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Socio-economic factors and the journey to work: A case study of AT&T GIS employees

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Socio-Economic Factors and the Journey to Work
A Case Study of AT&T GIS Employees

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Abstract

Individuals who must commute to work are often concerned with the spatial separation of their home and job site. In many of these cases the socio-economic characteristics of these individual's lives play an important part in deciding how long this commute is, in terms of both time and distance. The following study seeks to identify the relationships between several selected socio-economic characteristics and the journey to work distances for employees at AT&T GIS

The factors being examined in this study are age, education level, number of dependents, income, length of service to the company, occupation type and gender. Significant differences in commuting distances were identified for the subgroups of employees being compared for five of the above factors. Only income and number of dependents were found to have no significant effect on commuting distances. However, when maximum commuting distances were compared for men and women separately, the number of dependents claimed by the individuals in the subgroups was found to affect the spatial separation of home and work for many of these individuals.

Crosstabulations, difference of means t-tests and regression analyses were conducted to identify patterns and relationships inherent in the dataset provided by AT&T GIS. Unless stated otherwise, the confidence level selected for all statistical tests was 95%.

Acknowledgements

Firstly, I would like to thank my family for their encouragement and support over the years. Without their constant concern and help much of my success in the past would not have been possible. I would especially like to thank my sister Sharon and her husband Alan for their efforts in helping me to complete much of this thesis.

I would like to thank my advisor Dr. Al Hecht for his help, patience and understanding throughout the last few years. Despite all of the problems I presented to him he managed to continue to show faith in me. Dr. Hecht's knowledge and expertise proved to be an invaluable aid to my work.

Finally, I would like to thank Carolyn Moore and AT&T GIS for providing me with the data I needed to complete my research. Carolyn's efforts to provide me with an easy-to-use dataset were much appreciated.

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1.0 INTRODUCTION

AT&T Global Information Solutions (AT&T GIS), formerly National Cash Register (NCR) Canada, established its production, research and design and strategic management facility in Waterloo in 1972. Operations since then have centred around the production of computer components and imaging systems for numerous clients, from private businesses and banks to national governments. With an initial facility size of 70,000 square feet and a nucleus of 14 employees, the facility has since quadrupled in size to 280,000 square feet while employing over 500 full time staff. Operations at AT&T GIS have typically been high-tech, but the company still employs a wide range of people for a wide range of occupational types. AT&T GIS is currently Waterloo's largest industrial employer

The following thesis seeks to analyze the journey to work patterns of the employees of AT&T GIS. It is hypothesized that the distances traversed by AT&T GIS employees are a function of several factors including: sex, age, length of service to the company, level of education, income, occupation type and number of dependents. By analyzing the relationships between commuting distances and these factors it is hoped that a model can be developed which offers an explanation for the reason AT&T GIS employees commute the distances that they do.

AT&T GIS is located in the northern end of the Kitchener CMA region, a primarily urban area containing a population of 356,000 (Statistics Canada, 1991). This will inevitably affect the size of journey to work distances within the dataset. Since the cities of Kitchener and Waterloo have the population to support the labour demands of a facility such as AT&T GIS it can be expected that a sizable percentage of the cases within the dataset will come from the immediate area surrounding the facility. A survey conducted in 1992 suggested that as many as 50% of all employees may come from within 2 kilometres of the facility, an additional 45% may come from within 10 kilometres, while only 5% commute more than 10 kilometres to work AT&T GIS's close proximity to highway 86, highway 8 and the 401 should be noted as a contributing factor to the increased commuting distances of those cases which commute more than 10 kilometres to work.

Numerous studies on gender differences and commuting patterns have clearly established that female commuters travel shorter distances to work than their male counterparts (Blumen, 1994; Hanson and Johnston, 1985; Singell and Lillydahl, 1986, Tkocz and Kristensen, 1994; Hammers, 1994). The first question this thesis seeks to answer is whether or not this generality holds true for employees at AT&T GIS Given the variety of socio-economic and personal characteristics for male and female cases within the dataset it should be possible to perform an unbiased study of gender as a factor in commuting distance.

A second factor to consider is that of age. Does the age of a person affect the distance which they are willing to drive to work? Studies like that by Tkocz and Kristensen (1994) suggest that it does. Often age is closely related to the length of time an employee has worked for a company. Do differences in commuting distances reflect differences in the amount of time various employees have worked for AT&T GIS? Little has been written which addresses the notion that company loyalty affects the commuting pattern of employees.

Levels of education will also be examined as a potential contributor to the journey to work phenomenon By defining education categories (e.g 3 = considerably educated, 1 = limited education) it will be possible to analyse the potential relationship between the education variable and the corresponding commuting distance within the dataset.

Often the occupation or career a person pursues is a direct result of their educational experience. Occupation is said to have a definite impact on the commuting distances of employees (Hanson and Johnston, 1985; Villeneuve and Rose, 1988; Johnston-Anumonwo, 1988, Gordon et al., 1989). Considering the wide array of occupational types within AT&T GIS, it will be possible to examine the impact which this factor has on journey to work distances..

Income level is often a result of the occupation which a person holds. Past studies (Hanson and Johnston, 1985; Madden, 1981; Hecht, 1974) have suggested that lower income workers incur shorter journey to work times and distances. However, in light of the recent recession, does this hold true today: do lower income earners still commute shorter distances or are they forced to commute longer distances for work?

Finally, the number of dependents which an employee has will be examined as a potential contributor to journey to work distances. As the number of dependents for which an employee is responsible for increases, is that employee willing to commute longer distances to work? Given that children, as dependents, are often considered a household responsibility a discussion of household responsibilities will supplement this section.

Statistical methods such as crosstabulations, difference of means paired sample T-tests and regression tests will be employed in the analysis of the dataset

1.1 Why Did AT&T GIS Choose Waterloo?

As with many corporations, location considerations were a primary factor in deciding where to locate the production and administration facilities of NCR The first consideration was that of locating relatively close to consumer markets as well as component suppliers By opting to locate the production facility in Waterloo, NCR was able to remain relatively close to its large U.S. markets while situating itself near to its primary component suppliers. The major highways in this region of the province (highways 86, 8, 401, 402 and the QEW) facilitated the ease of movement of goods and personnel between facilities.

The second major reason for choosing Waterloo was that it was home to two world class universities Wilfrid Laurier University (WLU) and the University of Waterloo (U.W.). WLU is renowned for its School of Business and Economics and the University of Waterloo is one of the world's leading co-op universities specializing in computer science and engineering. Many of the students who conduct their co-op terms at AT&T GIS are from either WLU or U.W., and a number of the full-time staff at the facility have received their post secondary school educations from one or both of these schools WLU business students provide a labour pool of potential administration employees, while U W students are often selected for positions in AT&T GIS's research department

This close tie between AT&T GIS and student populations at both WLU and U W may be part of the reason why such a detailed dataset was provided by the company for this research. Having worked so closely with many of the students in this area, AT&T GIS

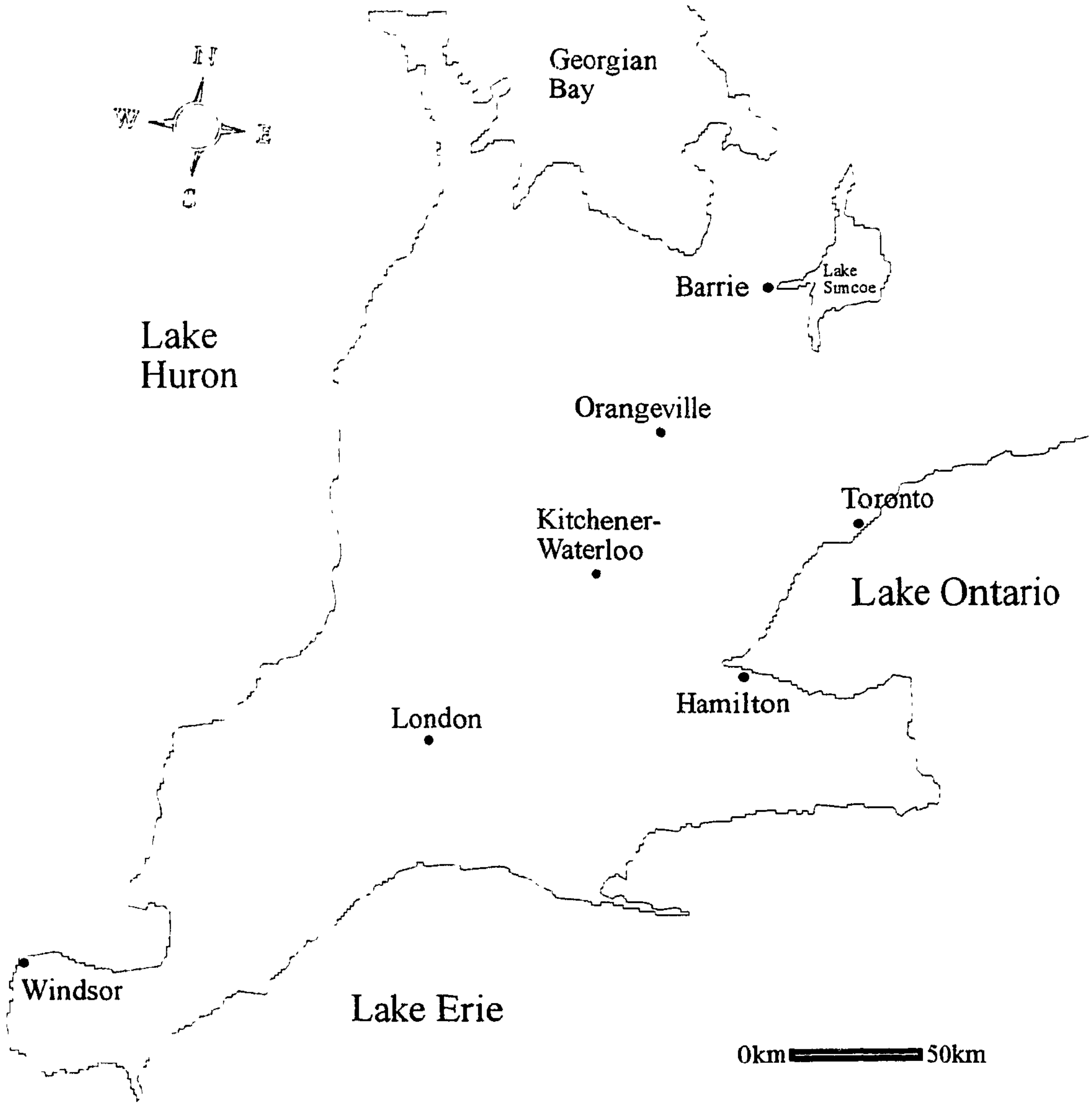


Figure 1: Map of Kitchener-Waterloo and South-Central Ontario

may feel linked in part to the two schools. In fact, AT&T GIS is a member of U W 's Institute for Computer Research, where they commission experts to conduct research relevant to their business. This thesis, therefore, may be viewed by the company as potentially another research project of interest to the corporation

2.0 LITERATURE REVIEW

A number of articles were reviewed in preparation for the writing of this thesis. A considerable proportion of these articles, however, were written during the last hey-day of journey to work research, some 20 to 30 years ago. While many of the arguments made in those research studies were valid when they were written (and may still be valid today), more contemporary research was given preference in regards to referencing material. Some current studies (i.e. Monroe and Mariaz, 1985) suggest that commuting patterns and lengths have changed since the early to mid 1970s. If this is true, a concentrated look at journey to work studies undertaken inside the last 10 years is warranted. If commuting patterns and lengths have not changed, then the more contemporary studies likely reiterate many of the results of those similar studies undertaken in the 1950s to 1970s.

Three main sources provide the basis for much of the reference material used for this study. Articles written and published by fellow academicians interested in the journey to work phenomenon provide most of the support for the arguments made hereafter. Only those articles which have contributed the most, in terms of ideas, conclusion and other references have been included in this review. Other references may be used, but only for a single conclusion. Texts provided an invaluable source of information on the value of commuters time. The last main source was the contact person at AT&T GIS who not only provided a tour of the AT&T GIS facilities and explanation of operations, but also helped to categorize select data and answer select questions on cases within the AT&T GIS dataset.

2.1 Journal Articles

"Gender Differences in Metropolitan Travel Behaviour" by Peter Gordon, Ajay Kumar and Harry W. Richardson (1989) was as an excellent source of information on the impact of dependents, income and occupation on commuting patterns. Their research, while agreeing with prior studies which suggest a difference in journey to work distance between males and females, does not however, support many of the constraint hypotheses posited by these other studies. Gordon, Kumar and Richardson found that while women do commute shorter distances than males, this pattern is not attributable to differences in the level of household responsibilities nor to the presence of children. While admitting that constraints may exist on females regarding their ability to commute/ their utility gained from commuting distances equal to their male counterparts, results of this study indicate that these constraints do not necessarily exist to the degree suggested to by previous studies.

Income was also found to negatively correlate to the journey to work for women, but not for men. For women, higher incomes mean that the individual is better able to afford to shorten the work-trip length. The type of occupation an individual had was not found to be a significant factor in determining work-trip distances.

Much of the support for the arguments made within this study came from the findings of other scholars and from simple visual examination of their tables of data. For those people who appreciate a quantitative approach to studies such as this, regression tests were undertaken, with the results provided in a simple table. More statistical analyses of the data or a more in-depth discussion on the regression tests undertaken would have led to an increased air of credibility.

"Gender differences in Work Trip Length: Explanation and Implications" by Susan Hanson and Ibipo Johnston (1985), addresses the impact of such factors as income, household responsibilities, mobility and occupation on journey to work distances. The focus of this article is clearly on the female perspective. This may hint at a feminist bias of the authors. Numerous references are made to studies which support the notions of constraint factors on the female journey to work experience with little, if any, reference to works which denounce such hypotheses. References to the lessened mobility and lower incomes of females are not found as prominently in any of the other articles used in this study as they are in Hanson and Johnston's article.

Hanson and Johnston found that women commute shorter distances than men for several reasons. The most significant reasons are that women are: paid lower wages, have greater household responsibilities and are less mobile (rely more heavily on public transportation) then men. These results were drawn from an examination of spatial differences between home and work. When travel times were concerned results were not as clear

"Commuting Distances and Gender: A Spatial Urban Model" by Zygmunt Tkocz and Gustav Kristensen (1994) is a highly quantitative look at the relationships between commuting distances and distances of residences to city centres. However, this is not where the value of this particular article lies to this thesis. Rather, Tkocz's and Kristensen's analysis and brief discussion on the impact of education, the presence of children and age on commuting distance is of primary interest.

Tkocz and Kristensen's research suggests that journey to work distances positively correlate to education for women but not for men. The presence of children, on the other hand, tends to hinder the commuting distances of women but encourages intercity commuting for men. Tkocz and Kristensen also found that age negatively correlates to the spatial separation of home and work. At higher ages the commuting distances of both males and females decline significantly. This pattern is more noticeable for females then for males.

The discussion of material relevant to this thesis is somewhat lacking in detail. A much more in-depth discussion of statistical results is warranted. Granted, the focus of the article is on the development of models but this should not detract from a discussion on the results of the models. Little reference to other contemporary works is made, with the exception of the introductory paragraphs. Generalities and limits of the findings are not adequately addressed nor are the contributions that a study such as this lends to the geographic discipline.

"Gender and the Separation of Employment from Home in Metropolitan Montreal, 1971-1981" by Paul Villeneuve and Damaris Rose (1988) examines the topic of gender and the journey to work by analyzing changes in commuting patterns over time. Some general conclusions from this article support the notion that commuting patterns have changed since the early 1970s.

As with similar studies, Villeneuve and Rose found a significant difference in the commuting patterns of men and women. Males in the Montreal area drive further distances to work then women. Villeneuve and Rose also go on to suggest that women base their job selection primarily on their residence location. This may explain why shorter commuting distances were observed for females. As well, household responsibility was also suggested as a reason for the difference in commuting distances between the sexes

Women still tend to undertake more household responsibility then males, therefore having less time to devote to the journey to work. Villeneuve and Rose further suggest, however, that this tendency may be changing. Women may be starting to concern themselves equally with their careers as they do their families.

Type of occupation was also found to affect commuting patterns. Individuals with white collar jobs (equalling higher incomes) tend to experience greater home to work separations. This holds true for both men and women.

As an approach to discussing their dataset, Villeneuve and Rose offer a brief critique of a similar study by Hanson and Johnston. This critique effectively prepares the study to address its own limitations as well as to identify the benefits which this study has to offer. As with Hanson and Johnston, Villeneuve and Rose address, albeit briefly, the issue of travel time vs. travel distance. This comparison illustrates that travel distance may be more apt to change than is travel time.

"The Journey to Work and Occupational Segregation" by Ibipo Johnston-Anumonwo (1988) seems, as with the article by Hanson and Johnston, to be written from a feminist perspective. This article deals primarily with the differences between male and female occupations and their journey to work. Johnston-Anumonwo concludes that type of occupation is related closely to the sex of the worker. It was also found that women tend to be concentrated in lower paying jobs.

