NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF RURAL AND SURVEYING ENGINEERING

DEPARTMENT OF INFRASTRUCTURE AND RURAL DEVELOPMENT

UNIVERSITY COLLEGE DUBLIN

SCHOOL OF CIVIL ENGINEERING

Diploma Thesis

FACTORS AFFECTING CYCLING AND WALKING PROPENSITY: THE CASE OF DUBLIN AND ATHENS

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Athens, February 2020

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΣΧΟΛΗ ΑΓΡΟΝΟΜΩΝ ΚΑΙ ΤΟΠΟΓΡΑΦΩΝ ΜΗΧΑΝΙΚΩΝ

ΤΟΜΕΑΣ ΕΡΓΩΝ ΥΠΟΔΟΜΗΣ ΚΑΙ ΑΝΑΠΤΥΞΗΣ

UNIVERSITY COLLEGE DUBLIN

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Διπλωματική Εργασία

ΠΑΡΑΜΕΤΡΟΙ ΕΠΙΡΡΟΗΣ ΤΗΣ ΤΑΣΗΣ ΓΙΑ ΜΕΤΑΚΙΝΗΣΗ ΜΕ ΠΟΔΗΛΑΤΟ ΚΑΙ ΠΕΖΗ: Η ΠΕΡΙΠΤΩΣΗ ΤΟΥ ΔΟΥΒΛΙΝΟΥ ΚΑΙ ΤΗΣ ΑΘΗΝΑΣ

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Αθήνα, Φεβρουάριος 2020

Acknowledgements

My deep gratitude goes first to Dr. Ioanna Spyropoulou, who expertly guided me and shared the excitement of conducting an International research. Her mentoring, encouragement and unwavering enthusiasm for the subject kept me constantly engaged with my research. My appreciation also extends to Dr. Aoife Ahern, who gave me the opportunity to study abroad, and her personal generosity helped make my time in University College Dublin enjoyable. Thanks also go to Sofia Antonopoulou and Christos Kokkalis, who heleped me in various parts of this thesis. Furthermore, I want to thank all the people who helped me with the questionnaires' distribution, both in Ireland and Greece, and last, I would like to thank each participant of the survey for his/her time.

Περίληψη

Σκοπός της παρούσας διπλωματικής εργασίας αποτελεί η διερεύνηση παραγόντων που επηρεάζουν την τάση για ποδηλασία και περπάτημα σε μεγάλα αστικά κέντρα καθώς και οι ανάγκες και προτιμήσεις των μετακινούμενων σχετικά με την ποδηλασία και το περπάτημα. Η παρούσα διπλωματική εργασία πραγματοποιήθηκε στα πλαίσια του προγράμματος ανταλλαγής φοιτητών Erasmus+ όπου τμήμα της πραγματοποιήθηκε στο University College Dublin (Πανεπιστημιακό Κολλέγιο του Δουβλίνου) και τμήμα της στο Εθνικό Μετσόβιο Πολυτεχνείο. Η διερεύνηση των παραγόντων πραγματοποιήθηκε στις πόλεις του Δουβλίνου και της Αθήνας, με σκοπό την ανάδειξη των κοινών (διεθνών) παραγόντων επιρροής αλλά και των επιμέρους παραγόντων που επηρεάζουν την κάθε πόλη καθώς και επιμέρους τμήματα του πληθυσμού τους ξεχωριστά.

Στο δεύτερο κεφάλαιο παρουσιάζεται η βιβλιογραφική ανασκόπηση των άρθρων και εργασιών στις οποίες βασίστηκε αυτή η διπλωματική εργασία. Την τελευταία εικοσαετία η Ευρωπαική Ένωση προσπαθεί μέσω ρυθμίσεων και πολιτικών να προωθήσει το περπάτημα και την ποδηλασία, έτσι ώστε να επιτύχει μια πιο βιώσιμη κινητικότητα στα αστικά της κέντρα. Οι πολιτικές αυτές συνοψίζονται στις Λευκές και Πράσινες βίβλους των μεταφορών καθώς και στις επανεξετάσεις τους. Με βάση την ελληνική, ιρλανδική και διεθνή βιβλιογραφία, δημιουργήθηκε μια κατηγοριοποίηση των παραγόντων που επηρεάζουν την τάση για ποδηλασία και περπάτημα καθώς και τις σχέσεις μεταξύ των εξεταζόμενων τρόπων μεταφοράς με τις υπόλοιπες συμβατικές μεθόδους μετακίνησης. Οι παράγοντες που επηρεάζουν το περπάτημα χωρίστηκαν στις εξής κατηγορίες: δομημένο περιβάλλον, απόσταση, προσβασιμότητα, ασφάλεια μετακίνησης και κοινωνικοοικονομικοί παράγοντες. Αντίστοιχα οι παράγοντες που επηρεάζουν την ποδηλασία χωρίστηκαν σε: δομημένο περιβάλλον, απόσταση, ασφάλεια μετακίνησης, κοινωνικοοικονομικοί παράγοντες και περιβαλλοντικοί παράγοντες. Αφού προήλθε η διερεύνηση των παραγόντων με βάση την υπάρχουσα βιβλιογραφία, η έρευνα συνεχίστηκε με τον σχεδιασμό ερωτηματολογίου για τη συλλογή δεδομένων στο Δουβλίνο και την Αθήνα, το οποίο βασίστηκε στους παράγοντες που αναφέρθηκαν.

Στο τρίτο κεφάλαιο παρουσιάζονται οι μεθοδολογίες οι οποίες ακολουθήθηκαν για τη συλλογή και ανάλυση των δεδομένων καθώς και για το σχεδιασμό του ερωτηματολογίου. Αρχικά ως μέθοδος για την έρευνα προτιμήσεων επιλέχτηκε η μέθοδος των δεδηλωμένων προτιμήσεων καθώς αυτή προσφέρει ένα μεγαλύτερο φάσμα επιλογών στον ερευνητή σε σχέση με αυτή των εκδηλωμένων προτιμήσεων που βασίζεται σε πραγματικές καταστάσεις, παρέχοντας έτσι πολύ περιορισμένες επιλογές στον σχεδιασμό του ερωτηματολογίου. Στην συνέχεια επιλέχθηκε η μέθοδος της προσωπικής συνέντευξης ως μέθοδος διεξαγωγής της έρευνας. Αυτή η μέθοδος επιλέχθηκε σε σύγκριση με τις υπόλοιπες καθώς το ερωτηματολόγιο ήταν

περίπλοκο και σχετικά μεγάλο σε διάρκεια. Έτσι η μέθοδος της προσωπικής συνέντευξης έδινε τη δυνατότητα να αποσαφηνιστούν τυχών απορίες των συμμετεχόντων στο ερωτηματολόγιο, διασφαλίζοντας έτσι ακριβέστερα αποτελέσματα. Στη συνέχεια έγινε η επιλογή της μεθόδου δειγματοληψίας. Για την παρούσα έρευνα επιλέχθηκε η μέθοδος της απλής τυχαίας δειγματοληψίας καθώς ταιριάζει στη φύση της έρευνας και αποτελεί την απλούστερη διαδικασία. Για την ανάλυση των επιλογών του πληθυσμού επιλέχθηκε η ανάλυση διακριτών επιλογών και συγκεκριμένα το μοντέλο probit. Ο λόγος που επιλέχθηκε το μοντέλο probit είναι καθώς αυτό μπορεί να συλλάβει συσχετισμούς μεταξύ εναλλακτικών επιλογών και να ξεπεράσει περιορισμούς που εμφανίζονται σε άλλα μοντέλα καθώς είναι γενικότερο.

Στο τέταρτο κεφάλαιο παρουσιάζονται τα χαρακτηριστικά των δύο εξεταζόμενων πόλεων, ο σχεδιασμός και η παρουσίαση του ερωτηματολογίου καθώς και η διεξαγωγή της έρευνας πεδίου. Η Αθήνα είναι η πρωτεύουσα της Ελλάδας με τον πληθυσμό της ευρύτερης περιοχής της να υπολογίζεται στους 3.800.000 κατοίκους, καθιστώντας την μια από τις πολυπληθέστερες πόλεις της Ευρώπης. Έχει ένα ζεστό μεσογειακό κλίμα με ζεστά καλοκαίρια και ήπιους χειμώνες και χαρακτηρίζεται από το έντονο ανάγλυφό της. Όσον αφορά τις ποδηλατικές της υποδομές αυτές χαρακτηρίζονται ως ελλιπείς καθώς το ποδηλατικό της δίκτυο εκτείνεται σε 55 χιλιόμετρα σε μια περιοχή 412 τετραγωνικών χιλιομέτρων. Επίσης το υφιστάμενο δίκτυο συχνά καταπατείται από χρήστες αυτοκινήτων και μοτοσυκλετών και η κακή συντήρησή του έχει οδηγήσει σε πολλές καταστροφές τμημάτων του. Οι υποδομές πεζών στην Αθήνα επίσης χαρακτηρίζονται ως κακές καθώς ιδιαίτερα στο κέντρο της συναντάμε στενά και απροσπέλαστα πεζοδρόμια τα οποία συχνά καταπατούνται από οχήματα ενώ οι πεζοδρομημένες περιοχές είναι επίσης ελάχιστες. Το Δουβλίνο είναι η πρωτεύουσα της Δημοκρατίας της Ιρλανδίας και η ευρύτερη περιοχή του κατοικείται από 1.900.000 κατοίκους. Η πόλη είναι χτισμένη στις εκβολές του ποταμού Λίφει και έχει επίπεδο ανάγλυφο. Το Δουβλίνο δεν βιώνει ακραίες θερμοκρασίες καθώς έχει δροσερά καλοκαίρια και ήπιους χειμώνες, ωστόσο πρόκειται για μια από τις πόλεις με τις περισσότερες βροχοπτώσεις και τους εντονότερους ανέμους στην Ευρώπη. Το ποδηλατικό δίκτυο που δημιουργήθηκε μέχρι το 2012 ανέδειξε το Δουβλίνο ως μια από τις πιο φιλικές προς το ποδήλατο πόλεις της Ευρώπης παρότι από το 2013 έως το 2019 οι μετακινήσεις με ποδήλατο έχουν μειωθεί, ο δήμος του Δουβλίνου προσπαθεί εκ νέου να τις αυξήσει με νέα μέτρα που πρόκειται να εφαρμοστούν. Οι υποδομές πεζών στο Δουβλίνο δεν χαρακτηρίζονται ούτε κακές αλλά ούτε και καλές, με Ιρλανδούς ερευνητές να τονίζουν πως η επισκευή των υποδομών για τους πεζούς θα παίξει πολύ σημαντικό ρόλο προς την επίτευξη βιώσιμης κινητικότητας στο κέντρο της πόλης.

Το ερωτηματολόγιο που σχεδιάστηκε αποτελείται από 4 μέρη. Στο 1^{ο} μέρος οι συμμετέχοντες καλούνται να δηλώσουν τις προσωπικές τους προτιμήσεις μετακινήσεων όπως το κύριο μεταφορικό τους μέσο ή τον μέσο χρόνο μετακίνησής τους για συγκεκριμένο σκοπό. Το 2^{ο} μέρος του ερωτηματολογίου αποτελείται από 18 υποθετικά σενάρια (από 9 για ποδηλασία και 9 για περπάτημα) στα οποία οι συμμετέχοντες καλούνται να δηλώσουν την πιθανότητα να πραγματοποιήσουν μια συγκεκριμένη μετακίνηση με ποδήλατο ή πεζή υπό συγκεκριμένα σενάρια. Τα σενάρια αυτά ορίζονται από 3 μεταβλητές τριών επιπέδων. Οι μεταβλητές είναι ο σκοπός μετακίνησης, η απόσταση μετακίνησης και οι υποδομές μετακίνησης. Ως πιθανοί σκοποί μετακίνησης ορίστηκαν η εργασία, τα εβδομαδιαία ψώνια και η νυχτερινή διασκέδαση, ως αποστάσεις: μικρή, μεσαία, μεγάλη, όπως αυτές ορίζονται από την βιβλιογραφία για περπάτημα και ποδηλασία και ως υποδομές: ανύπαρκτες, μέτριες, εξαιρετικές και πάλι όπως αυτές ορίζονται από την βιβλιογραφία για κάθε μέσο μετακίνησης. Τα πιθανά σενάρια που προκύπτουν ως συνδυασμός των μεταβλητών των επιπέδων τους είναι 27, τα οποία χωρίστηκαν σε 3 μπλοκ των 9 σεναρίων καθώς θα ήταν αδύνατο χρονικά ένας συμμετέχοντας να απαντήσει σε 27 σενάρια για ποδηλασία και 27 για περπάτημα. Το 3^{ο} μέρος του ερωτηματολογίου περιλαμβάνει τις προτιμήσεις των συμμετεχόντων όσον αφορά την ποδηλασία και το περπάτημα. Συγκεκριμένα οι συμμετέχοντες καλούνται να βαθμολογήσουν τις υποδομές της πόλης τους, τους λόγους για τους οποίους ποδηλατούν και περπατούν καθώς και τους παράγοντες που τους ενθαρρύνουν και αποθαρρύνουν από την ποδηλασία και το περπάτημα. Τέλος, στο 4^{ο} μέρος οι συμμετέχοντες καλούνται να απαντήσουν σε κάποιες προσωπικές ερωτήσεις όπως φύλο, επάγγελμα, εκπαίδευση και εισόδημα. Συνολικά στην έρευνα συμμετείχαν 300 μετακινούμενοι, 150 από κάθε πόλη. Η διανομή των ερωτηματολογίων έλαβε μέρος στο Δουβλίνο κατά την άνοιξη του 2019 και στην Αθήνα κατά το καλοκαίρι το 2019. Η διανομή έγινε σε πολλά διαφορετικά μέρη των πόλεων (σε κανένα μέρος δεν μοιράστηκαν πάνω από 20 ερωτηματολόγια) ενώ σε κάθε πόλη μοιράστηκε και ένα μικρό μέρος σε ποδηλατικούς συλλόγους, με σκοπό την συλλογή καλύτερων δεδομένων όσον αφορά την ποδηλασία.

Στο 5^{ο} κεφάλαιο πραγματοποιείται η ανάλυση των δεδομένων που συλλέχθηκαν και η εξαγωγή των αποτελεσμάτων. Συγκεκριμένα πραγματοποιείται στατιστική ανάλυση του δείγματος και των προτιμήσεων των μετακινούμενων καθώς και ο σχεδιασμός 14 διατεταγμένων μοντέλων probit. Το δείγμα αποτελείται κατά 45% από άντρες, 54% από γυναίκες, ενώ το 1% χαρακτήρισε τον εαυτό του ως «άλλο φύλο». Από αυτά τα ποσοστά στην Αθήνα οι άντρες αποτελούσαν το 44% και οι γυναίκες το 56% ενώ στο Δουβλίνο το 46% ήταν άντρες, το 52% γυναίκες και το 2% «άλλο φύλλο». Από ηλικιακές ομάδες στο συνολικό δείγμα 3% ήταν μικρότερο από 18 χρονών, 23% 18-24 χρονών, 32% 25-34, 15% 35-44, 15% 45-54, 8% 55-64 και το 4% άνω των 64 χρονών. Οι Αθηναίοι βαθμολόγησαν τις ποδηλατικές υποδομές της

Αθήνας αλλά και τις υποδομές πεζών πολύ χαμηλότερα από αυτές των κατοίκων του Δουβλίνου οι οποίοι βαθμολόγησαν τις ποδηλατικές τους υποδομές ως κακές και τις υποδομές πεζών ως μέτριες. Οι κάτοικοι της Αθήνας βαθμολόγησαν ως τους σημαντικότερους αποθαρρυντικούς παράγοντες από την ποδηλασία την οδική ασφάλεια και την παρουσία μεγάλων κόμβων κατά τη διαδρομή ενώ οι κάτοικοι του Δουβλίνου την οδική ασφάλεια και τις κακές καιρικές συνθήκες. Ως σημαντικότερους ενθαρρυντικούς παράγοντες για ποδηλασία οι κάτοικοι της Αθήνας βαθμολόγησαν τους προσεκτικούς οδηγούς και τις χωριζόμενες λωρίδες ποδηλατοδρόμων όπως και οι κάτοικοι του Δουβλίνου. Ως σημαντικότερους αποθαρρυντικούς παράγοντες οι κάτοικοι της Αθήνας βαθμολόγησαν τις κακές καιρικές συνθήκες και τη μεταφορά αγαθών/ατόμων ενώ οι κάτοικοι του Δουβλίνου τις κακές καιρικές συνθήκες και την ταχύτητα μεταφοράς. Ως σημαντικότερους ενθαρρυντικούς παράγοντες για περπάτημα οι κάτοικοι της Αθήνας βαθμολόγησαν τα πλατύτερα πεζοδρόμια και τους πεζοδρομημένους δρόμους ενώ οι κάτοικοι του Δουβλίνου τις καλές καιρικές συνθήκες και την όμορφη θέα – ύπαρξη πρασίνου στη διαδρομή. Δημιουργήθηκαν 7 μοντέλα probit για την τάση για ποδηλασία και 7 για την τάση για περπάτημα. Αυτά τα 7 μοντέλα αφορούν διαφορετικά τμήματα του πληθυσμού. Δημιουργήθηκε ένα κοινό μοντέλο με δείγμα το σύνολο των συμμετεχόντων, ένα για τον πληθυσμό της Αθήνας, ένα για τον πληθυσμό του Δουβλίνου και από ένα για τον πληθυσμό αντρών και γυναικών σε κάθε πόλη. Τα βασικά αποτελέσματα – συμπεράσματα που προέκυψαν από τα μοντέλα για την ποδηλασία είναι τα εξής: Αρχικά η τάση για ποδηλασία στο Δουβλίνο είναι υψηλότερη από αυτή στην Αθήνα. Η απόσταση μετακίνησης επηρεάζει την τάση για ποδηλασία και στις 2 πόλεις. Μεγαλύτερες αποστάσεις οδηγούν σε μειωμένη ποδηλατική τάση. Οι ποδηλατικές υποδομές επίσης επηρεάζουν την τάση για ποδηλασία και στις 2 πόλεις. Καλύτερες ποδηλατικές υποδομές οδηγούν σε υψηλότερη τάση για ποδηλασία. Ο σκοπός μετακίνησης επηρεάζει την τάση για ποδηλασία και στις 2 πόλεις. Οι μετακινήσεις με σκοπό την εργασία έχουν υψηλότερη ποδηλατική τάση από τις μετακινήσεις για ψώνια ενώ οι μετακινήσεις για νυχτερινή έξοδο συγκεντρώνουν την μικρότερη ποδηλατική τάση σε όλους του πληθυσμούς εκτός από αυτόν των ανδρών στο Δουβλίνο. Η ηλικία ως παράγοντας επηρεάζει την τάση για ποδηλασία εκτός του μοντέλου των ανδρών στο Δουβλίνο, καθώς όσο αυξάνεται η ηλικία τόσο μειώνεται η τάση για ποδηλασία. Επίσης η εκπαίδευση είναι ένας παράγοντας ο οποίος επηρεάζει θετικά καθώς όσο υψηλότερο είναι το επίπεδο εκπαίδευσης, τόσο αυξημένη η τάση για ποδηλασία εκτός από τους άνδρες στην Αθήνα για τους οποίους ισχύει το αντίθετο. Το εισόδημα επηρεάζει με αντίθετους τρόπους την Αθήνα και το Δουβλίνο καθώς στο Δουβλίνο υψηλότερο εισόδημα οδηγεί σε υψηλότερη ποδηλατική τάση ενώ στην Αθήνα το υψηλό εισόδημα μειώνει την τάση για ποδηλασία. Επίσης, οι φοιτητές και στις 2 πόλεις έχουν υψηλότερη τάση για ποδηλασία από τους εργαζόμενους. Στην Αθήνα οι γυναίκες έχουν υψηλότερη τάση για ποδηλασία από τους άντρες ενώ στο

Δουβλίνο το φύλο δεν φαίνεται να επηρεάζει. Επιπλέον ως παράγοντες που επηρεάζουν την τάση αρνητικά μπορούν να χαρακτηριστούν η κόπωση, η ταχύτητα μεταφοράς του ποδηλάτου και η οδική ασφάλεια ενώ οι άνθρωποι που επηρεάζονται από κυκλοφοριακή συμφόρηση στις μετακινήσεις τους έχουν υψηλότερη τάση για ποδηλασία. Τα βασικά αποτελέσματα – συμπεράσματα που προέκυψαν από τα μοντέλα για το περπάτημα είναι : σε αντίθεση με την ποδηλασία, δεν φαίνεται ο πληθυσμός σε κάποια από τις 2 πόλεις να έχει υψηλότερη τάση για περπάτημα από την άλλη. Η απόσταση μετακίνησης επηρεάζει την τάση για περπάτημα και στις 2 πόλεις καθώς μεγαλύτερη απόσταση οδηγεί σε μειωμένη τάση για ποδηλασία. Οι υποδομές για τους πεζούς επίσης επηρεάζουν την τάση για περπάτημα καθώς καλύτερες υποδομές οδηγούν σε υψηλότερη τάση για περπάτημα. Τέλος και ο σκοπός μετακίνησης επηρεάζει την τάση για περπάτημα. Στην Αθήνα οι μετακινήσεις που αφορούν την εργασία συγκεντρώνουν την υψηλότερη τάση για περπάτημα ενώ στο Δουβλίνο οι μετακινήσεις με σκοπό τη διασκέδαση συγκεντρώνουν την μεγαλύτερη τάση για περπάτημα. Οι μετακινήσεις με σκοπό τα ψώνια συγκεντρώνουν την χαμηλότερη τάση για περπάτημα και για τις 2 εξεταζόμενες πόλεις. Η ηλικία επηρεάζει την τάση για περπάτημα καθώς οι υψηλότερες ηλικίες συγκεντρώνουν χαμηλότερη τάση για περπάτημα. Το φύλο επηρεάζει την τάση για περπάτημα μόνο στο Δουβλίνο καθώς οι γυναίκες έχουν υψηλότερη τάση για περπάτημα από τους άντρες. Το μορφωτικό επίπεδο και το εισόδημα είναι δύσκολο να αξιολογηθούν καθώς το πρώτο δεν εμφανίζεται στα υπομοντέλα ενώ το 2^{o} έχει αντικρουόμενα αποτελέσματα για τα δύο φύλα στην Αθήνα. Η ταχύτητα μετακίνησης του περπατήματος μειώνει την τάση για περπάτημα, όπως και η κόπωση όμως μόνο για τον γυναικείο πληθυσμό του δείγματος. Οι καλές καιρικές συνθήκες αυξάνουν την τάση για περπάτημα, ιδιαίτερα στην Αθήνα ενώ οι κακές καιρικές συνθήκες μειώνουν την τάση για περπάτημα, ιδιαίτερα στο Δουβλίνο. Επιπλέον, αυξημένοι χρόνοι πρασίνου σε φανάρια πεζών οδηγούν σε υψηλότερη τάση για περπάτημα και στις 2 πόλεις. Όπως και για την τάση για ποδηλασία όσοι επηρεάζονται από κυκλοφοριακή συμφόρηση έχουν υψηλότερη τάση για περπάτημα και στις 2 πόλεις. Η έλλειψη οδικής ασφάλειας και η παρουσία μεγάλων κόμβων στη διαδρομή μειώνει την τάση για περπάτημα στο Δουβλίνο. Τέλος, καλύτερες περιβαλλοντικές συνθήκες και καλύτερη ποιότητα αέρα οδηγεί σε υψηλότερη τάση για περπάτημα για τις γυναίκες τόσο στην Αθήνα όσο και στο Δουβλίνο. Η παρούσα διπλωματική εργασία αποτελεί μια από της ελάχιστες εργασίες στο αντικείμενο με δεδομένα από διαφορετικές χώρες την παρούσα χρονική περίοδο. Θα ήταν ενδιαφέρον για μελλοντική έρευνα να πραγματοποιηθούν εργασίες πάνω σε δεδομένα διαφορετικών χωρών και να συγκριθούν με την παρούσα και μεταξύ τους, έτσι ώστε να κατανοηθεί περαιτέρω η επιρροή συγκεκριμένων παραγόντων στην τάση για ποδηλασία και περπάτημα σε διαφορετικές συνθήκες καταστάσεις και περιβάλλοντα.

