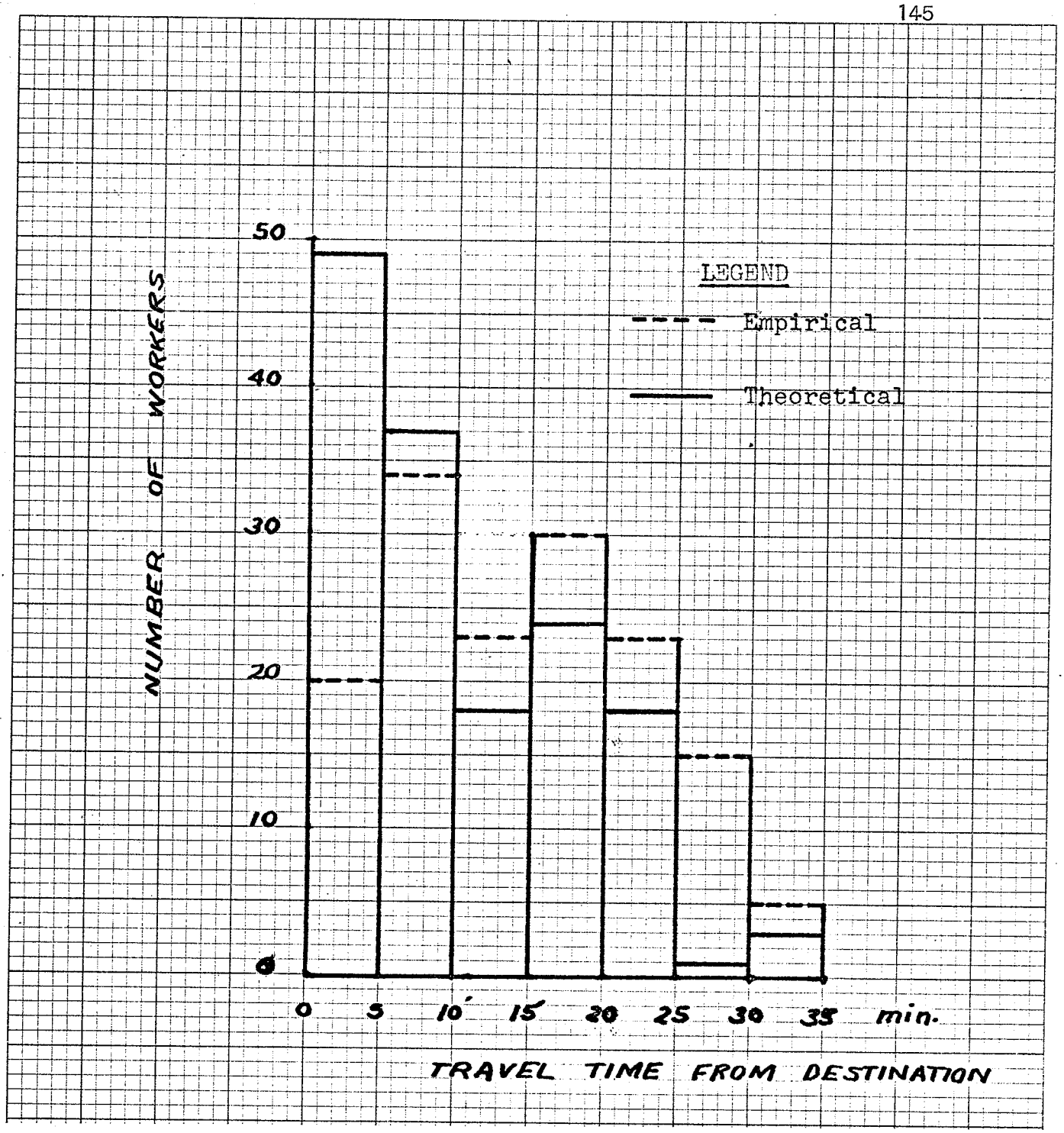

FIGURE 9. Theoretical and empirical trip origins by time interval for the clerical group.

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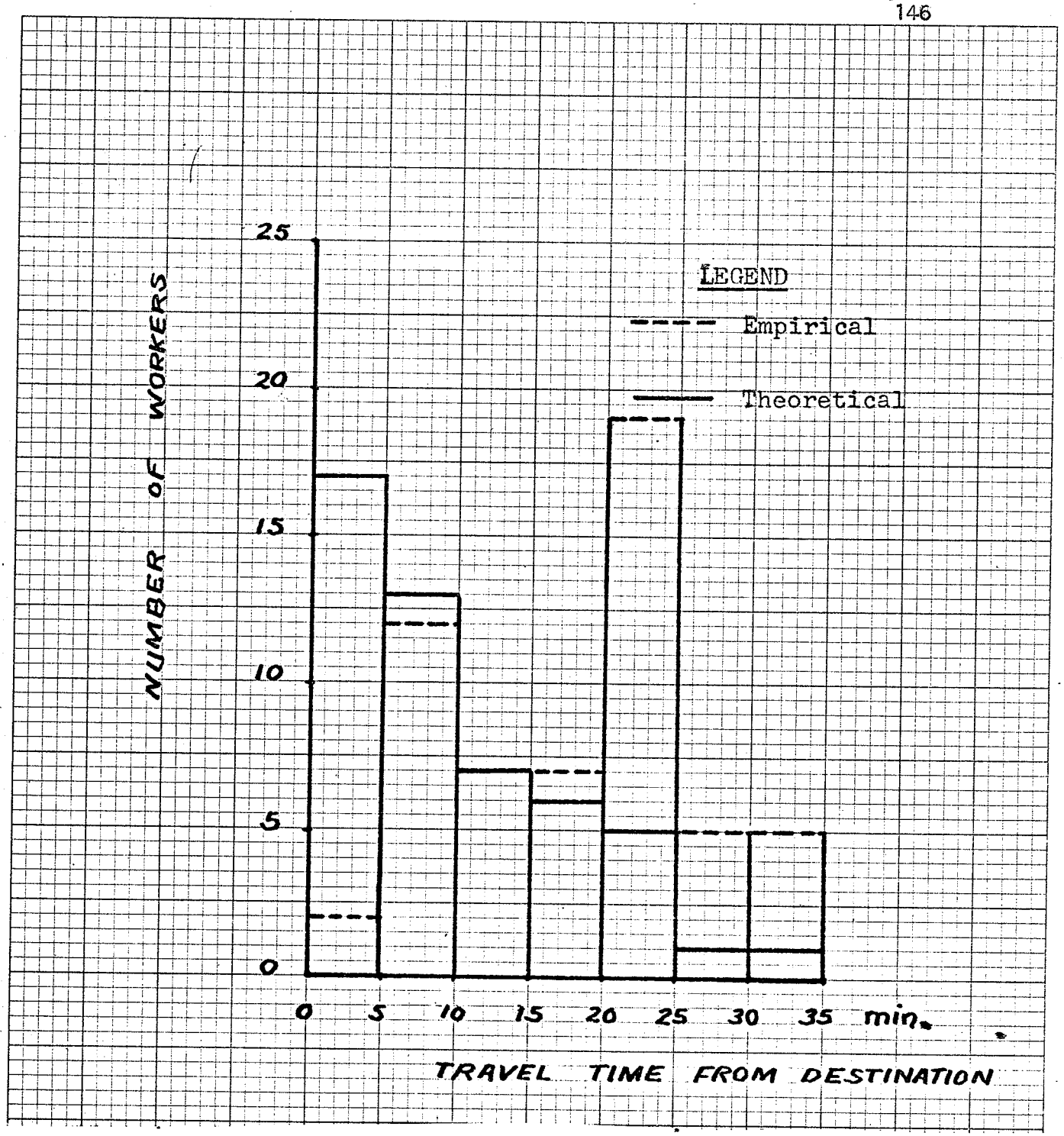

FIGURE 10. Theoretical and empirical trip origins by time interval for the managerial group.

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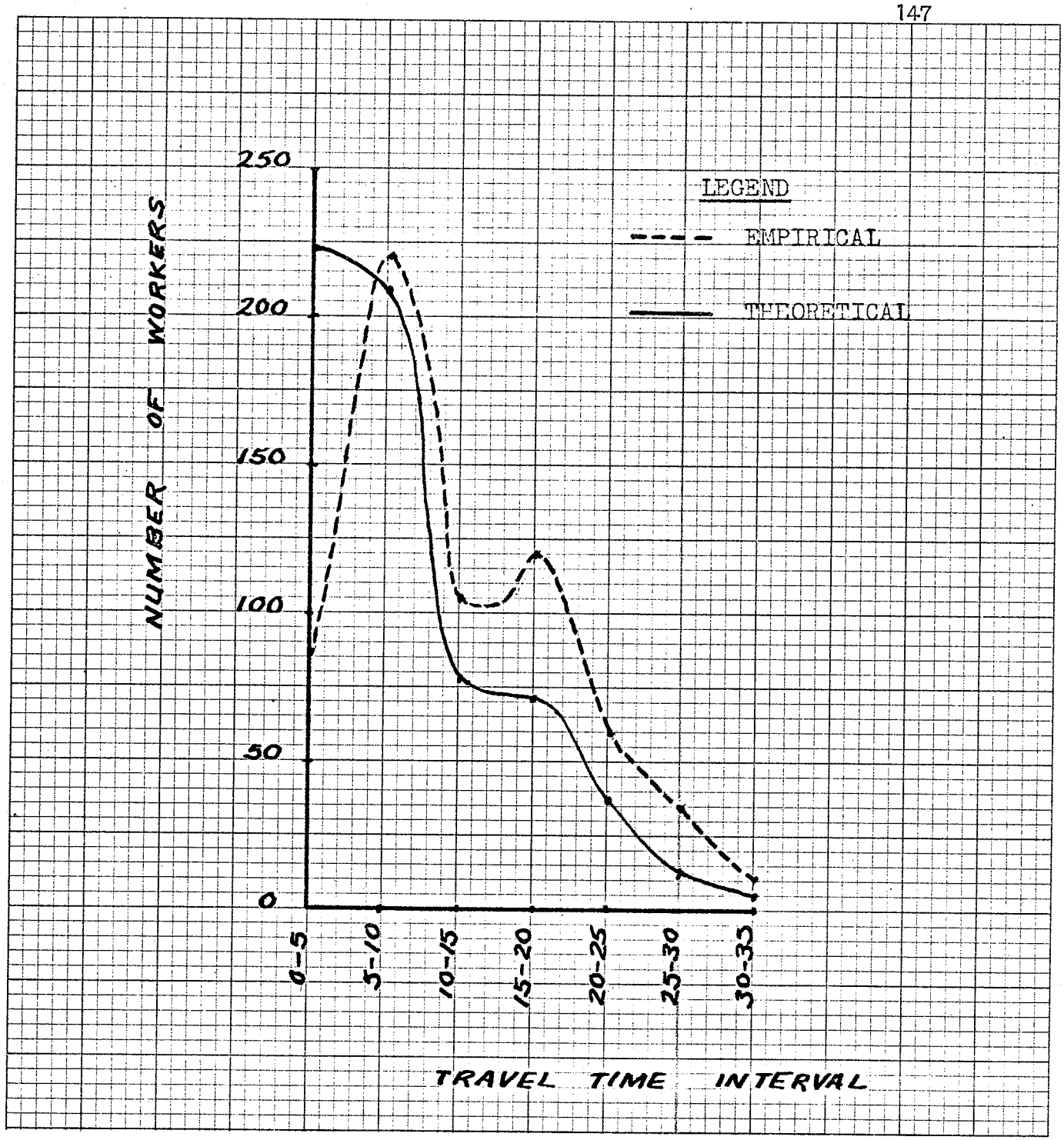

FIGURE 11. Theoretical and empirical trip origins by time interval for the labour group.