"The Impact of Family Status on Black, White and Hispanic Women's Commuting" by Valerie Preston, Sara McLafferty and Ellen Hamilton (1993), provides an in-depth look at the impact of family status on the commuting times for women in the New York Consolidated Metropolitan Area. While the focus is on the difference between white, black and Hispanic women, enough general conclusions are drawn regarding the impact of the number of dependents on commuting times to make this a valuable article to this thesis.

In their research Preston, McLafferty and Hamilton found a difference in commuting times between single, childless women and married women with children Children and marriage were found to shorten the time women devote to the work trip Women who were either married with no children or who were single mothers commuted longer times than married mothers. Preston, McLafferty and Hamilton also found that households with children tended to locate in the suburbs where residential space was in greater supply.

This article freely acknowledges the range of works of other academicians who have studied this particular phenomenon. The article gives equal attention to those whose arguments have supported and contradicted the results found within this research paper By doing this, the authors are able to answer questions the reader may have about potential alternative causes or scenarios applicable to this study as they arise The study then has an added level of comprehensiveness. Statistical analyses such as the included F test also serve to effectively provide support for the arguments and comments made within this article.

"American Work Trip Distances: A Reversal of the Historical Trend" by Charles Monroe (1985) provides evidence of the change in commuting distances since the mid 1970s. Through the use of historical records the analysis of commuting patterns extends back into the mid 1700s. The article acknowledges changes in transportation modes, transportation networks as well as economic prosperity and housing locations as being factors in the development of commuting patterns. Changes in the transportation system and the urban economy are cited as primary reasons for the changes in commuting patterns Monroe does acknowledge that the trend he observes may just be a short-term fluctuation in the long-term trend of increasing journey to work distances.

"Gender Differences in the Journey to Work" by Orna Blumen (1994) is another article seemingly written with a feminist perspective on the dual role of women, their mobility and choice of employment location.

One of Blumen's significant conclusions is that women are less mobile then men. This, in conjunction with their tendency to select jobs based on residential location, causes them to commute shorter distances to work than men. Furthermore, married couples with children tend to locate their households in suburban areas. Blumen suggests that these areas generally contain more female type jobs, thus contributing to the shorter work-trip distances experienced by these married women.

This article provides some important insight into commuting distances and times of women vs. men. Some statistical testing is conducted, but Blumen's article adequately addresses its topic easily without these tests. As a conclusion, Blumen devotes several pages to discussing the future implications of the research results. Limitations of the study are also addressed here. Worth attention are Blumen's comments on the lack of comparable methodology and on the age of some of the articles cited.

"An Empirical Analysis of the Commute to Work Patterns of Males and Females in Two-Earner Households" by Larry Singell and Jane Lillydahl (1986) discusses the impact which gender has on residential location and the commuting distances which result from the location decision. Again, as with many of the other articles referenced, modeling is the primary focus of the article. However, the general conclusions and discussions which surround the modeling procedure are of interest to this thesis, primarily as background material (rather than as support for arguments made).

Relevant discussion includes comments made on commuting time, wage, dependents, occupation, education and age. The conclusions drawn about these factors are clear albeit brief.

Singell and Lillydahl found that in households where children are present and females work significantly less than their husbands (if they work at all), residential location is selected based on family housing demands and the location of the male's job Additionally, commuting distances are greatest for the higher income earner in two income earner households. This holds true regardless of whether or not the male is the dominant income earner.

"Workplace Location, Residential Location and Urban Commuting" by Wayne Simpson (1987) is a quantitative look at the decisions people make as to their choice of workplace location and residence location. The models include such things as skill level of the individual, age, number of workers in the household and number of dependents It is not, however, the modeling which is of interest to this thesis. Rather it is the discussion and conclusions stemming from the use of the model which are of interest.

Simpson's major conclusion is that skill level affects the selection of workplace location. As skill level increases so does the spatial extent of the job search For lower skilled individuals the job search is conducted over a smaller area. Workplace location is therefore determined by local employment conditions, moreso for lower skilled individuals then for higher skilled individuals.

"A Model of Residential Location Choice and Commuting by Men and Women Workers" by Michelle White (1977) is a quantitative examination of the journey to work for men and women. Much of the analysis is approached from an economist's view: comments regarding rational economic behaviour of individuals and utility derived from consuming units of time proliferate throughout the study. There are two relevant conclusions to be found in White's article. The first is that when households behave in a purely economically rational manner female workers commute shorter distances than male workers. Second, there is a considerable amount of ambiguity surrounding income effects on commuting distances: a case can be made for either lower incomes being a constraint on the ability of women to commute longer distances or that females with lower incomes commute greater distances to work than similarly paid men.

White's comments regarding both the positive and negative impacts of income on commuting distances for men and women are interesting. While many other researchers lay claim to understanding the effects of income on the journey to work, White addresses the ambiguity of income effects early on in her study. The models she derives to address this ambiguity are thoroughly explained and should be of interest to anyone concerned with the modeling of these effects.

Some of the ideas presented within this study are clearly outdated. For example, in the introduction White states "Women who work must also keep house, cook dinner and perhaps be at home when their children arrive from school." (White, 1977). While in some of today's traditional type households this may still be the case more and more women are now devoting greater amounts of time to their careers instead of their families.

"The Wage Effects of Residential Location and Commuting Constraints on Employed Married Women" by Janice Madden and Lee-in Chen Chiu (1990) is another statistical examination of income effects on the journey to work, with focus here being on employed married women. Madden and Chiu manage to incorporate not only commuting distances but commuting times into their analysis of their dataset This helps them to conduct a more thorough investigation of their data.

In their discussion, Madden and Chiu point out the correlation of age and tenure as tenure increases, so does age. They find that since job tenure is not transportable, age does not affect work-home separations. Madden and Chiu also suggest that marital status may affect the choice of residence and work location. When an individual is not married, or the spouse is unemployed there are fewer constraints on the choice of residence and work location.

As with White's paper some quantitative modeling is conducted However, unlike White's paper, more attention is given to the conclusions drawn from the models then to the actual models themselves. The tables which are included with the paper are excellent summary tools of the respective text.

"The Journey-to-Work Distance in Relation to the Socio-Economic Characteristics of Workers" by Al Hecht (1974) addresses the impact of such factors as income, family size, age and gender on the commuting patterns of individuals from the city of Worcester and the surrounding region in Massachusetts. Although this is the oldest research paper being referenced in the writing of this thesis, it is one of the most valuable

Hecht introduces the subject with a thorough discussion of the theory behind the journey to work phenomenon. Focus here is on the development of urban economic residential location theory. From this discussion Hecht sets the framework for the hypotheses he will be addressing.

Hecht found a positive relationship between journey to work distance and both income and family size. As incomes increased, the spatial separation of home and work increased. As well, as family size increased so did work trip distances. This latter relationship was due primarily to the fact that job locations occurred in the urban core and the residential space required by larger households was found in greater supply, at a cheaper cost, in the urban periphery.

Hecht also found that males commuted greater distances than females. The regression test conducted later in the article contradicted this finding, but the difference in the equation was found to be insignificant.

Age was found to have no impact on journey to work distances.

Hecht employs a similar methodology to the one being used for this AT&T GIS thesis. The multiple regression analysis is an excellent summarization tool which, along with its results, is adequately explained. Unlike this thesis, however, Hecht concentrates considerably more on the theory behind the phenomenon. A theoretical surface is constructed for the Worcester region whereon jobs are located at the centre and residential space increases with distance from the surface centre. This contrasts the AT&T GIS situation where jobs are located on the periphery of the urban area and residential space differs throughout the study area.

"Why Women Work Closer to Home" by Janice Madden (1981) is a very thorough analysis of factors such as household location, income, gender, dependents and years of service (tenure) on the individuals studied in the 1976 Panel Survey of Income Dynamics.

Madden takes a quantitative approach and a seemingly economistic view to her discussion of the subject. Mathematical equations and references to utility dominate the introduction. This approach nicely lays out the foundation for the following analyses.

Madden makes several interesting conclusions in her paper She finds that workers with longer tenure tend to reside closer to work Madden proposes two reasons why this occurs. First, it may simply be because workers are less likely to quit nearer jobs. The alternative reason is that it could be these individuals have had longer times to have adjusted their residential location relative to their job location This relationship between tenure and journey to work distance is found to be stronger for females than for males Madden is one of the few authors found which addresses the factor of years of service as it relates to commuting distances.

Income is found to have an opposite effect to tenure on work trip length As income increases so does the spatial separation between home and work In this case Madden has found the relationship between income and work trip distance to be slightly stronger for males then for females.

Children also have a definite impact on journey to work distances. Madden's findings in this regard are that children have a negative effect on journey to work distances. Furthermore, women with children tend to commute shorter distances then men with children. In two income earner households residential location favours the periphery of the urban area since this region genc has greater residential space at a relatively cheaper cost compared to the urban core.

These conclusions are drawn from the same theoretical framework that Hecht uses. that jobs are located in the city centre and housing prices decrease and residential space increases with movement out from this centre.

The following table summarizes the findings of the above research studies. Where the effects of the factors were examined for both males and females the mathematical sign behind the gender indicates the nature of the relationship between that factor and journey to work distances. "Effect" denotes a significant relationship between the respective factor and journey to work distances but does not indicate the direction of that relationship Under "Gender" is the gender which was found to commute the greater distance.

Table 1: Summary of Literature Review: Relationships Between Journey to Work Distances and Selected Socio-Economic Factors

Researcher	Age	Education	Dependents	Income	Tenure	Occupation	Gender
Gordon, Kumar, Richardson			no effect	women (-)		no effect	males
Hanson, Johnston			women (-)	women (-)		effect (for women)	males
Tkocz, Kristensen	negative relationship	women (+)	women (-) men (+)				
Villeneuve, Rose				positive (due to occupation)		effect (see income)	males
Johnston-Anumonwo						effect	males
Preston, McLafferty, Hamilton			negative relationship				
Blumen							males
Singell, Lillydahl				positive relationship			
Simpson		positive relationship					
White				unclear			males
Madden, Chiu	no effect						
Hecht	no effect		positive relationship	positive relationship			males
Madden			negative relationship	positive relationship	negative relationship		males

2.2 Textbooks

Several books regarding the economics of commuting and residential location were used in the writing of this thesis as well These books are "Commuting Patterns of Industrial Workers" by Leonard Adams (1955), "The Economics of Residential Location" by Alan Evans (1973) and "The Value of Travel Time" by Nils Bruzelius (1979).

Leonard Adams' book addresses questions regarding time associated with the journey to work and the costs of travel. Although this source is almost 40 years old, the information it contains is still applicable to current research since it is not subject to change over time.

The most pertinent information within this source comes from the sections dealing with residential locations of employees, the amount of money and time they may be willing to spend on the journey to work and its analysis of persons who live at greater distances from work than the norm Through an analysis of these variables, Adams is able to identify comfortable commuting distances and times for the average worker Some of Adams' conclusions in this regard were helpful in the creation of the distance ranges found elsewhere in this study.

As the name of Alan Evans' book implies, this source concerns itself with the economic theories related to residential location, including such things as site and bid rents and transportation costs These theories, however, are all based on the analysis of sites located within one city. As such, they are not all applicable to this thesis.

There were several ideas found within this text which proved beneficial to the writing of the following paper. These ideas pertain to the barriers to residential mobility, factors of household location and social agglomeration. Many of Evans' conclusions are drawn from basic economic theory that the individual will behave in an economically rational manner, where the individual seeks to maximize his/her utility while minimizing financial costs

Nils Bruzelius' book deals primarily with economic theory and the analysis of existing economic models; models of utility and probability. It is a highly quantitative look at the value of commuters time However, the equations and models found throughout the text are not of interest to this thesis. Rather, it is the comments made regarding the utility commuter's derive from the journey to work which is of interest. Bruzelius recognizes that this utility may vary significantly from individual to individual thus making generalizations about this utility essentially worthless.

3.0 THE DATA

AT&T GIS graciously provided a generous amount of data for the completion of this thesis. For each of their employees, AT&T GIS provided the following personal information: sex, birth date, actual salary, department, seniority hire date, total number of dependents, postal code (of residence), degrees attained and the date those degrees were received. The table on the following page illustrates the format of the dataset.

3.1 Dataset Clean-up and Manipulation

The dataset as received from AT&T GIS was unfortunately not in a statistically manipulatable format. It was necessary to undertake several steps prior to the statistical analyses in order that these tests could be undertaken. These steps are outlined below

3.2 The Use of Postal Codes

This variable was crucial to the completion of the study. Without this variable commuting distances for employees in the dataset could not be calculated. In order to calculate distances between home and work for employees in the dataset, the AT&T GIS dataset had to be merged with the Statistics Canada's Geography Division Postal Code Conversion File (PCCF).

The first step in preparing the residential postal codes for merger with the PCCF was to eliminate all those cases within the dataset which had no postal code. Once this was completed it was then necessary to ensure that all of the remaining postal codes conformed to the set postal code format. Postal codes consist of 6 characters of alternating alphabets and numbers. This second step was excessively tedious, as all remaining 499 postal codes had to be checked manually.

Table 2: A Sample of the AT&T GIS Associate Roster

Sex	Birth Date	Actual Salary	Department	Seniority Hire Date	Total Number of Dependents	Postal Code	Degree Awarded	Degree Date
Male	6-Nov-65	19008.00	Soft Ware II	22-Aug-94	0		BSC Mechanical Eng.(IIT India)	1-May-87
Female	15-Aug-38	26184.36	ATM Assembly	1-May-84	0			
Female	31-Mar-57	30459.29	Thor Assembly	8-May-78	3		Computer Literacy	3-Sep-91
Male	16-Nov-47	69116.79	Marketing Support	8-Sep-81	1	K7L 2C3	Gen. Bachelor of Science	1-May-75
Female	19-Mar-66	15831.86	CSD, E&M Waterloo	26-Jul-94	0	N3C 3X3	Bachelor of Math Waterloo	1-May-94
Male	6-Jan-62	72822.79	Product Management	23-Apr-90	2	N3C 3Y1		1-Dec-86
Female	7-Jul-59	57042.86	Information Products	14-Jun-93	0	N3C 4A4	Univ of Dayton BBA	1-May-82
Male	24-Oct-58	54654.29	Eng. Expatriates	23-Nov-87	2	N3C 2S9		1-May-79
Male	20-Feb-66	43620.29	Imaging Adv. Dvlpm.	18-Oct-93	0	N3H 3A2		
Male	11-Mar-56	26333.36	Sub Assembly	16-Oct-78	0	N3H 3A5	LAURIER, WATERLOO, ONT.	1-Jun-73
Male	2-Feb-55	51961.57	Information Products	12-May-80	1	N3H 3R7	ENGL 307	5-Mar-93
Male	22-Jul-50	55523.14	Vendor Q.A	12-Nov-79	2	N3H 3B1	GBA Psych.(High Distinction)	28-May-94
Female	10-Aug-41	25952.29	7760 Assembly	11-Sep-78	0	N0B 2A0		
Female	13-Apr-54	29260.43	7721/23/24 TABLE TOP	9-Feb-76	1	N0G 1A0		
Male	17-Nov-55	42439.21	Adv. Ops.Engineering	5-May-80	1	N0G 1A0	GBA (withdrew) York Univ.	1-Apr-78
							Electronics Technician Diploma	1-Sep-80

In total some 49 of the 499 postal codes had been erroneously entered into the computer at AT&T GIS. Most of those cases consisted of a presumably misread character: O's were sometimes entered into the computer as 0's, L's were sometimes entered as 1's (e.g. a postal code such as N2L3C7 would appear in the computer as

N213C7), S's were also substituted for 5's and B's and 8's were sometimes confused. It is possible that many of these postal codes were scanned into the computer from handwritten address records. This would then explain why many of these postal codes were so blatantly incorrect. Only one case from the file had to be deleted at this point as no possible match could be found for the combination of characters which composed the accompanying postal code.

Once this last step was completed it was then possible to merge the AT&T GIS file with the PCCF. Unfortunately, the most recent copy of the PCCF only contains postal code data for postal codes existing as of 1991. Any postal codes created after this date did not appear in the dataset. An additional 45 cases from the 498 had to be deleted because no spatial data existed for these postal codes.

To calculate commuting distances for cases within the AT&T GIS dataset it was necessary to compare the residential locations of AT&T GIS employees with the location of the AT&T GIS facility. The PCCF uses the Universal Transverse Mercator (UTM) system which is an established international system of specifying point locations on the globe. These UTM co-ordinates were included in the PCCF.