Abstract

Mobility as a Service (MaaS) is a recent innovative transport concept, based on which travellers are provided with targeted mobility solutions based on their individual needs and preferences. Thus, acknowledging the needs and preferences of travellers plays a key role in deriving efficient solutions. The objective of this research is to identify the parameters that affect the propensity to cycle and walk in urban areas, as well as travellers' needs and preferences relative to cycling and walking. A stated survey was designed and conducted in two European cities: the city of Dublin and the city of Athens. The city of Dublin boasts a substantial increase in cycling during the past years as a result of the implementation of targeted measures promoting cycling, whereas walking is often overlooked and no real measures are taken towards increasing and facilitating walking in the city. At the same time, in Athens the design of dedicated cycling infrastructure has commenced only recently, and Athenians' attitudes towards cycling are still rather negative, while walking infrastructure lacks the quality and maintenance that most European cities have. Cycling and walking propensity were investigated through the design of a stated preference questionnaire, in which participants were asked to state the propensity to cycle and walk under specific scenarios, with trip purpose, trip distance and infrastructure quality being the parameters defining them. Probit models with random effects were designed and results highlighted both similarities and differences between the two sub-populations. Differences were also found between the needs and preferences of the two populations indicating issues that need to be considered towards the design of effective pro-cycling strategies in Athens. This isolation of specific parameters defining the cycling and walking propensity both regionally and internationally, could prove important to design a future suitable transport system for each city, focused on more sustainable transport modes.

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1. Introduction

Cycling and walking are two environmental friendly, cheap and sustainable transport modes that play a vital role towards the design of dedicated measures for achieving sustainable mobility in major city centers. Thus, a greater understanding of the factors affecting the propensity to cycle and walk in the urban areas is of great importance in the design of future transportation systems.

This thesis is a research performed in two cities: Dublin and Athens and was conducted within the framework of an Erasmus+ exchange program, between the University College Dublin and the National Technical University of Athens. Athens and Dublin exhibit several differences, including climate, topology, population characteristics and attitude towards cycling and walking. The aim is to identify the parameters that affect a persons' propensity to cycle and walk in these two urban areas as well as the travellers' needs and preferences regarding cycling and walking. These factors can be categorized as global factors which commonly affect both examined cities, or as dedicated factors representing different attitudes in the two cities.

The survey was conducted through a stated preference questionnaire, first in Dublin during the spring of 2019 and then in Athens during the summer of 2019, where participants had to state their preference in a series of questions regarding cycling, walking and travel preferences, give some personal information about themselves and state their probability to cycle and walk through a series of hypothetical scenarios These hypothetical scenarios were created through 3 variables, trip purpose, trip distance and dedicated infrastructure. 9 scenarios were included in each questionnaire for cycling and 9 for walking. In this survey a total of 300 participants answered the questionnaires, 150 in each examined city.

In the second chapter, the background knowledge in which this research was based is demonstrated. This includes Greek, Irish and international literature. In particular, first the recent European policies towards sustainable mobility are presented. The goals and later evaluations of the white and green bibles of transport concerning urban mobility and measures towards the promotion of cycling and walking are discussed. Then the factors affecting walking and cycling propensity based on international research are presented, categorized and discussed into greater detail. Last, the relation between cycling, walking and other transport modes, based on the literature review is discussed.

In the third chapter, the specific methodology employed within this research to evaluate parameters affecting cycling and walking propensity is presented. First, preference methods are discussed in order to select the most appropriate method to be used in the questionnaire design. Then the various data collection methods are

demonstrated in order to employ the most suitable one for this thesis. A presentation of the basic sampling methods follows and last discrete choice analysis models and in particular the logit and probit model are presented.

In the fourth chapter, the data collection is presented. In particular, the characteristics of the two cities/countries where this survey took place are presented in detail. More specifically, demographic data and infrastructure characteristics, as well as other unique traits of every city are analyzed. The field survey and questionnaire distribution is analyzed next, the designed questionnaire is presented.

In the fifth chapter, the results of the survey are demonstrated. First the descriptive statistics of the sample in both countries are presented in depth. Then, the designed probit models for cycling and walking propensity considering different population samples are presented and discussed.

In the sixth chapter, the conclusions emerged from the analysis conducted in the previous chapters of this thesis are presented. These conclusions are presented considering the cycling and walking propensity analysis and suggestions for future research are provided.

2. Background Knowledge

In this chapter, the field of existing knowledge, upon which this study is based, is analyzed into greater depth. In particular, European politics and strategies concerning transportation in cities, over the past years, are described in detail. Furthermore, a comparison between cycling and walking and other popular city transport modes is made. Last, factors affecting the decision to cycle or walk, are analyzed, based on Greek, Irish and International literature.

2.1 European Policies

Over the past decades, the European Union has developed and published a series of strategies in order to achieve sustainable mobility in its countries and cities. Many cities in Europe, of different sizes, are implementing measures towards promoting green transport modes. In Western Europe, cycling and walking comprise two of the most popular transport modes, while being supported by high standard dedicated infrastructure. Central European countries have made substantial improvements in their infrastructure, thus allowing more and more people to walk and cycle easily in their cities. In the following paragraphs, these policies are demonstrated.

2.1.1 Instructions from the European Union

In 2001, European Union published the “white paper”, aiming at the creation of new policies in transport by 2010 (White paper, 2001). In this paper, and being in line with the sustainable development strategy adopted by the European Council in Gothenburg in June 2001, the Commission proposes some 60 measures aimed at developing a European transport system capable of shifting the balance between modes of transport, revitalising the railways, promoting transport by sea and inland waterways and controlling the growth in air transport. This system provides full coverage of the city by shifting multiple transports, connecting central areas of neighborhoods, requiring minimum effort of each person. This guideline concludes that the most vital and effective transport modes to achieve this goal are cycling and walking.

In 2006, the mid-term review of the white paper took place. The review indicated that from a slow start, the European Union’s transport policy has developed rapidly over the past 15 years. The objectives of EU transport policy, from the transport White Paper of 1992 via the White Paper of 2001 to today’s Communication, remain

valid: to help provide Europeans with efficient, effective transportation systems (Mid-term review of the White paper, 2006). The implemented measures were evaluated as inadequate due to the continuous and rapid growth of transportation. Specifically for urban transportation it states that "One in three road fatalities occurs in cities. Congestion problems, too, are concentrated in and around cities. How to increase mobility while at the same time reducing congestion, accidents and pollution is the common challenge to all major cities. More than anyone else, city dwellers directly experience the negative effects of their own mobility and may be open to innovative solutions for creating sustainable mobility." The publication of the Green Paper on urban transport, to identify potential European added value to targeted actions at a local level, followed as an intermediate action.

In 2007 as the mid-term review of the White paper suggested, the Green Paper was published. With the Green Paper, the Commission set a new European agenda for urban mobility, while respecting the responsibilities of local, regional and national authorities in this field. The Green Paper addressed, how the quality of collective transport can be improved, how walking and cycling can be promoted and how the rights of passengers on public transport can be protected. Specifically, in order to reduce congestion it states that "alternatives to private car use, such as walking, cycling, collective transport or the use of the motorbike and scooter, should be made attractive and safe. Citizens should be able to optimize their travel through efficient links between the different modes of transport. To improve the attractiveness and safety of walking and cycling, local and regional authorities should ensure that these modes are fully integrated into the development and monitoring of urban mobility policies. More attention should be paid to the development of adequate infrastructure". Initiatives in cities, companies and schools can promote cycling and walking, for example through traffic games, road safety assessments or educational packages. Stakeholders have proposed that bigger towns and cities could consider appointing a policy officer specifically for walking and cycling (Green Paper, 2007).

In 2011, a new White Paper was published, which indicated that Europe had made good progress from 2001 as most of the goals of the previous White Paper had been achieved. The European Commission introduced ten targets to be met in order to reach a more competitive and resource efficient transport system. The following dual goal focused on urban transport and commuting: "To halve the use of 'conventionally-fuelled' cars in urban transport by 2030, to phase them out by 2050 and to achieve essentially CO_2-free city logistics in major urban centres by 2030. The main result is a roadmap that proposes a broad strategy to answer the question "Who has to do what, by when" to achieve the urban transport goal. It also addresses the importance of infrastructure by stating that: "Infrastructure shapes mobility. No major change in transport will be possible without the support of an adequate network and more intelligence in using it. Facilitating walking and cycling

should become an integral part of urban mobility and infrastructure design"(White Paper, 2011). Both the 2007 Green Paper and the 2011 White Paper are still to be evaluated.

2.2 Walking as a transport mode

Walking is the most common form of movement, therefore it is not always treated as a transport mode. The correct term of referring to it as a mode is "Pedestrian". Initially, pedestrian movement was mainly studied for specific groups (most commonly for handicapped and mobility restrained) and rarely as a whole. Information about walking and pedestrians was therefore largely limited to areas where government bodies had been required to take an interest, or where commercial investments relied upon passing pedestrians. Only injury data was collected and made available on a regular basis. As a result, most pedestrian policies focus on reducing reported injuries rather than integrating walking into the treatment of mobility (Wigan, 1995).

Walking is an essential component of almost all trips and determines physical access to different kinds of facilities. More or less all transport modes are connected in a variety of ways to walking and cannot function without it. For example public transport such as trains and buses require walking both for access and for movement within the transport vehicles themselves (Wigan, 1995). When it comes to areas such as traffic flow modelling, trip forecasting and transport appraisal, the pedestrian remains somewhat overlooked. In cases where walking is included, it is often in the form of a fusion with cycling, by the use of categories such as 'non-motorized transport', 'active commuting', 'healthy transport', and 'vulnerable road user'. However, pedestrians and cyclists have too many essential differences to justify such merges (Tight, 2011).

Factors Influencing Walking

Given its nature, the pedestrian is influenced by factors other than those related to the car travelers or public transport users. Unlike motorized modes, pedestrians are more or less exposed to topography, climate, weather, fear of crime and the so-called stranger danger (Cervero and Duncan, 2003).

Obstructions preventing walking analyzed by Schmeidler (2010) can be divided into three general areas: social environment, physical environment, travelling distance and needed time. These factors influence the stance and decision regarding choice of transportation modes for planned journey. James (et al. 2001) report five reasons

considered as impediments: time, infrastructure, comfort, community climate and free choice. Alfonso (2005) noted that “group, regional, and physical environmental variables may all affect walking”. Currently, however, it is not clearly understood which of these factors are most salient, nor is it clear how or whether these factors interact in affecting a person’s level of physical activity. Based on the existing literature, factors affecting the propensity to walk, could be summarized in the following categories: built environment, distance, accessibility, safety and socioeconomical factors. These groups and how they affect walking are analyzed below.

2.2.1 Built Environment

As researches conclude, the built environment may be fundamental in shaping walking and cycling behavior. The impact of urban design has been widely studied and studies prove a strong correlation between the built environment and traveler behavior. This relationship is expressed through the following attributes, better known as the ‘Ds’(Transportation Research Board, 2014) :

- Density : of population or employment
- Diversity: variety of different land uses (mix) and their proportional balance (entropy)
- Design : orientation between development and people, enabling efficient pedestrian access
- Distance to Transit : Nearest stop for particular services, stop density
- Destinations : access to regional opportunities, usually by transit

The main built infrastructure that is used by pedestrians are the sidewalks and so their existence and characteristics affect deeply their walking propensity. A wide and easy walkable sidewalk, has been shown to encourage walking (Booth et al. , 2000). In a survey for the Greater Dublin Area, Carroll et al. (2019) conclude that pedestrian infrastructure is a more important variable than trip duration and than most other factors affecting the propensity to walk. Its importance is highlighted by Carroll et al. (2019), they indicated that small improvements in the pedestrian infrastructure including longer pedestrian green lights, wider pavements and more crossing points were found to not only increase the propensity to walk, but also to increase the willingness to shift mode from cycling and driving to walking.

2.2.2 Distance

Distance and walking propensity are strongly correlated, thus defining a 'walkable distance' is fundamental to the concerns for impediments (Cervero & Kockelman 1997). James et al. (2001) defined a walking trip as anything under 2 kilometers. Notwithstanding, the overall distance is often reported as the principle concern, it is reasonable to suppose people walk much further than 2 kilometers a day and as much as five times this amount considering healthy adults (Tudor-Locke, 2005). A survey conducted in New Zealand indicates that walking trips made for social or recreational purposes are on average greater than 2 kilometers and walking trips made for shopping purposes are on average greater than 2.5 kilometers (O'Fallon & Sullivan, 2005). The magnitude of distance and time spent on walking influences greatly the impact of social and physical obstacles. The person will have to make decisions regarding when and where to go in accordance with the fact if their journey is considered leisure or not (Schmeidler, 2010). If a person decides to make a long trip by walking, then additional parameters such as better pedestrian infrastructure or prettier view, may need to be met opposed to a short trip (Alfonso, 2005).

2.2.3 Accessibility

"Accessibility encompasses the pattern, quantity, quality, variety and proximity of activities present, as well as the connectivity between the uses" (Handy, 1996). Accessibility is not just a simple ratio of retail to residential to office uses, but incorporates several more elements (Handy, 1996). Accessibility factors may include the presence of sidewalks, paths, trails, or features that provide perceived paths on which to walk. Accessibility may also involve actual or perceived barriers to walking, including physical barriers such as an impenetrable land use (a gated community through which one cannot pass), natural features (a ravine), or a psychological barrier to access (such as a particularly wide road). Accessibility may also include the number of destinations available within a reasonable walking distance as well as the integration of various land uses within a specified area. Specifically, for destination walking, the perception of distance to a particular destination may affect the person's level of satisfaction with accessibility; however, distance is not believed to affect the decision-making process for strolling trips as strongly, as strolling trips are not necessarily tied to specific destinations (Alfonso, 2005). Although walking is generally regarded as being convenient and accessible to all segments of the population, variations within greater and broader urban regions in walking for different purposes or through different paths, because of physical differences in the built environment are not well understood.

Factors related to accessibility have been found to affect walking behavior, but further research is required to better understand the complete effect of accessibility on walking.

2.2.4 Safety

Walking can be perceived as a dangerous activity: vehicles' speed, dangers from other people, dangerous bikers, issues considering the vulnerability of specific populations groups and several other external factors shape this perception (Schmeidler, 2010). Alfonso (2005) describes walking safety as one of the most important features in her hierarchy of the decision process considering walking propensity and when the safety criteria are not met, a person would not consider his or her need for comfort when deciding whether to walk. In other words, a very comfortable or pleasurable environment would not necessarily compel a person to walk if his or her safety needs are not met. In the U.S. Department of Transportation (1994) Seattle study, 'fear of crime' is ranked seventh among factors impeding walking. Ross (2000) examined the effect of fear on the likelihood of walking for exercise. People who felt more afraid in their neighborhoods were substantially less probable to walk than those who felt less afraid. This result was consistent across different types of neighborhoods out of the several included in the research. Muraleetharan et al. (2005) expressed the safety concerns of pedestrians in big junctions of large urban areas through a model which included crossing facilities, time and duration of signaling and crossing visibility.

2.2.5 Socioeconomics

Social environment comprises a range of walking obstacles that can have personal character, such as for instance age, gender, physical shape or financial status (Schmeidler, 2010). A person's psychological health, expectations, motivations, and other psychological, cognitive, or emotional-level attributes may all influence the decision process of a person's choice to walk or not (Alfonso, 2005). For example, young people have been found to walk considerably more compared to older people (Berrigan & Troiano, 2002; Frank & Pivo, 1994; Ross, 2000). Both a person's weight and a person's perception of his or her own weight have been found also to be an important barrier to any sort of physical activity (Ball et al., 2000). Ultimately, it may be that those who have mobility restrictions—temporary or permanent—do not really have the option to walk. High personal income is also considered a factor discouraging people from walking or cycling (Plaut, 2005).

2.3 Cycling as a transport mode

Cycling constitutes a modern, alternative transport mode. Modern societies, are adjusting to the growth cycling has demonstrated during the last decades, with the design of targeted infrastructure and implementation of relevant policies, in order to intergrade it in their transportation systems (Valavanis, 2015). Cycling as a mode of transportation has many advantages for both cyclists and the society: it is a low-cost, low-polluting, health-improving way to travel. Recognizing these benefits, an increasing number of cities throughout the world are implementing measures and policies to promote cycling (Handy, 2013).

Cycling, just as walking, is often not treated as a transport mode, but that has changed over the last few years as more and more cities are turning towards sustainable mobility (Valavanis, 2015).

Factors Influencing Cycling

The parameters affecting cycling are separated in several categories including the built and natural environment, transport characteristics, socioeconomics and other relevant factors (Kostantinidou and Spyropoulou, 2016). The propensity to cycle depends on several variables including cyclist characteristics, trip characteristics and available cycling infrastructure (Hensher, 1994; Witlox & Tindermans, 2004).

2.3.1 Built Environment

Just as walking, the 5 “Ds” are also applicable to describe the relation of the built environment and traveler behavior (Transportation Research Board, 2014).

As sidewalks are for pedestrians, cycling usually takes place on special cycleways or cycle lanes. Cycling infrastructure has been found to influence greatly cycling propensity. Especially cycleways and cycle route networks have been found to promote cycling and the wider the network the higher the probability to cycle (Pucher and Buehler, 2008; Pucher et al., 2010). Surface quality and lane width have also been found to affect cycling use (Antonakos, 1994; Sener et al., 2009; Li et al., 2012). Parking space availability, security of parking areas and proximity of parking areas with public transport nodes have been found to increase cycling rates (Noland & Kunreuther, 1995; Hunt & Abraham, 2007). Also considering infrastructure dedicated services such as showers and lockers at specific locations (universities, public transport nodes) also increase cycling use (Abraham et al., 2002).

2.3.2 Distance

Trip distance is another contributory factor, with both short and long trips discouraging bicycle use in different circumstances. As described by Xing (2009) a possible threshold for short distances is a distance that can be travelled on foot within 20 minutes; in this case people prefer to walk than cycle. A limit for cycling was set at 2 kilometers by Keijer and Rietveld (2000). By contrast, long distances are also found to discourage cycling as they require longer exposure to uncomfortable and unsafe travelling conditions (van Wee et al., 2006; Fraser & Lock, 2010).

2.3.3 Safety

Cyclists expose themselves in several risky conditions, especially in urban areas where the probability of traffic conflicts is considerably higher (Rissel, 2011). Safety is perceived by each individual differently, as there is special equipment for cyclists that can reduce the level of danger exposure they are put into. Studies have shown that non cyclists do not fully understand the dangers of cycling and often tend to exaggerate (Stinson & Bhat, 2004). Cycling infrastructure may even cause some safety issues, as cycleways often are not fully continuous, thus exposing the cyclist to the traffic, especially in big junctions where dangerous left turns are required (Krizek & Roland, 2005).

2.3.4 Socioeconomics

Traveler characteristics have been found to affect cycling. In particular, older people have been found to cycle less due to the deteriorating physical condition, as cycling is proven to be a physically demanding task (Shafizadeh & Niemeier, 1997). The majority of studies indicate that cycling declines with age (Pucher et al. 1999; Moudon et al., 2005; Dill & Voros, 2007; Sener et al., 2009), although some studies show that age does not really have a significant effect on cycling (de Geus, 2007; Wardman et al., 2007). The same contrast is also noticed for studies on gender. Several studies indicate that men ride more than women (Banister & Gallant, 1999; Moudon et al., 2005; Dill & Voros, 2007; Garrard et al., 2008), but for specific gender groups (working population) Wardmann et al (2007) and Witlox and Tindermans (2004) have found that women ride more than men. Garrad et al. (2008) concluded that in countries where cycling is popular gender does not affect cycling use, whereas in countries with low cycling percentages men cycle more than women. Other studies have shown that as income increases the propensity to cycle decreases (Plaut, 2005), and that status (Pucher et al., 1999; Moudon et al., 2005), profession (Dieleman, et al., 2002) also affect the willingness to cycle. Low cost is also a factor

that increases the propensity to cycle as fuel costs rise steadily (Pucher & Buheler, 2008). Low cost is also associated with cycling compared to other transport (Pucher & Buheler, 2008).