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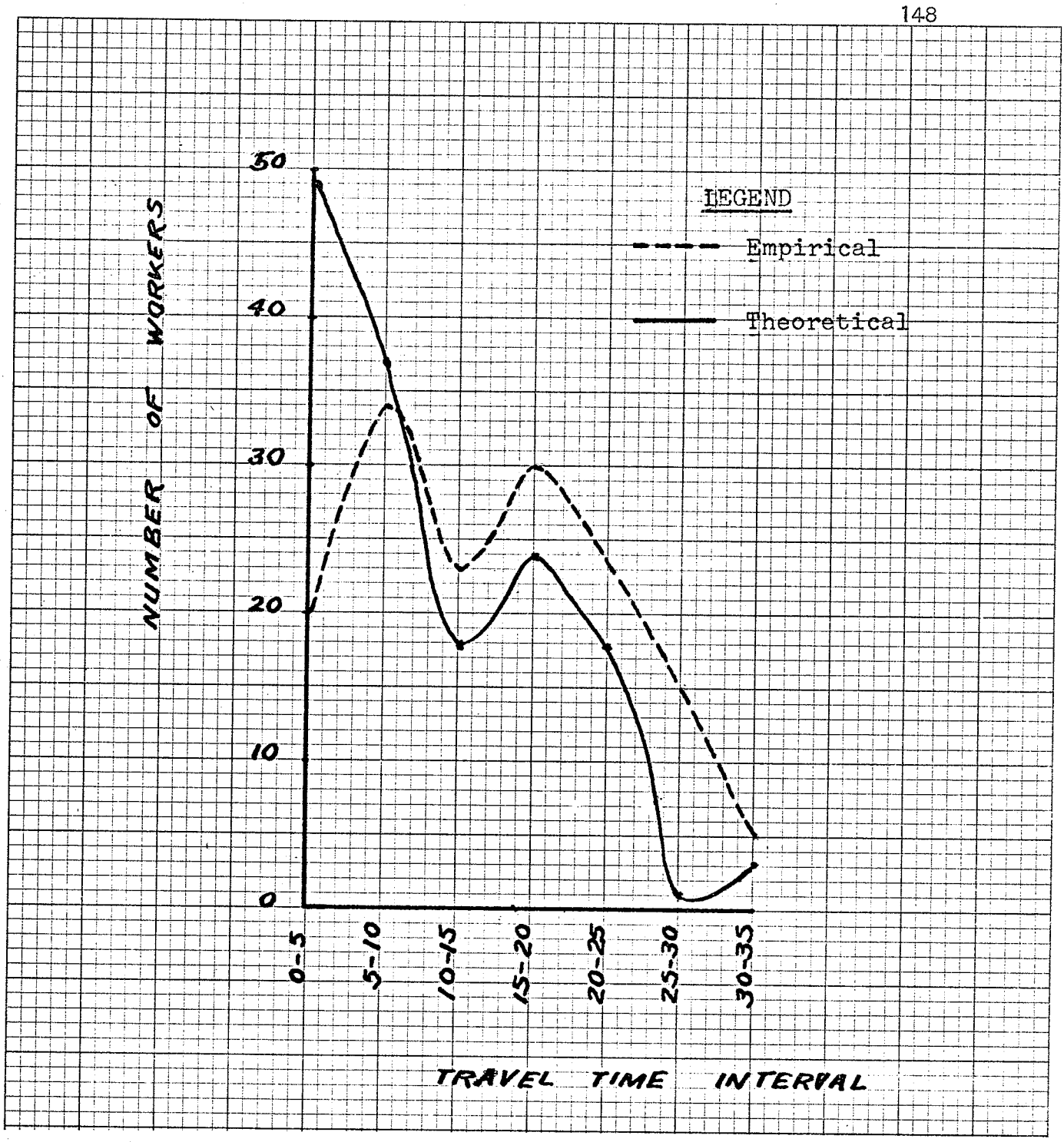

FIGURE 12. Theoretical and empirical trip origins by time interval for the clerical group.

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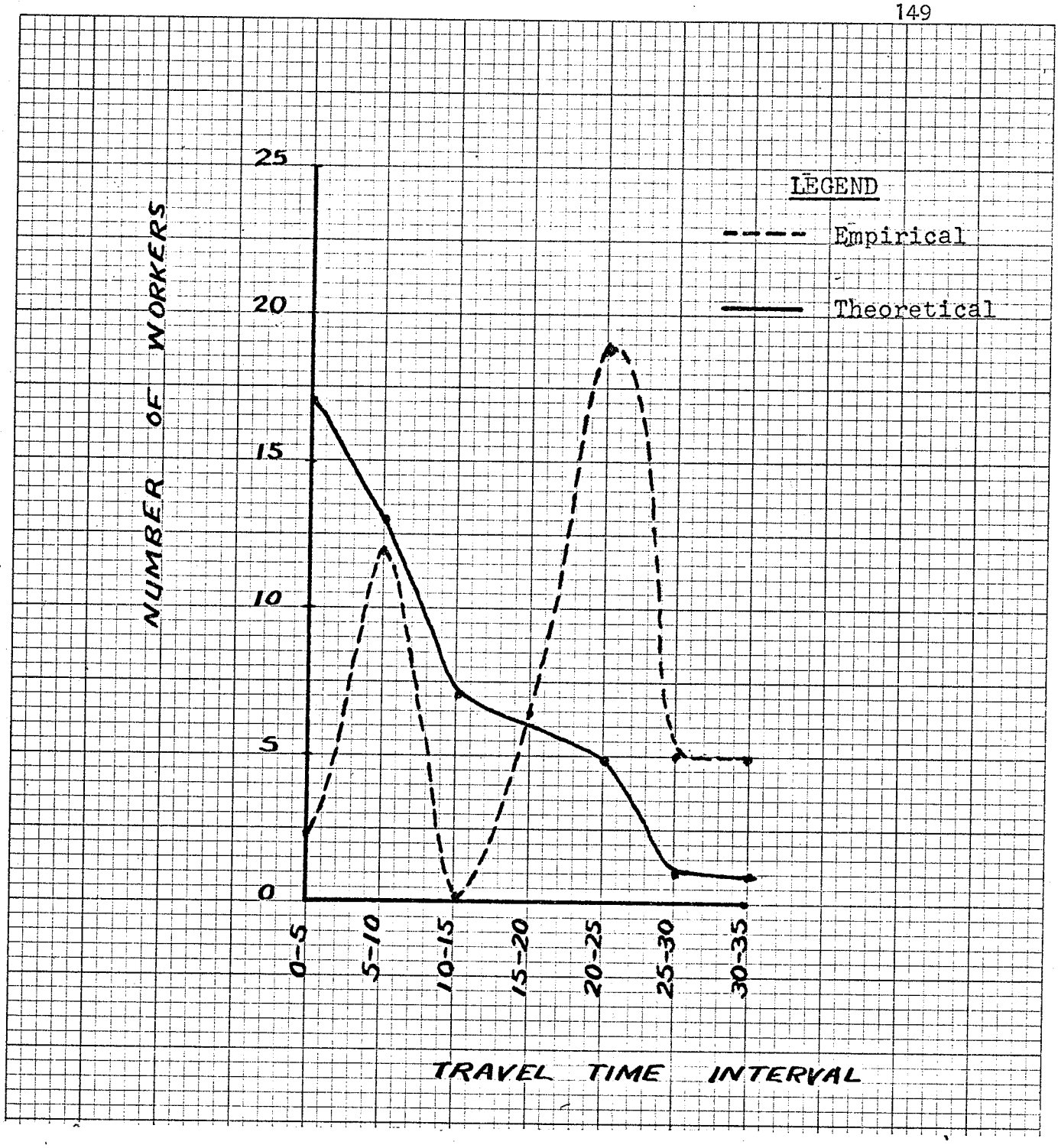

FIGURE 13. Theoretical and empirical trip origins by time interval for the managerial group.

TABLE XIII

ERROR IN THEORETICAL ORIGIN VALUES
BY TIME INTERVAL

Time Interval	Management	Clerical	Labour	Total
0- 5	+ 15	+ 29	+ 138	+ 182
5-10	+ 1	+ 3	- 12	- 8
10-15	+ 7	- 5	- 28	- 26
15-20	- 1	- 6	- 50	- 57
20-25	- 14	- 5	- 21	- 40
25-30	- 4	- 14	- 22	- 40
30-35	- 4	- 2	- 5	- 11
TOTAL	0	0	0	0

NOTE: Positive indicates theoretical value is greater than empirical value.