The system divides the globe into 60 vertical zones. Altogether, 16 zones bearing numbers 7 to 22 from west to east, cover the land mass of Canada. The zones which concern this study are numbers 17 and 18. Each zone has a width of 6 degrees longitude. In UTM, point locations within a zone are based on two distances, in metres (X and Y), from the zone axes. The two values are combined with a zone number to arrive at a unique coordinate value for every point on the land mass of Canada. (Statistics Canada PCCF Codebook, 3.3)

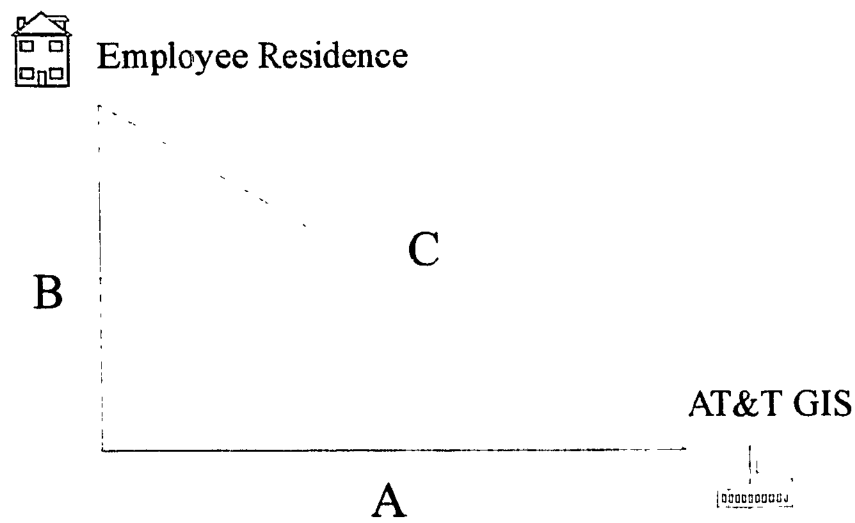
Simple air distances were used in calculating the commuting distances of cases within the dataset. Using simple trigonometry ($C^2 = A^2 + B^2$, see following page) it was possible to easily calculate these distances. "A" is defined as the distance in metres between the UTM X coordinates for the residential postal codes and the UTM X coordinate for AT&T GIS. "B" is defined as the distance in metres between the UTM Y coordinates for the residential postal codes and the UTM Y coordinate for AT&T GIS. "C" is then the air distance between the residential postal code of the cases in the dataset and the AT&T GIS facility. Originally calculated in metres, these distances were later converted to kilometres and classified into distance ranges.

Figure 3 shows the resulting distribution of male and female cases throughout the Kitchener-Waterloo area.

3.3 The Creation of Distance Ranges

Four distance ranges were created in preparing the dataset for crosstabulation analyses. These distance ranges take into account such things as travel times, travel modes possible and type of community found within the range.

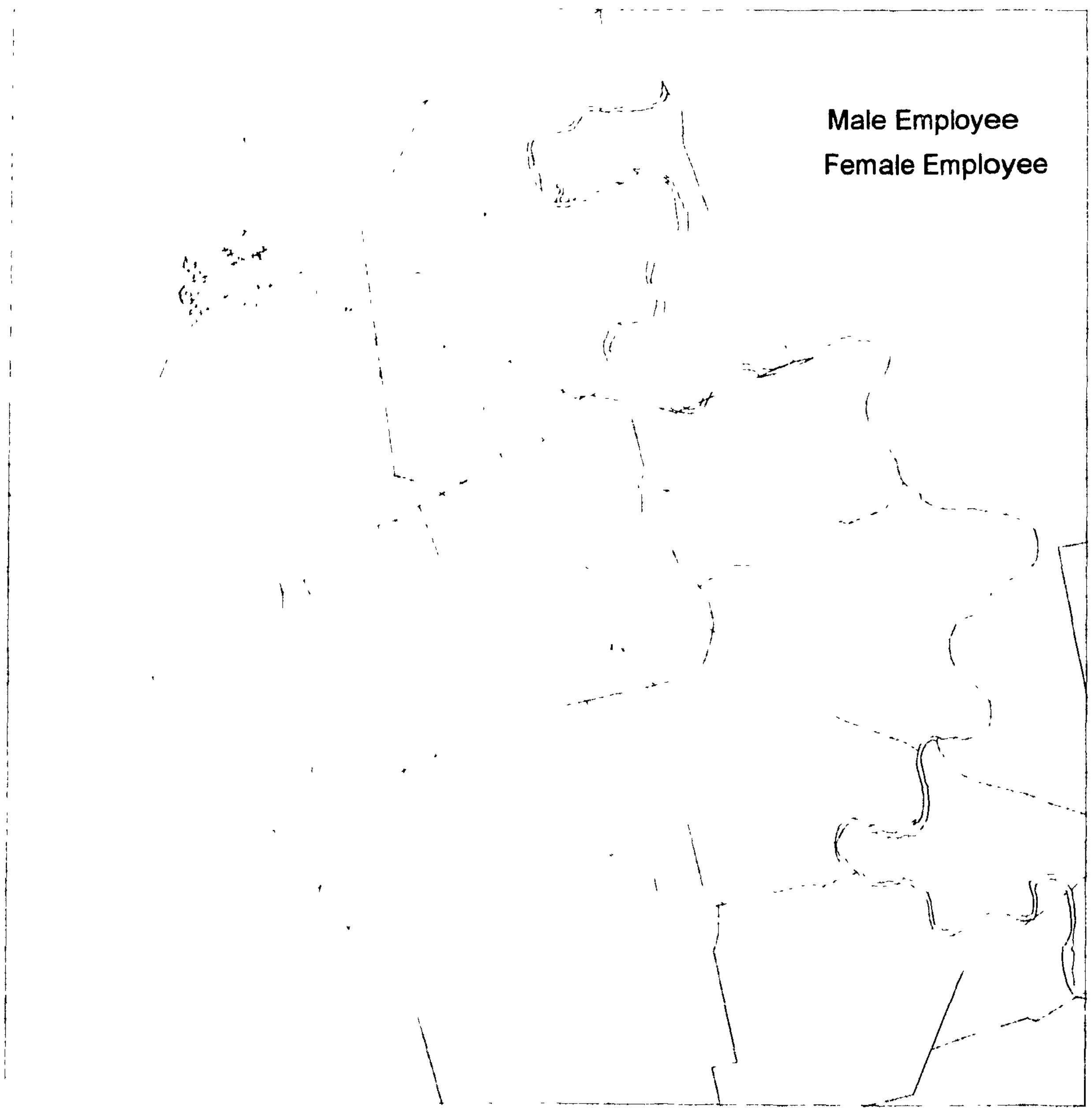
The first distance range is used to identify those employees who live in the immediate area surrounding the plant. The distance range of 0 to 5 kilometres encompasses the northern half of the city of Waterloo (delimited to the south by Erb Street), as well as the small town of St. Jacobs just north of the city. This range represents a very short commute to work. Employees in this range may still drive to work year round but all have the option of walking or biking to work when the weather is warmer. As well, it is possible, at least for those living in the city, to take the bus to work without having to endure bus transfers.



Where: $C^2 = A^2 + B^2$

Figure 2: Calculation of Distances

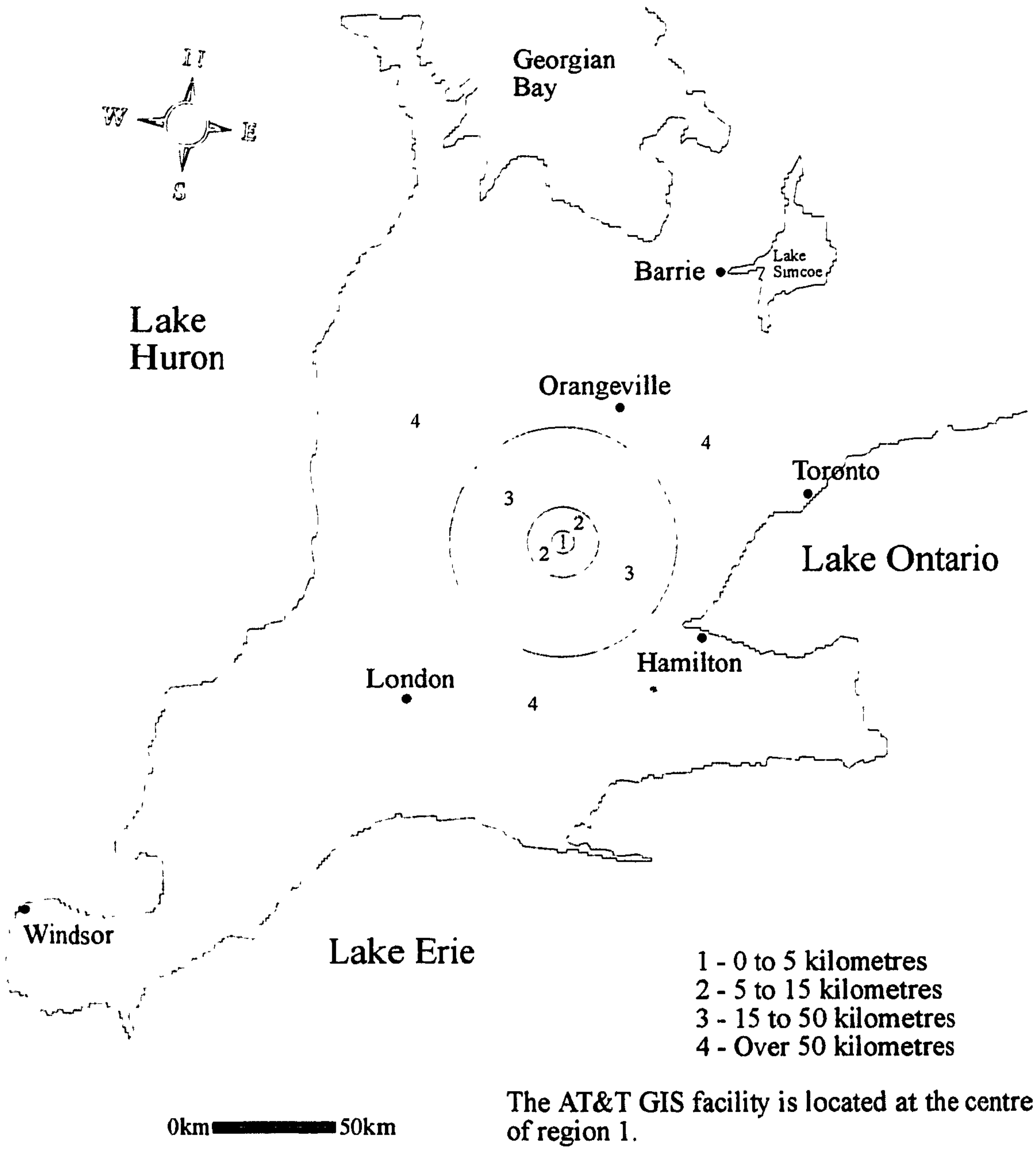
Figure 3: Distribution of Male and Female AT&T GIS Employees in Kitchener and Waterloo



The second distance range, 5 to 15 kilometres, is used to identify the remainder of the urban area immediately surrounding AT&T GIS. This range encompasses all areas as far south as the southern parts of Kitchener, as far west as Bamberg, as far east as Breslau and as far north as Elmira. While employees within this distance range still experience a relatively short commute to work it is unlikely that any will walk or bike to work when the weather is warm. As well, it is no longer possible to reach AT&T GIS by bus without enduring one or more transfers.

The third range defines what is primarily the rural region immediately surrounding Kitchener-Waterloo. This range (15 to 50 kilometres) represents a moderate commute to work. This translates into a maximum driving time of half an hour to 45 minutes (at approximately 80 km/hr, given road conditions and traffic levels). Studies suggest that most workers (an estimated 90%) live within 50 kilometres of their job site (Adams, 1955). For the AT&T GIS dataset this figure lies closer to 97% (96.8%). Employees within this range would definitely drive to work, either by themselves or in car pools Some urban centres located in this range are Woodstock, Brantford, Fergus and Guelph This range stops just west of Hamilton and just south of Orangeville.

The fourth range is used to define what may be considered a long commute, the maximum distance people are willing to commute to work The maximum the average person is willing to spend commuting in a car (one way) is one and a half hours in the summer and two hours in the winter (taking driving conditions into consideration) (Adams, 1955). Employees who drive this distance to work are likely making use of highways 8 and 86 as well as highway 401. Given the speeds permissible on these roads, the distances used to define this maximum comfort range are fairly accurate. Major urban



1 - 0 to 5 kilometres
2 - 5 to 15 kilometres
3 - 15 to 50 kilometres
4 - Over 50 kilometres

The AT&T GIS facility is located at the centre of region 1.

Figure 4: Geographical Regions Identified by Distance Ranges

centres within this range include London, Mississauga and Hamilton. The maximum distance in this last range is 116.3 kilometres.

3.4 The Recoding of Employee Gender

In order to facilitate a statistical analysis of distance and sex of employees it was necessary to convert the alphabetic characters originally in this variable into numeric characters. A code of 1 was assigned to males while a code of 0 was assigned to females Since previous studies have already suggested that males commute greater average distances then females, then if this were also the case with AT&T GIS employees the regression tests would illustrate this in a positive manner (e.g. the traditional form of the model: $y = a + bx$ would appear the same when y = commuting distance, a = some constant and b = sex).

3.5 The Use of Dates

The only two dates of concern to this study are Birth Dates and Seniority Hire Dates. From these dates it was possible to calculate the age of employees in the dataset as well as their length of service to AT&T GIS. While these dates were easily recognizable to the human eye, the computer read these dates as a string of alphanumeric characters Since it would be too time consuming to calculate ages and length of service to the company manually these dates had to be converted and re-entered into the computer Degree Date (the date which an employee received their degree(s)) was eliminated from the dataset. This variable was inconsistently recorded for many of the individuals who had formal educations.

As a point of reference, the date at which the dataset was formed was entered into the computer as the current date. All birth dates and seniority hire dates were then compared against this time (April 28 1995). Once ages and years of service were calculated it was then necessary to create ranges. Without these ranges it would not be possible to create crosstabulations of any meaning since too many table cells would be created.

3.6 The Establishment of Age Ranges

To facilitate the inclusion of the age variable into some of the statistical tests undertaken, age was reclassed into three categories: 1) ages up to 30, 2) ages 30 to 50 and 3) ages 50 and up. The first age category identifies people who have just finished school or taken on their first career job. AT&T GIS has provided these individuals with what is likely their first job since graduating high school, college or university. These people also are likely to have recently undertaken serious commitments (e.g. have recently gotten married, taken out a mortgage for a first home or started a family). The second age category identifies those cases who are beginning to settle in their lives: they have been married for a few years, their mortgages are being paid off and their children are becoming increasingly non-dependent. These individuals have selected a permanent residence and are not apt to relocate soon. The last category identifies those people who have been working for a number of years and are beginning to seriously contemplate retiring. Financial commitments and restraints for these people are minimal (e.g. these individuals may have mortgages paid off and their children may have moved out of the home).

3.7 The Establishment of Length of Service Ranges

As with age, this variable was broken into three classes. The first class (0 to 5 years of service) identifies that group of people who are relatively new to the corporation. These people are likely still employed at the job for which they are hired, or have experienced no more than one promotion. The second class (5 to 15 years) identifies that group of employees who have illustrated a considerable amount of company loyalty, but may yet leave the company for employment elsewhere. The last class (15 years of service and on) identifies those people who have been with the company the longest These people show the greatest commitment to AT&T GIS.

3.8 The Coding of Department (Occupation)

Promotional material written by AT&T GIS suggests that the breakdown of occupations within the company is such that 35% of all associates are engaged in research and design, 35% in manufacturing and the remainder are in administrative, marketing and support positions. Unfortunately the dataset did not reflect this breakdown. Upon consultation with an employee of the company it became apparent that there are many more occupational classifications then previously believed. A total of 11 different occupation types were found within the dataset. This was too many to be effectively analyzed, especially since some of the occupation types had only a few cases representing them. With the help of this associate the number of occupational categories was scaled down from 11 to 8. It was suggested that too great a difference existed between the 8 classes to enable any further reduction in numbers.

Problems with this component of the file lie in its lack of distinction between the personnel in each department who do the manual work and the personnel who supervise and coordinate activities. This distinction may have enabled a more comprehensive analysis of occupation type on commuting distances It is likely that some difference exists between the commuting distances of regular employees and their superiors, but the lack of distinction between the two in this dataset prohibits further analysis.

The breakdown of occupational classes is as follows:

- *Admin (Administration)*: personnel in this occupational category primarily belong to the Finance department and Human Resources
- *CS (Customer Service)*: these people are responsible for providing technical assistance to customers and field engineers
- *Maint (Maintenance)*: staff in this category are responsible for keeping the AT&T GIS facility in working order
- *Mktg (Marketing)*: these personnel decide product features, attend trade shows and assist sales people
- *Prod (Production)*: this department manufactures equipment
- *QA (Quality Assurance)*: personnel test new products and deal with warranty repair problems raised by field engineers
- *R&D (Research and Design)*· personnel in this category design and test new products (prototypes) and features
- *Tech (Technicians)*: are responsible for assisting production personnel with technical problems.

Since this variable contains nominal data and differences between classes are not quantifiable this variable must be reworked for inclusion in the regression tests found at the end of the statistical analyses section.