2.3.5 Environmental Factors

Studies have shown that attitudes towards the environment and other environmental factors such as elevation (Winters, 2010) and weather conditions (Buehler, 2012) affect the propensity to cycle. Winters (2010) has shown that the topology of the trip plays a major role in choosing whether to cycle or not. In particular, he concludes that a long steady existing elevation is disturbing for cyclists, but small lasting changes in incline are not discouraging people from cycling as they can be easily avoided or help making the cycling experience even better.

Buehler (2012) has shown that more people are using their bicycles in summer than in winter due to better weather conditions. On the contrary, other studies have shown that although some countries have worst weather conditions, more people are cycling, because of other factors such as income and differences in the built environment (Pucher & Buehler, 2006).

2.4 Relation between walking – cycling and other transport modes

2.4.1 Walking – Cycling

It is possible for cyclists and pedestrians to co-exist, mostly on pedestrian areas or even wide sidewalks. Cyclists can move freely between pedestrians but, special bike lanes (ideally segregated) are suggested, as the moving speed of a bicycle is dangerous for pedestrians, especially for those with certain disabilities (Vlastos, 2004). The co-existence of bicycles and pedestrians, also forces cyclists to drive at a slower and safer speed as there is a possibility of a pedestrian entering a cycle lane at any moment. At the same time, the bike lane protects the pedestrians from drivers, as it separates the road from the sidewalk (Valavanis, 2015). Both pedestrians and cyclists highly depend on the existing infrastructure, but pedestrians tend to be more sensitive to any infrastructure changes (Carroll et al. ,2019).

2.4.2 Relationship with driving

Walking and cycling are considered to be the least intrusive transport modes as they don t consist a threat to other road users. At the same time, pedestrians and cyclists are extremely vulnerable compared to car or motorcycle drivers. Pedestrians share the same surface when walking across a road through a crossing point and so they are exposed to drivers. Besides that, careful pedestrians and drivers do not share any other similarities. On the other hand, cyclists share the road with drivers, but in many different ways. There are 3 ways in which cyclists can share the road with other vehicles, depending on the infrastructure as described by Vlastos (2003). The first one is in a road without bike lanes, where cyclists can use buslanes where available, but especially in Greece, the extensive use of motorcycles that also drive in buslanes, makes this situation extremely dangerous for cyclists. The second one is a road with bike lanes, delimited with road markings from the rest of the road. This is not the safest situation, but to make it as safe as possible, these bike lanes have the same direction as the road. At the same time, such cycle lane types, allowing opposing cycle movements have also been designed. The aim of such design is to force drivers to drive more carefully. Last, cycle paths with dedicated lanes for cycle movement away from road infrastructure are also designed.

2.4.3 Relationship with Public Transport

In Europe public transport is closely connected to cycling and walking. In order to achieve sustainable mobility within a city, it is of great importance to link public transport nodes with cycling and walking, as through these modes, transportation in every part of the city can be made. This is why on most underground or train stations in Europe, parking for bicycles can be found, as well as dedicated cycling facilities including lockers, showers and so on. Furthermore, cyclists are allowed to take their bicycles with them inside the wagons, with most trains having now special room for bicycles, thus encouraging and making cycling more comfortable (Vlastos, 2003 ; Valavanis, 2015).

3. Method

This chapter focuses on the specific methodology employed within this research to evaluate the parameters affecting the propensity to walk or cycle in Dublin and Athens. In particular, characteristics considering the different preference methods, questionnaire design, data collecting methods and discrete choice modelling are discussed.

3.1 Preference methods

The two main methods used in questionnaires considering stating traveler preferences are revealed preferences and stated preferences. Between the two methods there is an important difference, revealed preference questionnaires are focusing on traveler's response in real situations, whereas stated preference questionnaires, provide travelers with a wider variety of choice through hypothetical scenarios. In order to select the appropriate method, both advantages and disadvantages are considered towards an attempt to identify the most suitable method considering the goals of this thesis.

3.1.1 Revealed preference method

Revealed preference methods use existing market data to derive implicit values for a good, for example travel costs. The upside of revealed preference is that real choices are examined, thus the results tend to be more accurate. The use of real values also make the design of the questionnaire easier. The downside is that valuation is indirect and must be inferred from empirical patterns. Revealed preference methods are indirect and require many simplifying assumptions to translate traveler behavior into valuations. This way data collection is harder as the sample needs to be specified in people with similar experiences in order to be able to answer fully the questions asked. Secondary parameters are almost impossible to be measured, as their estimation involves high measurement errors. Some characteristics may also show strong correlations, making it extremely hard to define the model's parameters. Probably the strongest disadvantage which makes this method improper for this research is that it cannot create a model with hypothetical characteristics which do not respond to the real environment.

3.1.2 Stated preference method

In contrast this method asks the individual, using comparative choice trials, directly or indirectly, to state his or hers value for the good or service. It analyses traveler behavior through a series of different hypothetical scenarios. This way the researcher can present to its sample a variety of choices in order to define the factors affecting this choice. This method adds on to the previous one, as it provides the option to overcome the limitations that revealed preferences set. That is why stated preference methods have become extremely popular when studying traveler behavior. It is a method easy to control as the researcher defines the conditions which are being evaluated by the respondents, it is more flexible being able to deal with a wider range of variable and variable values (like journey time and travel costs) and it is cheaper to apply as each respondent provides multiple observations for variations in the explanatory variables which interest the analyst. It also needs a smaller sample than revealed preference to produce accurate results. The main concern against this method is that respondents may not necessarily state their actual behaviour, thus making the results less accurate. They may also provide misleading or poorly thought out answers, believing it to be hypothetical. The design of the questions needs to be very careful as the way every question is stated may affect or influence the final answer. Some other factors may also influence the answers, for example the psychological state of the respondents.

3.1.3 Combining the two methods

As analyzed previously, the greatest advantage of the revealed preference method is the credibility of the collected data, as answers are based on real life behavior. That is why in transport studies most demand models are based on surveys, using this method for data collection. The biggest problem with this method is that it cannot be used for hypothetical scenarios, but only for existing ones. In that way, the collection sample is poor, minimizing the variety in the systems characteristics, thus the analyst is unable to separate any specific part of the sample. This can be easily witnessed in figure 3.1.

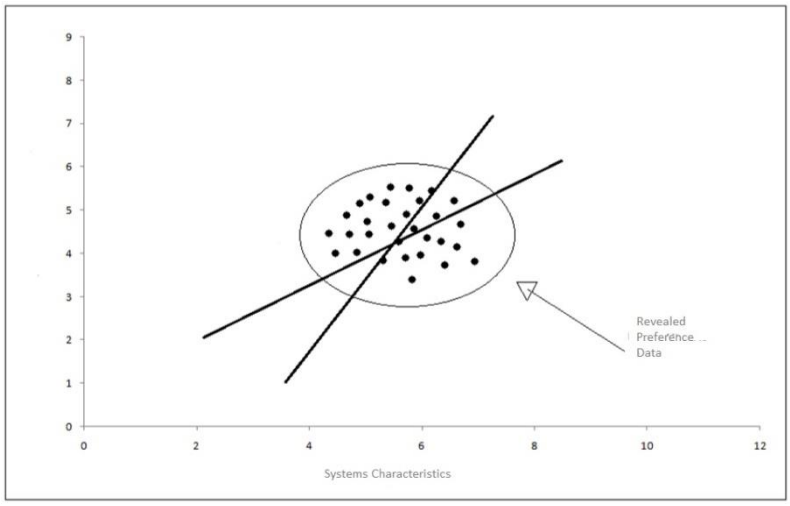


Figure 3.1: Choice probability - System Characteristics for Revealed Preference Research

On the contrary, stated preference methods provide less credible data as they are based on hypothetical scenarios, but giving the analyst the chance to create a controlled environment, using a wider range of variables and variable values. This way the demanded variability is secured in order to evaluate the parameters of the model.

All things considered, the ideal method would be a combination of the two methods to achieve the credibility of revealed preference methods data and the variability of the stated preference methods. This result is shown in figure 3.2.

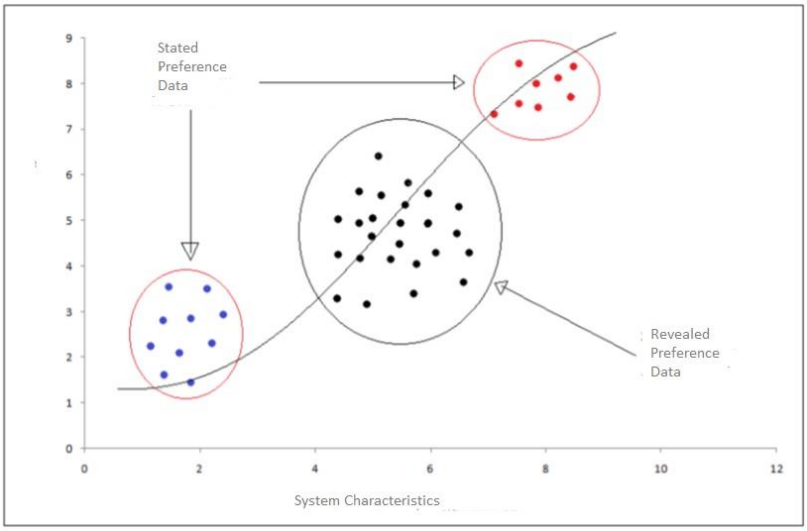


Figure 3.2: Choice Probability – System Characteristics for Stated Preference and Revealed Preference Data

3.2 Data Collection Methods

Employing the most suitable data collection method is a prerequisite for a successful questionnaire survey. Several times more than one method can be used, but selecting only one makes the sample more solid, as data collected with different methods is not comparable and adds an additional parameter to the survey. The most common data collection methods' advantages and disadvantages are presented in this section.

3.2.1 Face to Face Interview

Face to face interviews are really popular when an issue is to be investigated in an in-depth manner. The interview usually takes place in the house of the interviewed person or in a place related to the survey topic, while the questions are being asked and the answers are written down by the surveyor.

Advantages:

- They are useful to obtain detailed information about personal feelings, perceptions and opinions
- They allow more detailed questions to be asked
- They usually achieve a high response rate
- Respondent's own words are recorded
- Ambiguities can be clarified and incomplete answers followed up
- Precise wording can be tailored to respondent and precise meaning of questions can be clarified
- Interviewees are not influenced by others in the group
- Some interviewees may be less self-conscious in a one-to-one situation.

Disadvantages:

- They can be very time-consuming: setting up, interviewing, transcribing, analyzing, feedback, reporting
- They can be costly
- Different interviewers may understand and transcribe interviews in different ways
- Interviewees may not respond to personal questions

3.2.2 Telephone Interviews

Similar to face to face interviews, telephone interviews are appropriate when targeting detailed perceptions, opinions and attitudes. It is very important to have a good interviewer who can adapt to the conversation as the discussion may not flow exactly in sync with the discussion guide or questionnaire and the interviewee can easily hang up at any time given. Telephone interviewing is an in-between data collection method serving as the median between face to face interviews and surveys/panels. As a means of collecting primary, qualitative data, telephone interviews are becoming the preferred method as they deliver high quality response rate with less time and cost commitments compared to face to face interviews.

Advantages:

- Are more cost effective and easier to conduct than face to face interviews
- Can deliver similar quality data with face to face interviews
- Answers to questions are equally as valid as in face to face interviews
- Interviews can be conducted over a wider geographic scope, even globally
- Multiple points of view can be gathered through multiple interviews
- Answers are recorded and easily manageable
- Interviewees answer more easily to personal questions

Disadvantages:

- Respondents have to actually answer the call and can hang up at any time
- Behavior and body language cannot be observed
- Interviews tend to be shorter than face to face interviews
- Visual aids cannot be employed to assist in the interviewing

3.2.3 Mailed Questionnaires

Questionnaires can be mailed out to a sample of the population, enabling the researcher to connect with a wide range of people. The questionnaire is typically sent in a packet that contains a cover sheet, introducing the research being conducted, and a pre-paid return envelope for the responses. While the response rate is typically lower than other forms of questionnaires, this can be improved with reminders and incentives.

Advantages:

- Sample is not limited to access to technology such as phones or Internet
- Participants are able to think about their responses
- No interviewer being present helps control the interviewer effect on participants responses
- People tend to answer personal questions
- Cost is lower than telephone questionnaires

Disadvantages:

- Can have a low response rate if people view the questionnaire as junk mail
- Questions cannot be probed or explained
- Participants may return incomplete surveys
- Possibility of a self-selection bias
- Slow process

3.2.4 Online Questionnaire

Online surveys are easy to set up, especially with the software that is available for this purpose. Many researchers are tempted to do much of their data collection online. These surveys are either posted online so anyone can answer them, or emailed to specific individuals by the surveyor.

Advantages:

- They are the cheapest method
- They are accessible to most target audiences.
- They have no geographical restrictions
- Data is downloaded and managed instantly
- People tend to answer honestly
- Participants are able to think about their responses
- No interviewer being present helps to control the interviewer effect on participants responses
- High response quality
- Instant feedback

Disadvantages:

- Inaccurate demographic data
- Do not use a random sample
- Coverage error
- Questions cannot be probed or explained

For this survey, the method of face to face interview was used for the advantages mentioned previously. The most important reason though is that questions could be clarified and further explanations could be given to the interviewees, due to the length and complexity of the questionnaire.

3.3 Sampling Methods

Another very important step in questionnaire surveys is selecting the appropriate sampling method to yield the appropriate sample participating in the survey. The sample used in a survey must be representative of the examined population.

There are two types of sampling: sampling with or without probability. In most surveys, sampling with probability is preferred, as the probability of choosing each unit of the sample is predefined, thus making it possible to generalize the results on the examined population, including the generalization error. Sampling without probability is chosen only when the results cannot be generalized or sampling with probability is impossible.

The most common probability sampling strategies are presented with their advantages and disadvantages:

Simple Random Sampling: No easier method exists to extract a research sample from a larger population than simple random sampling. Selecting subjects completely at random from the larger population also yields a sample that is representative of the group being studied. It is used when population members are similar to one another on important variables. It ensures a high degree of representativeness when a big sample is collected but it is time consuming and tedious.

Systematic Sampling: It follows the same principle like in simple random sampling, but the sample is classified based on an important characteristic and then a sample is chosen after every n number of samples, where n is specified by the analyst. It ensures a high degree of representativeness when a big sample is collected and it is less random than simple random sampling.

Stratified Random Sampling: The examined population is divided into various identifiable subgroups, where random samples are chosen from each group and the samples taken from each subgroup are based on the percentage of the total population it consists. It is used when the population is heterogeneous and contains several different groups, some of which are related to the topic of the study. It ensures a high degree of representativeness and gives information both about the whole population and each subgroup, but it is time consuming and tedious.

Cluster Sampling: Random samples of successive clusters of subjects are chosen as units. It is used when the population consists of units rather than individuals and it ensures a high degree of representativeness within of all the strata or layers in the population. The problem is that often members of units are different from each other, thus decreasing the techniques effectiveness.

3.4 Discrete Choice Analysis

In order to yield accurate results when performing analysis on questionnaire data, it is vital to perform the appropriate analysis. Choice modelling analysis attempts to model the decision process of an individual or segment via revealed preferences or stated preferences made in a particular context or contexts. In this paragraph the theory of the data analysis employed in this research, is presented.

3.4.1 Discrete Choice Models

Discrete choice models, or qualitative choice models, describe, explain, and predict choices between two or more discrete alternatives. Such choices contrast with standard consumption models in which the quantity of each good consumed is assumed to be a continuous variable. These statistical models specify the probability distribution of discrete dependent variables as a function of

independent variables and unknown parameters. The discrete choice models have been very successful due to their ability to analyze the random behavior of individuals, when making a decision to choose a given solution or to appreciate the valuation of goods or services. Discrete choice models were applied for the first time to estimate transport demand. They were subsequently generalized and applied to deal with all the problems of choice concerning mutually exclusive alternatives or also to assess the subjective value of an event. Discrete choice models specify the probability of an individual choosing an option among a set of alternatives. The probabilistic description of discrete choice behavior is used not to reflect individual behavior that is viewed as intrinsically probabilistic. Rather, it is the lack of information that leads us to describe choice in a probabilistic fashion. In practice, we cannot know all factors affecting individual choice decisions as their determinants are partially observed or imperfectly measured. Therefore, discrete choice models rely on stochastic assumptions and specifications to account for unobserved factors related to choice alternatives, taste variation over people (interpersonal heterogeneity) and over time (intra-individual choice dynamics) and heterogeneous choice sets. In discrete choice models, a choice set must contain a finite number of alternatives. These choices have to be mutually exclusive. They also have to be collectively exhaustive. That means the individual making the choice must choose one alternative. If he/she picks nothing, it must be represented as a possible alternative in the choice set.

3.4.2 Logit Model

The Logit Model, better known as logistic regression is a binomial regression model. Logistic regression is used to associate with a vector of random variables to a binomial random variable. Logistic regression is a special case of a generalized linear model.

Logistic regression is the most common statistical procedure for computing propensity scores. In this procedure, all of the selected covariates are concurrently included in a logistic regression model to predict the assignment condition, and the propensity scores are the resulting predicted probabilities for each unit. Classification or regression trees are used to predict assignment through a sequence of hierarchical, binary splits. Each split is determined by the probability that a participant will select into each condition based on a single covariate. The splitting process continues for each subsequent covariate until a specified number of nodes is obtained or until all covariates are included in the model. The resulting binary tree has terminal nodes representing groups of participants who have the same predicted probability for being in the treatment condition (propensity score),

even though each node may have estimated the same propensity score from different predictors (Westreich et al., 2010).

3.4.3 Probit Model

Probit model, also called probit regression, is used to model dichotomous or binary outcome variables. In the probit model, the inverse standard normal distribution of the probability is modelled as a linear combination of the predictors. These models simply use the cumulative gaussian normal distribution rather than the logistic function for calculating the probability of being in one category.

For example, in the model of this thesis where 5 choices are given on the Likert scale (Definitely Not, Probably Not, Probably, Probably Yes, Definitely Yes) there are four threshold-critical values, that separate the five choices. If Y is the response factor with k levels then the model is written as:

$P(Y<=K|) = \Phi(\theta j - \beta'\chi)$

Where

Φ is the cumulative normal function ;
$\theta o = -00<\theta 1<\ldots<\theta\kappa<00$ are the breakpoints′;

X is the vector of the explanatory factor;

β is the vector of unknown parameters;

For this thesis, probit is selected over logit as it is more general and because random effects have been selected, as it can capture the correlation between the responses of the same individual

4. Data Collection

In this chapter, the characteristics of the two cities/countries where the survey took place are presented in detail. In particular, demographic data and infrastructure, as well as other unique traits of every city are analyzed. The field survey and questionnaire distribution is analyzed next and closing this chapter, the questionnaire given to the participants is presented.

4.1 The two Cities

The two cities where the survey took place are: the capital of Greece, Athens and the capital of the Republic of Ireland, Dublin. More information about these two cities is provided in this section, with information about demographics, physical environment, infrastructure and other relevant data for a transport survey.

4.1.1 Athens – Greece

Athens, one of the world's most ancient cities and the historic capital of Greece is located in the Attika region, right in the center of the modern Greek republic. Athens is a city with more than two millenniums of history, building its fame back to the classical era and throughout this huge amount of time has gone through many wars, different occupants and days of glory. Modern Athens is still a major touristic hotspot, hosting millions of tourists every year, who come to visit the ancient monuments, as most of them are very well preserved to this day. Athens also hosted the 2004 Olympic Games, where a significant number of new roads and infrastructure were built, in order to serve the increased number of visitors. Athens is considered to be a global city and one of the biggest economic centers in southeastern Europe. Its airport "Eleftherios Venizelos", which was built for the Olympic Games, is ranked amongst the top European airports and the port of Piraeus is both the largest passenger port in Europe and the second largest in the world. Athens is also known for its nightlife, which lasts until early in the morning every day, resulting in traffic on the city's main roads, even during the late hours.

When we refer to Athens as an urban area, we take into consideration the greater Athens and greater Piraeus area. This entity of municipalities has a population of 3.827.624 people, according to the last census survey in 2011, but as indicators say, this number in 2019 is probably over 4 million people. This means that almost 40% of the country's population lives in Athens. According to Eurostat in 2011, the

functional urban area of Athens was the 9th most populated in the European Union and Athens was the 6th most populated capital city of the European Union. The total area of the city's basin covers 412 square kilometers.