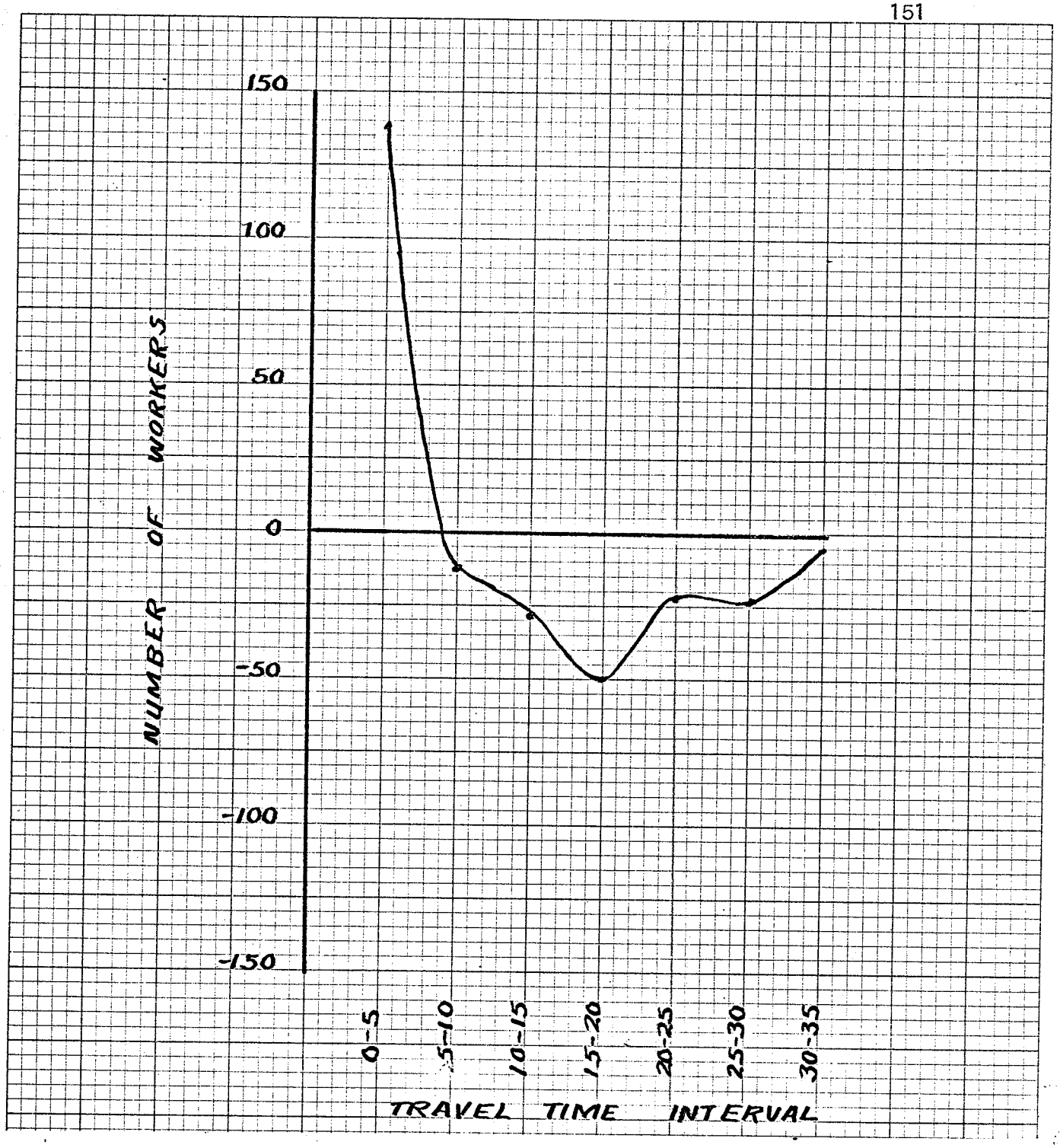

FIGURE 14. Error in trip origin prediction by time interval for the labour group.

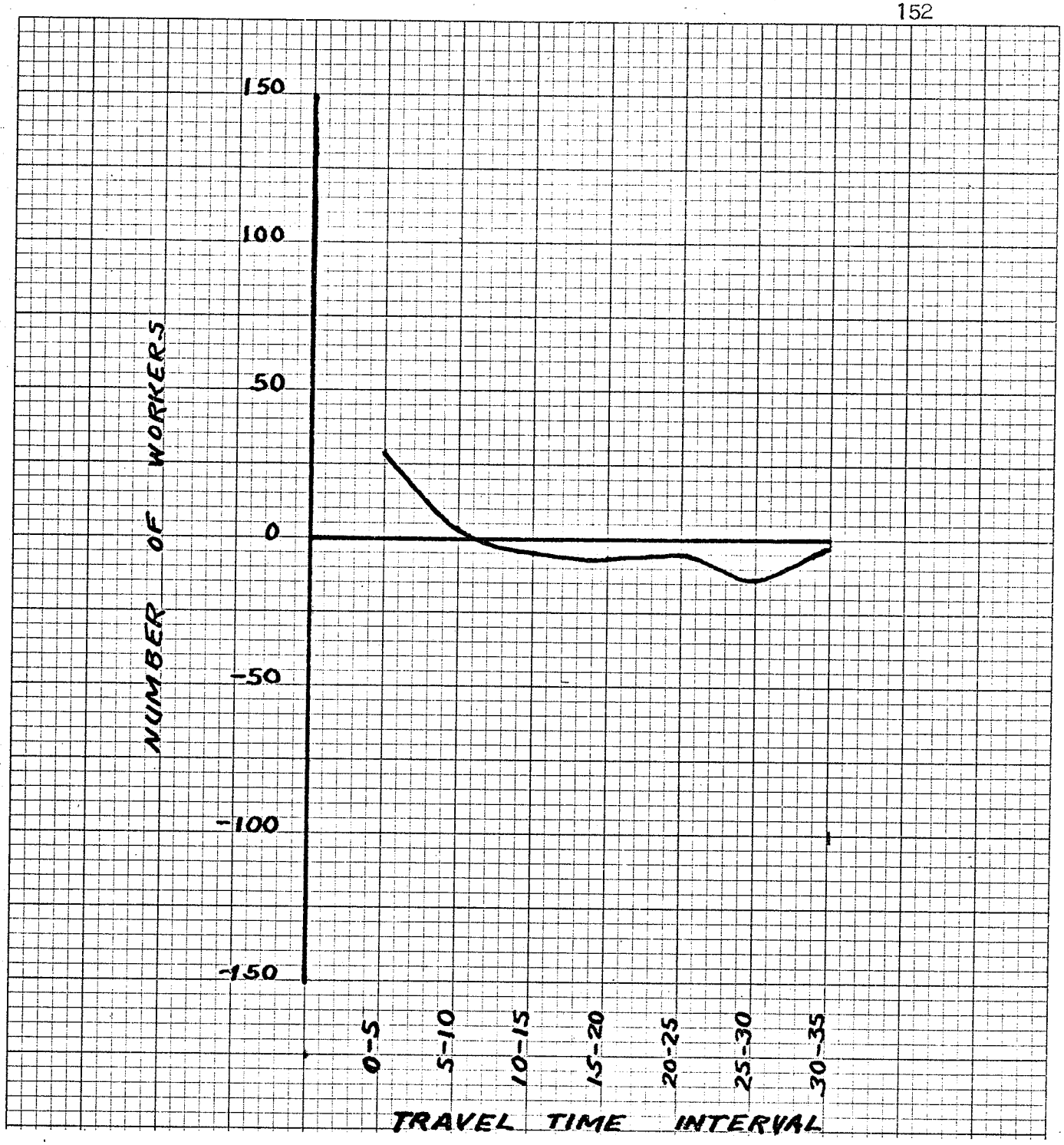

FIGURE 15. Error in trip origin prediction, by time interval for the clerical group.

CAUSING A SHORTAGE OF CHOICE POSSIBILITIES FOR INTERVALS T > 5 MINUTES.[1] LOOKING AT THE RESULTS FROM THIS POINT OF VIEW, ADJUSTMENT WOULD INVOLVE CHANGES TO THE WEIGHTS FOR T < 5 MINUTES, AND ALL OTHER INTERVAL ASSIGNMENTS WILL TAKE CARE OF THEMSELVES. THE OTHER VIEWPOINT PLACES THE ADJUSTMENT FUNCTION BY DEGREE ON ALL SEVEN INTERVALS IN THE ENTIRE STUDY AREA. THIS REASONING RAISES THE POINT THAT INACCURACY RESULTS NOT ONLY FROM A HIGH P_i VALUE FOR TRACTS WHEN T < 5 MINUTES, BUT ALSO FROM A PROPORTIONATELY LOW P_i VALUE FOR ALL OTHER TRACTS WHEN T > 5 MINUTES.

RECALLING THE BASIC METHOD ASSUMPTION ON WHICH THE MODEL IS BASED MAY SHED SOME LIGHT ON THE POSSIBLE NATURE OF ADJUSTMENT. IT WAS ASSUMED THAT THE PROBABILITY THAT A TRIP WILL ORIGINATE FROM A RESIDENTIAL DISTRICT, (OR A GROUP OF DISTRICTS WITHIN A TIME CODE) DEPENDS ON THE RATIO BETWEEN THE TRIP OPPORTUNITIES IN THE RESIDENTIAL DISTRICT AND ITS COMPETING OPPORTUNITIES. "COMPETING OPPORTUNITIES" HERE MEANS THAT WORKERS IN THE CODE T < 5 (H1) COMPETE ONLY AMONG THEMSELVES FOR JOBS IN THE PARK, WHILE WORKERS IN TIME CODE T = 5-10 MINUTES (H2-H1) COMPETE NOT ONLY WITH WORKERS IN THE 5-10 MINUTE INTERVAL BUT ALSO WITH THE WORKERS IN THE INTERVAL T < 5, (H1). THE COMPETITION ACCUMULATES PROPORTIONATELY UNTIL WORKERS BELONGING TO THE LAST GROUP, (H7-H6) WHERE T 25-30 MINUTES COMPETE WITH THE ENTIRE URBAN WORK FORCE FOR JOBS AT INKSTER PARK. THOUGH THE ASSUMPTION APPEARS LOGICAL, BASED ON THE FACT THE DISTANCE ACTS AS A DEPRESSANT FOR COMPETITION, ITS VALIDITY MUST BE

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[1] TABLE XIII SHOWS THAT THE IMBALANCE IN POSITIVE AND NEGATIVE DEVIATIONS ADD UP TO ZERO.

SUBJECT TO DEGREE OF INFLUENCE. IT APPEARS FROM THE RESULTS THAT EXCLUSIVE COMPETITION WITH WORKERS OF ONLY THE SAME OR MORE CONFINING TIME INTERVAL IS INACCURATE. IN SHORT, IT APPEARS THAT WORKERS IN TIME INTERVAL T< 5 MINUTES COMPETE NOT ONLY AMONG THEMSELVES BUT ALSO, BY DEGREE, WITH WORKERS IN T 5-10, AND T 10-15 ETC. THE FOCUS OF ADJUSTMENT IS TO MEASURE THE DEGREE OF COMPETITION BETWEEN INTERVALS IN AN INCLUSIVE MANNER.

THE INFLEXIBILITY OF MANAGEMENT PERSONNEL IN FINDING SUITABLE HOUSING BASED ON SOCIO-ECONOMIC CONSIDERATIONS WOULD TEND TO SUPPORT THE HIGH DEVIATIONS OF THEORETICAL AND EMPIRICAL VALUES ASSOCIATED WITH THIS OCCUPATIONAL GROUP. THE SUBSTANTIAL NUMBER OF MANAGERS, FROM THE SAMPLE, IN THE INTERVAL T 20-25 MINUTES IS A REFLECTION OF THE QUALITY OF HOUSING FOUND IN THIS AREA. A LARGE SECTION OF SOUTH WINNIPEG, INCLUDING RIVER HEIGHTS, ROSLYN ROAD, ST. JAMES-ASSINIBOIA AND THE MORE DEVELOPED SEGMENT OF TUXEDO FALLS WITHIN THIS TIME CODE. TIME OF TRAVEL OR RELATED COSTS IS NOT AS SIGNIFICANT A CONSTRAINT FOR THIS GROUP AS IT IS FOR LABOUR AND OFFICE WORKERS.

THE DISCREPANCIES BETWEEN THE THREE OCCUPATIONAL GROUPS INDICATES THAT THE EFFECT OF TRAVEL TIME ON COMPETITION IS NOT THE SAME FOR ALL WORKERS. A SELECTIVITY FACTOR SIMILAR TO THE ONE USED IN THE INTERVENING OPPORTUNITIES MODEL[1] MUST BE INCORPORATED IN DEFINING THE TIME INTERVALS. A CONSTANT OF FIVE MINUTES FOR ALL OCCUPATION GROUPS OVER THE URBAN AREA IS NOT SUPPORTED BY BEHAVIORAL PATTERNS BETWEEN OCCUPATIONS AS SHOWN BY THIS STUDY.

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[1] SUPRA, P. 52.