3.9 The Classification of Education

The second last field in the dataset was used to assign education levels to the employees in the dataset. Three different levels of education were defined, with each class distinguishable from the others by the amount of formal education received by each of the cases within that class. The first category - assigned a value of 1 - defines those individuals who have received a high school diploma and/or have taken introductory college or university courses in some academic discipline. The second class - assigned a value of 2 - represents that group of employees who have received a university or college degree. The last class - assigned a value of 3 - is composed of those individuals who not only received a college or university degree, but also went on to complete more formalized training (e.g.

CMA certification) or their degree in post graduate studies Individuals with no record of education were eliminated from the dataset.

3.10 The Creation of Income Ranges

Data in this variable was broken into three categories to identify low income, middle class and upper class groups. The low income group includes those people who make less than $30,000 a year. This class includes new employees, low level employees, part-time workers and contractors. The second category ($30,000 to $60,000) identifies those employees who have been with the corporation for a number of years and who may be more than entry level workers. The last category ($60,000 and up) identifies those people who at least hold management or supervisory positions with the company or are experts in their field.

3.11 The Categorization of Number of Dependents

This variable contains the number of dependents claimed by the employees within the dataset. Again, as with several of the other variables, this variable was classified into three categories: 1) employees with no dependents, 2) employees with one or two dependents and 3) employees with three or more dependents. The first category is used to identify those cases for which commuting distances are not affected by family constraints These people do not have any of the responsibilities associated with having children (or others to care for) to concern themselves with. Commitments which may include such things as driving children to and from daycare, school or recreational activities and taking children to doctor and/or dentist appointments act as constraints on the time a person with children is willing to spend driving to work. Commuting times for this group may increase as a result of the lack of family dependents. The second group identifies employees with one or two dependents. While these people are subject to more family commitment than the first group, they will not be as constrained as those in the third category. This second class identifies the "nuclear family": those families which have 1 to 2 children (the average number of children per family in Canada is approximately 2). This second category also acts as an intermediate group between those with little or no family commitment and those with considerable family commitment. The final category identifies those people with more than three dependents. These people have the greatest family commitment to attend to.

4.0 POINTS TO CONSIDER

There are several factors which other researchers have noted as being important regarding the journey to work phenomenon. These factors will be briefly addressed in the following section.

4.1 Measuring Spatial Separation: Travel Time vs. Travel Distance

There are many different ways of measuring spatial separation between residence and place of employment. Some past studies (e.g. Hanson and Johnston, 1985; Johnston-Anumonwo; 1988) have utilized travel time for the purposes of analyzing spatial separation. Others, on the other hand, have addressed the spatial separation problem by analyzing physical distance, using either highway distances (Taafe, Garner and Yeates, 1963; Horton and Wittick, 1969) or straight airline distance (Villeneuve and Rose, 1988; Madden, 1981; Hecht, 1974). This thesis utilizes straight airline distances as the means of measuring spatial separation. A comparison of travel times and travel distances would have been a beneficial addition to this study, however AT&T GIS was unable to provide commuting times for the employees in its database.

Given the spatial location of AT&T GIS, a definite difference between travel times and distances would exist for cases within the dataset. Located in the north end of Waterloo, the region to the north of AT&T GIS is primarily rural, agricultural farmland. Directly to the west and south of the facility are the cities of Waterloo and Kitchener. Less than half a kilometre east of the facility is highway 86, which is linked to highway 401 via highway 8. Holding all other factors constant, the differing nature of the transportation networks in the different areas surrounding AT&T GIS would seriously affect the time it takes an employee to traverse a set distance. Speed limits, traffic volumes, frequency of stops and modes of transportation available vary considerably from network to network. These factors will inevitably affect the travel times of employees. While increases in speed limits would act to decrease travel time, increases in traffic volume and frequency of stops would serve to increase travel time. The mode of transport affects travel time in that a set distance can be covered fastest by a car, next by public transit (bus), next by bicycle and lastly by foot.

Additionally, when utilizing travel times for calculations regarding spatial separation one must take into account the notion of utility. Utility is defined as the personal pleasure derived from consuming a unit of some good. In this example, if the good were time, the units could be hours or minutes and the utility derived from driving to work would be the pleasure gained, or lost (disutility) from spending time commuting to work. However, a problem arises when considering that utility will vary from person to person regarding commuting times. While some people dislike driving, others find it a relaxing and enjoyable experience. Unless a researcher assumes that utility values of time are fixed (i.e. there are no distributions for values of times) then modeling becomes overly complex (Bruzelius, 1979, 137).

Airline distances therefore are the easiest to use and potentially the most accurate gauge for measuring differences in spatial separation for cases within the AT&T GIS dataset.

4.2 Household Responsibilities

Marital status is often used, in conjunction with the number of dependents, as a gauge to measure household responsibility. These responsibilities would include such things as the running of errands, cleaning and maintenance tasks of the residence and child care. Household responsibility is commonly referenced as a primary determining factor in commuting distances (Singell and Lillydahl, 1985; Tkocz and Kristensen, 1994; Hanson and Johnston, 1985). While AT&T GIS would not provide information regarding the marital status of their employees they did provide information on the number of dependents for each employee in the dataset.

Results of research conducted by Villeneuve and Rose (1988) suggest that the impact of marital status on the distance which women commute to work may be changing Women may be commuting increasingly larger distances to work. Traditionally women have been socialized into considering their careers secondary to raising a family (Hanson and Johnston, 1985). While this may or may not have changed over the last decade it is still the case that women spend more time on household responsibilities then men (Preston, McLafferty and Hamilton, 1993). What is also the case is that it is becoming increasingly difficult to speculate as to the reasons why women, married or not, commute the distances they do to work, given the changing attitudes towards family and career

4.3 Household Location

In two income earner households it is still usually the case that residential location concerns itself primarily with the male's employment, as traditionally the male is the primary income earner for the family. However, what is often seen is that in situations where the male earns a greater proportion of the household income, residential location is determined such that the women commute lesser distances (Singell and Lillydahl, 1985) Often, when there are children in the household, the choice of location is the suburbs, a more family oriented setting then the downtown city centres. These areas also hold a relatively greater concentration of female jobs which may account for the shorter commuting distances witnessed for married females (Singell and Lillydahl, 1985).

Even though marital status has not been included in this thesis, it will inevitably affect the results of many of the tests, particularly for those cases which belong to two income earner households. Generally, as income increases so will the distance a person is willing to commute. In two income earner households, the workers in the household will have an enhanced ability to deal with the increased costs of commuting longer distances because they will have a greater pool of financial resources to draw from.

Villeneuve and Rose (1988) have suggested that women select their job location based upon their current residential location. If this is indeed the case, then if household location is moved do females automatically search out new employment relative to their new residential location? Common sense says no. A residential relocation will not automatically be accompanied by a change in the employment location of any income earners within the household. However, this will not be reflected in the dataset. There will inevitably be some cases within each dataset where the employee is not comfortable with the distance they commute, but does so simply because a residential relocation necessitated it.

4.4 Household Mobility

Residential relocations are not everyday occurrences for the average individual. There are certain barriers to mobility which play an important role in the decision to relocate. Legal and other charges must be incurred by the owner when relocating, and rent contracts must be dealt with by those who are paying rent for their homes (Evans, 1973).

There are also two primary factors regarding new household location which must be satisfied. The first is cost minimization:

> "It is assumed that the householder attempts to minimize his total location costs and that these location costs are the sum of the total rent that he pays, the direct, financial, cost of travel between his place of work and his residence, and the indirect cost of this journey to work which is the valuation he puts on the time that he must spend on the journey." (Evans, 1973)

For those individuals deciding whether or not to relocate, those costs incurred after the transition must be considered.

The second factor is that of utility maximization. A certain amount of pleasure is derived from the state of the house and its surrounding environment by the owner of that house. This utility is difficult to quantify. However, if the utility generated by the new household location does not, or is not capable of exceeding that generated by the current household location, relocation may not take place. Often the actual residence is of considerable importance to its occupants, as seen by the care many people give to its upkeep and upgrade. Many people are unwilling to sacrifice the time and effort which they put into the personalization of their home for the slight financial gains they would receive by moving closer to their work.

5.0 EMPIRICAL RESULTS

5.1 Notes About Crosstabulations

Each of the following sections is introduced by a discussion on the results of a crosstabulation between the variable under investigation and the distances associated with each of the samples. The first number in each of the cells is the number of observations witnessed for that cell's respective distance range and variable subgroup (n). Row percentages (Row%) and column percentages (Col%) are also given.

Added to the end (right side) of each table are the means and standard deviations associated with each variable subgroup. These values are calculated from the actual distances within the dataset, not from the distance ranges in the crosstabulations. The means were included as a comparative measure, while the standard deviations were included to illustrate the concentration of values in the variable subgroup distributions.

5.2 Age and Journey to Work Distances

Table 3: Age and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
Up to 30 years	0 0.0 0.0	42 85.7 11.9	5 10.2 8.9	2 4.1 16.7	49 (11.1%)	14.49	12.27
30 to 50 years	17 5.3 89.5	250 78.1 70.8	44 13.8 78.6	9 2.8 75.0	320 (72.7%)	14.79	11.82
Over 50 years	2 2.8 10.5	61 85.9 17.3	7 9.9 12.5	1 1.4 8.3	71 (16.1%)	14.21	13.17
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

One of the first things easily noticeable about the above table is that while a very large proportion (84.5%) of AT&T GIS employees live within a short commuting distance to work, very few of these employees (4.3%) live within only 5 kilometres of their job site. As was mentioned earlier, the first and second distance ranges are used primarily to define a short commute to work, the distance being defined as including all of those areas within 15 kilometres of AT&T GIS. The region defined by these ranges is primarily composed of the urban areas of the cities of Kitchener and Waterloo. Obviously the population density of this area is not uniform. If population density was consistent over the region, a greater proportion of employees would be located within 5 kilometres of the plant. One possible explanation for the lower counts in this first distance range may be due to the location of an industrial park immediately to the south of the AT&T GIS facility. This park takes up a considerable proportion of the land surrounding the AT&T GIS facility; land that could be used for subdivisions.

Why do such a large number of employees reside so close to AT&T GIS? The cities of Kitchener and Waterloo provide a large labour pool for AT&T GIS to draw from This pool is large enough that the company is able to meet the bulk of its labour demands by hiring individuals already located in the immediate area. In a similar study conducted on the Honda plant in Alliston (Hammers, 1994) the lack of sufficient labour supply in the immediate area surrounding the Honda facility meant that a greater proportion of employees had to be selected from outside of the immediate Alliston area.

What occurs in the upper distance ranges? A fairly significant number of employees are located within the third distance range. This group of individuals experience what was defined earlier as a moderate commute to work. While the numbers for this third range are significantly lower than those in the preceding range, this third range contains almost 5 times the number of cases within the last class. The number of employees who undergo long journeys to work are fewer than in any other class. The reasons for this difference will be made clear as this section on statistical analysis continues.

Other general conclusions from the above table can be made regarding the number of employees in each of the age categories. The smallest age category is composed of employees under 30 years of age. The la gest age category is composed of employees who are between 30 and 50 years of age. Clearly the majority of employees who work at AT&T GIS are in the middle of their careers.

The group which experiences the greatest commuting distance on average is the middle age group. The youngest age group, those under 30 years of age, experiences the second largest average commuting distance. The oldest employees at AT&T GIS commute, on average, the shortest distances to work.

Tkocz and Kristensen's 1994 study suggests that at higher ages the commuting distances for both women and men decline. Their results would seem to suggest that as age increases, commuting distances decrease. Why then does the middle age group experience the greatest average journey to work (as opposed to the youngest aged group) and why does the highest aged group contain the largest maximum distance (found to be 116.3 kilometres)? There are two reasons why results similar to Tkocz's and Kristensen's are not being found. First, within the youngest age category are cases belonging to WLU and U.W. co-op students. Many of these students have likely reported their school address as their home address. These school addresses are often located within 5 kilometres of AT&T GIS since this distance range includes not only the campuses of both WLU and

U.W. but a considerable area surrounding the campuses. Therefore, the residence locations reported by these employees will directly affect the average commuting distance of this group in a negative manner.

The second factor to consider is that mean distances are being compared, and for smaller sample sizes these means can be seriously affected by large extremes The 116.3 kilometres maximum witnessed in the third age category is indeed an extreme. Notice how it is the only value in the last distance range. When this maximum is dropped from the sample the mean value for this age category drops considerably to 12.7 kilometres.

What needs to be considered then, is whether or not the differences in distances commuted by employees in each of the age categories is significantly different.

Independent Samples T-Tests Results

Prior to a discussion on the results of the following t-tests it should be noted that the independent samples t-test involves an assumption of normality of the sampling distributions of the sample means. When sample size is large enough, the Central Limit Theorem assures us that this condition will be met regardless of the shape of the population distribution being sampled. However, even when sample size is extremely small violations of the sample size demanded by the Central Limit Theorem generally do not have a serious effect on the results of the t-test. (Olson, 378)

In assessing whether or not the means of multiple samples differ significantly from one another it is possible to compare the highest and lowest means and make inferences about the means that lie between. With this in mind, the Levene's test for difference in means was conducted on the mean for the middle aged subgroup and the highest aged subgroup.

Table 4: Difference of Means Test: Intermediate and High Age Groups

Sample	Number of Cases	Mean Distance	Standard Deviation
30-50 years of age	320	14.79	11.82
Over 50 years of age	71	14.12	13.18

Mean difference: 0.67
Calculated probability: p = 0.22

Given a desired confidence level of 95%, when the calculated p value (probability) is greater than 0.05 than the results of a test such as this is that the difference between the two means under examination is insignificant. Only when the probability of getting a difference between means such as exists is less than 0.05 are the test results significant.

From the above table it is clear that the difference in mean distance commuted for middle aged employees at AT&T GIS is insignificantly different from the mean distance traveled to work by AT&T GIS's senior employees. In other words, for all intents and purposes, the mean distance traveled to work by AT&T GIS employees is unaffected by age.

What happens when the extreme value of 116.3 is deleted from the dataset. Since this value had such a significant affect on the mean of the higher aged sample it is likely that the removal of this value will have a noticeable impact on our results.

Table 5: Difference of Means Test: Intermediate and High Age Groups With a Removed Extreme

Sample	Number of Cases	Mean Distance	Standard Deviation
30-50 years of age	320	14.79	11.82
Over 50 years of age	70	12.66	4.76

Mean difference: 2.13
Calculated Probability: p = 0.00

Not only has the mean of the older aged subgroup dropped but the standard deviation has also fallen considerably This means that with the removal of the extreme value the distribution for this sample is much more clustered about the mean

The results of removing the extreme value has led to a significant difference in the mean difference between the two samples. If this case could be arbitrarily deleted then it could be concluded that age does affect the distance which AT&T GIS employees are willing to commute or, more specifically, as age increases the journey to work decreases However, since the distance of 116.3 kilometres is a valid commuting distance it must remain in the dataset.

5.3 Education and Journey to Work Distances

Table 6: Education and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
Less than college or university	6 5.0 60.0	86 71.7 36.4	26 21.7 60.5	2 1.7 22.2	120 (40.3%)	14 43	8 65
College and/or university	1 2.3 10.0	39 88.6 16.5	4 9.1 9.3	0 0.0 0.0	44 (14.8%)	12.20	4 37
More than college and/or university	3 2.2 30.0	111 82.8 47.0	13 9.7 30.2	7 5.2 77.8	134 (44.9%)	16 49	15 48
Totals	10 (3.4%)	236 (79.2%)	43 (14.4%)	9 (3.0%)	298 (100.0%)		

The first important thing to notice regarding the above table is the decreased number of cases used in this crosstabulation. This is due to the way in which education levels were recorded by AT&T GIS in their dataset. Many of the cases in the dataset did not have any information regarding the amount of education the respective employee had attained. Since there was no clear pattern which could hint at what the missing education levels for these employees should have been, these cases were deleted for the purpose of this analysis Since the missing education levels belonged to a considerable range of individuals (e.g. young, old, male, female, high income, low income, varying numbers of children etc.) it would have been inappropriate to arbitrarily assign these cases to any one particular category.

There are any number of reasons why educational information was not recorded for so many of the employees in the dataset. Firstly, it is possible that many of the cases had not completed high school. Approximately half of the cases which were deleted belong to personnel in production areas of the facility. Since these jobs do not require a great deal of education it is possible that many of these cases do belong to people with less than a high school degree. The second possible explanation for the missing information is that record keepers in the past were not consistent in their recording of this data. Since a considerable number of cases with missing data belong to employees hired in the 1970's this second reason may also be true. A third possible explanation for the missing education information is that these employees may have been in the process of completing a degree when they were hired by AT&T GIS or have, since being hired, started and completed a degree. In these instances it is possible that the records for these employees were not appropriately updated.

Since the nature of operations at AT&T GIS tend to be high tech and professional, it is not surprising to see that almost 60% of these 298 employees have at least a college or university degree. This corresponds with AT&T GIS's claim that a little over 60% of their employees are engaged in either research and development or in professional occupations. Since the only jobs which would not require a considerable amount of education are those in production and maintenance areas it is likely that the majority of lower educated cases belong to these two groups. A quick scan of the dataset confirms this.