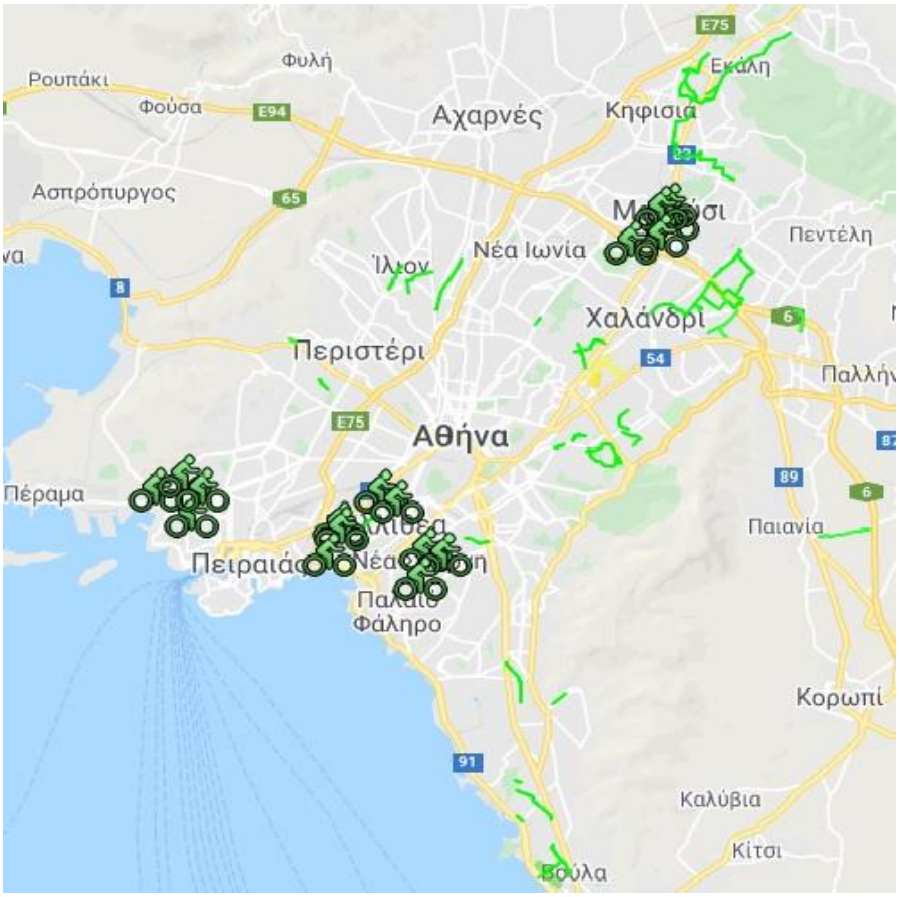
Athens is a city which geographically has some major elevation points. It is surrounded by the mountains of Immitos on the East, Penteli on the north, Parnitha on the North-West and Egaleo on the West and has many hills inside the city, like the famous Akropolis hill, Lykabettous and many others. This is why many of its municipalities (like Zografou) are developed on a mountainous terrain. The southern part of the city is coastal, surrounded by the Argosaronicos sea.

Athens has a hot summer Mediterranean climate and is listed as the warmest capital city of Europe. It is estimated that Athens enjoys 300 days of sunshine per year, the highest number in Europe. During the summer period, the average temperature is about 34 degrees Celsius.

The urban area of Athens consists of 53 municipalities, out of which only 23 have cycle routes. The total length of these cycleways is 55 kilometers and there are plans to expand the network in the next years. The expectation for the next years, is to expand the existing network, by creating a new continuous cycle network that would cover the whole urban area of Athens, from Kifissia on the north, to the Faliric bay on the south, with a total length of 27 kilometers. In the city there are also some new public bike rental stations with around 1000 bikes available. Nine of these stations are located in the southern suburbs and 5 in the northern. The biggest cycling network of any municipality can be found in the northern suburbs in Kifissia with a network of 13.2 kilometers. The center of Athens does not have any cycling infrastructure. Apparently though, a total length of 55 kilometers in an area of 412 square kilometers is extremely small.

In the past few years, the use of rental electric scooters in the city center has substantially increased. E-scooters are used by both tourists and Athenians and might be an alternative solution for green sustainable mobility in the center of Athens in the next years. Still substantial research is required to evaluate their impact.

The urban area of Athens is presented in the following picture, where the existing cycle routes are illustrated in green color and the existing cycle rental stations with the bicycle symbol.



Picture 4.1: Cycle routes and cycle rental Stations in the city of Athens

There are two main problems which are holding back the city's cycling infrastructure. The first one is that due to road safety issues every cycle route in Athens has to have segregated cycle lanes. Greek drivers usually do not pay attention to cyclists. In addition, non-segregated cycle lanes with the traffic lanes would be used by passenger cars and motorcycles (pic 4.2). The second problem is that there is lack of maintenance in the already existing network and cycle stations, which makes cycling in such conditions difficult.

The next pictures show a non-segregated cycle route in Peristeri and a segregated one next to the coast of Voula.

Picture 4.2: Non segregated cycle lane in Athens

Picture 4.3: Segregated cycle route next to the beach

Athens has an extensive network of buses and trolley buses, 3 lines of metro subway and 3 tram lines. Although the public transport is used by the Athenians, Athens is one of the cities in Europe which suffers most from traffic congestion. The proportion of passenger car and motorcycles (which are very popular in Greece) is rather high and thus the metropolitan center is often congested. There is also a substantial problem with parking in the center of the city as there are not enough parking spaces to serve the demand. Furthermore, implemented measures towards reducing the use of private cars have not yield the anticipated results.

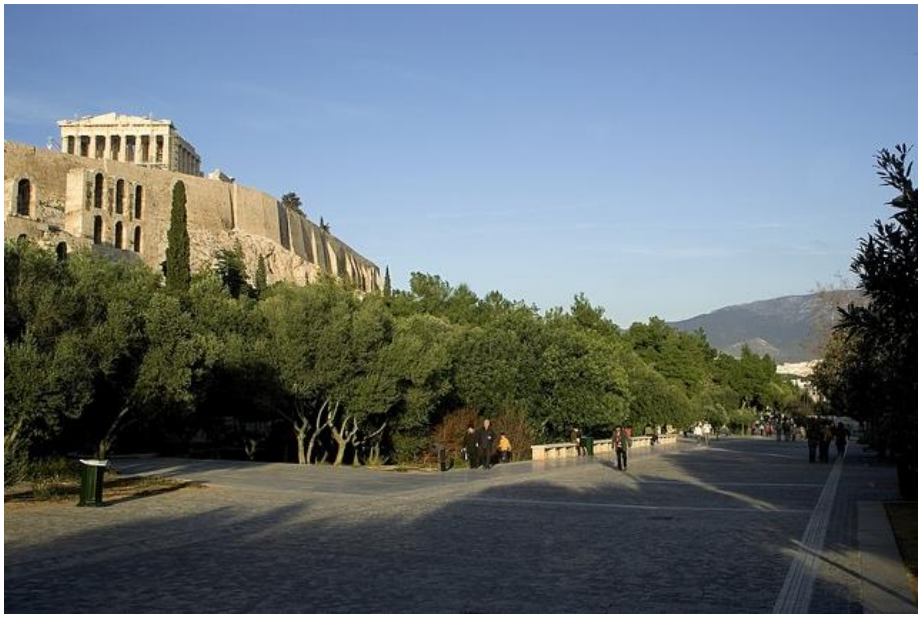
Walking in Athens is often combined with the use of some form of public transport. Athens as a city does not have many pedestrian areas and those can be found only where shopping districts or tourist attractions exist. Sidewalks exist almost in every road but lack space and quality. Although the weather conditions for walking are almost ideal, many people avoid walking, due to the lack of proper infrastructure

and the lack of respect from drivers. In the city center pavements are often too small, where only one person could fit, often used by cars that park on the sidewalk. Most pedestrians have to complete a considerable proportion of their trip entering the road constantly, as there is no space to walk on the sidewalks. Besides the lack of space, there is also lack of quality as it is a common view for Athenians to see destroyed pavements by roots of planted trees and other factors. In the following pictures some examples of sidewalks and pedestrian areas are demonstrated.

Picture 4.4: Sidewalk in the centre of Athens

Picture 4.5: Poor quality sidewalk in the centre of Athens

Picture: 4.6 Sidewalk occupied by parked cars in the suburbs



Picture 4.7: The Pedestrian Area of Acropolis in the city center

4.1.2 Dublin - Ireland

Dublin is the largest city and the capital of the Republic of Ireland. It is located at the center of the east coast of Ireland, on the Irish sea, in the province of Leinster. Not quite as old as Athens, but still quite old, Dublin was established in the 7th century by the Gaels and later inhabited and enlarged by the Vikings and the Normans. During later times, Dublin was the second biggest city of the British Empire and an

extremely important sea port, before becoming the capital of the first free Irish state in 1922. Over the last decade, Dublin has attracted a great number of corporations and several multinational companies have chosen Dublin to locate their central European offices. The Dublin region is the economic center of Ireland, and was at the forefront of the country's economic expansion during the Celtic Tiger period. In 2009, Dublin was listed as the 4th richest city in the world considering purchasing power and 10th richest considering personal income.

The greater Dublin area, which is investigated at present, had a population of 1.904.806 people according to the 2016 census, which similarly to Athens, constitutes almost 40% of the country's total population.

Geographically, Dublin is a city with no elevation as is situated at the mouth of the river Liffey and encompasses a land area of approximately 115 square kilometers (44 square miles) in east-central Ireland. It is bordered by the Dublin Mountains, a low mountain range and sub range of the Wicklow mountains, to the south and surrounded by flat farmland to the north and west. The river Liffey divides the city in two: the Northside and the Southside of Dublin. Two canals, the Grand Canal on the southside and the Royal Canal on the northside, ring the inner city on their way from the west and the river Shannon.

Dublin is a city with several parks and green. In particular, Phoenix Park located at the northwest of the city, is one of the largest city parks in Europe. Many tourists, not as many as Athens, visit the city of Dublin, especially on the St. Patrick's Day (on 17th of March) where all hotels are fully booked. Dublin, has also a busy nightlife, with lots of pubs escpecially in the city center, serving people until late at night.

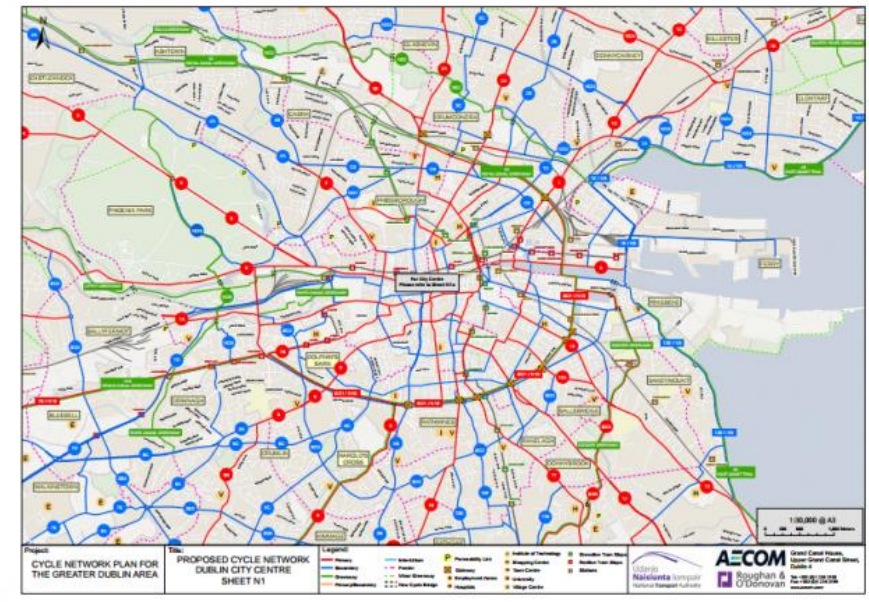
Similar to much of the rest of northwestern Europe, Dublin experiences a maritime climate with cool summers, mild winters, and a lack of temperature extremes. Temperature varies from low average in January to high average in July in between 8.8-20.2 degrees Celsius. Dublin ranks amongst the rainiest cities in Europe and rainfall is distributed evenly throughout the year. Dublin is also affected by massive Atlantic winds, especially in Autumn.

The 2016 TomTom Traffic Index ranked Dublin as the 15th most congested city in the world and the 7th most congested in Europe. That is why many people use public transport in the city, as well as in the suburbs. The public transport network of Dublin consists of nearly 200 bus routes, the rail of D.A.R.T (Dublin Area Rapid Transport) and two tram lines known as the Luas green and the red line.

In 2011 the census indicated that 5.9 percent of travelers in Dublin used their bicycle as their primary transport mode. A report in 2013 published by the Dublin City Council, noted that traffic made by cyclists was increased by 87.2% from the 2006 levels and by 14.1% within a year from 2012, constituting almost 10% of all traffic in

the city. This is attributed to dedicated measures and policies that were implemented including the provision of cycle lanes, public awareness campaigns to promote cycling, rental bike facilities installed throughout the city and the introduction of a 30 km/h speed limit in the city center. It all started in the 1990s when the Dublin City Council initiated the construction of cycle lanes and tracks throughout the city. In 2012 Dublin city had over 200 kilometers (120 miles) of different types of road tracks made for cyclists, thus covering the whole city. Currently in 2019 the city has around 500 kilometers of cycle routes. Most of these involve non-segregated cycle lanes, with many people addressing the issue of road safety. There are very few areas in Dublin where there is no cycling infrastructure today. In 2011, Dublin was ranked as the 9th amongst major world cities on the Copenhagenize Index of Bicycle-Friendly Cities. By contrast, the same index ranked Dublin as the 15th in 2015 and outside the top 20 cities in 2017. In 2017 the Dublin City Council introduced 30 km/h speed limits throughout the city center to promote cycling and walking. Dublinbikes, the rental scheme introduced by the City Council has 44 stationed terminal throughout the city center. By 2018, Dublinbikes had over 66.000 subscribers resulting in an estimated use of 2 million journeys per year.

There is an ongoing plan to expand the current network from 500 kilometers to 1.480 kilometers in Dublin by 2024. Another plan is to install 1.000 electric bikes in the city center. The introduction of parking lanes between cycle lanes and traffic lanes is also evaluated, in order to protect the vulnerable cyclists. The last few years Dublin turns again towards cycling, as the City Council wants to exceed the barrier of 10% of cycling in the modal split. The following map shows the current and future cycling network of Dublin.



Picture 4.8: Current and Future cycling network of Dublin City

Picture 4.9: Non-segregated bike lane in Dublin City Center

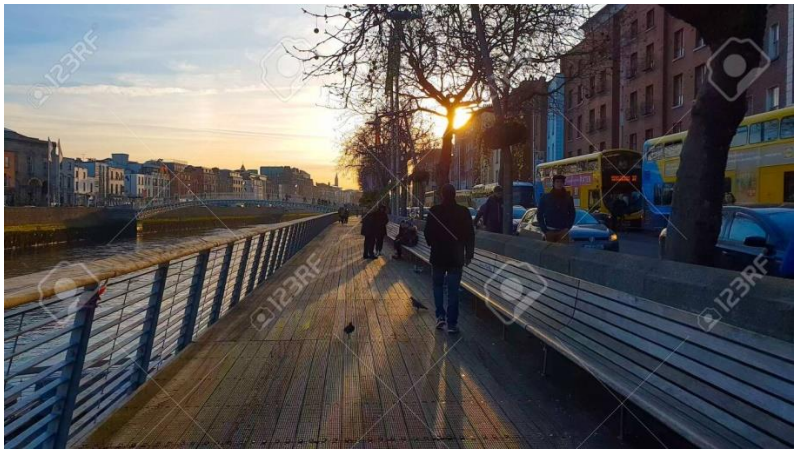
Picture 4.10: Semi-segregated bike lane in Dublin City Centre

Studies from Trinity College Dublin suggest that improving the city's walking infrastructure should be prioritized. Although walking infrastructure in Dublin is considered decent, with few pedestrianized areas in the city center, there are many improvements that could be made. It is estimated that the proportions of travellers selecting walking and the bus as their main transport mode for everyday trips in Dublin are almost equal. Sidewalks in the suburbs are somewhat wider than in the center, where the few pedestrianized areas of the city are located.

Brian Caulfield et al. (2019) examined how widening and decluttering footpaths, using low speed traffic zones and providing more 'green time' for pedestrians at traffic lights could encourage more people to walk or cycle for commuting purposes.

The researchers surveyed the preferences of commuters from the Greater Dublin Area, and used these in a large transport model to simulate the probable modal commuting changes.

Picture 4.11: Sidewalk in Dublin centre



Picture 4.12: Walking infrastructure on the river Liffey

4.2 Questionnaire Design

In this section, the distributed questionnaire is presented and analyzed. In particular, the process and aim of the different questions is discussed. The questionnaire consists of four distinct parts. The first part of the questionnaire is about general transport preferences. In the second part the survey participant has to state his/her probability to walk and cycle under specific hypothetical scenarios. The third part involves cycling and walking preferences where the participant has to state the factors that encourage/discourage him/her from cycling/walking. The fourth and final part of the questionnaire involves socioeconomic information.

In the first page, a small introduction is provided and the anonymity of the questionnaire is stated, in order to encourage the participants to answer the more private questions.

In this thesis, the questionnaire used in Dublin is presented as the questionnaire used in Athens is in Greek. The two questionnaires are exactly the same.

The first page of the questionnaire is presented in the next page.

SURVEY : FACTORS THAT AFFECT THE PROPENSITY TO WALK AND CYCLE – THE CASE OF DUBLIN AND ATHENS

National Technical University of Athens – University College Dublin

Konstantinos Tsepenta , Student of School of Rural and Surveying Engineering , NTUA

Ioanna Spyropoulou , Assistant Professor , School of Rural and Surveying Engineering , NTUA

Aoife Ahern , Head of School – Associate Professor , School of Civil Engineering , UCD

This questionnaire study is taking place within the framework of a graduate Thesis, with the collaboration of National Technical University of Athens and University College Dublin. The aim of the survey is to identify traveller behaviour and attitudes considering walking and cycling **.**

The questionnaire is anonymous and is filled-in on a voluntary basis. The participants may opt out of the survey at any time. The collected data will be used only for this study and its use, storage and processing complies with the General Data Protection Regulation (EU) 2016/679 ("GDPR").

4.2.1 Part I – Transport Preferences

In the first part of the questionnaire the participant is asked to answer questions considering his/her transport preferences. These questions consider the background knowledge of factors that affect the propensity to cycle and walk.

The first question is about the participant's main transport mode and the second question explores whether different modes are used for different trip purposes. The third question involves the frequency under which each transport mode is used per week. In the fourth question, the average travel time of different trip purposes is asked, as trip duration is anticipated to affect mode choice.

The fifth question involves parking space availability as the lack of parking space may affect negatively the propensity of travelling by car.

In the sixth and final question of this part, the participant is asked to state his/her opinion about car and public transport expenses, which may discourage or encourage him/her from using these modes of transport.

The first part of the questionnaire is presented below.

Part 1 : Transport preferences

1. Which of the following do you consider as your main transport mode ?

Car ☐

Public transport ☐

Bicycle ☐

Pedestrian ☐

Motorcycle ☐

Taxi ☐

Other ……..

2. Which of the following would you use for each purpose?

	Car	Public Transport	Bicycle	Pedestrian	Motorcycle	Taxi	Other
Work	☐	☐	☐	☐	☐	☐	☐
Social [Evening]	☐	☐	☐	☐	☐	☐	☐
Shopping [weekly]	☐	☐	☐	☐	☐	☐	☐

3. How many times per week do you travel by each mode ?

Car	Public Transport	Bicycle	Pedestrian	Motorcycle	Taxi	Other

4. How many minutes does a typical trip take (one-way) , for each purpose?

Work	
Social [Evening]	
Shopping [Weekly]	

5. For your typical trips (for each purpose) do you ? (answer only if you use car)

	Home	Work	Shopping	Recreation
Have your own parking spot	☐	☐	☐	☐
Pay for a parking spot	☐	☐	☐	☐
Park in a free parking spot	☐	☐	☐	☐
Have trouble finding a parking spot	☐	☐	☐	☐
No parking available	☐	☐	☐	☐

6. To what extent you agree or disagree with the following statements ?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I can not afford a private vehicle	☐	☐	☐	☐	☐

I can not afford public transport	☐	☐	☐	☐	☐
I find private vehicle costs too expensive	☐	☐	☐	☐	☐
I find public transport costs too expensive	☐	☐	☐	☐	☐
Congestion causes delays to my travel	☐	☐	☐	☐	☐
I find public transport unreliable	☐	☐	☐	☐	☐

4.2.2 Part II – Hypothetical Scenarios

In the second part of the questionnaire, the participant is asked to rate the probability of choosing walking and cycling under specific hypothetical scenarios forming the stated preference choices.

Each scenario is described by 3 parameters: the cycling/walking infrastructure, the trip purpose and the trip distance. Initially, specific characteristics of the trip scenario are presented. These remain constant in all scenarios. Each of the investigated parameters has 3 levels. This means that these 3 variables with 3 levels each, result in a total of 27 different scenarios. The levels are the following.

Travel purpose: work, social (evening), shopping (weekly)

Distance: short, medium, long

Infrastructure: non-existent/bad, decent/good, perfect

As long or medium distance is different for cycling and walking, different distances were presented for cycling and walking, based on background knowledge.

Distance for cycling

Short : <2 kilometers , Medium: 2-8 kilometers, Long: >8 kilometers

Distance for walking

Short: <2 kilometers, Medium: 2-4 kilometers, Long: >4 kilometers

In the same way, infrastructure variable levels are presented below.

Infrastructure for cycling

Non-existent/bad: No cycling infrastructure, decent/good: Some bike lanes exist but not continuous, perfect: Segregated bike lanes everywhere, fully continuous network

Infrastructure for walking

Non-existent/bad: Small narrow pavements, few crossing points

Decent/good: Wide pavements, many crossing points

Perfect : 100% pedestrian area

In the non-existent variable level, walking infrastructure could not be absolutely non-existent, as the pedestrian cannot share the road like the cyclist can. In the perfect variable level, it is assumed that the participant pedestrian/cyclist walks or cycles at fully dedicated infrastructure.

As mentioned before, the combination of 3x3 leveled variables, results in a total of 27 different scenarios. Apparently, with 27 scenarios for each investigated transport mode (walking and cycling), it is not realistic to design a questionnaire, thus the 27 scenarios were divided into 3 blocks of 9 scenarios per block. This means that in every questionnaire 18 scenarios had to be answered, 9 for cycling and 9 for walking. These 3 blocks have been designed based on the criteria of orthogonality, which ensures that the characteristics presented are statistically independent from each other (Hensher, 1994). In addition, the scenarios were presented in different order in different questionnaires, to avoid order affects, thus these 3 blocks were divided into 2 sub-blocks, where the scenarios are presented in different order.

In the tables below, the scenarios included in each block are presented.