HOW CAN THE FINDINGS OF THIS STUDY BE INCORPORATED INTO A MORE REFINED TECHNIQUE? A CRUDE ADJUSTMENT TO THE THEORETICAL VALUES WAS ATTEMPTED, TO BRING THESE VALUES CLOSER TO THE EMPIRICAL RESULTS. THE MANAGERIAL GROUPS, BECAUSE OF HIGH DISCREPANCY WAS LEFT UNADJUSTED, WHILE THE LABOUR AND CLERICAL GROUPS WERE CONSIDERED CLOSE ENOUGH TO WARRANT AN ATTEMPT AT A CRUDE ADJUSTMENT. FOR BOTH THE LABOUR AND CLERICAL GROUPS, THE THEORETICAL VALUES WERE DIVIDED INTO THEIR CORRESPONDING EMPIRICAL VALUES FOR EACH TIME INTERVAL. THE RATIOS FOR THE TWO OCCUPATIONS WERE PLOTTED AS INDICATED IN FIGURES 16 AND 17 AND POINTS WERE APPROXIMATED BY A STRAIGHT LINE. FOR EACH TIME INTERVAL A WEIGHT FACTOR WAS OBTAINED ON THE ORDINATE, WHICH WAS THEN APPLIED TO THE THEORETICAL VALUES. (SEE TABLE XIV.) THE ADJUSTED VALUES SHOWN ON FIGURES 18 AND 19 WERE OBTAINED. A CHI-SQUARE TEST FOR "GOODNESS OF FIT" WAS CONDUCTED ON THE ADJUSTED THEORETICAL VALUES, AND THE RESULTS OF THIS TEST ARE INCLUDED IN APPENDIX D.

THE SIGNIFICANCE OF THESE CRUDE ADJUSTMENT FACTORS IS A FUNCTION OF THE COMPETITION WITHIN EACH TIME INTERVAL FOR EACH OCCUPATION GROUP. TO DEMONSTRATE THIS RELATIONSHIP A NUMERICAL EXAMPLE IS USED.

EXAMPLE:

> FROM TABLE XII ON PAGE 134, TIME INTERVAL, $T \leq 5$ CONSISTS OF 3,402 LABOURERS. SUBSEQUENTLY UNDER THE EXCLUSIVE COMPETITION ASSUMPTION AN INDIVIDUAL LABOURER RESIDING IN THIS AREA WILL COMPETE ONLY WITH 3,401 NEIGHBOURS FOR A POSSIBLE JOB IN INKSTER PARK. UNDER A MORE REALISTIC, INCLUSIVE COMPETITION ASSUMPTION IT MAY BE THAT 5,000 LABOURERS FROM T 5-10, 3,000 LABOURS FROM T 10-15, 700 LABOURERS FROM T 15-20, ETC. WOULD ALSO COMPETE WITH THE INDIVIDUAL IN THE FIRST TIME INTERVAL FOR A JOB IN INKSTER PARK. COMPETITION FOR THIS JOB DECLINES PROGRESSIVELY AT 5 MINUTE INTERVALS BEYOND $T = 5$, BUT DOES NOT BECOME ZERO AS WAS PREVIOUSLY ASSUMED.

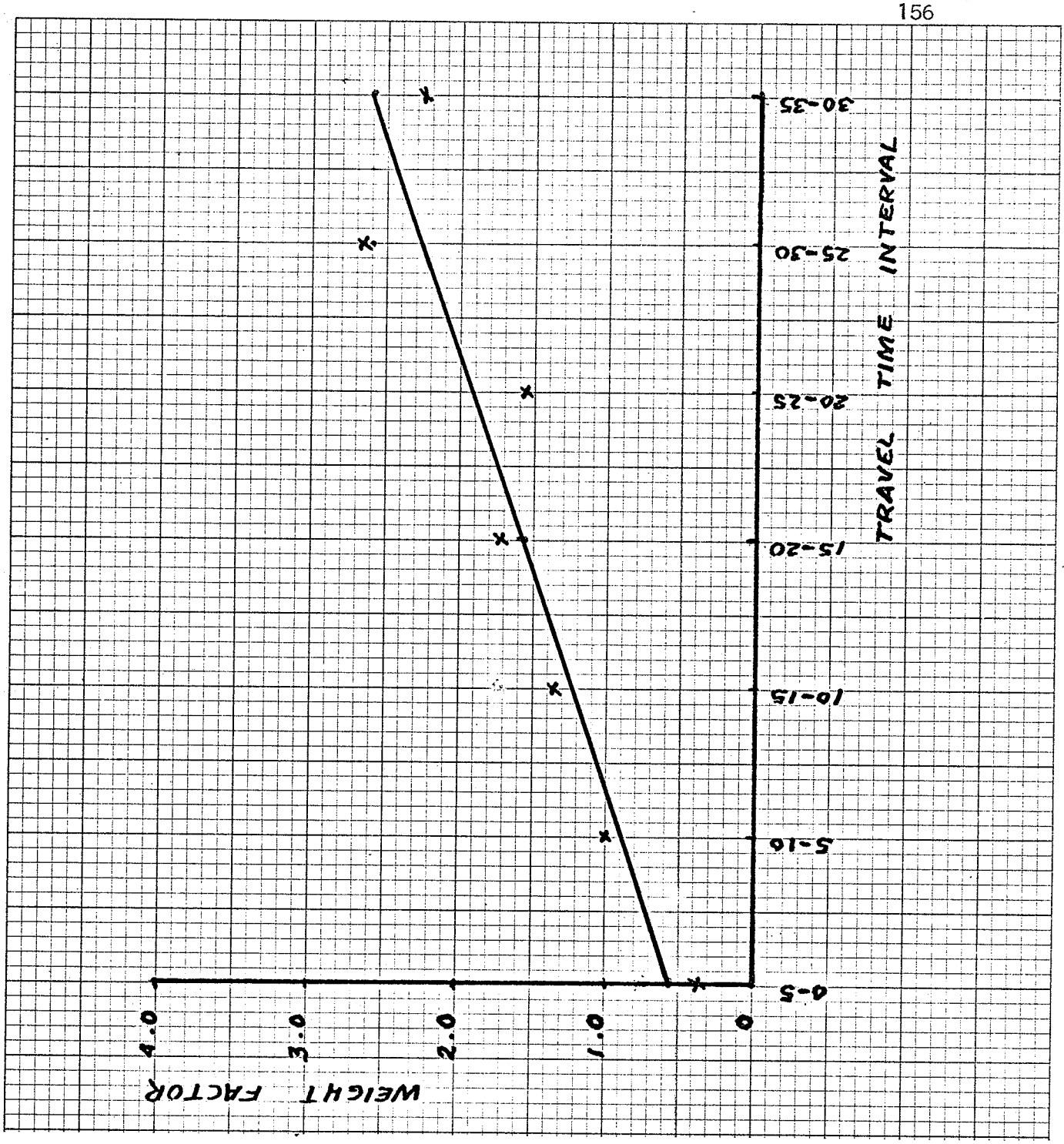
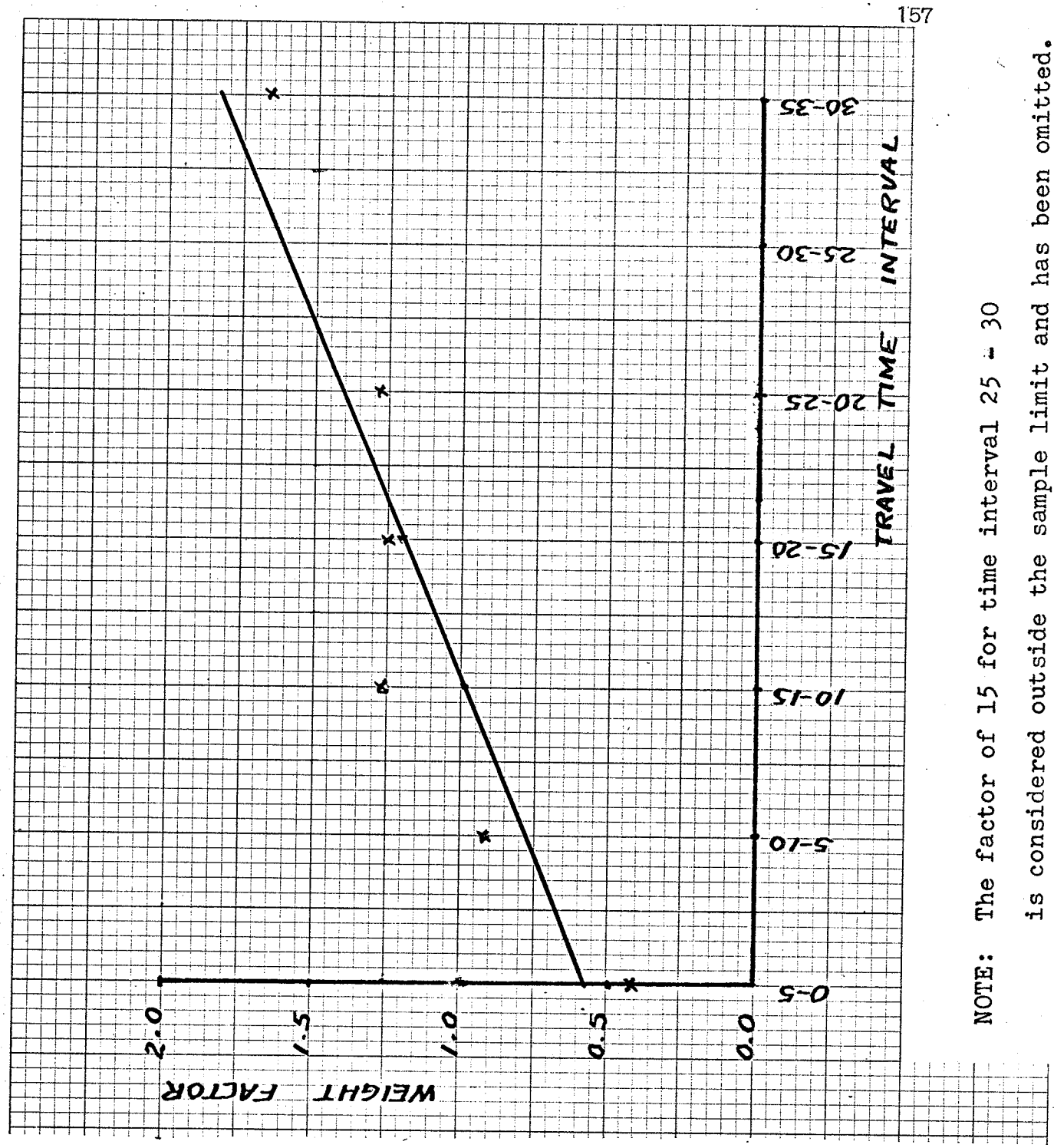


FIGURE 16. Straight line approximation of weights for the adjusted theoretical curve for the labour group.



NOTE: The factor of 15 for time interval 25 - 30 is considered outside the sample limit and has been omitted.

FIGURE 17. Straight line approximation of weights for the adjusted theoretical curve for the clerical group.

