# Commuting to Work in England and Wales in 1991 and 2001: Modelling Distance and Mode of Transport Using Microdata

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## 1. Introduction

Commuting to work is an activity that is carried out relatively frequently, often daily, by the vast majority of individuals in employment. It is, therefore, a relatively important part of many people's lives, with the nature of an individual's commute impacting upon their life, both directly and indirectly.

In the simplest case, commuting involves the regular movement of an individual from a place residence to a place of work and back again. People who work mainly at or from home and people with no fixed place of work are also classed as commuters by the Office for National Statistics (ONS), as both still have a place of residence and a place of work, albeit with individuals in the former category having both in the same approximate location, and individuals in the latter category having multiple places of work. Therefore, even with the inclusion of homeworkers and people with no fixed place of work, there are two key aspects of commuting that, by definition, are universal: commute distance and mode of transport.

However, different subgroups of the commuting population have different experiences of the two key aspects of commuting; that is, different experiences of commute distance and mode of transport. For example, it is unlikely that the commute of a young, black, female, with a limiting long-term illness and dependent children living in the relatively poor North East of England will be similar to that of an older, white, male, with no limiting long-term illness or dependent children living in the relatively wealthy South East of England.

Although some past research, much of which has been reviewed in Murphy *et al*. (2013), has attempted to establish how and why commuting behaviour and patterns vary by sociodemographic and geographic characteristics, extant research has dealt with the variations in a rather fragmented way and much of it is now out of date. No research has systematically and quantitatively analysed variations in commuting behaviour and patterns disaggregated by those variables which past research has suggested are important, such as age, sex, ethnicity and region of residence. It is these sociodemographic and geographic variations in commute distance and mode of transport that this research attempts to identify, analyse and understand.

Furthermore, the research analyses the relationships between the different sociodemographic and geographic variables and commuting behaviour and patterns in both 1991 and 2001. The analysis of comparable data for two points in time is critical in order to identify what temporal changes occurred in commuting behaviour and patterns in England and Wales over the ten year period (with the aim of extending the analysis further to cover the twenty year period 1991-2011, when the 2011 data become available). By analysing both cross-sectional and temporal variations, the research presents a more complete and dynamic picture of the relationships between different sociodemographic and geographic variables and commuting behaviour and patterns than could be achieved by only carrying out a cross-sectional analysis of data for only one point in time.

## 2. Research Aims

The research reported here aims to do three things. First, it is designed to contribute new analyses of the relationships between commuting behaviour and patterns and individual predictor variables to the extant research. Second, it endeavours to fill a substantial gap in the literature related to the systematic, simultaneous and quantitative analysis of multiple important sociodemographic and geographic variables and their relationships with commuting behaviour and patterns. Third, it attempts to shed light on the changes in commuting behaviour over time, between 1991 and 2001 in the first instance.

## 3. Policy Context

Variations in commuting behaviour and patterns by individual sociodemographic and geographic characteristics are important to understand from a policy perspective. If one accepts that economic and social inequalities are sub-optimal, and should therefore be addressed by policy makers, then local, regional and national transport policies need to be designed with variations in commuting behaviour and patterns in mind. If it is the case that more affluent white males are more likely to commute to work by car while less affluent black females are more likely to commute to work by bus, important issues are raised about the provision (or non-provision) of bus services in areas inhabited by large black populations in particular, and the distribution of economic and social resources in general. However, whilst it is necessary to understand how commuting behaviour and patterns vary by sociodemographic and geographic variables independently, it is also important, as suggested by the example given above, to understand how these sociodemographic and geographic variables interact with each other and what effect this interaction has on the commuting behaviour and patterns of different population subgroups. Very little research on commuting behaviour and patterns has looked at intersectionality and the interaction effects between the different sociodemographic and geographic variables or what impact the interaction has on commuting behaviour and patterns. It is envisaged that the detection and analysis of these interaction effects will lead to a greater understanding of the sociodemographic and geographic drivers of commuting.