The maximum and the average commuting distances for each sample (relative to the other samples) correspond with one another. The most educated employees at AT&T GIS not only commute the longest distance on average to work but also commute the furthest extreme distances. Employees with a college or university degree commute on average the shortest distances and also have the shortest maximum extreme distance. When compared with the column percentages supplied in the table this trend is further strengthened. Employees with higher levels of education are considerably over represented in the long commute to work range (Over 50 kilometres), while those with a college or university degree are the most over represented in the short commute to work range (5 to 15 kilometres). Employees with less than a college or university degree are over represented in the moderate commute to work range (15 to 50 kilometres).

Tkocz and Kristensen (1994) have suggested that as education increases so does average commuting distance (significantly at least for women). If this is the case then why does the pattern in the above table exist: why do people with less than a college or university degree commute further distances than those with college and/or university degrees?

One possible explanation is that many of those employees at AT&T GIS who have college or university degrees received their education from either WLU, U.W. or Conestoga College. Once these people completed their degrees they may have simply made their school address their permanent address. This would lead to a decrease in the average commuting distance of employees in this education range since many of the cases added to this group each year live so close to AT&T GIS.

A second possible explanation for the difference is that many of the people with lower education levels may come from rural backgrounds: they may have grown up in small communities outside of the Kitchener-Waterloo area or on farms. This is not to say that these individuals are likely to be less intelligent than people who grow up in the city. Rather, it is possible that these people did not have the same opportunities as their urban counterparts (e.g. they had to spend more time helping out on the farm) and accordingly received less education. It is also possible that these individuals, having grown up in a rural setting, elected to remain there rather than locate their permanent residence to an urban area such as Kitchener-Waterloo.

Are the differences in mean commuting distances for these education level samples significantly different from one another? Can it be said that education affects the distance which individuals are willing to commute to work?

Table 7: Difference of Means Test: Intermediate and High Education Groups

Sample	Number of Cases	Mean Distance	Standard Deviation
More than a college or university degree	134	16.49	15.48
University and/or college degree	44	12.20	4.37

Mean difference: 4.29
Calculated probability: p = 0.00

As can be seen from the results of this first difference of means test there is a significant difference between the mean distances which highly educated employees at AT&T GIS commute to work and the mean distances their slightly less educated colleagues commute to work. Education would seem to have a positive impact on the commuting distances of individuals: as education increases, so does the distance one is willing to commute to work. This finding is in agreement with Tkocz and Kristensen's research. However, what about the difference in mean distances for those with college and/or university degrees and those with less than a college or university degree?

Table 8: Difference of Means Test: Low and Intermediate Education Groups

Sample	Number of Cases	Mean Distance	Standard Deviation
Less than a college or university degree	120	14.43	8.65
University and/or college degree	44	12.20	4.37

Mean difference: 2.23
Calculated probability: $p = 0.00$

Again, as with the first test, there is a significant difference between the means in question. However, unlike the first test the relationship between education and distance in this case is negative. as education increases, the distance an individual is willing to commute decreases. Given that there are 3 post secondary school academic institutions in this area and that AT&T GIS is known to hire graduates from these institutions, it may not be unreasonable to assume that the proximity of these institutions is affecting the results of this study. However, since it is not possible to clearly identify or quantify this relationship then this possibility must remain only a possible solution to the problem.

5.4 Number of Dependents and Journey to Work Distances

Table 9: Dependents and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
No dependents	9 4.6 47.4	160 82.5 45.3	19 9.8 33.9	6 3.1 50.0	194 (44.1%)	14.47	13.61
1 or 2 dependents	8 4.1 42.1	147 75.8 41.6	35 18.0 62.5	4 2.1 33.3	194 (44.1%)	14.96	10.93
3 or more dependents	2 3.8 10.5	46 88.5 13.0	2 3.8 3.6	2 3.8 16.7	52 (11.8%)	14.16	10.04
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

From an examination of the totals for each of the subgroups in the analysis we see that only 52 employees (11.8% of the total) report having 3 or more dependents. This is the result of the growing trend away from large families to smaller family size. Witness the equally large proportions of employees with no dependents and with one or two dependents. Clearly the employees at AT&T GIS are electing to have smaller families.

The mean distance commuted to work by each category appears relatively similar. Only a distance of 0.8 kilometres separates the maximum mean from the minimum mean. Perhaps of more importance is the maximum distance any individual in each of the classes is willing to commute. The largest distance maximum (116.3 kilometres) is traversed by an individual with no dependents. The second largest distance traversed is covered by an individual with only one or two dependents. The maximum distance driven to work each day by any individual with 3 or more dependents is only 65.8 kilometres. These figures suggest that the number of dependents in a family does affect the maximum distance individuals are willing to commute.

Why would the presence of dependents affect these distances? There are two primary reasons. In the case where the dependents are children, parents often wish to spend as much of their free time with their children as possible. The time these parents must spend in a car commuting to work is often seen as a waste of valuable time which could be spent with their families. It is not uncommon to hear individuals complain about how little they see their children, especially when the individual works odd hours (e.g. shift work or sizable overtime). In interviews conducted at the Honda plant in Alliston on this topic, many employees expressed dissatisfaction with the amount of time they are able to spend with their families. Several of these individuals even suggested they would go so far as to move their residence closer to their work site in order to increase the amount of time they could spend with their children (income permitting). Honda of Canada Manufacturing is currently considering implementing a job share program at their facility. Some employees spoken to have expressed an interest in the program as it will enable them to spend less time on their jobs and to devote more time to their home and their families (Hammers, 1994).

The second primary reason to consider is that dependents, children and others, can take a considerable amount of effort to take care of. Children must be prepared for day care or school in the mornings and they often must be picked up from these places at the end of the day. Children must also be taken to dentist and doctor appointments and to recreational and extracurricular activities (at older ages). Other dependent (e.g. spouses or handicapped individuals) can also significantly affect the responsibilities a person has, particularly if the dependent does not have access to transportation or they need special care. The point being made here is that dependents can seriously affect an individual's free time. When an individual has a long distance to commute to work then the time they have free to address these responsibilities is significantly reduced.

In the case where the dependents are children, it should be noted that their presence may also increase the importance of an additional income (Preston, McLafferty and Hamilton, 1993). This usually means that the mother must join the workforce. In such cases where two incomes are necessary to support the family it may also be that individuals are willing to commute longer distances to find the work which will support their families. In such cases the individual exchanges the advantages of working near home for better paying jobs farther away (Preston, McLafferty and Hamilton, 1993). This may explain the increase in average journey to work distance from the first category to the second.

Unfortunately data was not provided regarding marital status. It is likely, however, that if such information had been provided an analysis would have shown that the impact of dependents on commuting distances would have been more significant for single individuals (as opposed to married individuals) since these people lack a partner to share in any of the responsibilities resulting from the presence of dependents.

As was mentioned earlier, the means for the subgroups in this analysis appear to be relatively equal. Does a difference of means test confirm this?

Table 10: Difference of Means Test: Intermediate and High Number of Dependents Groups

Sample	Number of Cases	Mean	Standard Deviation
One or two dependents	194	14.96	10.93
Three or more dependents	52	14.16	10.04

Mean difference: 0.80
Calculated probability: $p = 0.14$

As can be seen from the above results, the difference in mean distance driven by individuals with one or two dependents is insignificantly different from those individuals with three or more dependents. In other words, the number of dependents AT&T GIS employees have does not significantly affect the distances which they commute to work

Results by other researchers vary on this topic. Hanson and Johnston (1985) and Preston, McLafferty and Hamilton (1993) argue that dependents such as children do significantly affect commuting distances, particularly for females. However, studies such as that by Gordon, Kumar and Richardson (1989) would corroborate the results found in the above analysis. Still others have found that the presence of dependents has an indeterminable effect on commuting habits (Johnston-Anumonwo, 1992). Clearly the effect of dependents on commuting distances is poorly understood.

5.5 Income and Journey to Work Distances

Table 11: Income and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
Low Income	7 5.2 36.8	111 82.2 31.4	12 8.9 21.4	5 3.7 41.7	135 (30.7%)	14.56	13.74
Middle Income	7 3.5 36.8	155 78.3 43.9	31 15.7 55.4	5 2.5 41.7	198 (45.0%)	14.55	9.33
High Income	5 4.7 26.3	87 81.3 24.6	13 12.1 23.2	2 1.9 16.7	107 (24.3%)	14.95	14.26
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

As with many of the other crosstabulation results in this study, patterns were difficult to establish simply by using this analysis method. The mean commuting distances for employees in each of the subgroups are relatively equal and the maximum commuting distances driven by individuals within each sample yield no pattern of the effects of income on commuting distance.

What some researchers have observed is that as income increases so does the distance individuals are willing to commute. Hecht (1974) and Hanson and Johnston (1985) note a significant effect of income on commuting distances. Hanson and Johnston note considerable differences between women in low and high income groups but fail to draw similar results for tests in which males and females are under study. Women and men within similar income groups do not commute similar distances.

For many people, income is the major factor in determining an acceptable commuting distance. The more a person earns, the greater is the distance they are willing to travel. Larger incomes increase not only the options for residential location, but the resources available to offset fiscal travel costs. With increased residential options individuals are more free to locate in places where rents or such things as property taxes may be higher and in homes which may cost more. This will increase the spread of high income earners throughout a study region. Notice that the high income group has the largest standard deviation. Higher salaries also act as an incentive for many individuals to allocate more time to their commute to work. For employees who have working spouses the pool of financial resources they have to draw from is even larger.

Basic locational theory suggests that as distance from an activity increases, so does the associated travel cost to that activity. In terms of this study, as distance to AT&T GIS from home increases for any given employee, so will the cost of driving to and from the plant. Such financial costs include, but are not limited to, gas and vehicle maintenance.

These costs can fluctuate considerably from individual to individual, taking into account such things as the differing makes and models of vehicles driven by individuals under study, gas price differentials throughout a region and insurance rate differentials.

Commuting distances may also be higher for lower income groups Given the latest recession and the accompanying scarcity of jobs, people may be more willing to commute longer distances in order to gain or keep employment. For these individuals, long journeys to work do not occur because it is financially possible, but rather because they are necessary. People within low income groups may not have the financial resources available to undergo a change in residency location in order to decrease travel costs, particularly if the new residence location will cause them to incur larger residency costs as a result

Table 12: Difference of Means Test: Intermediate and High Income Groups

Sample	Number of cases	Mean	Standard Deviation
Middle Income	198	14.55	9.33
High Income	107	14.95	14.26

Mean difference: 0.40
Calculated probability: $p = 0.64$

Since the calculated p value is considerably larger than 0.05 there is clearly not a significant difference in mean commuting distances for the samples in this analysis. Income does not have a significant effect on the commuting distances of employees at AT&T GIS.

5.6 Length of Service and Journey to Work Distances

Table 13: Length of Service and Distance to Work

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
0 to 5 years	2 2.3 10.5	73 83.9 20.7	4 4.6 7.1	8 9.2 66.7	87 (19.8%)	17.25	18.95
5 to 15 years	4 2.9 21.1	113 81.3 32.0	19 13.7 33.9	3 2.2 25.0	139 (31.6%)	14.79	12.06
15 years or more	13 6.1 68.4	167 78.0 47.3	33 15.4 58.9	1 0.5 8.3	214 (48.6%)	13.50	7.55
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

From the above table it should be clear that a large proportion of the employees at AT&T GIS have been with the corporation for quite some time. Given that the facility began operations in 1972, some 23 years prior to the creation of the dataset, and has since undergone some significant expansions in employment levels and size, one would expect fewer cases to occur in the last years of service category. This last range spans 8 years, or a little more than 34% percent of the total years the facility has been in operation and yet it accounts for almost 50% of all the cases. The first category (0 to 5 years of service) contains a little less than a fifth of all the cases in the dataset despite all of the recent hirings that have taken place at the facility.

A definite pattern is noticeable in the above table, both when examining cell values and when examining mean distances for each subgroup. Upon comparison of column percentages for the first temporal range with what would be expected given the number of cases in that range (19.8%) a considerable difference is noted between these two values for cases which commute long distances to work. A sizable 66.7% of all long distance commuters have been with the corporation for 5 years or less. This is more than three times the expected amount.

Within the second temporal range a more dispersed pattern is recognized. Some 31.6% of all cases lie within this range, and many of the cell values for this subgroup lie close to or slightly under the expected amount. This suggests that the cases within this group are spread throughout the study area much as would be expected given the proportion of the population that these cases represent.

The last temporal range is concentrated in the lower commuting distance ranges They are proportionately over represented in the very short commute to work range (0 to 5 kilometres) and the moderate commute to work range (15 to 50 kilometres). As well, the number of cases in the intermediate distance range is only slightly less than is expected.

Mean commuting distances for each of the subgroups is noticeably different. New employees to AT&T GIS commute on average the greatest distance to work. Employees who have been with the corporation an intermediate amount of time commute average distances considerably less than this first group. Employees who have been with the corporation the longest commute the shortest distances. Even the maximum commuting distance for this last group of individuals is considerably smaller (56.3 kilometres, compared to 99.5 kilometres for the first group and 116.3 for the second group). The standard deviation calculated for this group of individuals also suggests that the cases within this class are much more clustered about the mean then for the other two classes.

Are these results significant however? Can it be said that commuting distance is affected by the years of service an individual puts in with a company, AT&T GIS specifically?

Table 14: Difference of Means Test: Low and Intermediate Years of Service Groups

Sample	Number of Cases	Mean	Standard Deviation
0 to 5 years of service	87	17.25	18.96
5 to 15 years of service	139	14.79	12.06

Mean difference: 2.46
Calculated probability: p = 0.01

The results from the above test clearly conclude that there is a significant difference in commuting distances for employees who have been with AT&T GIS less than 5 years and those who have been with the company for less than 15 years. Newer employees tend to commute longer distances than those who have seniority over them.

Does this trend exist for employees who have been with the corporation for less than 15 years when compared to employees who have been with the corporation for over 15 years?

Table 15: Difference of Means Test: Intermediate and High Years of Service Groups

Sample	Number of Cases	Mean	Standard Deviation
5 to 15 years of service	139	14.79	12.06
15 or more years of service	214	13.50	7.55

Mean difference: 1.29
Calculated probability: p = 0.08

Although the calculated p value is very close to 0.05 it is still greater than the accepted limit. Therefore, at the 95% confidence level, it cannot be said that employees who have worked less than 15 years (excluding newer employees) commute a different distance than those individuals who have worked for AT&T GIS for more than 15 years. However, the results are significant at the 90% confidence level. At this level the commuting distances of these employees are affected by the years for which they have worked for their company.

What would cause these differences to occur? The current economic recession, which started in the early 1990s, may be a contributor to this result. Individuals new to the work force have likely had to extend the region over which they conduct their job search due to the lack of available jobs in their own immediate area. These individuals are more willing to commute longer distances to attain jobs which are not available in their home communities.

Newer employees also are not likely to immediately relocate their residences when having received a new job. It was mentioned earlier that residential relocation is a considerable matter for many individuals. Most people will not relocate their permanent address until they know for sure that the job they have is secure, that they are not likely to be laid off if their company experiences negative growth due to market fluctuations. Unfortunately, when company turnover rates are low (as in a recession), many employees must endure low seniority status for longer periods of time. Only when they feel their job is secure will employees seriously consider relocating closer to their job site

5.7 Occupation Type and Journey to Work Distances

Table 16: Occupation Type and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
Admin	6 8.1 31.6	59 79.7 16.7	9 12.2 16.1	0 0.0 0.0	74 (16.8%)	12.24	5.34
CS	0 0.0 0.0	9 56.3 2.5	3 18.8 5.4	4 25.0 33.3	16 (3.6%)	28.22	25.67
Maint	0 0.0 0.0	4 66.7 1.1	2 33.3 3.6	0 0.0 0.0	6 (1.4%)	15.94	7.99
Mktg	1 3.6 5.3	23 82.1 6.5	4 14.3 7.1	0 0.0 0.0	28 (6.4%)	14.53	8.62
Prod	5 5.5 26.3	77 84.6 21.8	9 9.9 16.1	0 0.0 0.0	91 (20.7%)	12.55	6.99
QA	1 4.8 5.3	15 71.4 4.2	5 23.8 8.9	0 0.0 0.0	21 (4.8%)	14.27	7.25
R&D	4 2.1 21.1	158 83.6 44.8	20 10.6 35.7	7 3.7 58.3	189 (43.0%)	14.87	12.39
Tech	2 13.3 10.5	8 53.3 2.3	4 26.7 7.1	1 6.7 8.3	15 (3.4%)	22.25	27.65
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

* see page 33 for descriptions of the above occupations

Few other researchers have addressed occupation as it will be addressed here. Other studies (e.g. Hanson and Johnston, 1985; Johnston-Anumonwo, 1988) generally concern themselves with examining the gender make up of professions, or discussing commuting differences of individuals in female-type jobs and male-type jobs. Villeneuve and Rose (1988) do briefly address differences in commuting distances between higher level occupations and lower level occupations. Their conclusions suggest that the relationship between occupational status and journey to work distance reflects the fact that individuals with higher level occupations earn higher wages and therefore have a higher probability of owning a car and of living in more spacious housing farther away from their job sites. This hypothesis is not easily supported by the AT&T GIS dataset since the average wage for all employees in the facility is over $45,000 per year; more than enough to purchase a car. In this section the relationship between commuting distances and occupation will be discussed ignoring the effects of gender and income on the underlying patterns. That is not to say that these factors are not important, but it is not necessary to address these factors in this particular analysis.