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TABLE XIV

ADJUSTED NUMBER OF EMPLOYEES

LABOUR			CLERICAL		
TIME INTERVAL	FACTOR	POPULATION	TIME INTERVAL	FACTOR	POPULATION
0- 5	0.55	123	0- 5	0.57	28
5-10	0.90	187 + 5	5-10	0.78	29 + 4
10-15	1.24	95 + 2	10-15	1.00	18 + 2
15-20	1.49	104 + 2	15-20	1.22	29 + 1
20-25	1.96	73	20-25	1.44	26
25-30	2.27	30 + 2	25-30	1.66	2 + 5
30-35	2.60	10	30-35	1.88	6
		Σ 633			Σ 150

"THE ADJUSTED POPULATION NUMBERS OBTAINED BY THE DIRECT APPLICATION OF THE WEIGHT FACTORS HAS BEEN BALANCED TO EQUAL THE UNADJUSTED SAMPLE TOTALS FOR THE TWO OCCUPATIONAL GROUPS.

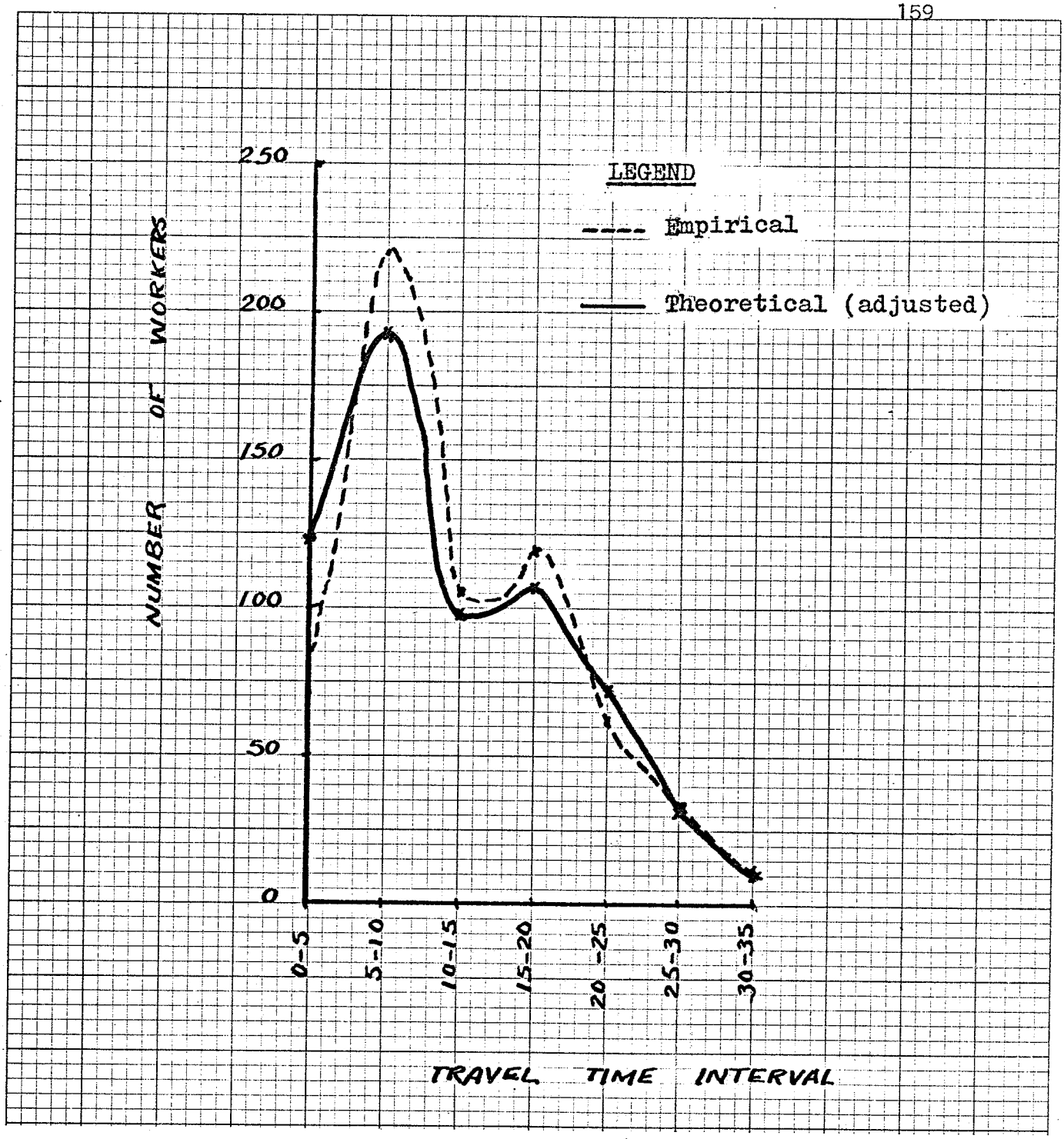

FIGURE 18. Adjusted theoretical and empirical trip origins by time interval for the labour group.

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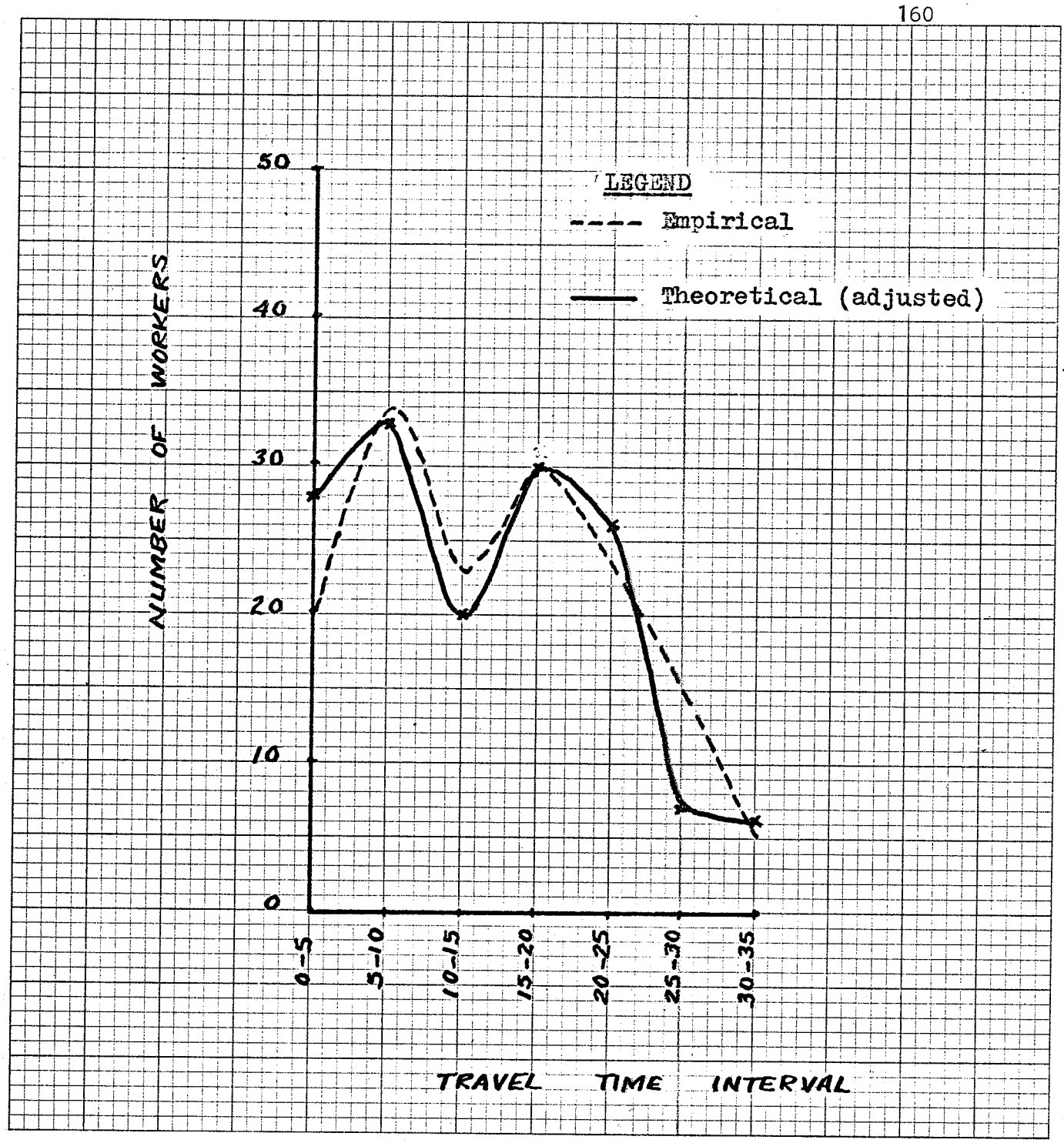

FIGURE 19. Adjusted theoretical and empirical trip origins by time interval for the clerical group.

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THE RATE OF DECLINE IN THE PERCENTAGE OF COMPETING WORKERS IS A FUNCTION OF BOTH, OCCUPATIONAL GROUP SELECTIVITY, AND THE SUPPLY-DEMAND RATIO FOR JOBS IN THE CITY UNDER STUDY. HAVING OBTAINED A SET OF ADJUSTMENT FACTORS FOR COMPETITION DECLINE, IT IS REASONABLE TO EXPECT THAT THE PREDICTION CAPACITY OF THE METHOD INTRODUCED IN THIS STUDY WILL BE GREATLY IMPROVED, AND APPLICABLE TO ANY SIMILAR SITUATION.

B) RAMIFICATIONS

ALTHOUGH THE APPLICATION OF THE MODEL IN THE STUDY HAS BEEN CONFINED TO INTRACITY, RESIDENTIAL LOCATION WITH RESPECT TO INDUSTRIAL WORK PLACE, THE POSSIBILITIES OF THIS METHOD DO NOT END HERE. THE BASIC METHOD CAN BE APPLIED TO DETERMINE TRIP ORIGINS FOR A MULTIPLICITY OF PURPOSES.

1) THE ORIGIN POINT FOR CUSTOMERS OF A PROPOSED SHOPPING CENTER CAN BE OBTAINED BY USING AVERAGE DISTRICT INCOME FIGURES OR EVEN TOTAL POPULATION NUMBERS AS OPPOSED TO THE OCCUPATIONAL DATA USED IN THIS STUDY.

2) THE EFFECT OF A PROPOSED HOSPITAL ON PATIENT ORIGINS MAY BE OBTAINED GIVEN THAT THERE ARE OTHER HOSPITALS IN THE AREA WITH SIMILAR FACILITIES AND THAT AVAILABILITY OF HOSPITAL BEDS IS NOT A PROBLEM.

3) THE EFFECT OF A HIGH SCHOOL LOCATION CAN BE DETERMINED USING STUDENT DATA.

THE POSSIBILITIES OF APPLICATION, OF COURSE, ARE NOT CONFINED TO AN ISOLATED URBAN STAGE. IN TERMS OF REGIONAL INDUSTRIAL LOCATION THEORY, THE DECISION TO LOCATE A GIVEN INDUSTRY IN ONE COMMUNITY OUT OF A COMPACT CLUSTER OF SEVERAL, SIMILAR COMMUNITIES, CAN BE BASED ON EXISTING WORKER RESIDENTIAL PATTERNS BY USING THIS MODEL. CONSIDERA-

TION OF THIS ASPECT WILL ELIMINATE WASTE OF TRAVEL TIME AND REDUCE TRAFFIC CONGESTION ON THE ROADS CONNECTING THE COMPONENT CITIES OF THE REGIONAL CLUSTER. ANY CHANGE IN RESIDENTIAL DISTRIBUTION IN THE REGION BY THE LOCATION OF INDUSTRY IN ONE PARTICULAR COMMUNITY CAN BE PREDICTED AND INCORPORATED INTO THE REGIONAL PLAN.