## 4. Data, Methods and Software

The research makes use of the census microdata from the 1991 and 2001 Census Individual Samples of Anonymised Records (I-SARs). The microdata are being used for three main reasons. First, they are created from a large random sample of the UK population (Boyle and Dorling, 2004), which means that they are statistically reliable and representative, and are therefore ideal for carrying out robust statistical analyses. Second, they have a great deal of variable and category detail at the expense of having little geographical detail (Tranmer *et al.*, 2005), which means that they are good for carrying out national-level analyses of commuting behaviour but less good for more geographically detailed analyses at the small area level.

Third, they are extremely flexible, providing the opportunity to combine different variable categories in different ways depending on what question or issue is being addressed at the time.

Binary Logistic Regression is the statistical method that has been used to quantitatively analyses the variations in commute distance and mode of transport disaggregated for those variables which past research has suggested are important. Binary Logistic Regression modelling has been used because the I-SAR data used for the research is categorical, but also because it is possible to use Binary Logistic Regression to analyse both the main effects of, and interaction effects between, the different sociodemographic and geographic predictor variable categories while controlling for other predictor variables in the model.

Microsoft Excel 2010 and IBM SPSS Statistics 19 are the two software packages that have been used for the data analyses in this particular piece of research. Microsoft Excel 2010 has been used for some basic data analyses and visualisations, while IBM SPSS Statistics 19 has been used to carry out the more in-depth statistical analyses, including the cross-tabulations and the Binary Logistic Regressions.

## 5. Equations, Figures and Tables

A simple Binary Logistic Regression model, with a single binary dependent variable ($Y$) and $n$ independent variables ($X_i$), and can be written as:

$$L = ln\ (o) = ln\ (p/1\text{-}p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \qquad (1)$$

where $L$ is the natural log of the odds ($ln\ (o)$) of an event (a response) occurring, where the latter is defined as the natural log of the proportion of successes ($p$) divided by 1-$p$, and the $\beta$ values represent the intercept on the $Y$ axis and the regression parameters or slopes of the regression lines relating to each $X$ variable, where $i$ varies from 1 to $n$. The final term, $\varepsilon$, is the random error term.

In contrast to the Binary Logistic Regression model in equation (1), which is similar to an additive model equation and does not take into account any possible IEs, a model with a single dependent variable ($Y$), two predictor variables ($X_1$ and $X_2$), and IEs between $X_1$ and $X_2$ can be written as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 (X_1 * X_2) + \varepsilon \qquad (2)$$

with the $\beta_3(X_1*X_2)$ term indicating the interaction between the two predictor variables, $X_1$ and $X_2$.

The model can be extended to include many predictor variables, such that a model with a single dependent variable ($Y$), three predictor variables ($X_1$, $X_2$ and $X_3$), and IEs between $X_1$, $X_2$ and $X_3$ can be written as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 (X_1 * X_2) + \beta_5 (X_1 * X_3) + \beta_6 (X_2 * X_3) + \varepsilon \qquad (3)$$

with the $\beta_4(X_1*X_2)$ term, as in equation 2, indicating the interaction between the two predictor variables, $X_1$ and $X_2$, the $\beta_5(X_1*X_3)$ term indicating the interaction between the two predictor variables, $X_1$ and $X_3$, and the $\beta_6(X_2*X_3)$ term indicating the interaction between the two predictor variables, $X_2$ and $X_3$.

Following from the above, it is possible to calculate the probabilities that certain groups will express certain behaviours. For example, the probability that females aged 65-74 will commute long distance can be defined as:

$$Pr\ (Y) = (EXP(X) / (1+EXP(X)))*100 \qquad (4)$$

where:

$$X = \ln\ (Constant) + \ln\ (PE1\ OR) + \ln\ (PE2\ OR) + \ln\ (IE\ OR_{1*2}) \qquad (5)$$

in the case of two independent variables, in this case sex and age group.