Table 4.1: Block 1

	PURPOSE	DISTANCE	INFRASTRUCTURE
1	WORK	<2 KILOMETERS	NO CYCLING INFRASTRUCTURE
2	SHOPPING (WEEKLY)	<2 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
3	WORK	2-8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
4	SOCIAL (EVENING)	<2 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
5	SHOPPING (WEEKLY)	2-8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
6	SOCIAL (EVENING)	>8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
7	WORK	>8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
8	SHOPPING (WEEKLY)	>8 KILOMETERS	NO CYCLING INFRASTRUCTURE
9	SOCIAL (EVENING)	2-8 KILOMETERS	NO CYCLING INFRASTRUCTURE

Table 4.2: Block 2

	PURPOSE	DISTANCE	INFRASTRUCTURE
1	WORK	<2 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
2	SOCIAL (EVENING)	>8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
3	SHOPPING (WEEKLY)	2-8 KILOMETERS	NO CYCLING INFRASTRUCTURE
4	SOCIAL (EVENING)	<2 KILOMETERS	NO CYCLING INFRASTRUCTURE
5	WORK	2-8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
6	SHOPPING (WEEKLY)	>8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
7	SHOPPING (WEEKLY)	<2 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
8	WORK	>8 KILOMETERS	NO CYCLING INFRASTRUCTURE
9	SOCIAL (EVENING)	2-8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS

Table 4.3: Block 3

	PURPOSE	DISTANCE	INFRASTRUCTURE
1	WORK	<2 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
2	SOCIAL (EVENING)	>8 KILOMETERS	NO CYCLING INFRASTRUCTURE
3	WORK	2-8 KILOMETERS	NO CYCLING INFRASTRUCTURE
4	SHOPPING (WEEKLY)	<2 KILOMETERS	NO CYCLING INFRASTRUCTURE
5	SOCIAL (EVENING)	<2 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
6	WORK	>8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
7	SHOPPING (WEEKLY)	2-8 KILOMETERS	SOME BIKE LANES EXIST, BUT NOT CONTINUOUS
8	SOCIAL (EVENING)	2-8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK
9	SHOPPING (WEEKLY)	>8 KILOMETERS	SEGREGATED BIKE LANES EVERYWHERE, FULLY CONTINUOUS NETWORK

The three blocks above are presented with cycling information. The same order is followed for variables considering the walking scenarios.

Part 2 of the questionnaire is presented below, (block 1)

Part 2 : Hypothetical Scenarios

Assume you want to make a trip with good weather conditions in the city of Dublin.

1. How probable would it be for you to <u>walk</u> in the following scenarios?

<u>Please read and answer carefully</u>

a)

Purpose	Work
Distance	<2 km
Infrastructure	Small narrow pavements , few crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

b)

Purpose	Shopping [weekly]
Distance	<2 km
Infrastructure	Wide pavements , many crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

c)

Purpose	Work
Distance	2-4 km
Infrastructure	Wide pavements , many crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

d)

Purpose	Social [Evening]
Distance	<2 km
Infrastructure	100% pedestrian area

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

e)

Purpose	Shopping [weekly]
Distance	2-4 km
Infrastructure	100% pedestrian area

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

f)

Purpose	Social [Evening]
Distance	>4 km
Infrastructure	Wide pavements , many crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

g)

Purpose	Work
Distance	>4 km
Infrastructure	100% pedestrian area

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

h)

Purpose	Shopping [weekly]
Distance	>4 km
Infrastructure	Small narrow pavements , few crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

i)

Purpose	Social [Evening]
Distance	2-4 km
Infrastructure	Small narrow pavements , few crossing points

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

Assume you want to make a trip with good weather conditions in the city of Dublin.

2. How probable would it be for you to cycle in the following scenarios?

Please read and answer carefully

a)

Purpose	Work
Distance	<2 km
Infrastructure	No cycling infrastructure

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

b)

Purpose	Shopping [weekly]
Distance	<2 km
Infrastructure	Some bike lanes exist but not continuous

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

c)

Purpose	Work
Distance	2-8 km
Infrastructure	Some bike lanes exist but not continuous

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

d)

Purpose	Social [Evening]
Distance	<2 km
Infrastructure	Segregated bike lanes everywhere , fully continuous network

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

e)

Purpose	Shopping [weekly]
Distance	2-8 km
Infrastructure	Segregated bike lanes everywhere , fully continuous network

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

f)

Purpose	Social [Evening]
Distance	>8 km
Infrastructure	Some bike lanes exist but not continuous

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

g)

Purpose	Work
Distance	>8 km
Infrastructure	Segregated bike lanes everywhere , fully continuous network

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

h)

Purpose	Shopping [weekly]
Distance	>8 km
Infrastructure	No cycling infrastructure

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

i)

Purpose	Social [Evening]
Distance	2-8 km
Infrastructure	No cycling infrastructure

Definitely Not	Probably Not	Probably	Probably Yes	Definitely Yes
☐	☐	☐	☐	☐

4.2.3 Part III – Cycling and Walking Preferences

In the third part of the questionnaire, the participant is asked to state factors that may encourage or discourage him/her from cycling or walking. Possible answers are provided in a 5 point Likert scale. The possible answers are: Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree.

In the first question the participant is asked to rate the cycling and walking infrastructure of Athens/Dublin, as it is important to know what each participant believes for the existing infrastructure, in order to evaluate the propensity results better.

Many factors are examined in questions 2,3,5 and 6, for example: fatigue , traffic, road safety, costs, weather, elevation and many others which were analyzed in the background knowledge. Furthermore, the survey participant is asked to state possible reasons as in why he/she walks or cycles in question 4. Also through these questions the participant states his/her personal preferences considering walking and cycling.

Part 3 of the questionnaire is presented below

Part 3 : Cycling and walking preferences

1) Please answer the following questions

	Non Existent	Poor	Decent	Good	Excellent
How would you rate the cycling infrastructure of Dublin	☐	☐	☐	☐	☐
How would you rate the walking infrastructure of Dublin	☐	☐	☐	☐	☐

2) Factors that discourage me from cycling.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Fatigue	☐	☐	☐	☐	☐
Presence of many big junctions - roads	☐	☐	☐	☐	☐
Overcrowded pavements	☐	☐	☐	☐	☐
Steep incline	☐	☐	☐	☐	☐
Bad weather conditions	☐	☐	☐	☐	☐
Mode too slow	☐	☐	☐	☐	☐
Transporting goods/people	☐	☐	☐	☐	☐
Road safety	☐	☐	☐	☐	☐
Other ……..					

3) Factors that discourage me from walking.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Fatigue	☐	☐	☐	☐	☐
Presence of many big junctions - roads	☐	☐	☐	☐	☐
Overcrowded pavements	☐	☐	☐	☐	☐
Steep incline	☐	☐	☐	☐	☐
Bad weather conditions	☐	☐	☐	☐	☐
Mode too slow	☐	☐	☐	☐	☐
Transporting goods/people	☐	☐	☐	☐	☐
Road safety	☐	☐	☐	☐	☐
Other ……..					

4) To what extent do you agree or disagree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I walk because I have trouble finding/paying	☐	☐	☐	☐	☐

parking spots					
I walk for the pleasure of it	☐	☐	☐	☐	☐
I walk because it is healthy	☐	☐	☐	☐	☐
In short trips I prefer to walk	☐	☐	☐	☐	☐
I walk because I have no other transport option	☐	☐	☐	☐	☐
I walk because it is cheap	☐	☐	☐	☐	☐
I walk to enjoy the view	☐	☐	☐	☐	☐
I walk because I can use my phone	☐	☐	☐	☐	☐
Walking is a way of living	☐	☐	☐	☐	☐

<u>If you do not cycle do not answer the following statements , go to question no. 5</u>

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I cycle because I have trouble finding/paying parking spots	☐	☐	☐	☐	☐
I cycle for the pleasure of it	☐	☐	☐	☐	☐
I cycle because it is healthy	☐	☐	☐	☐	☐
In short trips I prefer to cycle	☐	☐	☐	☐	☐
I cycle because I have no other transport option	☐	☐	☐	☐	☐
I cycle because it is cheap	☐	☐	☐	☐	☐
I cycle to enjoy the view	☐	☐	☐	☐	☐
Cycling is a way of living	☐	☐	☐	☐	☐

5) Factors that would encourage me to cycle more.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
More extensive cycle route network	☐	☐	☐	☐	☐
More continuous cycle routes	☐	☐	☐	☐	☐
Wider bike lanes	☐	☐	☐	☐	☐
More(bicycle) parking spots	☐	☐	☐	☐	☐
Segregated bike lanes	☐	☐	☐	☐	☐
Better air quality	☐	☐	☐	☐	☐
Less traffic	☐	☐	☐	☐	☐
More respectful – careful drivers	☐	☐	☐	☐	☐
Good weather	☐	☐	☐	☐	☐
Better road surface	☐	☐	☐	☐	☐
Low incline	☐	☐	☐	☐	☐
Special biker facilities to transport connection points (parking spots , showers , lockers)	☐	☐	☐	☐	☐
More off street routes (parks etc)	☐	☐	☐	☐	☐
Beautiful landscape - view	☐	☐	☐	☐	☐
Other ……..					

6) Factors that would encourage me to walk more

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
More pedestrian areas	☐	☐	☐	☐	☐
Wider pavements	☐	☐	☐	☐	☐
More crossing points	☐	☐	☐	☐	☐
More respectful – careful drivers	☐	☐	☐	☐	☐
Pedestrianised roads	☐	☐	☐	☐	☐
Better air quality	☐	☐	☐	☐	☐
Routes with more green	☐	☐	☐	☐	☐
Less traffic	☐	☐	☐	☐	☐
Less crowded pavements	☐	☐	☐	☐	☐
Easier big junction – roads crossing (bridges – underpasses)	☐	☐	☐	☐	☐
Longer green pedestrian lights	☐	☐	☐	☐	☐
Countdown pedestrian lights	☐	☐	☐	☐	☐
Beautiful landscape – view	☐	☐	☐	☐	☐
Good weather	☐	☐	☐	☐	☐
Low incline	☐	☐	☐	☐	☐
Other ……					

4.2.4 Part IV – Personal Information

In the fourth and final part of the questionnaire, the participant is asked to provide personal information. In particular, information about their, gender, age and country of residence are requested. Furthermore, participants not from the country where the survey takes place, need to provide information about their duration of residency in this country. The limit for this survey was set on at least one year of living in Athens or Dublin, thus participants with shorter period of residency were excluded from the survey. Questions about profession, family status, vehicle ownership or access to vehicles and membership at cycling communities were also included. For the last two questions, a small reminder of the anonymity of the questionnaire is provided, as the most private question that participants may not answer is about their income. In addition, the number of people comprising their household is also requested, in order calculate the average personal income. The presented income answers differ between the Greek and Irish questionnaire, as the two countries have completely different economies, wages and living costs.

Part 4 of the questionnaire is presented below.

Part 4 : Personal Information

1. Gender :

Male	☐
Female	☐
Other	☐

2. Age group :

<18	☐
18-24	☐
25-34	☐
35-44	☐
45-54	☐
55-64	☐
>64	☐

3. Nationality :

Irish ☐

Other ……..

3.1 Country of residence ……

3.2 How long have you been in Ireland ……..

4. What is your current work status ?

Employed	☐
Self Employed	☐
Homemaker	☐
Unemployed	☐
Student	☐
Retired from employment	☐
Other ……..	

5. What is the higher level of education you have completed ?

Primary education	☐
Some secondary education	☐
Completed secondary education	☐
Third level education (non-degree)	☐
Bachelors degree	☐
Masters degree	☐
PhD	☐

6. What is your current family status ?

Single	☐
Married	☐
Divorced	☐
Widower	☐

7. Do you own a?

Car	☐
Motorcycle	☐
Bicycle	☐
None of the above	☐

8. If you do not own a car/motorcycle/bicycle , do you have an access to ?

Car	☐
Motorcycle	☐
Bicycle	☐
None of the above	☐

9. Are you a member of a bicycle community (rental – sharing – sports club) ?

Yes	☐
No	☐

We know people don't like to talk about income. The reason we ask is to see if there is a relationship, for example, between level of incomes and transport problems. Thus it is important to this study. Please be assured that your answers are completely **confidential** and can remain **anonymous**.

10. What is the (after tax) annual income of your household (in euros) ?

<25.000	☐
25.000-40.000	☐
40.000-60.000	☐
60.000-80.000	☐
80.000-100.000	☐
>100.000	☐

11. How many people live under that income ?

……

Thank you for your participation

Block 1_b , a/a ……..

4.3 Field Survey

In this section, details of the field survey conducted are presented.

In order to collect the necessary data for this thesis, stated preference designed and distributed questionnaires were used in both cities. The reason for selecting stated preference over revealed is the freedom this method entails, as with the revealed preference method, all participants would have to walk and cycle. Also this method gives the analyst the opportunity to experiment with hypothetical scenarios. Face to face interview was selected as the data collection method. The reason is the high response rates that this method ensures and the possibility to clarify the survey questions if required. This allows for more accurate answers.

Following the questionnaire design, pilot tests were performed in order to improve the questionnaire. In these tests, 10 questionnaires were distributed, in order to identify possible mistakes and confusing questions. 300 questionnaires were completed in total, 150 in Dublin and 150 in Athens. These questionnaires were distributed at different times of the day and in different places, to increase population representativeness.

The average time of completing the questionnaire was 13-18 minutes. Although this was a long questionnaire to fill, dropout rates were only about 5% confirming that dropouts rarely occur on face to face interviews.

4.3.1 Athens – Greece

The process of completing the questionnaires in Athens started in 01/08/2019 and ended in 12/09/2019 with a total of 150 correctly completed questionnaires. There was a strategic planning of the different areas where the questionnaire survey took place, in order to increase population representativeness. No more than 20 questionnaires were given at the same place.

The survey took place at:

- Chalandri's main square
- Kifissia's rail station
- Egaleo's main square
- National Technical University of Athens (Zografou)
- Economic University of Athens (City Centre)
- Monastiraki square
- Syntagma square
- Georgios Karaiskakis Stadium (following a sport event)
- OAKA Stadium (following a sport event)

- Glyfada's main square
- Stavros Niarchos Foundation

In addition, 15 questionnaires were distributed at an halbike event. Halbike is a cycling event organization located in Chalandri. These questionnaires were distributed to receive better feedback for cycling in Athens, considering the cyclist population.

Picture 4.13: Questionnaire Distribution Points in Athens

4.3.2 Dublin – Ireland

The process of completing questionnaires in Dublin started in 25/05/19 and ended in 12/07/19 with a total of 150 correctly completed questionnaires. There was a strategic planning of the different areas where the questionnaire survey took place, in order to increase population representativeness. No more than 20 questionnaires were given at the same place.

The survey took place at:

- University College Dublin
- Croke Park (after sport event)
- Trinity College Dublin
- St. Stephen's Green Park
- Smithfield's square
- Aviva Stadium (after sport event)
- Phoenix Park
- Rathmines Rathgar road
- St. Patrick's Cathedral

In addition 20 questionnaires were distributed in Dublinbikes terminal stations, in order to receive better feedback for cycling in Dublin, considering the cyclist population.

Picture 4.14: Questionnaire Distribution Points in Dublin

5. Results

In this chapter, the results produced from the collected data are analyzed. In particular, descriptive statistics exhibiting sample characteristics and 14 probit models (7 for cycling and 7 for walking propensity) are presented.

5.1 Descriptive Statistics

5.1.1 Sample characteristics

The total sample collected consists of 300 respondents, 150 from Athens and 150 from Dublin. From the total sample, 45% were men 54% women and 1% identified themselves as "other". This breaks down in 44% men and 56% women in Athens and 46% men, 52% women and 2% "other" in Dublin. Considering age groups, 3% is <18 years old, 23% 18-24 years old, 32% 25-34, 15% 35-44, 15% 45-54, 8% 55-64 and 4% >64 years old. Age group distribution for Dublin and Athens is presented in figure 5.1.

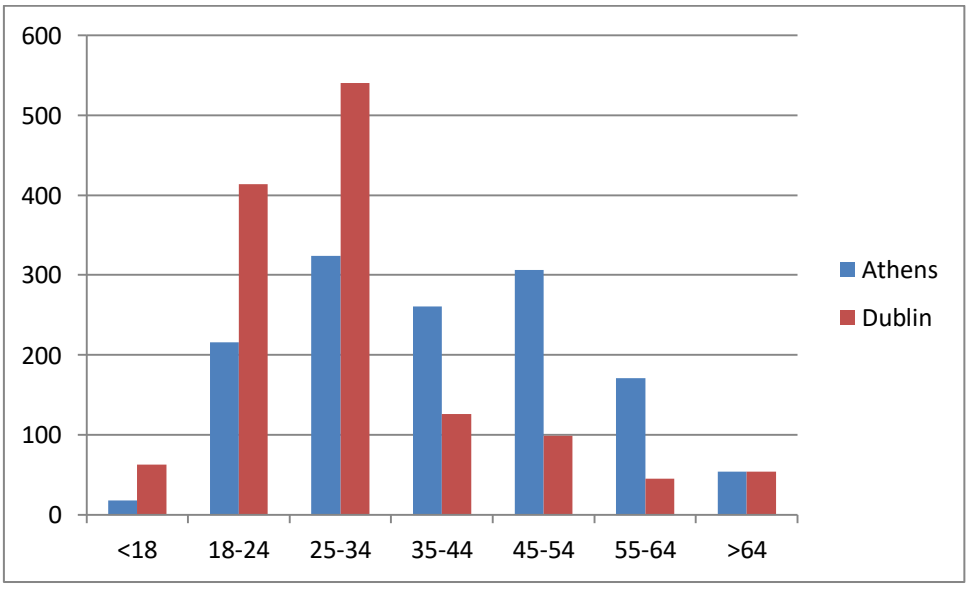


Figure 5.1 Age groups

According to participants' answers, 15% of the participants have completed only secondary education or lower education levels, 17% have attended university or finished an institute of vocational training (IEK), 43% have a bachelor's degree or a diploma from a university or technological education institute (TEI), 23% have completed a master's degree and 2% have a Phd. The educational level distribution for each sample is presented in figure 5.2.

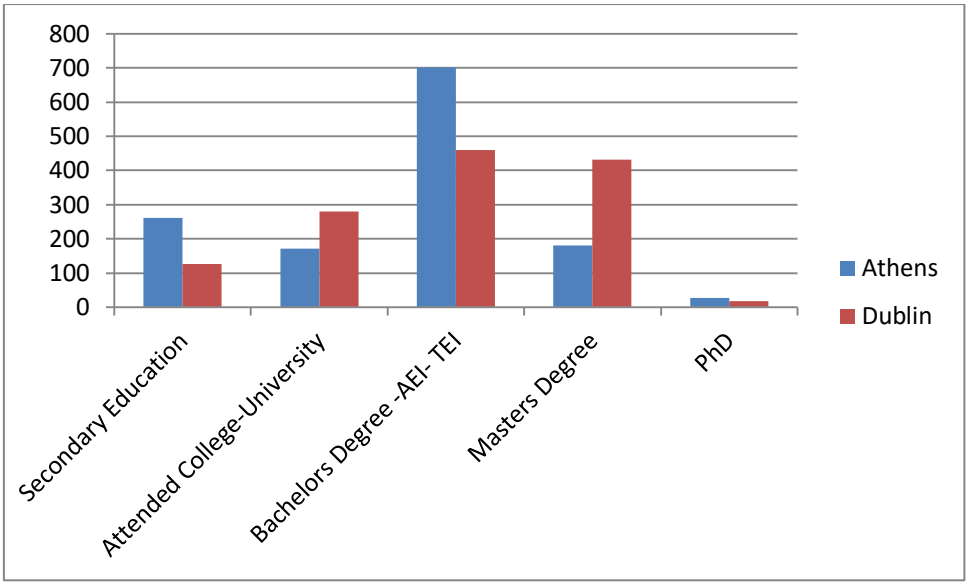


Figure 5.2 Education groups

Considering the sample's marital status, 64% of the participants are single, 29% are married, 5% are divorced and only 2% are widowers. More specifically, in Athens 49% are single and 43% are married, while in Dublin 80% are single and 15% are married. Personal income was calculated and divided in 6 categories, from extremely low to very high. Considering both Greek and Irish participants, 7% of the total participants belong to the first category, 22% to the second, 35% to the third, 20% to the fourth, 12% to the fifth and 4% of all participants to the sixth category. Income categories for Athens and Dublin are presented in figure 5.3.

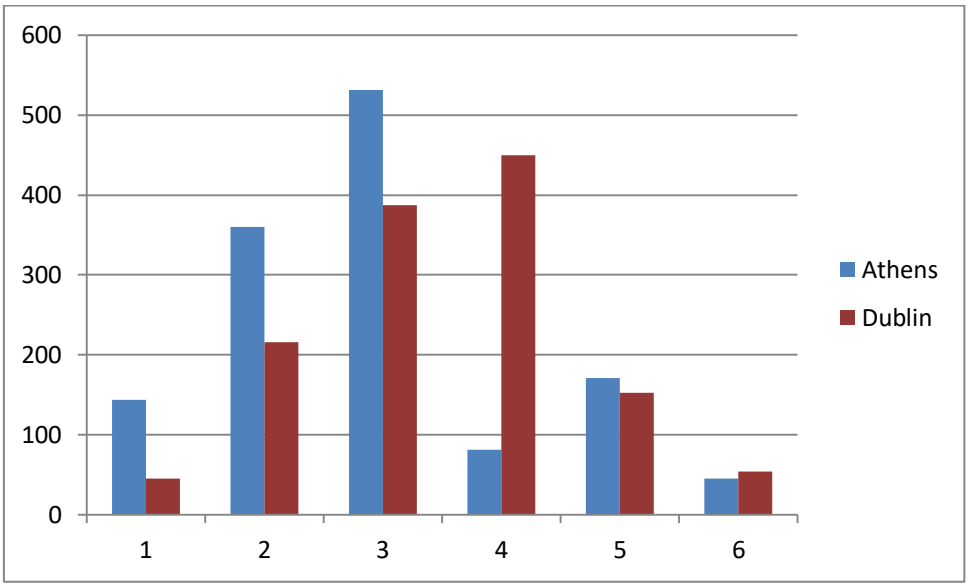


Figure 5.3 Personal income

Research findings indicate that cycling and walking propensity depend on vehicle ownership. In Athens 70% of the participants own at least one motorized vehicle, while in Dublin this percentage is rather lower, and is 40%. On the contrary in Athens only 9% of the participants own a bicycle, whereas in Dublin the respective proportion is 32%. 39% of the participants use their car as their primary transport mode, while 34% use the public transport 11% cycle and walk respectively, 4% use a motorcycle and only 1% use a taxi. These transport preferences are demonstrated for Athens and Dublin separately in figure 5.4.