OBVIOUSLY ANY CHANGE IN THE FOCUS OF STUDY WOULD REQUIRE SUBSTANTIAL ALTERATIONS TO SOME OF THE BASIC COMPONENTS OF THE MODEL. THERE MAY BE A CHANGE IN THE MEASURE OF THE COMPETITION VARIABLE, OR THE CHANGE MAY INVOLVE THE MEASURE OF IMPEDANCE (NOT ALL TRIPS ARE DISCOURAGED BY A SLOW RATE OF PRIVATE VEHICULAR MOVEMENT, EG., SCHOOL TRIPS). THE TWO FUNDAMENTAL REQUIREMENTS FOR THE APPLICATION OF THIS METHOD OF ORIGIN PREDICTION ARE:

1) THERE MUST BE SOME FORM OF IMPEDANCE TO TRAVEL EG. WALKING, FLYING, DRIVING, ETC.

AND

2) THE COMMUTER MUST HAVE A CHOICE AMONG A NUMBER OF SIMILAR DESTINATION FACILITIES, LOCATED AT VARIOUS DISTANCES FROM HIS ORIGIN POINT, I.E., THE PROPOSED DESTINATION FACILITY IS ONLY ONE OF SEVERAL ESTABLISHED FACILITIES, WHICH PERFORM ESSENTIALLY THE SAME FUNCTION.

DESPITE THE LIMITED SCOPE OF APPLICATION ADOPTED AS THE BASIS OF THIS PILOT STUDY, FURTHER REFINEMENT AND MORE EXTENSIVE TESTING ARE JUSTIFIED BY THE POSSIBILITIES OF APPLICATION. THE FURTHER DEVELOPMENT OF THIS TECHNIQUE COULD WELL SIMPLIFY AND SYSTEMATIZE THE TASK OF LAND DEVELOPMENT AND OF CONVINCING THE PUBLIC AT LARGE, AS WELL AS THE PLANNER, THAT THE PATTERN OF LOCATION PROPOSED IS THE BEST UNDER THE PREVAILING CIRCUMSTANCES.

APPENDICES

APPENDIX A

METHOD OF TRAFFIC ASSIGNMENT TO ROAD NETWORK

THE TRAFFIC ASSIGNMENT METHOD IS BASED ON THE CALCULATION OF MINIMUM TIME PATHS BETWEEN ZONES OF AN ACTUAL ROAD NETWORK. ALTHOUGH COMPLEX NETWORKS WOULD INVOLVE THE USE OF A COMPUTER, A MANUAL PROCEDURE CAN BE ATTEMPTED FOR SIMPLE SYSTEMS.

FOR CODING PURPOSES THE ROAD NETWORK IS BROKEN DOWN INTO A SERIES OF LINKS AND NODES. A LINK IS THE ONE-WAY PATH ON A ROUTE BETWEEN TWO INTERSECTIONS FOR WHICH INFORMATION CONCERNING LENGTH, SPEED EXISTING VOLUME AND TRAVEL TIME IS OBTAINED AND STORED. NODES MAY BE EITHER ZONAL OR INTERSECTION CENTROIDS. NODES ARE IDENTIFIED BY A NUMERICAL CODE APPLIED SYSTEMATICALLY TO THE NETWORK, WHILE LINKS ARE IDENTIFIED BY THE NODE NUMBERS AT THE END OF THE LINK. A HYPOTHETICAL ROAD NETWORK DIVIDED INTO LINKS AND NODES IS SHOWN IN FIGURE 20.

THERE ARE THREE MAJOR PROCEDURES FOR TRIP ASSIGNMENT. THEY ARE

1) ALL-OR-NOTHING ASSIGNMENTS.

2) DIVERSION CURVE ASSIGNMENTS.

3) CAPACITY RESTRAINT ASSIGNMENTS.

THE THIRD PROCEDURE, WHICH IS THE METHOD USED IN THIS STUDY, ACCOUNTS FOR THE VOLUME CAPACITY OF THE ROAD NETWORK IN CALCULATING THE LINK TRAVEL TIME. THE CAPACITY RESTRAINT PROCEDURE ASSIGNS AN ADJUSTED TRAVEL TIME TO A LINK WHOSE VOLUME CAPACITY HAS BEEN EXCEEDED BY THE DESIGN HOUR VOLUME.

FOR A NETWORK OF THE SIZE SHOWN IN FIGURE 20 MINIMUM PATH TREES CAN BE ESTABLISHED BY INSPECTION. HOWEVER, EVEN IN NETWORKS USED IN CONJUNCTION WITH SMALLER CITIES, A FORMALIZED TREE-BUILDING METHOD IS REQUIRED.

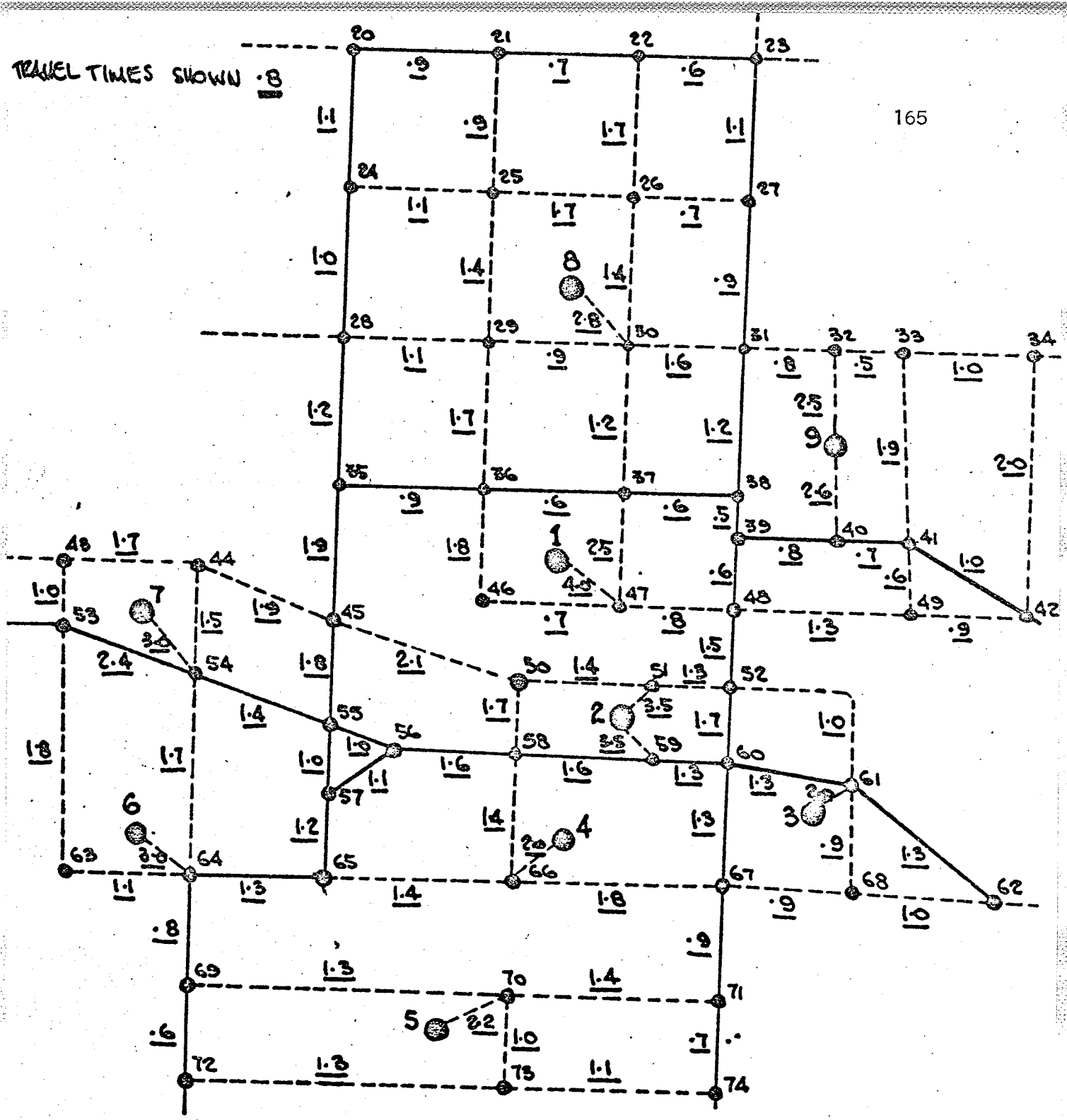

FIGURE 20. Road network showing P.M. peak hour travel times on each link.

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Source: United States Department of Transportation

FOR THE HYPOTHETICAL NETWORK, IDENTIFICATION OF THE MINIMUM PATH TREE ASSOCIATED WITH CENTROID "1" IS DEMONSTRATED BY FIGURE 21. THOUGH THE CHART IS INCOMPLETE, THE MINIMUM PATH BETWEEN CENTROID "1" AND ANY OTHER CENTROID MAY BE OBTAINED FROM THIS TYPE OF INFORMATION. THE TABLE IS ENTERED AT 1 AND THE NEXT NEAREST NODE IS READ AT THE TOP OF THE COLUMN FOR WHICH THE MINIMUM PATH IS SHOWN, IE. NODE "40". THE TABLE IS THEN ENTERED AT 11 WITH NODE 40 AS THE POINT OF DESTINATION AND THIS GIVES NODE 39 AS THE NEXT NEAREST NODE. FOLLOWING THIS PROCEDURE, THE MINIMUM PATH BETWEEN CENTROIDS 9 AND 1 IS ESTABLISHED AS

9 40 39 48 47 1

WITH A TRAVEL TIME OF 8.8 MINUTES.