**Table 1: sex, age and ethnicity crosstabulation showing the number of commuters in each sociodemographic group in the I-SAR for all commuters (including homeworkers) in England and Wales aged 16-74 in 1991 and 2001**

| Sex, Age and Ethnicity (1991 and 2001) | | | White | Indian | Pakistani | Bangladeshi | Other Asian | Black | Chinese | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | Male | 16-24 | 33331 | 444 | 205 | 89 | 78 | 401 | 64 | 153 | 34765 |
| | | 25-44 | 109736 | 2130 | 686 | 198 | 488 | 1381 | 381 | 558 | 115558 |
| | | 45-64 | 71618 | 925 | 266 | 89 | 208 | 864 | 132 | 181 | 74283 |
| | | 65-74 | 3506 | 26 | 2 | 2 | 4 | 27 | 3 | 5 | 3575 |
| | Female | 16-24 | 32002 | 404 | 147 | 39 | 66 | 503 | 64 | 157 | 33382 |
| | | 25-44 | 87527 | 1615 | 159 | 19 | 461 | 1640 | 334 | 387 | 92142 |
| | | 45-64 | 52745 | 452 | 54 | 9 | 150 | 791 | 110 | 112 | 54423 |
| | | 65-74 | 1905 | 5 | 0 | 1 | 1 | 11 | 2 | 0 | 1925 |
| | | Total | 392370 | 6001 | 1519 | 446 | 1456 | 5618 | 1090 | 1553 | 410053 |
| 2001 | Male | 16-24 | 48610 | 1059 | 769 | 310 | 252 | 730 | 214 | 127 | 52071 |
| | | 25-44 | 182308 | 4525 | 2375 | 947 | 1121 | 4382 | 895 | 794 | 197347 |
| | | 45-64 | 131643 | 2263 | 711 | 152 | 569 | 1611 | 420 | 315 | 137684 |
| | | 65-74 | 6676 | 109 | 34 | 9 | 16 | 105 | 16 | 6 | 6971 |
| | Female | 16-24 | 45231 | 1020 | 596 | 254 | 168 | 865 | 231 | 141 | 48506 |
| | | 25-44 | 157218 | 3871 | 894 | 215 | 601 | 4919 | 850 | 828 | 169396 |
| | | 45-64 | 108304 | 1546 | 195 | 55 | 341 | 1636 | 383 | 452 | 112912 |
| | | 65-74 | 4252 | 32 | 4 | 0 | 12 | 59 | 4 | 9 | 4372 |
| | Total | | 684242 | 14425 | 5578 | 1942 | 3080 | 14307 | 3013 | 2672 | 729259 |