It should be noted at this point that, with the exception of the Administration, Production and R&D subgroups, with so many categories under examination it may be hard to accurately interpret the results from the above table. With so few cases in so many of the classes extreme values will have an increased effect on the calculations of means.

Of primary interest from the above table is the mean distances calculated for each of the occupation types. Up until now, the majority of means discussed have been close to the 15 kilometre mark. In the above table lies two means considerably larger than this 15 kilometre average: the mean for CS (28.22 kilometres) and the mean for Tech (22 25 kilometres). These large means are easily explained.

For the CS subgroup, mean commuting distance is so large because of the nature of that occupation. Employees in this group very rarely come from the Waterloo area. Instead, these individuals are drawn from marketing-type organizations external to the Kitchener-Waterloo region. Many of these individuals likely come from the Toronto area since this is not only where they likely received their training, but it is also the location where they report back to (Toronto as well as Dayton Ohio) (Bean, 1996). In this case it is clearly the characteristics of the occupation acting in conjunction with the residential patterns held by the individuals in this subgroup prior to being hired by AT&T GIS that lead to the resulting mean commuting distance.

In the case of employees in the Tech subgroup, the large mean is the result of one extreme case (Bean, 1996). Upon examination of the table we see that there is indeed only one case in the distance range "Over 50 kilometres". Given that the number of cases in this occupation category are so small, an extreme value such as lies within this group (116.3 kilometres) will easily influence the mean. When this extreme value is removed from the calculations the average commuting distance for these employees drops to 15.53 kilometres, a value much more similar to those of the remaining categories in the table.

Special mention should be made regarding residential locations of some of the cases in the dataset. Given the high tech nature of operations at AT&T GIS and the relative scarcity of individuals with the skills necessary to perform many of the essential tasks, AT&T GIS sometimes finds it necessary to hire individuals from outside of the province. These individuals are aided in finding or provided with the housing they need (Bean, 1996). More often than not this housing will be relatively close to the facility. This will inevitably negatively affect commuting distances (averages will be smaller).

Table 17: Difference of Means Test: Customer Service vs. Maintenance

Sample	Number of Cases	Mean	Standard Deviation
CS	16	28.22	25.67
Maint	6	15.94	7.99

Mean difference: 12.28
Calculated probability: $p = 0.03$

Several difference of means tests were conducted on the samples in this particular analysis. The difference in commuting distances between CS employees and Tech employees was insignificant. The difference in commuting distances between Tech employees and Maint employees was also insignificant. However, there was a significant difference between CS employees and Maint employees.

If for the Tech subgroup the extreme value can be regarded as disposable (since it is the only case in the last distance range), then the mean commuting distance for this group is similar to all of the others, with the exception of CS employees. This means that there is a significant difference between the distance that CS employees commute to work and the distance that all other AT&T GIS employees commute. In this one particular case, the type of occupation has a significant effect on commuting distances.

5.8 Gender and Journey to Work Distances

Table 18: Gender and Distance

n Row % Col%	0 to 5 kms	5 to 15 kms	15 to 50 kms	Over 50 kms	Total Cases	Mean	Standard Deviation
Females	7 4.1 36.8	140 81.4 39.7	23 13.4 41.1	2 1.2 16.7	172 (39.1%)	13.56	10.01
Males	12 4.5 63.2	213 79.5 60.3	33 12.3 58.9	10 3.7 83.3	268 (60.9%)	15.35	13.20
Totals	19 (4.3%)	353 (80.2%)	56 (12.7%)	12 (2.7%)	440 (100.0%)		

Sex is by far the most extensively and thoroughly analyzed factor in the study of the journey to work phenomenon. Virtually every paper written on the journey to work phenomenon addresses the differences in commuting patterns between the sexes All other factors: income, education, dependents, are in contention by researchers but all generally agree that males commute further distances to work than females

Similar results have been found for the employees at AT&T GIS. Not only do male employees at the company commute, on average, greater distances than their female counterparts but they also drive the longest distances. The maximum distance driven by any male in the dataset is 116.3 kilometres, while the maximum distance driven by any female is 98.7 kilometres. Males are also considerably over represented in the highest distance range (they account for 83.3% of all cases in this range), while this is the range where females are most underrepresented.

While these numbers appear to be significant, are they really?

Table 19: Difference of Means Test: Males and Females

Sample	Number of Cases	Mean	Standard Deviation
Females	172	13.56	10.01
Males	268	15.35	13.20

Mean difference: 1.79
Calculated probability: $p = 0.02$

When tested at a 95% confidence level the difference in the mean distance driven to work between males and females is found to be significant. Males do indeed commute, on average, further than females.

Clearly there are additional factors causing the men and women in this dataset to commute the distances they do to work. It is simply not enough to say that males drive further to work then females. What impacts do factors such as age, education, income, number of dependents and years of service to a company have on the journey to work distances of men and women?

Table 20: Average Commuting Distances for Females and Males for Several Selected Factors

Sample	Mean distance for females	Number of cases	Mean distance for males	Number of cases
Under 30 years of age	16 81	19	13.02	30
30 to 50 years of age	13.51	121	15.57	199
Over 50 years of age	11.85	32	15.98	39
Less than college or university	13.68	43	14.85	77
College or university educated	11.91	9	12.27	35
More than college or university	15.95	28	16.63	106
Low income	13.70	107	17.85	28
Middle income	13.54	56	14.94	142
High income	12.11	9	15.22	98
No dependents	13.96	96	14.97	98
1 or 2 dependents	13.27	69	15.89	125
3 or more dependents	11.06	7	14.66	45
Less than 5 years of service	16.47	29	17.64	58
5 to 15 years of service	12.91	46	15.72	93
Over 15 years of service	13.00	97	13.91	117

The impact of occupation on the commuting distances of both males and females will be omitted from this discussion since a considerable number of the averages would be based on distances for less than 5 cases. With so few cases contributing to the average values being calculated extremes would have a considerably greater impact on these numbers.

The effects of age on journey to work distances differs for men and women For women, mean commuting distances decrease with age, whereas with men, mean commuting distances increase with age. For women, the difference in averages are significant at a 99% confidence level. Age would appear to have a considerably significant impact on the commuting distances of female employees at AT&T GIS.

For men, however, the results are insignificant even at a 90% confidence level. While average distances increase with age the differences are inconsequential. Age does not have a significant effect on the commuting patterns of the males in question.

Tkocz and Kristensen, in their 1994 study of commuting distances and gender, experienced similar results to those above for females. Their results were not as significant as above (they were significant at the 95% level). In this study males also appeared to exhibit a similar commuting trend (decreasing distance with age) but these results were not significant.

The impact of education on commuting distances is indeterminate. As was found earlier, the middle education level subgroup exhibits the lowest mean commuting distance; now it does so not only for all employees in general but for both males and females. For females there is a significant difference in commuting distances between those with less than a college or university degree and those with more. This was found to be true at a 90% confidence level and almost at the 95% confidence level (p=0.051). For males the difference between these categories was calculated to be insignificant.

Results for tests on the effects of income on both genders were surprising. Normally we would expect that as income increases so will commuting distances, since the individuals with higher incomes are more capable of offsetting the fiscal costs associated with greater distances. However, what is found within AT&T GIS is that for both males and females as income increases commuting distances decrease. In other words, the individuals that drive on average furthest to work are not those who have the highest incomes but rather those with the lowest. For men, the difference in distances between the middle and higher income groups was statistically insignificant but the difference in distances between the low and middle (or high) income groups was found to be statistically significant at the 99% confidence level. For women, however, no statistical significance could be found.

For women in the dataset, as the number of dependents increases average commuting distance decreases. The difference in means was, however, found to be statistically insignificant. No pattern could be derived from the means for the male cases and accordingly no tests on significance were run. What may be interesting is the maximum distances driven by individuals in all of the categories. For both sexes the largest maximum distance occurred in the groups with no dependents. As was mentioned earlier, these individuals will likely have the least amount of household responsibilities and therefore the most amount of free time to devote to the journey to work. For males this maximum was 116.3 kilometres while for females it was slightly less at 98.7 kilometres. The maximum value for males with one or two dependents was slightly less than for the previous group (99.5 kilometres) while for females with one or two dependents the maximum distance commuted dropped noticeably to 42.2 kilometres. The most noticeable difference in commuting maximums is evidenced when the maximum commuting distances for individuals with three or more dependents are examined. For males, this distance drops to 65.8 kilometres, somewhat less than males in the previous group, but considerably larger than females in the same category. Female employees at AT&T GIS with three or more dependents commute no more than 13.6 kilometres to work. Clearly there are some impacts of dependents on the commuting distances of both females and males, particularly for females.

The length of time that both males and females have worked at AT&T GIS was found to correlate to the distances which each gender commutes. For both sexes, as the number of years of service to AT&T GIS increases the average distances between points of residence and work decreases. For both males and females there was a significant difference between individuals who were relatively recently hired by the corporation and individuals who have been with the company for a longer amount of time (proven at the 99% confidence level for both sexes). The most likely explanations for this is that these newer employees are more anxious for work (given the poor health of the economy and low employment levels of the last 5 years) and are more willing to drive further distances to gain employment. Also, these individuals may not be as sure that their job will be permanent and may be putting off relocating to sites closer to their work until they feel their job is secure.

6.0 REGRESSION TEST

To identify the relationship between commuting distances and the variables provided by AT&T GIS on their employees a multiple regression analysis was performed Residence to work distances were regressed against 16 variables. These 16 variables included age, number of dependents, income, years of service to the company, sex, education level (subdivided into 3 variables) and occupation type (subdivided into 8 variables). Actual values (rather than classes) were used for the first 4 variables while sex, education and occupation type had to be reclassed.

While there are obvious differences between males and females, individuals with different levels of education and different occupation types these differences are not scaled similarly to the differences in such things as age, number of dependents, income or years of service. Data such as sex and occupation type are scaled nominally: it can be said that a difference exists for the cases under study but it cannot be said that one case is better or worse or worth more or less than another. Education is scaled ordinally. While individuals with an education level of 2 (having a college or university degree) have more education than those with an education level of 1 (having less than a college or university degree) it cannot be said that the individuals in class 2 are twice as educated as those in class 1. Therefore, to properly conduct the regression test it was necessary to manipulate these nominally and ordinally scaled variables to be included in the test.

Dummy variables were created from both the education and occupation type variables. Each dummy variable represented a particular subgroup from one of the two parent variables. Values within each dummy variable consisted then of either a "1" or a "0", where "1" implied the individual in question belonged to the subgroup being represented while a "0" meant they did not. Education, for example, was broken into three dummy variables: "Edu1" = less than college or university educated, "Edu2" = having a college or university degree and "Edu3" = having more than a college or university education. For an individual with a college or university degree the respective value for that individual under "Edu1" would be 0, under "Edu2" it would be 1 and under "Edu3" it would again be 0. By undertaking this step it was possible to then ascertain from the regression test results what the effect of belonging to the different classes represented by these dummy variables was.

Below are the results of the multiple regression analysis conducted on the AT&T GIS dataset:

Figure 5: Regression Test Results
Multiple R: 0.31
R^2: 0.09
$F_{calculated} = 2.96$ and $F_{significant} = 0.00$

Y = 14.15 + 0.08(Age) + 0.16(Dep) - 0.20(Wage) - 0.11(Work) - 0.11(Sex) - 1.33(Edu1) - 3.93(Edu2) + 1.53(Edu3) - 2.21(Admin) +14.64(CS) + 1.06(Maint) - 0.51(Mktg) - 2.86(Prod) - 0.77(QA) + 8.4(Tech)

Where Y = Distance between home and work (in kilometres)
Age = age (in years)
Dep = the number of dependents
Wage = income (in $10,000's)
Work = number of years of service
Sex = "1" for males, "0" for females
For the following variables: "1" = yes, "0" = no
Edu1 = having less than a college or university degree
Edu2 = having a college or university degree
Edu3 = having more than a college or university degree
Admin = works in Administration
CS = works in Customer Service
Maint = works in Maintenance
Mktg = works in Marketing
Prod = works in Production

QA = works in Quality Assurance
Tech = works as a technician

RD (workers in Research and Design) was excluded from the results since its contribution to R (and R^2) was negligible.

The magnitude of R is used as a measure of the magnitude of the relationship between the independent variables and the dependent variable. Possible values for this statistic lie between 0 and 1 with 0 representing no relationship and 1 representing a perfect relationship. The above R value (0. 31) indicates that there is a relationship, albeit seemingly small, between the variables under study and home-to-work distances for AT&T GIS employees. The R^2 value reflects the percentage of the data explained by the regression equation. For this test the R^2 value is 0.09 indicating that 9% of the data can be explained by the equation. Although this number is quite small the two F values indicate that it is indeed a significant relationship ($F_{calculated} > F_{significant}$).

The partial regression coefficients in the above equation illustrate the nature of the relationship between each of the independent variables and the journey to work distances in the dataset. What is found is that distance to work increases with age, being female, having more than a college or university degree, having more dependents and being employed in either Customer Services or Maintenance or as a Technician. Home to work distances decrease with higher wages, longer years of service to the company, having a college or university degree or less, being male and being employed in any of the remaining occupations (with the exception of R&D - results are unknown for that occupation).

There are few surprises in the regression equation. The CS and Tech subgroups had the two largest mean commuting distances and their partial regression coefficients are both positive and significant. The Admin and Prod subgroups had two of the lowest mean commuting distances and their partial regression coefficients are negative and significant. The education subgroups also appear to be appropriately represented as does the Work variable. What is surprising is that the partial correlation coefficient for the Sex variable suggests that women commute greater distances then men. However, when the T-value calculated for this variable is compared to the significant value for T it is found that the results for the Sex variable are insignificant.

6.1 Regression Test Results: Males vs. Females

To better compare the effects which the above factors play in the commuting habits of males and females two more regression tests were conducted. The table on the next page summarizes the results of these analyses.

What the table illustrates is that there is a correlation between age, being employed in the Administration department or the Customer Services department and journey to work distances for both male and female employees at AT&T GIS. The distances which male employees commute to work also correlate to income, length of service to the company, having a university or college degree or less and being employed as a Technician. For females fewer correlations exist. The only additional, significant relationship to commuting distances is found when the employee works in the Maintenance department.

Table 21: Regression Test Results: B Values and Their Significance for Males and Females

Variable (see above for descriptions)	B Value for Males	Significant	B Value for Females	Significant
Age	0.24	yes	-0.06	yes
Dep	0.36	no	-0.23	no
Wage	-0.36	yes	-0.29	no
Work	-0.26	yes	0.07	no
Edu1	-2.19	yes	0.11	no
Edu2	-5.38	yes	-2.00	no
Edu3	1.10	no	0.98	no
Admin	-2.59	yes	1.48	yes
CS	13.89	yes	28.35	yes
Maint	-1.25	no	4.62	yes
Mktg	0.44	no	-0.38	no
Prod	1.77	no	not in equation	
QA	0.01	no	1.01	no
Tech	9.97	yes	-1.51	no
RD	not in equation		not in equation	
Regression Constant	10.40		14.92	
Multiple R	0.33		0.34	
R^2	0.11		0.12	

Results from the above regression analyses concur with the data found in Table 20 Age regressed as expected for both males and females. Income and years of service also regressed as expected for males. Number of dependents was found to be insignificant for both males and females. No clear pattern is immediately recognizable when examining data on education levels, however, the associated B values relatively coincide with the averages calculated for Table 20.

Results regarding the correlation of occupation to journey to work distance are equally clear. The largest average commuting distances are experienced by employees in the Customer Services, Technicians and Maintenance departments The B values calculated for these occupations reflect this (where significance is attained) Administration employees commute, on average, the shortest distances of any employees at AT&T GIS. For males, the correlation between this occupation and the spatial separation of home and work is negative. A small positive correlation was established for females. This positive relationship is due to the intercorrelations found between this variable and the others included in the regression test.

7.0 SUMMARY

The journey to work patterns of AT&T GIS employees have been found to be dependent on several socio-economic factors. Significance was ascertained for such things as age, education level, length of service to the company, type of occupation and gender. For age and education level patterns in commuting habits could not be firmly established yet significant differences did occur between the subgroups examined in these variables Length of service was found to negatively correlate to home-to-work distances for individuals. It was also found that individuals employed in Customer Services tended to drive the greatest average distances to work. Males, not surprisingly, also commute greater average distances than females.