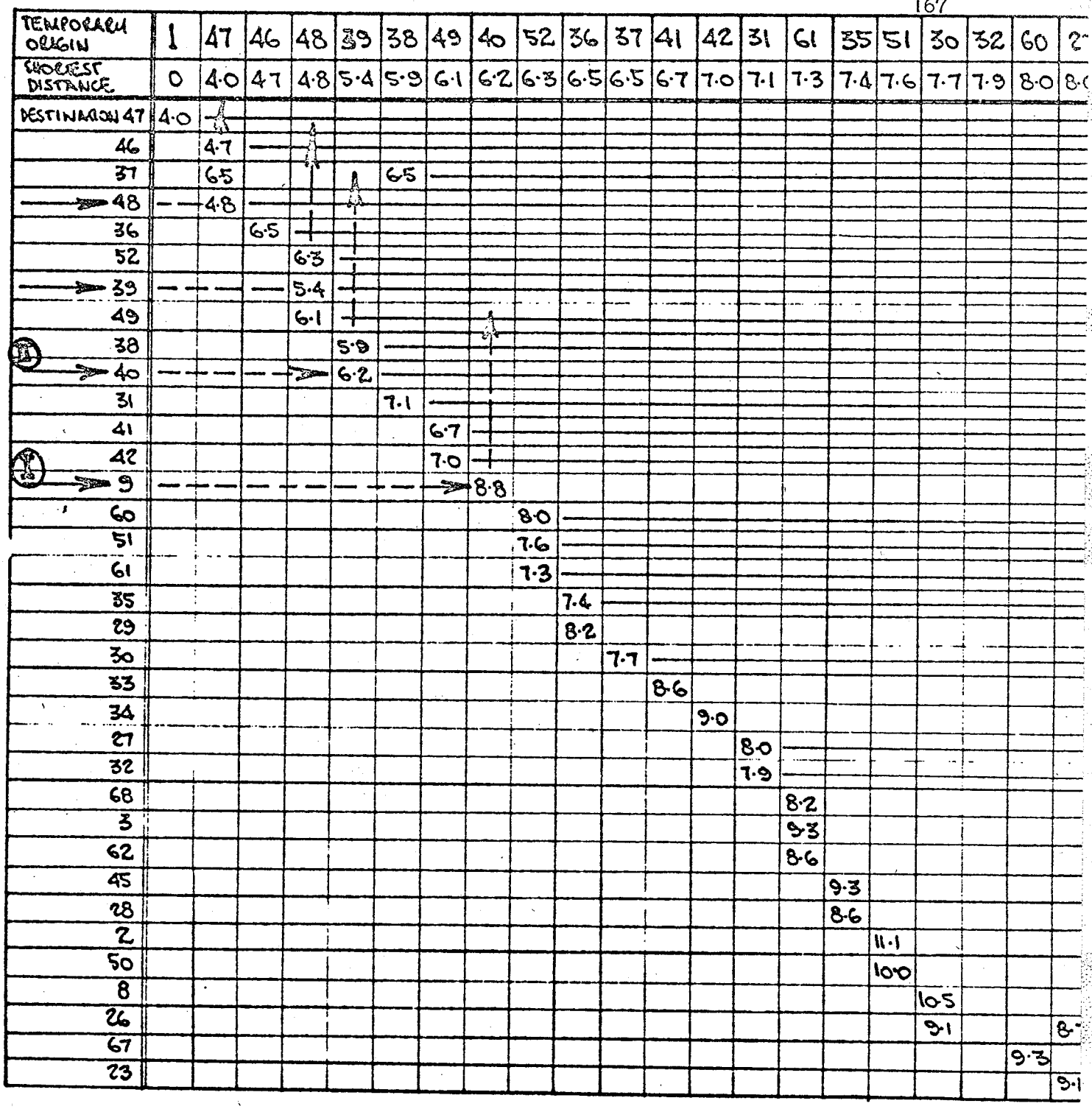

FIGURE 21. Identification of minimum time paths for centroid 1.

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APPENDIX B

CRITERIA FOR OCCUPATIONAL BREAKDOWN

FOR THE PURPOSE OF STUDYING GROUP BEHAVIOR WITH RESPECT TO RESIDENTIAL-WORK PLACE LOCATION AS IT IS AFFECTED BY SOCIO-ECONOMIC CONDITIONS, THE WORK FORCE WAS DIVIDED INTO THREE BROAD OCCUPATIONAL GROUPS: MANAGERIAL, CLERICAL AND LABOUR. THE CHOICE, FOR ANALYSIS, OF THESE THREE CATEGORIES WAS BASED ON CERTAIN BEHAVIORAL PATTERNS DISTINCTIVE TO EACH INDIVIDUAL GROUP AND THE TECHNICAL DIFFICULTY OF MATCHING CENSUS OCCUPATIONAL DATA WITH OCCUPATIONAL DATA OBTAINED FROM THE SAMPLE. THE DETAIL OF CENSUS GROUPINGS NECESSITATED RE-CLASSIFICATION TO FIT THE MORE BROADLY CLASSIFIED SAMPLE GROUPINGS.

SOCIO-ECONOMIC CHARACTERISTICS

THE MANAGERIAL GROUP IS GENERALLY CHARACTERIZED BY AN ABOVE-AVERAGE INCOME WHICH MAKES DECISIONS CONCERNING RESIDENTIAL LOCATION AND TRAVEL COSTS MORE FLEXIBLE. THERE ARE FEW HOMES IN AN URBAN AREA WHERE FACTORS OF PROPERTY VALUE AND TRAVEL COSTS PLACE THESE HOMES BEYOND THE RANK OF A MANAGERIAL INCOME. BALANCING THE LOCATIONAL FLEXIBILITY PROVIDED BY HIGHER INCOMES ARE TWO CHARACTERISTICS OF THE MANAGERIAL GROUP WHICH STABILIZE RESIDENTIAL AND WORK AREA LOCATION TO CERTAIN AREAS OF THE CITY. ON THE AVERAGE MANAGEMENT PERSONNEL HAVE A HIGH SELECTIVITY FOR THE SUITABLE JOB. ASPECTS OF PERSONAL ASPIRATION AND ADVANCEMENT LIMIT THE DESIRABILITY OF AVAILABLE JOBS TO THIS GROUP. IRRESPECTIVE OF LOCATIONAL INCONVENIENCE, THIS ASPECT TENDS TO STABILIZE MANAGERS IN EXISTING JOBS OR DIRECTS MOVEMENT TO ONLY THOSE JOBS WHICH BETTER SATISFY ADVANCEMENT POSSIBILITIES. THE OTHER CHARACTERISTIC OF THE MANAGEMENT GROUP WHICH STABILIZES HOUSING LOCATION IS A FUNCTION OF GROUP SOCIAL-STATUS BEHAVIOR PATTERNS. STATED SIMPLY, THE FACT THAT CERTAIN HOUSING TYPES MAY BE WITHIN THE

MANAGER'S INCOME DOES NOT MEAN SUITABILITY WITHIN A MANAGER'S SOCIAL EXPECTATIONS. HOUSING AS A SYMBOL OF STATUS HERE OVERRIDES THE COMMODITY ASPECT OF HOUSING IN ESTABLISHING RESIDENTIAL LOCATION CRITERIA.

THE UNIQUE SOCIO-ECONOMIC CHARACTERISTICS OF THE CLERICAL GROUP ARE BASED ESSENTIALLY ON LOCATIONAL LIMITATIONS IMPOSED BY AVERAGE OR LESS THAN AVERAGE INCOME, AND ABOVE-AVERAGE STATUS CONSIDERATIONS. THOUGH THE QUALITY AND STATUS OF HOUSING ACCOMMODATION SOUGHT BY THIS GROUP IS HIGH, A COMPROMISE FORCED BY LIMITED INCOME MAKES TRAVEL COSTS AND PROPERTY VALUES IMPORTANT TO THESE INDIVIDUALS. PECULIAR, TO THE CLERICAL GROUP IS THE HIGH PERCENTAGE OF FEMALE AND SUBSIDIARY WAGE EARNERS COMPRISING THIS GROUP. IN GENERAL, UNLESS A FEMALE WORKER IS THE PRINCIPLE WAGE EARNER IN THE HOUSEHOLD, RESIDENTIAL LOCATION IS NOT DICTATED BY HER SPECIFIC WORK DESTINATION.

THOUGH JOB ADVANCEMENT AS A FACTOR IN STABILIZING WORK PLACE LOCATION CAN BE EXPECTED AMONG THE LABOUR GROUP, ITS IMPACT IS CERTAINLY NOT AS SIGNIFICANT AS IN THE TWO PREVIOUSLY MENTIONED GROUPS. BASED SOLELY ON ECONOMIC CONSIDERATIONS (IE. HOUSING COST, TRAVEL COST AND INCOME), THIS GROUP CAN BEST BE EXPECTED TO FOLLOW TRADITIONAL LOCATION THEORY. IT SHOULD BE RECOGNIZED, HOWEVER, THAT INCOMES IN MOST CASES EQUALING OR EXCEEDING THE CLERICAL GROUP INJECT INTO LABOUR PERSONNEL NEW SOCIAL NEEDS WHICH MAY CAUSE READJUSTMENTS IN TRADITIONAL TRAVEL PATTERNS.

RECLASSIFICATION OF CENSUS OCCUPATIONAL CRITERIA

ACCORDING TO STATISTICS CANADA THE OCCUPATIONAL BREAKDOWN OF THE WORK FORCE IS DIVIDED INTO NINE CATEGORIES.

1) MANAGERIAL
2) PROFESSIONAL AND TECHNICAL
3) CLERICAL
4) SALES
5) SERVICES AND RECREATION
6) TRANSPORT AND COMMUNICATION
7) PRIMARY
8) CRAFTSMEN, PRODUCTION PROCESS AND RELATED WORKERS
9) LABOURERS

THE RECLASSIFICATION OF THESE NINE CATEGORIES INTO THREE BROADER GROUPINGS NECESSITATED ALTERATIONS IN DEFINITIONS. UNDER THE ADJUSTED CLASSIFICATION SOME OCCUPATIONS PREVIOUSLY INCLUDED IN A GIVEN CATEGORY WERE OMITTED, OTHER OCCUPATIONS WERE ADDED AND STILL OTHERS REMAINED UNCHANGED. THE ADJUSTED CATEGORIES ARE AS FOLLOWS:

1) ALL INDIVIDUALS, IN THE SAMPLE WHOSE EMPLOYMENT TYPE WAS LISTED AS MANAGERIAL, REGARDLESS OF OVERLAP WITH PROFESSIONAL, TECHNICAL, SALES ETC. CATEGORIES, WERE INCLUDED UNDER THE MANAGEMENT GROUP. INDIVIDUALS WHOSE SUPERVISORY RESPONSIBILITY EXCEEDED THAT OF A FOREMAN WERE ALSO CONSIDERED UNDER MANAGERIAL PERSONNEL.

2) ALL INDIVIDUALS WHOSE EMPLOYMENT TYPE WAS GIVEN IN TERMS OF THEIR PROFESSIONAL OR TECHNICAL COMPETENCE (EG. INDUSTRIAL ENGINEER OR PLANT CHEMIST) WERE OMITTED FROM THE SAMPLE.

3) ALL OFFICE PERSONNEL, EXCLUDING OFFICE MANAGERS, ARE INCLUDED UNDER THE CLERICAL GROUP. EXCLUDED FROM THIS GROUP WERE INDIVIDUALS WHOSE AREA OF OFFICE RESPONSIBILITY WAS CLEARLY PROFESSIONAL

(EG. CHARTERED ACCOUNTANTS, LAWYERS, ETC.) AND WAS STATED AS SUCH.

4) WITH THE EXCEPTION OF SALES MANAGERS AND WAREHOUSEMEN, ALL PERSONNEL RELATED TO SALES, WHETHER IN RECEIVING OR IN DISTRIBUTION WERE OMITTED FROM THE SAMPLE. ALSO OMITTED WERE OFFICE PERSONNEL EMPLOYED IN SALES.

5) ALL PERSONNEL IN SERVICE AND RECREATION, WITH THE EXCEPTION OF PERSONNEL MANAGERS WERE OMITTED.

6) TRUCK DRIVERS, FOREMEN AND OTHER WORKERS WHOSE EMPLOYMENT TYPE ARE RELATED TO TRANSPORTATION AND COMMUNICATION WERE ALSO OMITTED. EXCLUDED FROM THIS CATEGORY ARE AUTO MECHANICS OR INDIVIDUALS WHO SERVICE TRANSPORTATION EQUIPMENT.