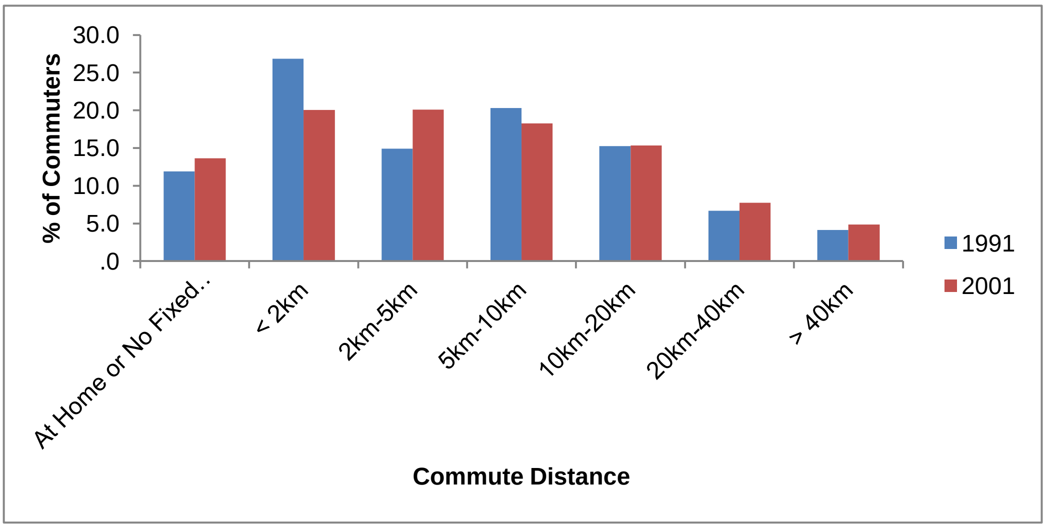


**Figure 1: Percentage of commuters in England and Wales aged 16-74 in each commute distance band in 1991 and 2001**

**Table 2: Multiple logistic regression model results for the percentage of commuters with long commutes (5km cut-point) by sociodemographic and geographic characteristics for all commuters (incl. homeworkers) in England&Wales aged 16-74 in 1991 and 2001**

| Sociodemographic and Geographic Characteristics | | 1991 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Categories | Exp(B) | | 95 CI | | Exp(B) | | 95 CI | |
| Sex | Male | 1.000 | | | | 1.000 | | | |
| | Female | 0.733 | * | 0.722 | 0.743 | 0.760 | * | 0.751 | 0.769 |
| Age group | 16-24 | 1.000 | | | | 1.000 | | | |
| | 25-44 | 0.925 | * | 0.906 | 0.945 | 1.045 | * | 1.028 | 1.064 |
| | 45-64 | 0.756 | * | 0.739 | 0.772 | 0.849 | * | 0.834 | 0.864 |
| | 65-74 | 0.479 | * | 0.446 | 0.515 | 0.634 | * | 0.601 | 0.670 |
| Ethnic group | White | 1.000 | | | | 1.000 | | | |
| | Indian | 0.832 | * | 0.783 | 0.883 | 0.821 | * | 0.787 | 0.857 |
| | Pakistani | 0.630 | * | 0.559 | 0.709 | 0.662 | * | 0.619 | 0.707 |
| | Bangladeshi | 0.853 | | 0.668 | 1.089 | 0.858 | * | 0.763 | 0.966 |
| | Other Asian | 0.929 | | 0.819 | 1.054 | 0.962 | | 0.878 | 1.054 |
| | Black | 0.957 | | 0.899 | 1.020 | 1.068 | * | 1.024 | 1.114 |
| | Chinese | 0.904 | | 0.776 | 1.054 | 0.835 | * | 0.758 | 0.921 |
| | Other | 1.098 | | 0.974 | 1.238 | 0.868 | * | 0.784 | 0.961 |
| LLTI | LLTI | 1.000 | | | | 1.000 | | | |
| | No LLTI | 1.121 | * | 1.078 | 1.166 | 1.094 | * | 1.069 | 1.119 |
| Dependent Children | No Dependent Children | 1.000 | | | | 1.000 | | | |