Income level was found to have no significant impact on the commuting patterns of AT&T GIS employees in general. This is surprising in that basic economic theory suggests that income levels should affect journey to work distances and past studies by other researchers have supported this theory. Regression test results do however suggest that income may have a significant relationship to journey to work distances for males.

The number of dependents AT&T GIS employees have also proved to be insignificant. However, patterns did emerge when examining maximum commuting distances for individuals in the different subgroups. This pattern suggests that as the number of dependents claimed by an individual increases, the less willing they are to commute longer distances to work

An analysis of the relationship between these variables and journey to work distances, by gender, reiterated what was found in the crosstabulation discussions Education levels yielded no commuting patterns except that individuals (both male and female) with colleges or university degrees commute the shortest distances to work. The number of dependents both males and females have proved to be an insignificant factor in journey to work distances but patterns were identifiable when maximum commuting distances were examined for each gender. These patterns concurred with earlier findings that individuals with more dependents are not as willing to drive long distances to work. In this case the pattern was considerably stronger for females then for males. The number of years of service that AT&T GIS employees contribute to the company negatively correlated to home-to-work distances for both males and females.

Short comings of this thesis lie in its inability to examine the impacts that such things as travel times and marital status have on commuting patterns. Travel times may be a more appropriate measure of commuting distances since it is time which individuals are most concerned with. However, the utility derived from spending time on the journey to work varies inconsistently from individual to individual making conclusions about time effects difficult to discuss.

Marital status will inevitably affect commuting patterns when its impacts on level of household responsibility, selection of household location and household mobility are addressed. Of the factors examined in the empirical analysis, the number of dependents an individual has and the income level which they are at will be the most affected by marital status. For married individuals, children become a shared responsibility. Married individuals, when their spouses are employed, also have greater financial resources to draw from.

Through this research it has become apparent that the tyranny of space has been upset. What is now being witnessed is that a more varied group of individuals are commuting greater and greater distances. In the past it seemed that strong relationships could be established between a considerable number of socio-economic factors and journey to work distances of individuals. Many of these factors (e.g. income and dependents) are no longer as significant as they once were. Space seems to be coming less and less of a concern for more and more commuters.

7.1 Contributions to Journey to Work Research

The most obvious contribution this thesis makes to the geographic discipline is its contribution to the body of knowledge concerning the journey to work phenomenon The previous discussion of the socio-economic factors affecting the commuting habits of AT&T GIS employees enhances the understanding of the general role which these factors play in the spatial separation of home and work. Particularly, this thesis lends itself to a better understanding of the commuting patterns of individuals who work in high income industries and of employees who work at sites located on the periphery of a major urban centre. Most other journey to work studies have concerned themselves with cases where jobs are located in the centre of an urban area. Few other researchers have examined situations where the job site(s) are located on the periphery.

This thesis also contributes to the volume of contemporary literature on this subject. Given the changing economy the changing attitudes of individuals (particularly women) towards both careers and families and the changing value people place on time it is necessary to keep research on this subject current. Without a current body of knowledge and results of studies to draw from other researchers may find it difficult to find support for their arguments. Furthermore, some urban planners (e.g. those concerned with transportation policies and programs) may find it difficult to accurately and appropriately address the issues which they face.

Appendix A: Copy of the Dataset Used for the Generation of Crosstabulations and Regression Test Results

Sex	Age	Actual Salary	Department	Years with AT&T GIS	Number of Dependents	Level of Education	Distance between residence and AT&T GIS (in kms)
1	28.22	15831 86	CS	.76	1	3.00	62.13
1	58.62	80467.71	Mktg	32.53	0	.	35.30
1	35.31	41344.00	R&D	1.07	1		50.86
1	34.26	36794.00	R&D	1.05	1	3.00	56.30
1	38.29	48169.29	CS	14.98	0	1.00	51 90
1	30.80	23826 00	R&D	.89	0	3.00	51.52
0	30.74	25384 00	R&D	.78	0	3.00	98.75
1	37.76	66517.64	R&D	4.07	1	3.00	99.49
1	39.41	19836 00	CS	.80	0	3.00	85 35
1	33.88	43597.64	Tech	14.58	2	2.00	34 27
0	43.89	27653.57	Prod	19.00	1	.	12.54
1	26.46	44986.00	CS	2.75	1	1.00	20.26
1	39 08	70053.36	Mktg	15 86	2	3.00	20.26
0	29.65	29952.50	R&D	10.72	1	.	22.80
1	42.72	8471.15	Admin	23.32	0		4.74
1	39.69	48108.57	R&D	16.97	0	1.00	4 74
1	55.82	47580.79	Maint	3 40	2	.	13.24
1	59.61	64997.86	R&D	14.38	0	2.00	13.24
0	28.30	46940.43	R&D	3.65	0	3.00	24.77
1	54.54	51593.14	CS	30.48	1	1.00	24.36
1	37.76	52517.14	Tech	15.99	4	1.00	24.36
1	39.90	58753.29	R&D	15.61	0		24.36
1	51.89	64451.43	CS	32.78	3	1.00	24.36
1	49.00	68034.64	R&D	17.43	0	.	24.36
0	53.71	25952.29	Prod	16.63	0	.	29.25
0	49.46	39622.14	Admin	16 64	0	1.00	29.25
1	39.42	40992.43	Tech	14.69	2	1.00	29.25
0	39.58	27865.86	Admin	19 69	0	.	6.79
0	46.57	28214.29	Prod	16.84	1	.	26.30
1	44.84	63768.57	R&D	10 69	2	1 00	26.30
1	40.38	74079.14	R&D	6.09	2	3.00	26 66
0	36.95	58331 43	R&D	16 78	0	1.00	17 41
0	38.2'	29808.71	R&D	10.89	2	1.00	24.36
0	49.70	36582.50	R&D	19 52	2	1.00	24 36
0	48.90	43091.29	Admin	21.49	1	1.00	24.36
0	31.59	57824.00	Admin	8.56	1	3 00	24 36
1	36.32	52265.21	Mktg	13.04	2	1.00	24 36
1	36.12	57673.21	R&D	16.09	2	1 00	24.36
1	41.19	60720.86	Admin	20.23	2	2.00	14.23
0	43.84	28603.43	Prod	20.90	0	.	39.04
1	43.24	57393.57	R&D	20.93	2	1.00	39.04
1	38.67	120969.16	Admin	5.15	2	3.00	20.94
0	41.32	26700.71	Prod	11.81	2	.	29 64
1	41.18	40955.29	Maint	17.07	2	.	29.64
1	33.90	61333.93	Admin	7.58	0	3.00	29 64
0	35.28	28865.64	Prod	16.05	2	1.00	20.90
1	36.64	56327.14	R&D	1.35	2		27.26
0	41.04	29260.43	Prod	19.21	1		42.21
1	39.44	42439.21	R&D	14.98	1	3.00	42 21
1	38.12	55707.64	R&D	11.59	4	3.00	65 81
0	23.43	24508.07	CS	1.58	0		76 77
1	51.44	67113.64	Tech	13.20	0		116 27
0	43.25	14252.21	Prod	20.90	2		28 94
1	47.10	42244.29	R&D	16.81	5	1.00	56.33
1	55.39	42570.71	R&D	20.53	2	2.00	15 77
1	54.37	63114.36	QA	19.98	0	1.00	16.33
0	26.43	39190.29	R&D	5.17	0	2.00	17.21
1	29.62	24926.29	Mktg	.82	0	3.00	13 75
1	51.15	82385.57	R&D	14.25	3	3.00	14.48
1	34.74	51747.14	Tech	6.22	0	1 00	27 22

1	40 90	63888.36	Admin	19 39	2	1.00	26 73
0	28.77	34842.86	Admin	5.64	0	3.00	27.08
1	36.77	55291.86	QA	12.93	0	3.00	27.08
1	39.94	73023 71	R&D	15.98	2	3.00	14.54
1	26.11	30316.07	R&D	1.05	1	3.00	13.36
1	52.84	74240.86	R&D	20.23	3	3.00	13.62
1	43.93	34714 64	R&D	23.22	2	.	14.48
0	32.49	30616.07	R&D	8.98	1	3.00	14.47
1	34.36	70011 36	R&D	4.69	2	1.00	11.78
1	64.87	75938.21	Admin	20.84	0	.	4.89
0	38.05	29713 79	Prod	16.97	0	.	4.55
1	34.92	42553 14	Tech	14.08	0	2.00	4.55
0	52.84	31944 57	Prod	19.90	0	.	5.12
0	47.56	27110.50	Admin	20.32	0		3.82
0	37 31	27779.36	Prod	14.86	3	.	3.73
1	41.69	49340.00	QA	21 42	2	1.00	4.89
0	36.55	29491 86	Prod	16.78	2	.	4.70
1	38.42	44344.64	Admin	16.99	2	1.00	4.76
1	43.91	73799.07	Admin	16.03	3	1.00	4.91
1	37.29	71374.29	Mktg	4.50	0	3.00	4.18
0	40.36	27871.00	Prod	20.02	2	.	4.41
1	43.78	73511 79	R&D	18.66	2	3.00	3.36
0	42.44	20038.07	Prod	.18	2	.	5.58
1	36.55	46383.64	R&D	15.97	1	1.00	5.44
0	45.17	29127.43	Prod	16.78	1	1.00	5.75
0	28.76	12480.00	Prod	5.69	0	.	5.51
1	55.17	85342.00	R&D	30.87	1	3.00	4.00
0	42.29	29612.57	Prod	16.21	1	.	3.71
0	40.86	41941.50	R&D	14.38	2	1.00	3.34
1	34 16	53388.29	Admin	4.82	0	1.00	3.44
0	53.04	27789.79	Prod	16.71	1	.	6.80
1	32.64	55794 71	R&D	7.96	1	1.00	6.80
0	44.08	16899 14	Prod	20.65	0	.	5.79
0	45.19	24253.21	Prod	8.85	2	.	5.79
1	23.71	17317.86	R&D	.78	0	3.00	5.52
0	42.18	27717.86	Prod	20.15	0	.	8.48
0	43.54	57821.57	QA	7.18	1	3.00	9.32
1	41 08	57342.14	Admin	16 21	2	1.00	8.50
1	48.97	30295.86	Prod	19.92	2	.	10.26
1	42.14	73226.29	Admin	13.20	2	1.00	8.51
0	33.16	27472.07	Prod	16.15	1		8.15
1	46.99	84102.64	R&D	22.30	3	3.00	8 56
1	45.89	63171.79	R&D	22.32	6	1.00	9.68
1	34.10	43556 21	Admin	14.59	4	2.00	10.11
1	39.71	73534.71	R&D	13 54	3	3.00	10.22
0	43.58	29345.71	R&D	1.35	1	.	9.81
1	34.11	46253.21	R&D	13.96	2	1.00	9.24
1	34.58	55175.29	R&D	8.98	1	1.00	8.49
0	56.10	29462.71	Prod	20.07	0	1.00	9.51
1	35.25	48672.14	R&D	14.98	0	1.00	7.17
1	40.34	16618.29	R&D	16.45	2	2.00	6.63
0	41.50	30599.29	Prod	19.58	1	1.00	7.34
1	34.31	56415.14	QA	4.82	0	1.00	7.89
0	54.37	29395.64	Prod	19.48	0	.	8.97
0	32.44	30139.86	Prod	14.82	0	.	9.29
0	32.93	17873.89	R&D	9.86	0	3.00	9.19
1	48.42	81722.21	R&D	21.25	1	.	8.81
1	48.52	97422.00	Admin	2.56	2	3.00	9.76
1	54.59	40821.36	R&D	16.40	0	2.00	9.13
1	32.14	53297.57	R&D	7.93	0	1.00	8.62
1	43.54	75140.50	R&D	20.15	2	3.00	8.58
1	28.05	28803.43	Admin	1.00	0	3.00	9.08
1	45.23	63316.64	Mktg	12.70	0	3.00	9.07
1	36.05	55094.00	R&D	11.55	0	.	8.96
1	25.58	37459 64	R&D	.20	0	.	10.25

0	43.59	27784.57	Prod	19.18	0	.	10.15
0	40.54	19234.71	Prod	.18	0	.	9.41
1	39.16	43093.57	R&D	15.98	3	.	9.30
1	30.66	68476.64	Admin	6.58	1	3.00	9.21
1	44.95	62393.71	R&D	15.69	2	2.00	8 56
1	25.97	32744.57	R&D	2.21	0	2.00	8.66
0	43.22	3159.29	Prod	.18	1	.	9.49
1	32.60	38352.07	Tech	9.50	0		.00
1	47.94	73190.00	Mktg	12.72	0	2.00	9.46
1	27 73	38241.93	R&D	5.17	0	2.00	8.22
0	60.93	28209.93	Prod	19.89	0		8 12
0	45.27	27664 00	Prod	19.73	2	.	8.38
0	41.83	40264.21	Admin	15.80	2	2.00	8.26
1	26.80	38579.50	Admin	2 83	0	3.00	9.07
1	43.79	61299.14	R&D	21.80	0	.	9.07
1	28.04	21471.43	CS	.78	0	1.00	9.59
0	57 20	24798.29	Prod	20.48	1	1.00	9.61
0	36.12	25789.14	Prod	16.22	2	.	8.66
1	45.17	41665 64	Maint	16.76	1	.	5.71
0	32.16	27080.71	R&D	6.07	0	.	9.42
0	59.16	28956.43	Prod	20.15	0	.	7.41
1	56.47	53053.29	R&D	16.72	2	1.00	9.60
0	30.92	62576.79	R&D	3.94	0	3.00	9.96
1	56.24	86163.29	R&D	19.21	0	1.00	10 42
1	47.70	51797.71	R&D	15.74	0	1.00	9.37
1	36.63	36083.14	Mktg	16.53	2	1.00	9.19
1	51.65	58895.71	Admin	20.90	2	1.00	9 19
0	48.59	25406.29	R&D	20.31	0	2.00	8.94
1	40.46	68696.36	R&D	16.91	4	.	9 80
1	45.20	51104.79	Admin	20.13	0	3.00	9.10
0	43.92	33774.93	Admin	19.60	2	1.00	9.88
1	50.50	82784.93	Admin	22.43	3	1.00	9 40
1	44.09	48106.43	R&D	15.21	1	1.00	10.17
0	55.22	35343.29	Tech	20.67	2	1.00	9.97
1	28.02	35688.14	Admin	4.05	0	3 00	10.06
1	26.31	39798.86	Admin	5.11	0	1.00	9.77
1	38.39	68572.50	R&D	14.94	2	.	9.34
1	27.58	24850.36	Admin	.91	0	2.00	10.20
1	46.59	77062.43	R&D	16.55	2	3.00	8.52
1	28.62	28542.86	R&D	.93	0	3 00	10.92
0	39.18	39849.86	Admin	20.17	2	1.00	10.18
1	41.57	70238.43	QA	16.91	0	3.00	10.18
1	48.72	52657.64	Admin	21.26	0	2.00	10.41
1	50.09	164270.84	Admin	7 07	3	3.00	10.56
0	45.31	26524.86	Prod	14.81	0	.	10.01
1	39.88	52663.57	R&D	5.95	2	3.00	10.20
0	29.43	58466.93	Admin	7.66	0	1.00	10.20
1	35.20	40640.36	R&D	15.93	0	1.00	8.84
1	35.23	58046.71	R&D	10.97	2		10.26
0	30.63	53750.71	QA	5.07	0	3.00	10 01
1	43.02	60840.00	Admin	13.89	2	3.00	9 94
1	41.72	54449.57	R&D	15.99	3	1 00	10.20
1	49.97	60485.14	R&D	1.26	0	3.00	8.87
0	33.26	70447.43	R&D	5.11	0	3.00	10.01
1	37.74	96070.14	R&D	16.74	4	.	9 94
1	39.62	35869.43	Admin	11.74	2	3.00	10 20
1	34.11	53092.36	Admin	11.07	0	1.00	10 20
0	34.52	33355.29	R&D	10.97	2	3 00	9.94
1	35.65	63922.07	R&D	12.97	2	3 00	9.94
0	36.69	15996.29	Prod	6 05	1		10.01
0	43.41	36791.14	Admin	16.66	2	1 00	10 97
1	34.28	47099.36	R&D	3.79	0	3 00	11 32
1	26.60	34580.57	R&D	.20	0		11.47
0	41.14	27875.43	Prod	16.57	2	.	10.09
0	53.38	27809.64	Admin	20.65	1	1.00	9 94