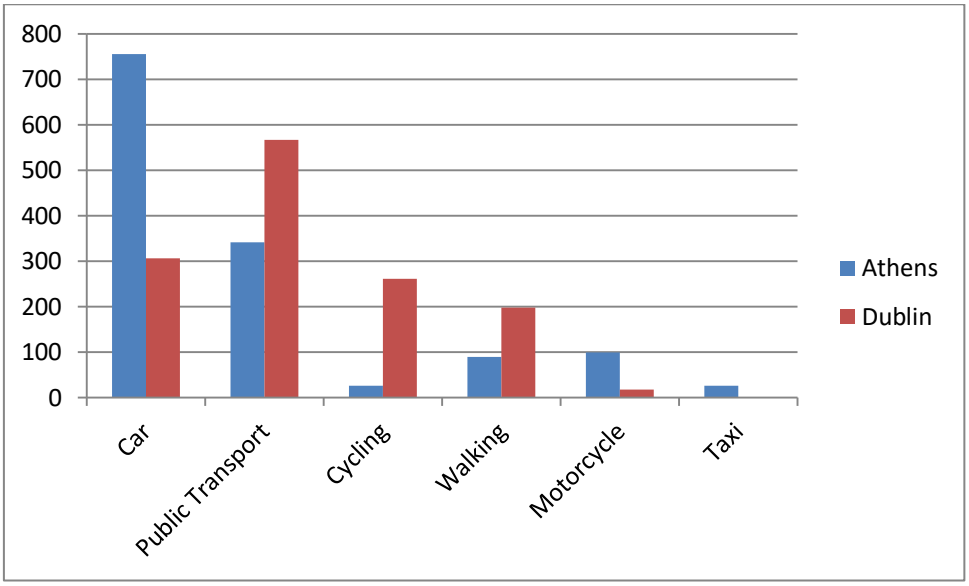


Figure 5.4 Main transport mode

5.1.2 Sample preferences

In this section, participants' attitudes on encouraging and discouraging factors considering walking and cycling and other preferences are demonstrated. Possible answers are presented on a 5-point Likert scale.

Figure 5.5 demonstrates how the participants rated the cycling and walking infrastructure of their city with 1 representing "non-existent" and 5 representing "excellent" infrastructure. In all other figures 1 represents "strongly disagree" and 5 stands for "strongly agree" on the 5-point Likers scale.

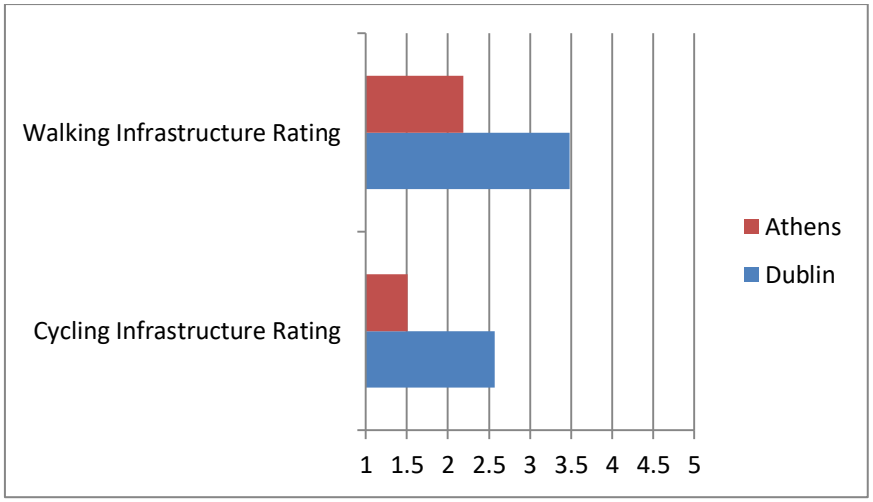


Figure 5.5 Walking-Cycling infrastructure ratings

It is clear that people in Dublin rate the walking and cycling infrastructure of their city higher than those in Athens. Except the walking infrastructure of Dublin which is rated slightly above average (3.5) the rest are all below average. More specifically, results in Athens are disappointing and represent a reflection of the problems Athenian infrastructure has, that were addressed in previous sections of this thesis.

Figure 5.6 demonstrates the answers to the question no. 6 of the questionnaires' first part, which is to rate the following statements in the 5-point Likert scale.

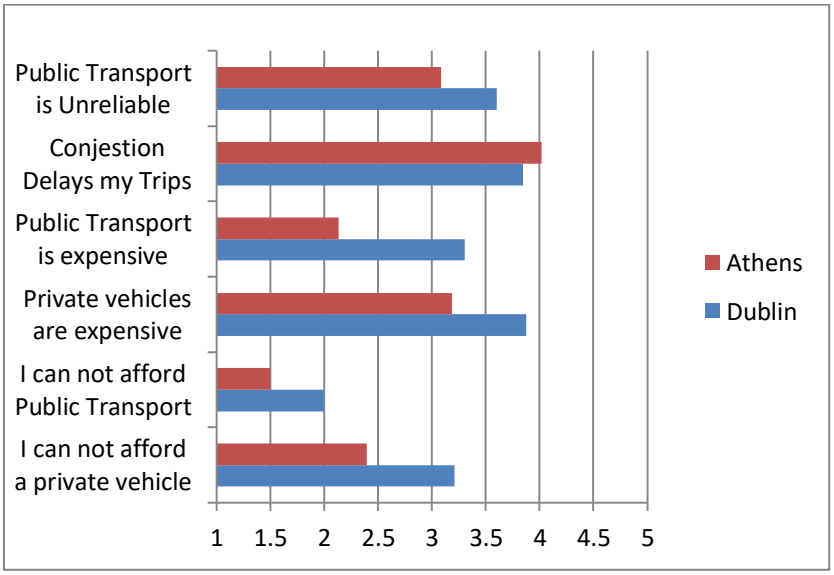


Figure 5.6

From the answers it is clear that congestion consists a problem in both cities. Furthermore, people find public transport unreliable to some degree, especially in Dublin. In addition, people in Dublin consider public transport and private vehicles to be expensive, while Athenians do not.

Figure 5.7 presents factors discouraging people from cycling.

Figure 5.7 Factors discouraging people from cycling

Road safety and the presence of big road junctions seem to be the factors that discourage people the most, especially in Athens. Elevation, bad weather conditions and the transportation of goods/people are also rated above average in both cities. More specifically, people in Dublin rated bad weather conditions as the most discouraging factor considering cycling.

Figure 5.8 demonstrates the factors discouraging people from walking.

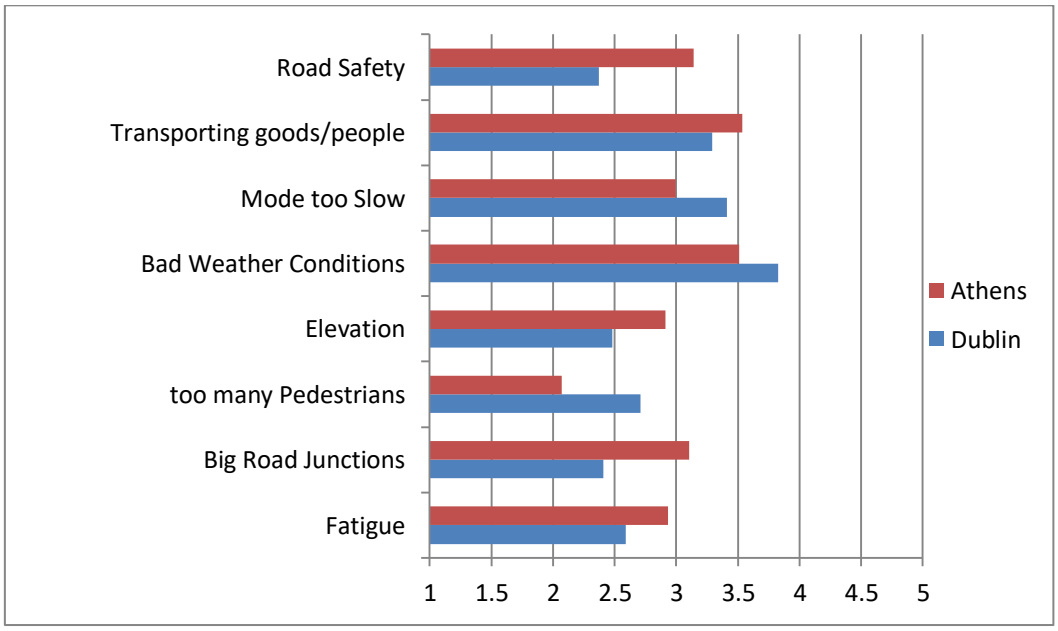


Figure 5.8 Factors discouraging people from walking

It becomes apparent that all variables have received lower ratings than they did in cycling. The highest rated discouraging factor for both cities is bad weather conditions, followed by the transportation of goods/people and the low speed associated with walking. All other factors were rated as average or even below.

Figure 5.9 presents the reasons why people choose to cycle.

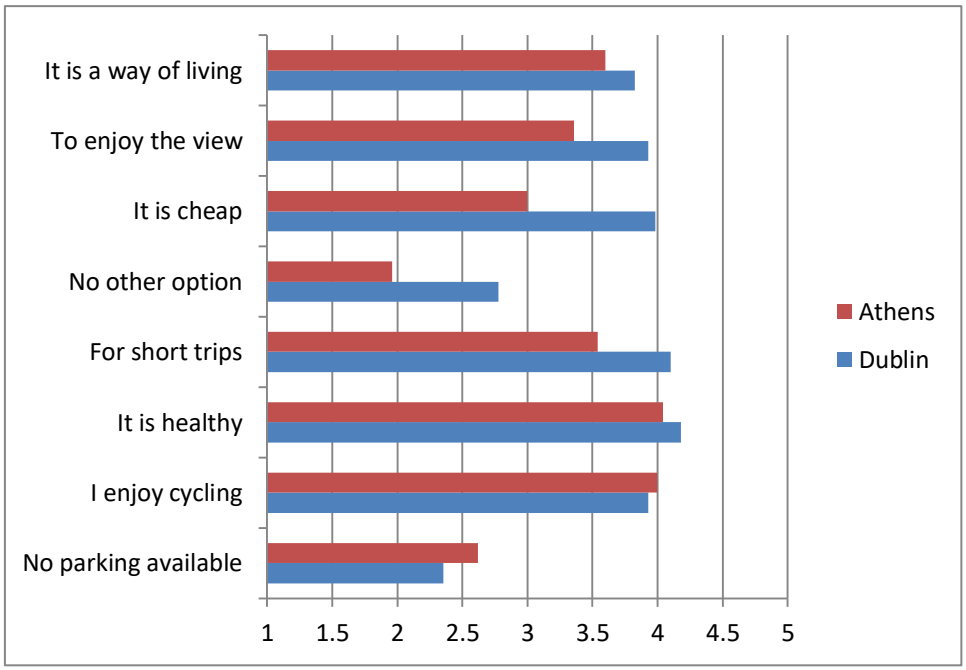


Figure 5.9 Reasons to cycle

In Dublin all categories except the lack of parking and other option are rated highly. For Athens the main reasons are because cycling is healthy and because people enjoy cycling. In Dublin people rated that they cycle because it is healthy and that they prefer to cycle for short trips. The ratings these two answers received was higher than 4, which is an extremely high rating.

In figure 5.10 the reasons why people choose to walk are demonstrated.

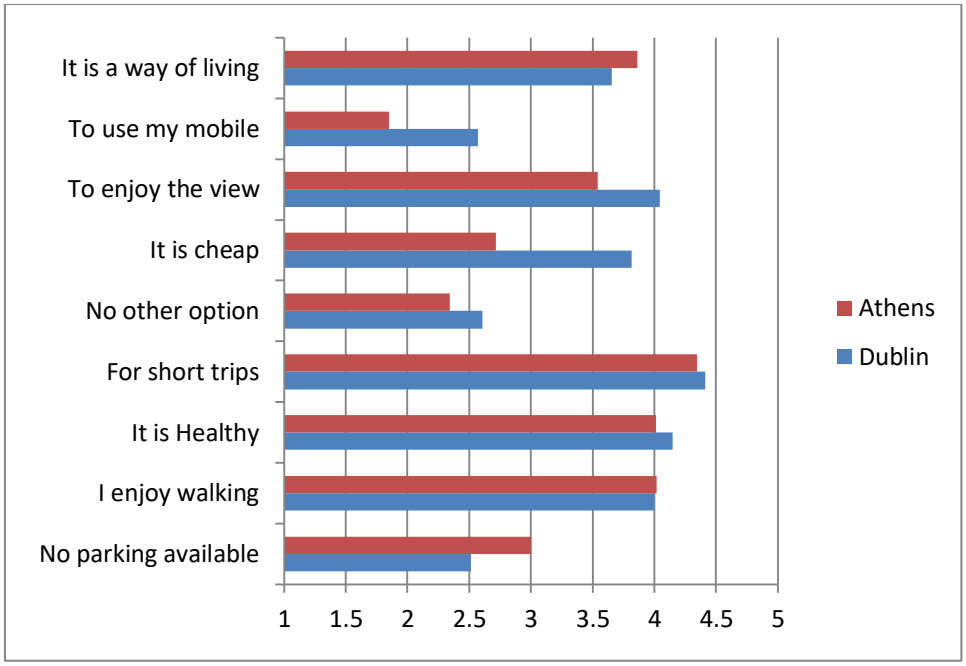


Figure 5.10 Reasons to walk

In both cities, people mainly prefer to walk for short trips. The next two reasons why they walk is because it is healthy and because they enjoy walking.

Figure 5.11 presents the factors encouraging people to cycle.

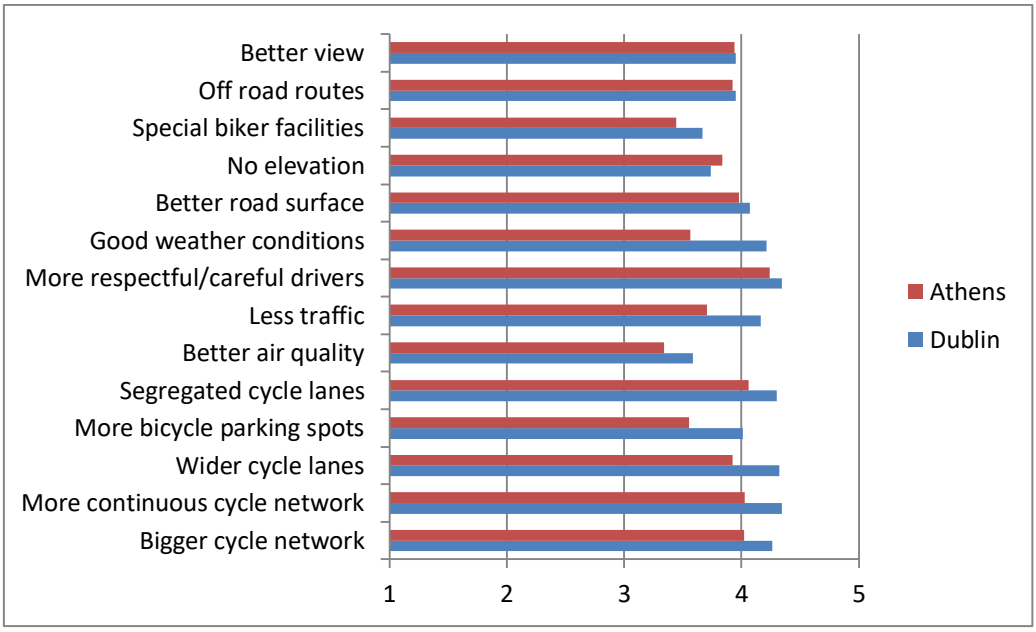
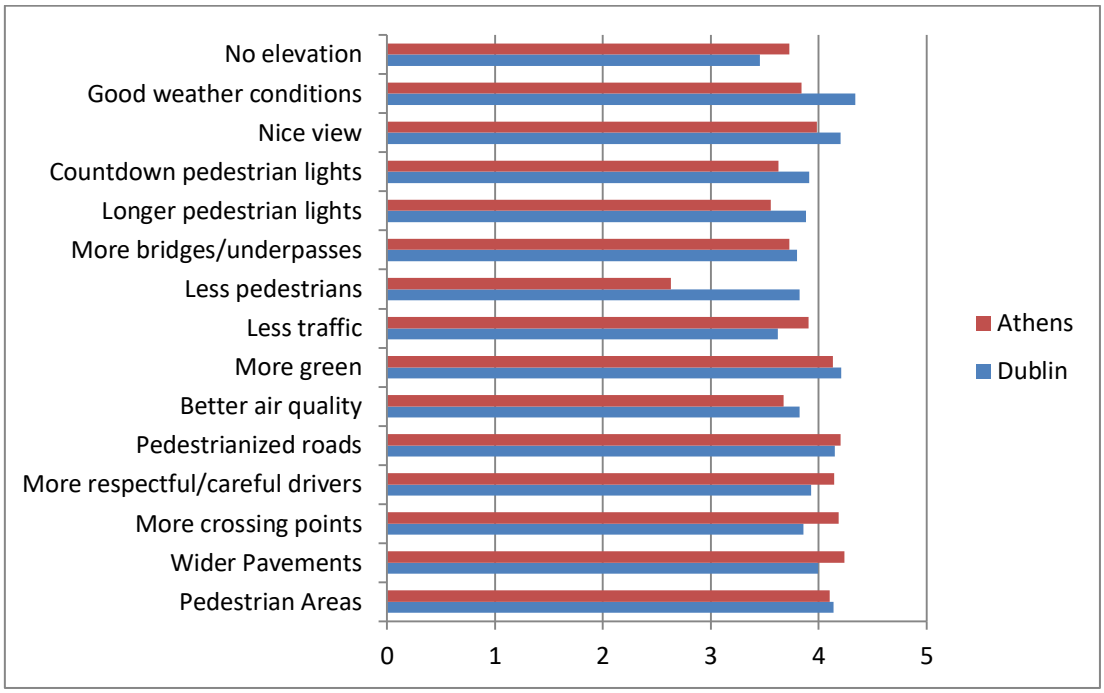


Figure 5.11 Factors encouraging cycling

All 5 variables concerning cycling infrastructure have received high ratings, along with the more respectful/careful drivers variable. It is important to note that all variables in both cities are rated above average.

In figure 5.12 the factors encouraging people to walk are demonstrated.



5.12 Factors encouraging walking

It is important to note that for cycling encouraging factors, the highest ratings were given from participants from Dublin, whereas in this chart they are given by Athenians. Variables concerning infrastructure along with more green and more respectful/careful drivers are the highest rated variables, with good weather conditions and nice view receiving high ratings from participants from Dublin.

5.2 Probit Models

In this section, the 14 (7 for cycling and 7 for walking) probit models that were designed are presented and discussed. The different variables and their levels presented on the model tables are demonstrated in table 5.

Table 5

Question – Variable	**Variables' code name**	**Levels**
	Hypothetical Scenarios	
Work Purpose	Purp	1=working, 2=social, 3=shopping
Infrastructure (cycling)	Infr	1=non=existent, 2=some bike lanes exist but not continuous, 3=segregated bike lanes everywhere, fully continuous network
Infrastructure (walking)	Infr	1=small narrow pavements, few crossing

		points, 2= wider pavements, many crossing points, 3=100% pedestrian area
Distance (cycling)	Dist	1= <2km , 2= 2-8km, 3= >8km
Distance (walking)	Dist	1= <2km, 2= 2-4km, 3= >4km
	Socioeconomical Factors	
Age	Age	1=<18, 2=18-24, 3=25-34, 4=35-44, 5=45-54, 6=55-64, 7= >64 years old
Gender	Sex	1=male, 2=female, 3=other
Profession	Job	1=civil servant(employed), 2=employed, 3= self-employed, 4=housekeeper, 5=unemployed, 6=student, 7=retired
Educational level completed	Educ	1=completed secondary education or lower, 2=third level education(non degree)/"IEK", 3=bachelors degree, 4=masters degree, 5=PhD
Residency	Cor	1=Irish/Greek, 2=other
Family status	Fam	1=single, 2=married, 3=divorced, 4=widower
Personal income (Athens)	Income	1=<300, 2=300-550, 3=550-800, 4=800-1100, 5=> 1100-1500, 6->1500 Euros per month
Personal income (Dublin)	Income	1= <7.000 , 2=7.001-14.00, 3= 14.001-21.000, 4=21.001-30.000, 5=30.001-50.000, 6=>50.001 Euros annually
Numerical personal income	Mo_inc	Numerical Value
	Transport preferences	
Main Transport Mode	M_trans	1=car, 2=public transport, 3=bicycle, 4=pedestrian, 5=motorcycle, 6=taxi,

		7=other
I cannot afford a private vehicle	No_ix	1=strongly disagree…5=strongly agree
I cannot afford public transport	No_public	1=strongly disagree…5=strongly agree
Traffic congestion causes delays to my trips	Jam_slow	1=strongly disagree…5=strongly agree
I find the public transport unreliable	Public_unr	1=strongly disagree…5=strongly agree
How would you rate the cycling infrastructure of your city	Bike_inf	1=non-existent, 2=poor, 3=decent, 4=good, 5=perfect
How would you rate the pedestrian infrastructure of your city	Ped_inf	1=non-existent, 2=poor, 3=decent, 4=good, 5=perfect
	Cycling Discouraging Factors	
Road Safety	B_road_sfty	1=strongly disagree…5=strongly agree
Fatigue levels	B_fatigue	1=strongly disagree…5=strongly agree
Presence of many big junctions	B_road_junct	1=strongly disagree…5=strongly agree
Low transportation speed	B_mode_slow	1=strongly disagree…5=strongly agree
Presence of many pedestrians	B_many_ped	1=strongly disagree…5=strongly agree
	Walking Discouraging Factors	
Road Safety	P_road_sfty	1=strongly disagree…5=strongly agree
Fatigue levels	P_fatigue	1=strongly disagree…5=strongly agree
Presence of many big junctions	P_road_junct	1=strongly disagree…5=strongly agree
Low transportation speed	P_mode_slow	1=strongly disagree…5=strongly agree
Adverse weather conditions	P_bad_wthr	1=strongly disagree…5=strongly agree
	Cycling Encouraging Factors	
Bigger cycling network	Big_c_netw	1=strongly disagree…5=strongly agree
More continuous cycling network	Cont_c_netw	1=strongly disagree…5=strongly agree

Less traffic	C_less_traf	1=strongly disagree…5=strongly agree
Better air quality and environmental conditions	C_bet_air	1=strongly disagree…5=strongly agree
	Walking Encouraging Factors	
Longer green pedestrian light duration	P_lights	1=strongly disagree…5=strongly agree
Countdown pedestrian lights	P_count_lights	1=strongly disagree…5=strongly agree
Better air quality and environmental conditions	P_bet_air	1=strongly disagree…5=strongly agree
Good weather conditions	P_good_wthr	1=strongly disagree…5=strongly agree
More pedestrian crossing points	P_more_cp	1=strongly disagree…5=strongly agree
More green routes	P_more_gr	1=strongly disagree…5=strongly agree
More careful-respectful drivers	P_car_dri	1=strongly disagree…5=strongly agree
Beautiful view	P_view	1=strongly disagree…5=strongly agree

5.2.1 Cycling Propensity Models

General model

Table 5.C.1 presents the probit model of cycling propensity considering the whole population.