| | Dependent Children | 0.870 | * | 0.857 | 0.884 | 0.876 | * | 0.865 | 0.887 |
| Occupation | Professional and Managerial | 1.000 | | | | 1.000 | | | |
| | Non-Professional and Non-Managerial | 0.542 | * | 0.533 | 0.550 | 0.574 | * | 0.566 | 0.581 |
| Region of usual residence | North East | 0.994 | | 0.952 | 1.037 | 1.005 | | 0.969 | 1.041 |
| | North West | 0.909 | * | 0.876 | 0.943 | 0.835 | * | 0.811 | 0.860 |
| | Yorkshire and The Humber | 0.961 | * | 0.925 | 0.999 | 0.888 | * | 0.862 | 0.916 |
| | East Midlands | 0.951 | * | 0.914 | 0.989 | 0.920 | * | 0.892 | 0.950 |
| | West Midlands | 0.974 | | 0.938 | 1.011 | 0.846 | * | 0.821 | 0.872 |
| | East of England | 0.926 | * | 0.884 | 0.969 | 0.937 | * | 0.909 | 0.966 |
| | South East | 0.978 | | 0.945 | 1.013 | 0.868 | * | 0.844 | 0.893 |
| | South West | 0.795 | * | 0.764 | 0.826 | 0.792 | * | 0.768 | 0.817 |
| | Inner London | 0.588 | * | 0.559 | 0.618 | 0.511 | * | 0.491 | 0.531 |
| | Outer London | 0.950 | * | 0.912 | 0.989 | 0.860 | * | 0.832 | 0.888 |
| | Wales | 1.000 | | | | 1.000 | | | |
| Mode of Transport | Train, Underground and Tram | 8.505 | * | 8.127 | 8.900 | 5.936 | * | 5.743 | 6.136 |
| | Bus | 1.000 | | | | 1.000 | | | |
| | Car (Driver) | 1.384 | * | 1.351 | 1.417 | 1.508 | * | 1.478 | 1.539 |
| | Car (Passenger) | 1.000 | | 0.970 | 1.031 | 0.954 | * | 0.929 | 0.980 |
| | Bicycle | 0.238 | * | 0.226 | 0.251 | 0.287 | * | 0.275 | 0.299 |
| | On Foot | 0.061 | * | 0.058 | 0.064 | 0.118 | * | 0.114 | 0.122 |
| | Homeworker | 0.000 | * | 0.000 | 0.000 | 0.000 | | 0.000 | ####### |
| | Other | 1.113 | * | 1.058 | 1.170 | 0.967 | | 0.929 | 1.007 |
| | Constant | 1.797 | * | | | 1.647 | * | | |