7) ALL PRIMARY WORKERS WERE OMITTED.

8) THE CATEGORY OF CRAFTSMEN, PRODUCTION PROCESS AND OTHER RELATED WORKERS, WAS COMBINED WITH THE LABOUR GROUP. TO INCLUDE ALL SKILLED AND UNSKILLED PERSONNEL IN PRODUCTION UNDER THE SINGLE LABOUR CATEGORY. THIS CATEGORY INCLUDES TECHNICAL PERSONNEL ENGAGED IN PRODUCTION AND CATEGORIZED AS PRODUCTION WORKERS, WAREHOUSEMEN, AUTO MECHANICS AND ALL THE EMPLOYMENT TYPES SPECIFIED IN THE CENSUS TO BELONG TO THE TWO FORMER GROUPS. FOREMEN ARE EXCLUDED FROM THIS CATEGORY, AS ARE PRODUCTION MANAGERS.

APPENDIX C

COMPUTER PROGRAM FOR TRIP ORIGIN ASSIGNMENT USING MONTE CARLO METHOD

(INCLUDING SAMPLE OUTPUT FOR MANAGEMENT GROUP)

```
FORTRAN IV G LEVEL  20.1                MAIN                DATE = 72083        17/32/45

                C     CALCULATES ACCUMULATIVE PROBABILITY AND ASSIGNS TO CENSUS TRACTS
0001                  DIMENSION APROB(750),PROB(750)
0002                  READ(5,100)APROB(1)
0003              302 FORMAT('0',2F10.5,I5)
0004              100 FORMAT(F10.5)
                C     N IS NUMBER OF CENSUS TRACTS
0005                  READ(5,101)N
0006              101 FORMAT(I5)
0007                  DO 10 I=1,N
0008                  READ(5,100)PROB(I)
0009               10 CONTINUE
0010                  WRITE(6,102)PROB(1),APROB(1)
0011              102 FORMAT('0',2F10.5)
0012                  READ(5,101)NOB
0013                  DO 15 I=1,NOB
0014                  APROB(I+1)=APROB(I)+PROB(I+1)
0015                  WRITE(6,102)PROB(I+1),APROB(I+1)
                C     CHECK TO SEE IF FIRST PAIR ARE THE SAME
0016               15 CONTINUE
0017                  EROR=1.0-APROB(I+1)
0018                  WRITE(6,102)EROR
0019                  IF(ABS(EROR).GT.0.01)GO TO 22
                C     RANDU SUBROUTINE PICKS RANDOM NOS. FROM 0 TO 1
                C     M IS NUMBER OF TRIALS
0020                  READ(5,101)M
0021                  IX=1477
0022                  DO 21 J=1,M
0023                  CALL RANDU(IX,IY,RAND)
0024                  IX=IY
0025                  DO 19 I=1,N
0026                  IF(RAND.LT.APROB(I))GO TO 20
0027               19 CONTINUE
0028               20 WRITE(6,302)APROB(I),RAND,I
0029               21 CONTINUE
0030               22 CALL EXIT
0031                  END
```

SAMPLE OUTPUT
(MANAGEMENT)

RANDOM NUMBER	ACCUMULATIVE PROBABILITY	TRACT NUMBER	RANDOM NUMBER	ACCUMULATIVE PROBABILITY	TRACT NUMBER
0.04508	0.10362	1	0.53668	0.53785	28
0.27045	0.28460	3	0.57333	0.57503	33
0.21703	0.28460	3	0.60986	0.61115	40
0.86810	0.90712	73	0.49916	0.50271	25
0.25532	0.28460	3	0.50624	0.51396	26
0.71907	0.72186	53	0.54500	0.54676	29
0.01649	0.10362	1	0.71382	0.71793	52
0.62732	0.64005	43	0.37796	0.38382	8
0.61550	0.62118	42	0.84331	0.84951	72
0.04714	0.10362	1	0.65825	0.66966	46
0.74339	0.74355	62	0.35974	0.37032	7
0.03605	0.10362	1	0.23417	0.28460	3
0.52578	0.52901	27	0.16732	0.21008	2
0.83023	0.84951	72	0.89640	0.90712	73
0.24938	0.28460	3	0.87251	0.90712	73
0.02423	0.10362	1	0.16748	0.21008	2
0.90096	0.90712	73	0.15230	0.21008	2
0.18772	0.21008	2	0.40651	0.40694	12
0.01766	0.10362	1	0.06837	0.10362	1
0.41647	0.43487	13	0.75164	0.75269	64
0.33991	0.34672	6	0.89455	0.90712	73
0.29118	0.31725	4	0.60249	0.60714	39
0.68790	0.69851	48	0.56403	0.56990	32
0.50680	0.51396	26	0.96177	0.96998	81
0.84964	0.90712	73	0.69437	0.69851	48

APPENDIX D

OUTPUT FROM CHI-SQUARE (χ^2) "GOODNESS OF FIT" TEST FOR LABOUR AND CLERICAL GROUPS

CLERICAL GROUP

TIME CODE	OBSERVED ORIGINS	EXPECTED ORIGINS
1	20.00	28.00
2	34.00	33.00
3	23.00	20.00
4	30.00	30.00
5	23.00	26.00
6	15.00	7.00
7	5.00	6.00
	150.00	150.00

DEGREES OF FREEDOM = N - 1 = 7 - 1 = 6

CHI SQUARE = 12.422

$\chi^2_{0.95}$ = 12.6 12.422 GOOD FIT

$\chi^2_{0.05}$ = 1.64 12.422 FIT NOT SO GOOD AS TO BE UNBELIEVABLE

LABOUR GROUP

TIME CODE	OBSERVED ORIGINS	EXPECTED ORIGINS
1	86.00	123.00
2	220.00	192.00
3	105.00	97.00
4	120.00	106.00
5	58.00	73.00
6	35.00	32.00
7	9.00	10.00
	633.00	633.00

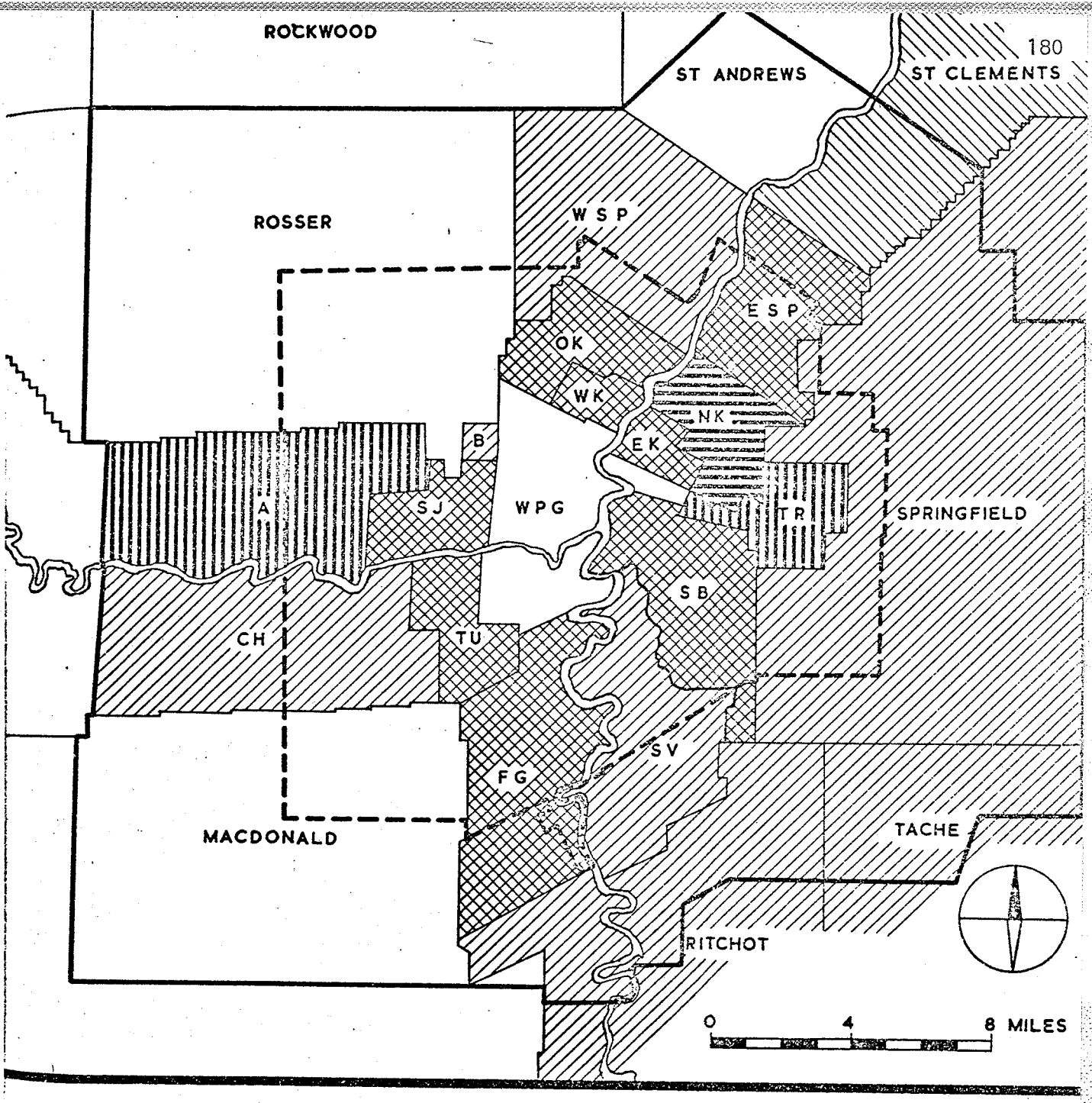
DEGREES OF FREEDOM = N-1 = 7-1 = 6

CHI SQUARE = 21.186

$\chi^2_{0.95} = 12.6 \quad 21.186$)
)
$\chi^2_{0.05} = 1.64 \quad 21.186$) FIT NOT GOOD

APPENDIX E

INTERNAL POPULATION GROWTH FOR GREATER WINNIPEG



ASSINIBOIA	SB	ST BONIFACE
BROOKLANDS	SJ	ST JAMES
CHARLESWOOD	SV	ST VITAL
EAST KILDONAN	TR	TRANSCONA
EAST ST PAUL	TU	TUXEDO
FORT GARRY	WK	WEST KILDONAN
NORTH KILDONAN	WSP	WEST ST PAUL
OLD KILDONAN	WPG	WINNIPEG

ANNUAL DECREASE LESS THAN 1%
ANNUAL INCREASE LESS THAN 1%
ANNUAL INCREASE 1% – 5%
ANNUAL INCREASE 5% – 10%
ANNUAL INCREASE 10% – 15%
ANNUAL INCREASE OVER 15%

AVERAGE ANNUAL INCREASE FOR METRO AREA 2.7%

Source: Winnipeg Development Plan Progress Report No. 1

POPULATION INCREASE 1956-1961

MAP VII. Internal population increase for Greater Winnipeg and umland, 1956 - 1966.

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