Table 5.C.1

Variable	Estimate Value	T-Value
Infr=2	0.62086	9.923
Infr=3	1.06675	16.723
Dist=2	-0.74845	-12.404
Dist=3	-1.26658	-19.611
Purp=2	-0.69169	-11.135
Purp=3	-0.39623	-6.568
	Socioeconomical Factors	
City=2	-0.53458	-6.618
Age=2	-0.28320	-3.267
Educ = 5	1.07802	5.303
Income>=3	0.22466	2.954
Job=6	0.41114	3.807

Transport Preferences		
m_trans=4	-0.41045	-4.055
m_trans=5	0.41858	2.720
Jam_slow>=2	0.35949	2.200
No_ix=2 & no_ix=3	0.52811	4.781
No_ix=4	0.68234	5.266
No_ix=5	0.83310	6.042
Discouraging Factors		
B_fatigue=2	-0.51493	-3.671
B_fatigue=3 & B_fatigue=4	-0.90807	-6.767
B_fatigue=5	-1.25441	-8.399
B_mode_slow=5	-1.12801	-5.580
Encouraging Factors		
big_c_netw>=4	0.86977	5.933
c_bet_air>=2	0.98293	3.113
Intercept	-0.70159	-1.817
Mu_1	1.00023	25.753
Mu_2	1.75608	35.095
Mu_3	2.62220	40.568
Sigma	1.43079	23.661
Observations	2700	
Degrees of Freedom	28	
Initial Log-Likelihood	-3469.191	
Final Log-Likelihood	-2674.469	
AIC	5404.938	

The model presented above was produced from the combined data gathered in Dublin and Athens and was created in order to isolate global factors affecting cycling propensity in both countries and see how Greek and Irish cyclists are affected by different variables.

To begin with, it is clear that infrastructure and distance are the variables affecting most of the respondents in a consistent manner from the model as they present the highest t-value overall. Distance is a discouraging factor reducing greatly the propensity to cycle medium distances compared to short distances (-0.74 value) and reducing it even further for long distances (-1.26 value). At the same time, infrastructure increases the propensity to cycle significantly, with the average and great level compared to the poor level, obtaining the value of 0.62 and 1.07 respectively. It is also important to note that both infrastructure and distance (in opposite manners) demonstrate a bigger leap from level 1 to level 2 than from level

2 to level 3, meaning that moving from short distance/no infrastructure to medium distance/average infrastructure is decreasing/increasing the propensity to cycle at a higher degree than moving from medium distance/average infrastructure to long distance/great infrastructure.

Results concerning the third variable of the hypothetical scenarios, trip purpose, indicate that people in Athens and Dublin have the highest propensity to cycle when trips involve working purposes. For the trip purpose of shopping (compared to work), the propensity to cycle decreases with a value of -0.39, but is not as reduced as the purpose of socializing, for which the propensity to cycle decreases even more at the rate of -0.69.

From the socioeconomical factors, in this joint model, education, income, age and profession were found to influence the propensity to cycle in Athens and Dublin. In particular, highly educated people that belong in the 5^{th} level of this variable (completed PhD), have shown a much higher propensity to cycle than people who have not continued their studies after school. Furthermore, people with higher personal income also demonstrate a slightly higher propensity to cycle. Concerning profession, the model indicates that students in both countries have a higher propensity to cycle compared to people with other professions. The last socioeconomical parameter that affects the propensity according to the designed model is age, for which the propensity to cycle decreases for people aged 18-24 years old compared to underaged people.

Another subgroup of factors included in this model involves transport preferences. The model indicated that people who choose walking as their main transport mode have a reduced propensity to cycle, while people riding motorcycles as their main transport mode have an increased cycling propensity, both compared to people whose primary transport mode is their private cars. In addition, the more people cannot afford a private vehicle the higher the propensity to cycle. Last, people who experience delays in their daily trips have a higher propensity to cycle.

This model included two cycling discouraging factors: fatigue and transport speed and two encouraging: bigger cycling network and better environmental conditions. Fatigue is the factor discouraging the most as, the higher people declared to affect them the lower the propensity to cycle. Furthermore, people who totally agreed that the bicycle is too slow for their needs have a lower propensity to cycle than those who disagreed. By contrast, people who answered that better environmental conditions and better air quality would encourage them to cycle have a higher propensity to cycle than those who did not. The same applies to people who would be encouraged to cycle if the cycling network in their city was bigger.

Last, the model demonstrates that Athenians have a significantly lower propensity to cycle than people living in Dublin city.

Athens model

Table 5.C.2 presents the probit model of cycling propensity considering the population of Athens.

Table 5.C.2

Variable	Estimate Value	T-Value
Infr=2	0.86418	9.521
Infr=3	1.23628	13.331
Dist=2	-0.71217	-8.329
Dist=3	-1.12595	-12.457
Purp=2	-0.93677	-10.419
Purp=3	-0.32291	-3.840
Socioeconomical Factors		
Income=6	-0.53503	-2.561
Educ=5	1.65601	5.772
Age=2	-0.61106	-2.313
Age=3	-0.38960	-1.682
Age=4	-1.31731	-4.717
Age=5	-0.61641	-2.644
Age=6	-0.67489	-2.775
Fam=3	-0.93476	-4.697
Job=7	-0.73119	-2.945
Sex=2	-0.32860	-3.256
Transport Preferences		
M_trans=2	0.28179	2.363
Jam_slow>=2	1.60900	4.955
Discouraging Factors		
B_mode_slow=5	-1.69451	-6.098
B_many_ped	-0.49372	-2.734
B_fatigue>=3	-0.61284	-5.533
Encouraging Factors		
C_less_traf=2 & C_less_traf=3	1.24787	2.780
C_less_traf>=4	1.61249	3.667
Big_c_netw=5	0.39983	3.189
Intercept	-0.84147	-1.396
Mu_1	0.93913	17.629
Mu_2	1.84629	25.499

Mu_3	2.72113	28.160
Sigma	1.53826	14.657
Observations	1350	
Degrees of Freedom	29	
Initial Log-Likelihood	-1668.000	
Final Log-Likelihood	-1303.973	
AIC	2665.944	

The increase of infrastructure quality results in higher cycling propensity. Increased distance results in lower cycling propensity. Values in both these variables present a similar increase/decrease as the distance/infrastructure-quality increases. Considering trip purpose, working is the purpose demonstrating the highest propensity to cycle, followed by shopping, while social purposes show a substantially lower propensity compared to the other two purposes.

Five socioeconomical factors were included in this model. The most noticeable one (which was not included in the general model) is the gender factor. The results demonstrate that women in Athens have a significantly lower propensity to cycle than men. Furthermore in this model age constitutes a more important factor with many age groups being included, with older people (with the exception of those aged between 44 and 54 years old) presenting reduced propensity to cycle compared to underaged people. In accordance to this, people retired from employment demonstrate also a low cycling propensity. Just like in the general model, highly educated people have a higher propensity to cycle. In addition, high personal income results to reduced propensity as opposed to the general population model. This model also indicates that divorced people have a much lower propensity to cycle.

From travel preference factors, two were found to affect cycling propensity. People using the public transport as their main transport mode in Athens have a higher propensity to cycle compared to those using passenger cars. In addition, people affected by traffic congestion are more likely to cycle.

Last, this model consists of three discouraging and two encouraging factors. Athenians are deeply affected by fatigue, as it drastically reduces the propensity to cycle. Also, people who believe that cycling is a slow mode have a significantly lower propensity to cycle. Last, the presence of many pedestrians is also discouraging Athenians to cycle. The two most important changes that would increase the cycling propensity of people in Athens are the construction of a bigger cycling network and the reduction of traffic on the streets, as indicated by this model.

Dublin model

Table 5.C.3 presents the probit model of cycling propensity considering the population in Dublin.

Table 5.C.3

Variable	Estimate Value	T-Value
Infr=2	0.41182	4.711
Infr=3	0.96098	10.774
Dist=2	-0.81272	-9.435
Dist=3	-1.44740	-15.490
Purp=2	-0.49193	-5.630
Purp=3	-0.48152	-5.523
Socioeconomical Factors		
Income=6	0.41228	1.690
Age>=6	-0.54359	-2.308
Educ>=2	1.30833	6.766
Job=6	1.24055	5.157
Transport Preferences		
M_trans=2	-1.05226	-8.839
M_trans=4	-1.23005	-6.631
No_ix=2 &No_ix=3	1.54199	6.744
No_ix>=4	2.13645	8.468
Discouraging Factors		
B_road_sfty>=2	-2.19424	-5.481
B_many_ped>=4	-0.49803	-3.808
B_fatigue=5	-1.91345	-9.495
Encouraging Factors		
C_bet_air>=2	1.62541	3.446
Intercept	0.17026	0.267
Mu_1	1.12087	18.844
Mu_2	1.75308	24.496
Mu_3	2.63807	29.281
Sigma	1.41517	12.966
Observations	1350	
Degrees of Freedom	23	
Initial Log-Likelihood	-1788.103	
Final Log-Likelihood	-1322.183	
AIC	2690.366	

Results indicate that as infrastructure quality increases the propensity to cycle increases and as the distance increases the propensity decreases. Compared with

the propensity to cycle in Athens, the effect of distance on the propensity is higher, while that of infrastructure is lower. In this model, like in the previous ones, working purpose results in a higher cycling propensity, while shopping and socializing purposes demonstrate similar (lower than working) propensities.

Four socioeconomical factors are included in this model. People aged over 54 years old have a significantly lower propensity to cycle in Dublin, while students have a high cycling propensity compared to employed people. Unlike people in Athens, higher private income in Dublin results in an increased cycling propensity. In addition, people who have finished at least one graduate degree have a higher propensity to cycle in Dublin.

Once more unlike Athens, people whose main transport mode is public transport or walking have a considerably lower propensity to cycle compared to travelers using passenger cars. In addition, the more a person in Dublin cannot afford a private vehicle, the higher his/her propensity is to cycle, as demonstrated by the model's results.

Three discouraging and one encouraging factor were included in Dublin's model. The two factors reducing cycling propensity most are poor road safety and fatigue. The presence of many pedestrians is also reducing the cycling propensity in Dublin but not as much as the two aforementioned factors. Better environmental conditions and better air quality is the only encouraging factor identified in the model, which increases significantly the propensity to cycle in the city of Dublin.

It is important to mention that for a confidence level of 95% and for the degrees of freedom of the previous 3 models, the final LRT was considerably higher than the value of chi-squared, meaning that the two submodels of the populations in Athens and Dublin, represent more accurately results for the two cities than the joint model.

Athens men model

Table 5.C.4 demonstrates the probit models for cycling propensity considering the population of men in Athens.

Table 5.C.4

Variable	Estimate Value	T-Value
Infr=2	0.76037	5.576
Infr=3	1.00367	7.253
Dist=2	-0.82775	-6.287
Dist=3	-1.30280	-9.267
Purp=2	-0.86214	-6.336

Purp=3	-0.36526	-2.806
Socioeconomical Factors		
Age>=3	-0.79860	-4.662
Educ<=4	-1.03133	-4.285
Transport Preferences		
Bike_inf=3	1.24932	4.667
M_trans=2	1.32262	7.273
Public_unr>=2	-0.47569	-2.300
Discouraging Factors		
B_mode_slow>=2	-1.02216	-4.801
B_fatigue=5	-0.88133	-3.997
Encouraging Factors		
Cont_c_netw>=4	0.94500	5.248
C_less_traf=5	0.65294	3.493
Intercept	2.29363	5.104
Mu_1	1.12370	12.328
Mu_2	1.90166	16.721
Mu_3	2.90917	19.019
Sigma	1.62219	13.390
Observations	594	
Degrees of Freedom	20	
Initial Log-Likelihood	-719.8586	
Final Log-Likelihood	-561.4283	
AIC	1162.857	

Results indicate that higher infrastructure quality leads to higher propensity to cycle and greater travel distance leads to lower propensity to cycle. The purpose of working is the one with the highest propensity, with shopping being the second and socializing having a significantly reduced propensity.

From the socioeconomical factors only two were included in the model. Men in Athens over 25 years old have a significantly lower propensity to walk as opposed to younger men. In addition, and unlike the general model of Athens, higher education for men leads to lower cycling propensity.

Men in Athens who use public transport as their primary transport mode have a considerably higher propensity to cycle compared to car users. In addition, men that consider the public transport unreliable have a reduced propensity to cycle. Furthermore, men who rated the cycling infrastructure of Athens as decent have a higher propensity to cycle than those who find it poor.

Men's propensity to cycle in Athens is reduced when considering cycling to be a slow mode, while men affected by fatigue are also less probable to cycle. By contrast, reduced traffic in the city and more continuous cycling routes increase the cycling propensity of men in Athens substantially.

Athens women model

Table 5.C.5

Table 5.C.5 presents the probit model for cycling propensity considering the population of women in Athens.

Variable	Estimate Value	T-Value
Infr=2	0.97960	7.817
Infr=3	1.44240	11.003
Dist=2	-0.69107	-5.990
Dist=3	-1.09281	-8.821
Purp=2	-1.08509	-8.636
Purp=3	-0.31825	-2.842
Socioeconomical Factors		
Age<=5	-1.20834	-4.058
Fam=2	-0.95417	-3.750
Fam=3	-2.06793	-4.619
Educ>=2	0.38667	1.837
Transport Preferences		
Bike_inf=3	1.45924	5.931
M_trans=4	-0.70944	-2.967
No_ix>=3	0.61182	3.594
Discouraging Factors		
B_many_ped=2	-0.47573	-1.649
B_many_ped=3	-1.21249	-4.411
B_many_ped=4	-0.99353	-3.175
B_many_ped=5	-2.08261	-3.235
B_mode_slow=5	-2.02196	-3.454
B_fatigue>=4	-0.54339	-2.636
Encouraging Factors		
Big_c_netw=3	2.92035	3.053
Big_c_netw=4	3.60609	3.983
Big_c_netw=5	4.32901	4.662
Intercept	-1.47073	-1.533
Mu_1	0.86981	11.908
Mu_2	1.91141	17.565

Mu_3	2.71877	19.751
Sigma	1.04826	5.255
Observations	747	
Degrees of Freedom	27	
Initial Log-Likelihood	-919.106	
Final Log-Likelihood	-710.6981	
AIC	1475.396	

Results indicate that better infrastructure levels increase the propensity to cycle substantially. Greater travel distance results to reduced propensity to cycle. Working is the travel purpose with the highest cycling propensity, with shopping being the second and socializing having a substantially lower propensity.

Older women have a lower propensity to cycle compared to young women, while women who attended college or university have a higher cycling propensity compared to women who did not. Married women have a significantly lower propensity to cycle compared to single women, and a significant reduction in cycling propensity is witnessed for divorced women.

Women who cannot afford a private vehicle and women who rated the cycling infrastructure of Athens as decent compared to those who rated it as non-existent have a higher propensity to cycle. Women who mainly walk to perform their trips have a slightly lower cycling propensity than women using private cars.

The presence of many pedestrians influences greatly women's propensity to cycle and in particular it reduces it. Furthermore, women who consider cycling associates with fatigue and low speed as discouraging factors demonstrate reduced cycling propensity in Athens. Last, women's propensity to cycle in Athens is greatly increased by the presence of bigger cycling networks.

For a confidence level of 95%, the final LRT value is higher than the value of chi-squared, meaning that the two submodels of men and women in Athens are more accurate than the general model of Athens.

Dublin men model

Table 5.C.6 presents the probit model for cycling propensity considering the population of men in Dublin.

Table 5.C.6

Variable	Estimate Value	T-Value
Infr=2	0.41515	3.238
Infr=3	0.74655	5.786
Dist=2	-1.01919	-7.904
Dist=3	-1.75898	-12.378
Purp=2	-0.66060	-5.128
Purp=3	-0.77156	-5.946
Socioeconomical Factors		
Educ<=4	2.20384	4.824
Job=6	0.76753	2.985
Income=4	0.52256	2.335
Transport Preferences		
M_trans=2	-1.28875	-9.193
M_trans=4	-1.37079	-5.621
No_ix=2	1.51645	6.445
No_ix>=3	1.82034	7.654
Discouraging Factors		
B_mode_slow>=3	-1.84365	-11.347
B_road_sfty=2 & B_road_sfty=3	-1.09267	-2.817
B_road_sfty>=4	-1.44409	-3.678
Intercept	0.49660	0.743
Mu_1	1.18534	12.821
Mu_2	1.80335	16.840
Mu_3	2.71305	20.594
Sigma	1.83593	12.266
Observations	612	
Degrees of Freedom	21	
Initial Log-Likelihood	-874.1062	
Final Log-Likelihood	-607.071	
AIC	1256.142	

The model results indicate that considering men in Dublin distance decreases the cycling propensity, and infrastructure quality increases cycling propensity. In addition, this model is the only one in which socializing travel purposes demonstrate a higher cycling propensity compared to shopping purposes, with working purposes obtaining the highest cycling propensity.

Considering socioeconomical factors, age does not seem to influence the cycling propensity of men in Dublin. Male students have an increased propensity to cycle

compared to employed men, and men with higher personal income have also increased cycling propensity. Men who have at least attended college have a substantially higher propensity to cycle.

Considering transport preferences, men using public transport as their main transport mode or men who walk, have a considerably reduced propensity to cycle compared to people using passenger cars. In addition, the more men cannot afford a private vehicle, the higher their propensity to cycle.

Considering discouraging factors, two were included in this model, while encouraging factors were not found to be significant. The low speed associated with the bicycle reduces the propensity to cycle most. Furthermore, lower road safety levels lead to reduced cycling propensity for men in Dublin.

Dublin women model

Table 5.C.7 demonstrates the probit model for cycling propensity considering the population of women in Dublin.

Table 5.C.7

Variable	Estimate Value	T-Value
Infr=2	0.48187	3.933
Infr=3	1.22760	9.649
Dist=2	-0.68649	-5.779
Dist=3	-1.26443	-9.931
Purp=2	-0.36161	-2.972
Purp=3	-0.24823	-2.064
Socioeconomical Factors		
Age=2 & age=3 & age=4 & age=5	-0.93304	-3.898
Age=>=6	-1.89055	-5.399
Educ>=2	0.41743	2.188
Job=6	1.07141	3.058
Fam=2	0.43067	2.474
Cor=2	0.86921	6.138
Transport Preferences		
No_ix>=2	0.39615	1.880
Discouraging Factors		
B_road_sfty=3	-0.93640	-3.207
B_road_sfty=4	-1.16402	-4.515
B_road_sfty=5	-1.15304	-4.480
B_mode_slow=5	-2.17904	-3.777
B_fatigue=5	-1.96105	-8.299

Intercept	1.75300	3.745
Mu_1	1.11121	13.850
Mu_2	1.83474	18.277
Mu_3	2.67824	21.148
Sigma	1.92419	15.068
Observations	702	
Degrees of Freedom	23	
Initial Log-Likelihood	-862.4702	
Final Log-Likelihood	-681.3696	
AIC	1734.94	

Infrastructure quality and distance are important for women in Dublin. The more infrastructure quality improves the more the cycling propensity increases with travel distance following the exact opposite trend, similarly to all the other cycling models. Like in all previous models, working is the travel purpose that leads to the highest cycling propensity, while shopping and socializing purposes result in slightly reduced propensities.

Women's cycling propensity in Dublin, unlike men, is greatly affected by age. In particular, women aged 18-54 years old demonstrate a lower propensity to cycle compared to women who are younger than 18 years old, with the propensity reducing even further for women aged between 55-64 years old. Students have a significantly higher propensity to cycle, compared to employed women and married women, as opposed to Athenian women, have an increased cycling propensity. Furthermore, just like men, women in Dublin who have attended college have a higher cycling propensity compared to those who have not.

The model indicates that travel preferences do not have a significant impact on the cycling propensity of women in Dublin. Women who cannot afford a private vehicle have a higher cycling propensity.

Like men in Dublin, women's propensity to cycle is substantially reduced by the slow travel speed associated with cycling. In addition, lower road safety levels lead to lower cycling propensity, and women affected by fatigue have also a low cycling propensity.

However, the most noticeable feature in this model, which did not influence any other of the previous 6 models, is that women living in Dublin (at least for a year), but are not Irish, have a considerably higher propensity to cycle than Irish women.

In the same manner with the previous submodels, the two models of subpopulations in Dublin for men and women present more accurate results of the general Dublin

population model and are more suitable to describe the factors affecting the propensity to cycle in Dublin city and Dublin Greater Area.

5.2.2. Walking Propensity Models

General model

Table 5.W.1 presents the probit model for walking propensity considering the whole population.