Source: Derived from 1991 and 2001 Census Individual Licenced SARs (*= OR significant at 95% CI level) (####### indicates a very small number)

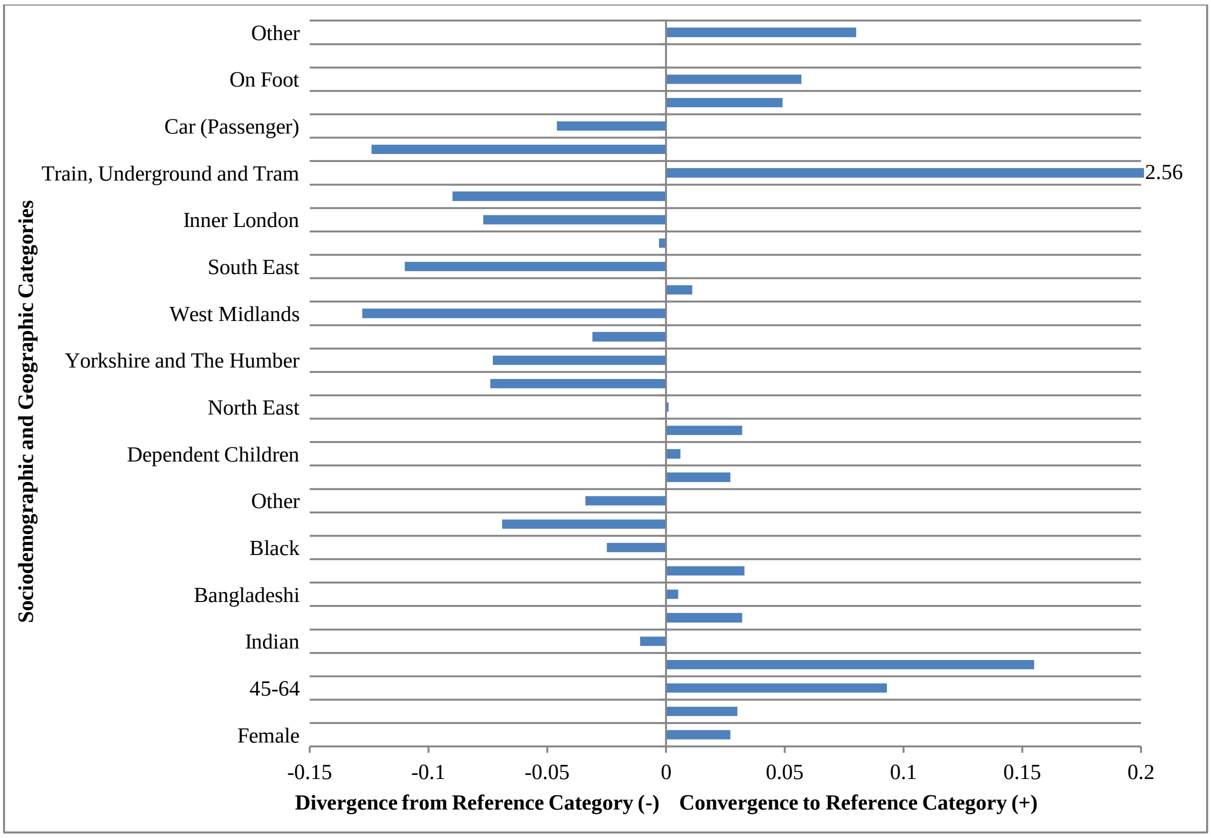


**Figure 2: Point convergence/divergence of ORs for long distance commuting (5km cut-point) to/from ORs of reference categories between 1991 and 2001 for different sociodemographic and geographic categories**

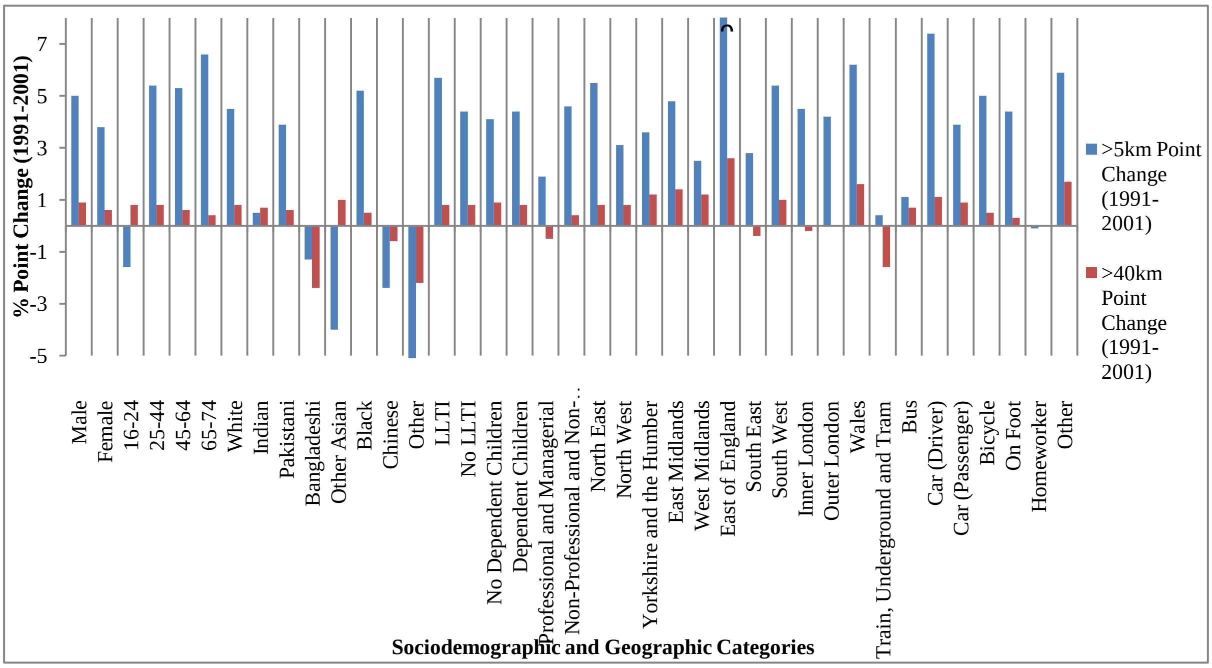


**Figure 3: Percentage point changes in long (5km cut-point) and very long (40km cut-point) commutes by sociodemographic and geographic characteristics for all commuters (including homeworkers) in England and Wales aged 16-74 between 1991 and 2001**