0	31.53	40052.21	Admin	2.23	0	.	10.37
1	40.30	24444.86	R&D	.20	1	3.00	10.72
1	47.50	55380.86	R&D	18.62	0	1.00	11.40
0	43.94	30408.93	Admin	10.93	2	.	12.23
0	34.35	16377.00	Admin	1.35	2	.	10.87
1	26.93	-1710.00	QA	.28	2	.	11.01
1	3.29	-707.43	R&D	.31	0	3.00	11.17
0	26.81	17502.00	R&D	.20	0	.	11.35
0	41.26	27797.86	Prod	19.61	0	.	10.47
1	33.92	38796.50	Admin	16.55	1	.	10.53
1	26.92	40319.64	R&D	1.24	0	3.00	10.88
1	25.43	9892.71	QA	.20	0		10.42
1	23.91	26614.29	R&D	.95	0	3.00	11.69
0	49.24	28710.71	Prod	20.61	0	.	11.80
0	38.20	34330.36	R&D	8.92	2	1.00	11.80
0	37.17	-82.14	Admin	.32	0	.	11.01
1	25.63	26834.29	R&D	.99	0	3.00	10.70
0	26.07	27184.93	R&D	6.68	0	1.00	11.06
1	25.76	27556.57	QA	.99	0	3.00	10.95
0	23.90	23992.36	Prod	1.97	0	.	10.95
0	47.08	35504.29	Admin	16.84	1	2.00	11.23
1	37.85	29127.43	Mktg	19.58	3	1.00	11.07
1	46.97	80733.00	R&D	15.27	2	2.00	11.15
1	33.30	14271.43	R&D	.62	2	.	11.60
1	40.53	41980.36	R&D	18.91	2	1.00	10.61
1	39.57	43802.57	R&D	13.85	2	1.00	13.06
1	38.26	23537.43	Prod	15.72	0		12.63
1	45.51	55673.86	Admin	16.45	2	3.00	13.04
1	47.95	62093.21	QA	17.49	2	3.00	13.33
1	38.11	34904.43	Tech	16.70	2	1.00	13.19
1	38.30	45276.29	Admin	16.97	3	.	13.15
0	60.74	25465 21	Prod	15.52	0	.	13.21
1	41.76	51363.64	R&D	19.00	3	3.00	13.01
1	35.11	33744.00	R&D	.93	2	.	12.81
0	61.62	26579.50	Prod	19.00	0	.	12.65
1	40.01	59796.29	R&D	14.98	0	3.00	12.65
0	56.13	24901.71	Prod	19.75	0	.	12.69
0	57.19	25913.21	Prod	16.22	0	.	12.69
0	42.07	27326.21	Prod	19.94	0	.	12.69
1	42.50	41381.07	Tech	15.25	2	1.00	12.69
0	57.38	25464.00	Prod	11.80	0	.	12.71
0	46.78	27709.14	Prod	16.57	0	.	12.69
1	35.19	71787.14	R&D	10.99	3	.	12.97
1	58.32	76135.79	QA	20.48	2	3.00	12.97
0	54.93	4144.36	Prod	.18	0	.	12.47
1	21.26	-164.29	R&D	.31	0	1.00	12.47
0	53.03	18207.43	Prod	15.15	0		12.56
1	43.02	56143.29	R&D	7.31	2	3.00	12.75
1	51.84	48382.64	R&D	15.25	1	1.00	12.51
0	37.39	16939.06	Admin	19.16	1	1.00	12.55
1	43 18	75504.14	R&D	19.96	1	.	12.55
1	43.84	54622.29	R&D	17.60	0	3.00	12.72
1	34.72	72884.50	Admin	11.31	3	1.00	12.46
1	35.21	53686.29	R&D	4.72	2	.	12.27
1	40.49	60934.07	R&D	16.99	2	3.00	12.36
0	43.33	21652.86	Prod	6.07	0	.	12.18
1	36.31	41386.07	CS	15.96	0	2.00	12.18
0	24.66	12326.60	R&D	6.03	0	.	12.04
0	36.35	27170.00	Prod	16.57	1	1.00	12.04
1	51.95	53620.36	R&D	16.53	2	2.00	13.26
0	54.55	12512.21	Prod	15.23	2	.	13.49
0	41.76	28102.79	Prod	16.21	2	.	13.52
0	48.79	26714.64	Prod	15.21	0	.	13.82
1	34.93	71680.79	R&D	2.71	3	3.00	12.78
1	31.94	43456.14	R&D	2.90	0	3.00	11.98

0	43.59	32728.57	R&D	20.42	0	3.00	11.94
1	30.39	52208.57	R&D	6.58	0	3.00	11.94
1	47.87	73385.14	QA	22.68	2	3 00	11.94
1	51.99	50050.50	R&D	17.76	2	1.00	13.59
1	43.39	67842.07	R&D	19.31	0	.	13.59
0	25.72	37251.43	Admin	2.67	0	3.00	13.44
1	34.00	57873.07	R&D	7.83	0	3.00	13.44
1	36.57	74082.14	Mktg	7.73	3	.	13.77
0	38.38	45294.79	Mktg	11.07	1	1.00	12.45
0	43.09	27299.50	Prod	17.57	2	.	13.58
0	33.60	10528.86	Prod	11.78	0	.	13.57
0	36.73	30806.93	Prod	16.57	0	.	13.70
0	40.91	63752.00	R&D	1 39	2	3.00	13.70
1	45.48	74478.21	R&D	13.91	3	3 00	12 80
1	44.39	109588.07	Admin	20.63	4	1.00	12.80
1	56.56	44566.07	R&D	19.96	1	1.00	12.73
1	39.64	73356.07	R&D	16.47	2	3.00	12.82
1	50.06	62294.43	R&D	16 09	2	3.00	12.63
1	57.48	63970.93	R&D	16.38	2	3.00	13.20
1	37.56	75321.14	R&D	10.97	2	1.00	13.06
1	40.66	69322.71	R&D	13.73	3	3.00	13.05
1	28.52	45936.[illegible]	R&D	3.07	2	3.00	13 33
0	23.78	16174.29	Admin	.81	0	3 00	12.16
1	41.51	51055.36	Admin	16.40	0	1.00	10.49
0	48.85	27856.93	Prod	15.19	1	.	10.07
0	64.62	26037.93	Prod	16.55	0	.	9.57
0	29.53	27812.29	R&D	7.27	0	1.00	10.20
0	57.47	30890.21	Prod	20.98	0	.	11.11
0	43.18	60798.29	Admin	19.96	0	1.00	11.10
1	51.03	76564.79	Mktg	12.95	0	1.00	10.13
1	48.81	50966.36	R&D	12.30	1	2.00	8.97
1	30.56	51732.21	R&D	7.31	0	3.00	7 91
1	34.67	37476.50	Tech	14.07	1	1.00	8.19
0	38.93	29118.36	Prod	19.20	1	.	8 95
1	38.28	56394.00	R&D	13.77	0	.	9.55
0	31.28	24813.29	Prod	5.72	0	1.00	10.61
0	39.57	28642.14	Prod	16.57	0		8.02
0	50.36	45935.57	R&D	16.51	0	2.00	9.94
0	27.12	15291.43	Mktg	.76	0	3 00	10.49
0	34.89	27909.64	Prod	16.57	3	.	10.97
1	46.78	46775.71	R&D	20.44	3	2.00	10.97
0	26.28	15392.57	R&D	.72	0	3.00	10.49
0	49.03	5401.14	Prod	.18	2		10.82
0	55.20	29122.79	Prod	19.17	0		10.82
0	46.09	40476.64	R&D	13.08	3	1.00	11.41
0	40.68	69019.43	Admin	10.89	3	2.00	11.48
1	49.57	78136.93	Mktg	13.73	0	3 00	11.89
1	37.02	69895.71	Mktg	4.69	2	3.00	12.36
1	63.24	45155.71	R&D	.59	2	2.00	11.49
1	51.34	93451.14	R&D	22.64	3	3.00	11.75
1	52.77	87442.43	R&D	9.19	3	.	12.00
0	50.23	33421.43	Admin	13.75	2	3.00	12.60
1	61.27	50901.36	R&D	22.41	2	2.00	12.63
1	45.98	84667.29	Admin	11.53	2	3.00	11.69
0	35.46	35336.86	R&D	16.86	2	.	13.01
0	44.94	25114.93	Prod	19.63	2	.	13.45
1	35.41	54627.71	Admin	15.93	3	2.00	12.13
1	42.05	54221.86	R&D	20.96	1	2.00	12.77
1	50.87	31695.00	Admin	18.92	3	1 00	13.25
0	39.10	66239.57	R&D	20.27	0	1.00	13.25
0	40.34	5401.14	Prod	.18	3	.	13.06
0	46.87	26296.07	Prod	16.05	0	.	13.48
0	32.24	64129.36	Admin	7.94	0	3.00	12.85
1	32.83	54626.00	CS	7.96	0	1.00	12.85
1	42.99	85983.50	R&D	3.74	3	3.00	12.85

1	31.88	45943.57	Mktg	5.82	0	3.00	13.25
1	40.95	59450.50	Tech	7.29	2	3.00	13.25
0	30.06	43166.07	R&D	4.50	0	3.00	8.52
1	40 60	59127.21	R&D	12.99	1	3.00	9.22
0	42.08	27308.07	Prod	19.00	1	.	10.60
1	40.16	61853.93	Admin	20.01	1	1.00	9.23
1	43.34	71086.36	R&D	21.48	0	3.00	12.78
0	37.83	37563.00	R&D	1.28	2	.	12.70
1	49.26	72044.14	R&D	15.04	2	3.00	12.96
1	53 48	39392.43	Maint	22.59	1	1.00	13.37
1	28.65	49833.57	R&D	4.65	0	.	12.72
1	35.11	36285.71	R&D	.87	4	3.00	13.14
1	46.08	82066.43	R&D	18.49	3	.	12.90
0	42.62	65836.79	R&D	7.56	2	3.00	13.47
1	48.34	77087.14	R&D	7.64	3	3.00	13.73
1	41.92	52436.36	R&D	13.81	0	2.00	13.73
0	37.17	34358.07	Admin	16.76	0	2.00	13.73
1	38 68	58885.71	R&D	14.90	0	3.00	13.73
1	38.30	69496.00	Mktg	13.73	3	3.00	13.30
1	27.56	48494.50	R&D	4.99	0	.	13.19
0	60.14	26385.71	Prod	16.97	0	.	12.96
1	45.12	74791.57	R&D	16.63	2	2.00	14.51
0	53.47	27186.50	Prod	20.08	0	.	13.17
0	59.12	28836.14	Admin	20.00	0	.	13.17
1	41.42	49281.36	CS	20.19	2	2.00	12.43
1	40.12	62160.50	R&D	14.98	3	3.00	12.90
1	45.25	55215.43	QA	20.21	3	2.00	12.43
0	32.70	47115.43	Admin	12.96	0	3.00	13.19
1	38 89	50570.00	CS	15.00	0	1.00	13.19
0	43.48	19294.71	Prod	15.53	2	.	12.43
1	29.07	56222.29	R&D	5.51	0	1.00	12.43
1	42.22	74973.57	R&D	1.79	3	3.00	12.43
1	41.70	53900.43	QA	19.54	3	3.00	12.43
1	36.51	77295.64	R&D	8.10	4	1.00	13.30
1	42.40	51275.14	QA	21.53	0	1.00	14.51
1	28.27	46615.57	R&D	3.94	0	1.00	14.51
0	39.69	26973.93	Maint	10.63	2	1.00	14.51
1	30.44	54790.07	R&D	7.03	0	3.00	12.43
0	53.63	27964.00	Prod	19.71	0	.	12.93
0	34.50	58196.29	R&D	10.99	0	3.00	12.93
1	26 11	18771.43	Admin	.72	0	3.00	12.88
1	39.17	29317.00	Prod	16.83	2	1.00	12.88
1	51.84	76261.36	R&D	13.22	1	3.00	12.88
0	39.38	26473.86	Prod	15.52	2	.	12.79
0	51 61	28932.29	Prod	19.73	0	.	13.07
0	50.18	28020.07	Prod	19.73	1	.	13.22
0	50.53	35573.07	Admin	21.15	0	.	13.27
0	40.24	29291.07	R&D	17.56	0	1.00	13.15
0	52.99	29146.43	Prod	21.05	0	.	13.01
1	37 37	60042.50	Admin	7.39	2	2.00	12.90
1	54.32	62135.64	R&D	4.69	2	2.00	13.27
0	48 97	27417.07	Prod	15.53	0	.	13.18
1	42 44	42447.86	QA	16.55	0	1.00	13.36
1	53.66	25160.43	Prod	19.56	1	.	13.73
0	44 79	31106.29	QA	11.09	3	1.00	13.61
1	36.71	67459.43	Mktg	7.98	0	3.00	13.31
1	43.76	27992.14	Prod	19.29	1	.	13.83
0	39.92	25936.57	Prod	16.51	0	1.00	13.83
1	33.76	40602.29	Tech	14.00	0	1.00	13.83
1	32.56	60371.29	Mktg	11.82	0	2.00	13.83
1	41.55	56005.29	R&D	15.61	1	3.00	13.49
1	49.88	47902.14	CS	13.18	2	1.00	13.43
1	33.02	51340.50	R&D	7.94	1	.	13.43
1	40.10	70640.57	R&D	14.98	0	3.00	13.63
0	48.89	40194.07	Mktg	16.57	2	3.00	13.82

0	47.53	28899.43	R&D	15.61	0	1.00	13.82
1	49.49	6542.43	Prod	14.38	3	2.00	13.70
1	36.64	50340.71	Admin	14.98	0	3.00	13.70
1	37.02	69462.71	R&D	9.77	0		13.83
0	44.63	39491.43	Admin	13.43	3	1.00	13.18
0	35.12	54082.57	R&D	8.71	0	3.00	13.18
1	38.40	60898.86	Mktg	9.36	1	3.00	13.18
0	39.85	38053.57	Admin	19.20	0	.	13.18
1	36.38	62170.14	R&D	15.71	3	3.00	13.18
1	37.75	58983.86	R&D	12.91	2	3.00	13.18
1	36.20	40446.43	Admin	16.84	2	3.00	13.18
1	40.06	51692 43	R&D	16.36	2	1.00	13.18
1	44.05	35203.57	Tech	20.94	2	1.00	13 49
0	45.16	23579.71	Prod	11.80	2	1.00	13.59
1	38.08	58804.21	R&D	14.82	2	.	13.73
1	30.08	54597.71	R&D	1.52	1	.	14.00
1	38.36	41117.07	R&D	1.40	1	3.00	13 99
0	41.02	17532.29	Prod	.18	0		13 18
0	29.22	52785.86	Admin	6.64	0	3.00	13.18
1	50.70	53858.64	CS	15.76	0	2.00	13.18
1	42.70	75129.93	R&D	16.47	2	1.00	13.18
0	32.46	46667.57	R&D	6.41	0	.	13.18
1	53.04	102261.07	R&D	18.15	2	3.00	13.18
1	36.85	59860.14	Tech	9.06	3	3.00	13 18
0	26.61	17871.43	R&D	.70	0		13.18
1	40.13	54460.43	R&D	4.72	0	1.00	13.18
0	53.72	27286.00	Prod	19.59	0	.	13.18
1	48.22	75559.29	CS	27.69	1	2.00	13.18
0	33.83	43401.36	Mktg	16.53	1	2.00	13.18
1	31.09	53733.00	Mktg	7.96	0	3.00	13.18
0	36.93	70770.64	R&D	15.9C	0	2.00	13.18
1	37.40	58261.86	Mktg	4.51	0	3.00	13.18
1	42.23	50908.00	R&D	20.38	2	1.00	10.20
0	32.77	50827.93	R&D	3.84	0	.	13.18
1	31.91	51586.43	Mktg	8.88	0	3.00	13.18
1	54.93	73998.79	QA	22.74	0	1.00	19.20
0	36.14	48181.00	R&D	16.58	0	1.00	21.10
0	40.22	34435.86	QA	19.02	2	.	19.17
0	41.36	29171.64	Maint	19.56	2	1.00	19.20
1	43.24	52320.86	R&D	11.72	0	3.00	21 10
0	45.26	36689.93	Admin	8.31	2	1.00	17 17
0	34.80	26558.21	Prod	16.51	0		17.17
0	35.39	35698.00	Admin	16.55	1	1.00	19.68
1	41.12	58464.29	R&D	19.98	2	2.00	19.20
1	38.76	79438.86	R&D	3.17	2	3.00	19.56
0	34.46	30818.29	Mktg	1.08	1	1.00	8.39
1	36.51	54654.29	R&D	7.43	2	.	8 65
1	51.69	99332.57	R&D	10.49	2	2.00	8.29
0	29.11	15831.86	CS	.76	0	3.00	6 43
1	33.31	72822.79	Mktg	5.01	2		9.44
0	35.81	57042.86	R&D	1.87	0	3.00	6.43
1	39.13	26333.36	Prod	16.53	0	1.00	38.98
1	44.77	55523.14	QA	15.46	2	3.00	38.62
1	40.23	51961.57	R&D	14.96	1	1.0	38.43
1	38.61	94385.29	Mktg	15.98	1	3.00	47.84

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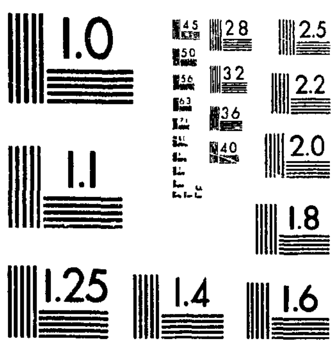
PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT



PRECISION[SM] RESOLUTION TARGETS