Table 5.W.1

Variable	Estimate Value	T-Value
Infr=2	0.45727	8.333
Infr=3	0.71552	12.829
Dist=2	-0.84266	-14.974
Dist=3	-1.54191	-25.717
Purp=1	0.31501	5.723
Purp=2	0.23200	4.249
Socioeconomical Factors		
Income=6	-0.3678	-2.805
Age=6	-0.52673	-4.363
Educ>=3	0.15841	1.846
Sex=2	0.35222	4.245
Transport Preferences		
M_trans=2	0.31986	3.510
M_trans=3	0.23949	1.966
No_ix=3 & no_ix=4	0.34052	4.126
Discouraging Factors		
P_mode_slow>=2	-0.84418	-4.973
P_fatigue>=3	-0.42240	-5.083
Encouraging Factors		
P_good_wthr	1.59758	3.748
P_lights>=2	1.34769	2.550
P_bet_air>=2	1.02333	2.648
Intercept	-1.80208	-2.353
Mu_1	0.94802	25.074
Mu_2	1.67166	36.543
Mu_3	2.63606	47.358
Sigma	1.15957	21.937
Observations	2700	
Degrees of Freedom	23	

Initial Log-Likelihood	-4085.267
Final Log-Likelihood	-3318.402
AIC	6682.804

This model was produced using the data collected both in Athens and Dublin. The most important variable considering t-value is trip distance. As in the cycling models the greater the distance is the more the walking propensity decreases. In the same manner, increase in the quality of infrastructure leads to increased propensity. In particular, compared to the cycling general model, distance appears to be more significant, while infrastructure is less significant considering walking propensity. As for trip purpose, working is the purpose with the highest walking propensity, followed by socializing, with shopping obtaining the smallest walking probability.

People aged between 55-64 years old have a considerably lower propensity to walk than younger people. Furthermore, according to the model educated people have a higher propensity to walk. Gender also influences walking propensity in the general model, as women demonstrate a higher tendency to walk. Last, high income affects walking propensity, as people with higher income tend to walk less, as the model results indicate.

Considering transport preferences, two factors are included in the general model. Both people using public transport or cycling as their main transport mode, have a higher propensity to walk compared to travellers using passenger cars. In addition, people who cannot afford a private vehicle, also have an increased walking propensity.

Considering other factors, three encouraging and two discouraging factors were included in the model. Good weather conditions lead to higher walking propensity, by contrast to cycling propensity where it did not seem to affect it in any model. Better environmental conditions and better air quality also increase walking propensity in the joint model. Furthermore, pedestrian lights with longer green duration increase walking propensity according to the model. Just like in the cycling propensity model, the low speed associated with walking decreases the propensity to walk, while the high fatigue levels resulting from walking significantly reduce walking propensity.

Athens model

Table 5.W.2 demonstrates the probit model for walking propensity considering the population of Athens.

Table 5.W.2

Variable	Estimate Value	T-Value
Infr=2	6.440e-01	8.213
Infr=3	8.564e-01	10.767
Dist=2	-8.014e-01	-10.145
Dist=3	-1.480e+00	-17.584
Purp=2	-3.197e-01	-4.118
Purp=3	-1.925e-01	-2.483
Socioeconomical Factors		
Mo_inc	1.296e-04	1.716
Educ=2	5.790e-01	3.798
Educ=4	2.934e-01	1.832
Educ=5	1.008e+00	3.978
Age>=2	-1.122e+00	-3.886
Transport Preferences		
Jam_slow>=2	1.263e+00	5.541
M_trans=2	3.383e-01	2.686
Discouraging Factors		
P_mode_slow>=3	-4.148e-01	-3.272
P_fatigue>=3	-2.334e-01	-1.693
Encouraging Factors		
P_good_wthr>=2	9.420e-01	2.380
P_lights>=2	2.049e+00	3.919
P_more_cp>=3	6.938e-01	2.977
Intercept	-2.049e+00	-2.607
Mu_1	8.213e-01	16.857
Mu_2	1.609e+00	25.953
Mu_3	2.632e+00	33.569
Sigma	1.254e+00	11.253
Observations	1350	
Degrees of Freedom	23	
Initial Log-Likelihood	-2050.831	
Final Log-Likelihood	-1656.179	
AIC	3358.358	

As in the joint model, for the Athens model, trip distance is the most statistically significant variable. The longer the trip is the lower the propensity to walk. In addition, infrastructure quality increases walking propensity. Working is the trip purpose with the highest walking propensity, while socializing demonstrates the lowest propensity, in contrast to the general model results.

Three socioeconomical factors were included in the model for Athens. As age increases the propensity to walk decreases, while better education levels lead to higher walking propensity. Furthermore, the model demonstrates that the propensity to walk increases as personal income increases.

People who use public transport as their main transport have a higher propensity to walk compared to passenger car drivers. In addition, people affected by traffic congestion are more probable to walk.

Similarly to the general model, speed and fatigue are discouraging Athenians from walking as they reduce the walking propensity. Good weather conditions increase walking propensity. In addition, improvements on junctions including more pedestrian crossing points and longer green duration of pedestrian lights, increase the propensity to walk.

Dublin model

Table 5.W.3 presents the probit model for walking propensity considering the population of Dublin.

Table 5.W.3

Variable	Estimate Value	T-Value
Infr=2	0.29878	3.860
Infr=3	0.59478	7.555
Dist=2	-0.89135	-11.075
Dist=3	-1.63790	-19.011
Purp=2	0.20301	2.593
Purp=3	-0.42674	-5.452
Socioeconomical Factors		
Age=7	-0.57378	-2.974
Educ<=4	1.02068	3.520
Sex=2	0.20398	1.776
Discouraging Factors		
P_bad_wthr>=2	-0.95381	-3.278
P_mode_slow>=2	-0.45141	-1.780
P_road_junct<=4	-0.94003	-4.820
P_fatigue=5	-0.79112	-5.200
Encouraging Factors		
P_more_gr=2	1.01892	2.048
P_more_gr=3	1.44266	3.343
P_more_gr=4	1.11243	2.929
P_more_gr=5	1.26739	3.201

Intercept	2.29137	4.030
Mu_1	1.08814	18.398
Mu_2	1.75865	25.669
Mu_3	2.66535	33.127
Sigma	1.21273	12.536
Observations	1350	
Degrees of Freedom	22	
Initial Log-Likelihood	-2021.678	
Final Log-Likelihood	-1639.211	
AIC	3322.423	

Model results indicate that longer trip distances reduce the propensity to walk substantially. In addition, better infrastructure quality results in higher walking propensity. As opposed to the previous models, socializing is the travel purpose associated with the higher walking propensity, followed by work, with shopping being the purpose with the lowest propensity.

People aged over 64 years old in Dublin have a significantly lower propensity to walk. Furthermore, women have a considerably higher propensity to walk compared to men. Higher education levels, as in the previous models, result in higher walking propensity.

Four discouraging factors were included in the model for Dublin. In particular, people affected by fatigue have a significantly lower propensity to walk. Adverse weather conditions discourage Dubliners from walking, as their walking propensity decreased. In addition, the presence of many big junctions within the route, reduces the propensity to walk considerably. The low speed associated with walking also decreases the walking propensity in Dublin. The only encouraging factor included in this model is the presence of more green and green areas within the route, which significantly increase the propensity to walk in Dublin.

For a confidence level of 95%, the LRT of the 3 models above is higher than the value of chi-squared for the parameters included, which means that the two submodels of Athens and Dublin produced more accurate results than the general one.

Athens men model

Table 5.W.4 demonstrates the probit model for walking propensity considering the population of men in Athens.

Table 5.W.4

Variable	Estimate Value	T-Value
Infr=2	0.55609	4.590
Infr=3	0.69428	5.694
Dist=2	-1.07241	-8.670
Dist=3	-1.85432	-13.682
Socioeconomical Factors		
Income=6	-1.71327	-4.321
Educ=5	1.61958	6.468
Age=5 & age=6	-0.42074	-2.602
Transport Preferences		
M_trans=2	0.56417	3.032
M_trans=3	1.92007	5.160
Jam_slow>=2	0.90207	3.884
Public_unr=5	0.32567	1.652
Discouraging Factors		
P_mode_slow=5	-1.19768	-4.616
P_road_sfty>=2	-1.26271	-5.558
Encouraging Factors		
P_lights>=2	1.84622	3.731
P_more_cp>=3	1.00068	2.354
Intercept	-0.74021	-1.012
Mu_1	1.01371	12.085
Mu_2	1.76620	17.108
Mu_3	2.93168	22.313
Sigma	1.40116	8.511
Observations	594	
Degrees of Freedom	20	
Initial Log-Likelihood	-895.039	
Final Log-Likelihood	-668.5105	
AIC	1377.021	

Results indicate that the longer the trip distance the lower the propensity to walk. Infrastructure quality is not as significant as in other models, but still quite important. Better infrastructure quality results in higher walking propensity. The most noticeable feature in this model is that trip purpose does not seem to affect walking propensity.

Age influences walking propensity in Athens, as men older than 44 years old demonstrate a considerably lower propensity to walk compared to underaged men. Furthermore, higher education levels result in higher walking propensity. In contrast

to the model produced for Athens, high income leads to lower walking propensity for men in Athens.

Men using public transport or bicycle as their main transport mode, have a higher propensity to walk compared to private vehicle users. In addition, men affected by traffic congestion and men who consider the public transport unreliable have a higher walking propensity.

Road safety is the most important discouraging factor in this model, as the lack of road safety and fear of a potential accident reduces the walking propensity of men in Athens. Travel speed is also a factor decreasing the propensity to walk. Junction infrastructure improvements, the presence of more pedestrian crossings and the longer duration of green lights for pedestrians are infrastructure based factors that increase the propensity to walk, for men in Athens.

Athens women model

Table 5.W.5 presents the probit model for walking propensity considering the population of women in Athens.

Table 5.W.5

Variable	Estimate Value	T-Value
Infr=2	0.76205	7.193
Infr=3	1.04007	9.601
Dist=2	-0.66011	-6.241
Dist=3	-1.33587	-11.992
Purp=2	-0.50804	-4.823
Purp=3	-0.17619	-1.692
Socioeconomical Factors		
Income=5	1.34391	4.461
Age>=5	-0.82091	-5.954
Transport Preferences		
Ped_inf	0.98949	2.276
Jam_slow=5	0.53325	4.213
M_trans=2	0.24267	1.853
Discouraging Factors		
P_mode_slow>=2	-0.88904	-4.189
P_fatigue>=4	-0.39013	-3.087
Encouraging Factors		
P_count_light>=2	1.71893	3.831
P_lights=5	0.36886	1.909
P_bet_air>=3	1.33485	5.014

P_car_dri=2	2.89132	5.567
P_car_dri=3	2.05868	4.539
P_car_dri=4	1.50939	3.687
P_car_dri=5	1.16492	2.865
Intercept	-2.03951	-3.046
Mu_1	0.75557	11.992
Mu_2	1.56242	19.135
Mu_3	2.55336	24.718
Sigma	1.35422	11.815
Observations	747	
Degrees of Freedom	25	
Initial Log-Likelihood	-1137.027	
Final Log-Likelihood	-921.9335	
AIC	1893.867	

Longer trip distance reduces the propensity to walk, and better infrastructure quality increases walking propensity. Unlike men, travel purpose is affecting women's walking propensity. Working is the purpose with the higher propensity, followed by shopping, while socializing is associated with the lowest propensity.

The only socioeconomical factors included in this model are age and income. High personal income, by contrast with the previous model, increases walking propensity, while women over the age of 44 demonstrate a significantly lower propensity to walk, compared to underaged women.

Considering transport preferences, women in Athens using public transport show a higher propensity to walk compared to travellers using passenger cars. Women affected by traffic congestion also demonstrate a higher probability to walk. Last, women who rated the walking infrastructure of Athens as good, have a higher propensity to walk compared to those who rated it as poor.

Similarly to men, low speed discourages women from walking, reducing their propensity to walk significantly. Women affected by fatigue also demonstrate a lower propensity to walk. Longer duration of green lights for pedestrians are encouraging women to walk more. Countdown pedestrian lights also increase walking propensity. Better environmental conditions and air quality also increase the propensity to walk. Last, more careful drivers would encourage women to walk more.

For a confidence level of 95%, the LRT produced by the Athens model and its subgroups is greater than the value of chi-squared for the parameters included, thus

the submodels of men and women in Athens produced more accurate results than the model for the joint population in Athens.

Dublin men model

Table 5.W.6 presents the probit model for walking propensity considering the population of men in Dublin.

Table 5.W.6

Variable	Estimate Value	T-Value
Infr=2	0.45776	4.075
Infr=3	0.60681	5.365
Dist=2	-1.04452	-8.892
Dist=3	-1.93635	-15.019
Purp=2	0.33712	3.001
Purp=3	-0.60416	-5.342
Transport Preferences		
No_ix>=2	0.46694	2.739
No_public=5	1.21373	2.892
Discouraging Factors		
P_road_sfty=3	-0.53213	-3.039
P_bad_wthr>=2	-2.74347	-5.153
Encouraging Factors		
P_view>=3	1.16856	2.855
Intercept	3.66160	5.308
Mu_1	1.10771	12.749
Mu_2	1.80953	17.804
Mu_3	2.80700	22.838
Sigma	0.54279	5.227
Observations	612	
Degrees of Freedom	16	
Initial Log-Likelihood	-957.1769	
Final Log-Likelihood	-749.2699	
AIC	1530.54	

Model results indicate that longer travel distance leads to lower walking propensity, while better infrastructure results in increased propensity. Socializing is the travel purpose with the highest propensity, followed by work, with shopping purposes demonstrating the lowest propensity according to the model.

Men in Dublin who cannot afford a private vehicle or public transport have both a significantly higher propensity to walk. Adverse weather conditions discourage men from walking, considerably reducing their walking propensity. Furthermore, road safety is a factor influencing walking propensity, as the lack of road safety and fear of a potential accident reduces the walking propensity. Last, beautiful view throughout the trip increases the propensity to walk for men in Dublin.

Dublin women model

Table 5.W.7 demonstrates the probit model for walking propensity considering the population of women in Dublin.

Table 5.W.7

Variable	Estimate Value	T-Value
Infr=2	0.25149	2.285
Infr=3	0.70818	6.235
Dist=2	-0.83050	-7.215
Dist=3	-1.50723	-12.320
Purp=1	0.26268	2.352
Purp=2	0.32486	2.929
Socioeconomical Factors		
Cor=2	-1.27332	-5.457
Educ=4	0.46454	2.309
Age>=5	-0.95652	-4.759
Transport Preferences		
No_public>=4	0.68353	2.008
Discouraging Factors		
P_road_junct=3 & p_road_junct=4	-0.83164	-4.616
P_mode_slow>=3	-0.56258	-3.555
P_fatigue=5	-1.57879	-6.558
Encouraging Factors		
P_bet_air=5	0.68642	4.080
P_more_gr>=4	0.43432	2.182
Intercept	2.53944	10.495
Mu_1	1.11271	12.916
Mu_2	1.77915	17.834
Mu_3	2.67885	22.882
Sigma	1.14120	9.044
Observations	702	
Degrees of Freedom	20	

Initial Log-Likelihood	-1000.526
Final Log-Likelihood	-793.862
AIC	1627.738

Model results indicate that longer travel distance leads to lower walking propensity, while better infrastructure results in higher walking propensity. Socializing is the trip purpose leading to the highest propensity, with shopping leading to the lowest.

Women over 44 years old compared to underaged women demonstrate a significantly lower propensity to walk in Dublin. In addition, highly educated women have a higher walking propensity according to the model. Also, women who cannot afford public transportation have a higher propensity to walk.

Three discouraging and two encouraging factors were included in this model. Women affected by fatigue demonstrate a noticeably lower propensity to walk. The presence of many junctions in a trip and the low speed associated with walking also reduce the propensity to walk for women in Dublin. On the contrary, more green routes and better environmental conditions increase considerably walking propensity.

Last, unlike the model for cycling propensity of women in Dublin, women who live in Dublin (for over a year) and are not Irish, have a significantly lower propensity to walk than Irish women, as the produced model results indicate.

For a confidence level of 95%, the LRT of the Dublin models is higher than the value of chi-squared for the parameters included, meaning that the models of men and women in Dublin produced more accurate results than the joint Dublin model.

6. Conclusions

The objective of this thesis is to collect data and provide evidence considering the factors affecting cycling and walking propensity. Furthermore, as the survey took place in two cities presenting different mobility characteristics concerning cycling and walking, another objective is to identify both global and regional contributing factors. This is why joint data models were produced, in order to witness the correlation between different variables in a larger and different audience. Besides the conclusions of this thesis, potential future research suggestions are provided.

6.1 Conclusions from the cycling models

Travel distance and infrastructure in most models are the most statistically significant variables. These two factors influence in the same manner the sample in both countries. In particular, infrastructure changes seem to affect women slightly more than men, whereas men are more affected by travel distance. Trip purpose affects cycling propensity greatly. In all seven models, people have a higher propensity to cycle to work than for any other trip purpose. In Athens, people are more probable to cycle for shopping purposes than socializing, while in Dublin shopping and socializing demonstrate similar cycling propensities.

First of all, it is important to indicate that as the general model indicates, people in Dublin have a higher propensity to cycle than people in Athens. This confirms that Dublin is a more bicycle friendly city than Athens, confirming the data presented in chapter 4. Six out of the seven models produced are influenced by the age factor. More specifically, in all models except that considering men in Dublin, older people exhibit lower cycling propensity, and thus age can be treated as a global factor, affecting both populations. Education is also included in every model. In six of the seven models, higher education levels result in higher cycling propensity, except for men in Athens where by contrast, higher education leads to significantly reduced propensity to cycle. In the general model, higher income leads to increased cycling propensity. This is confirmed by the Dublin model, but in the Athens model, higher income reduces cycling propensity. In the rest of the models, income is included only in the Dublin men population model and results in higher cycling propensity. Thus, it is not safe to make any conclusions about income, as each country and community has different tendencies considering personal income. Fatigue is another factor that can be found in all models except one (Dublin men). In all produced models, people affected by fatigue demonstrate a lower propensity to cycle. Fatigue could be considered a global factor, although is seems to affect travellers in Athens slightly more. The low speed associated with cycling is one more factor that could be considered as global, as it appears in six out of the seven models. Similarly to fatigue, it reduces cycling propensity and it affects the models of Athens more than the models of Dublin. Students in Dublin have a higher tendency to cycle, while in

Athens this tendency does not appear. On the other hand, people affected by traffic congestion have a higher propensity to cycle in Athens, while in Dublin traffic congestion does not seem to affect cycling propensity. People who cannot afford a private vehicle, have a higher propensity to cycle in both countries. In Athens gender influences cycling propensity, unlike Dublin. In particular, women in Athens are more probable to cycle than men. People who walk are less probable to cycle than people using public transport in most models, however this relationship is not as clear. Gender does not necessarily influence the propensity to cycle as already mentioned, but there are different factors affecting men and women in Athens and Dublin. In Athens the presence of greater cycling networks and more continuous cycle networks increases the propensity to cycle, unlike Dublin. The presence of many pedestrians affects women in Athens, while less traffic would increase cycling propensity for men. Road safety is very important in Dublin as low levels of it lead to reduced cycling propensity for both men and women in the city. Last, women in Dublin who are not Irish have a significantly higher propensity to cycle than Irish women.

6.2 Conclusions from the walking models

Considering walking propensity, distance is by far the most statistically significant variable in all seven models produced. Longer distance reduces greatly the propensity to walk in both cities. Infrastructure is also a significant factor with better infrastructure resulting in higher walking propensity. In the cycling models, working was the travel purpose resulting in the highest propensity. Considering walking, in Athens work is still the purpose exhibiting the highest walking propensity but in Dublin it is more probable to walk for socializing purposes. In both cities, shopping is the purpose resulting in the lowest walking propensity.

Results do not indicate that people in Dublin have a higher propensity to walk compared to people in Athens, unlike cycling. The age factor is included in six out of seven models and indicates that older people have a lower propensity to walk. The only model in which age did not influence walking propensity, similarly to the cycling models, is the one considering Dublin's men. Gender influences propensity in Dublin, as women in Dublin have a higher propensity to walk than men. Education levels influence the 3 general models, indicating that higher education levels result in increased propensity to walk, but does not influence the four subpopulation models, thus it is difficult to evaluate it as a factor. Income affects people in Athens, as men in Athens with higher income present a lower walking propensity, while women with higher income exhibit a higher walking propensity. Fatigue affects all investigated populations except for men. Thus, we conclude that fatigue is a factor reducing the propensity to walk for women both in Dublin and Athens. The low speed associated with walking also reduces the propensity to walk in six out of seven models; only

men in Dublin are not affected by this factor. Good weather conditions increase the propensity to walk, especially in Athens, while adverse weather conditions reduce the propensity to walk, especially in Dublin. In Athens, both for men and women, longer durations for pedestrian green lights increase the propensity to walk and escpecially for women, while countdown pedestrian lights also increase walking propensity. Furthermore in Athens, just like for cycling, traffic congestion increases walking propensity for both genders. In Dublin road safety and the presence of big junctions reduce walking propensity for both men and women. In particular, road safety affects significantly men in both cities. Better environmental conditions and better air quality affect women, increasing their propensity to walk in both cities. In Athens people using the public transport as their main transport mode are more probable to walk compared to travellers using passenger cars. Last, women in Dublin who are not Irish, have a noticeably lower propensity to walk, unlike cycling.

6.3 Suggestions for future research

This present research uses combined data from two different countries demonstrating different infrastructure characteristics and probably traveller attitudes considering their personal mobility and attempts to identify global factors affecting the propensity to cycle and walk. It would be interesting for future researchers to conduct similar surveys in several countries in order to understand how different factors affect the choice to walk and cycle in different situations and conditions, and compare them. Furthermore, it is important to conduct more research, especially considering walking propensity as it is a matter of study that has not yet been as much explored as cycling and can have a great impact in designing future sustainable transport systems. Last, similar data could be collected through a large-scale revealed preference questionnaire survey. This would capture the prevailing trip characteristics considering cycling and walking of travellers.

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