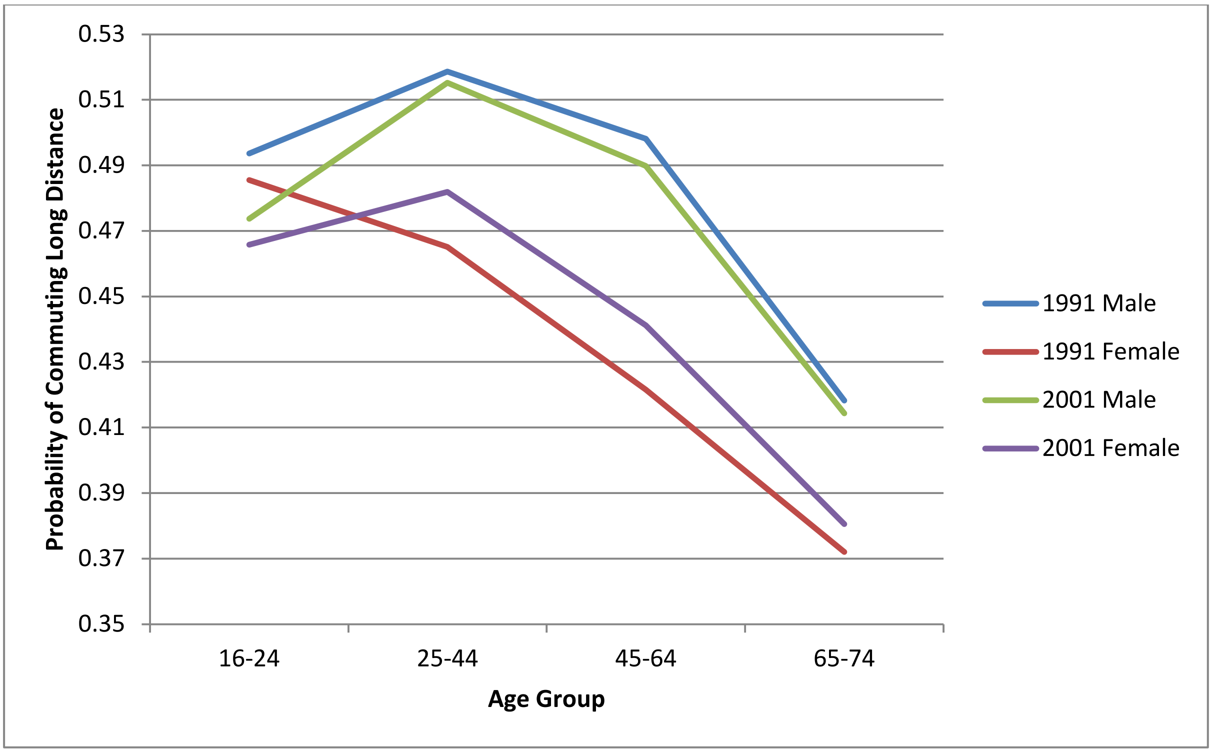


**Figure 4: Interaction graph from BLR results of percentages of commuters with long commutes (5km cut-point) by sex and age group for all commuters (including homeworkers) in England and Wales aged 16-74 in 1991 and 2001**

## 6. Research Context

In the overall scheme of the PhD thesis, this part of the research is going to provide a national overview of sociodemographic and geographic variations in commuting behaviour and patterns in England and Wales. The national overview will sit between the earlier literature review and data review chapters, which have already been carried out, and the later data analysis chapters, which will provide in-depth statistical and spatial analyses of sociodemographic and geographic variations in commuting behaviour and patterns at the regional and local levels.

All of the research carried out for the PhD is policy oriented. Ultimately, the findings from the research will inform the presentation of some policy suggestions. These policy suggestions could eventually be implemented by regional or local governments or any other organisation with a responsibility to supply and maintain transport networks for those who require them.

## 7. Acknowledgements

The PhD research is being funded by a University of Leeds Innovations in Quantitative Methods (IQM) scholarship.

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## 9. Biography

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